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NOTES.

State Ownership of Telephones.

LAST month an instructive debate took place in the Canadian House of Commons on the subject of telephone rates in Canada. A resolution was moved urging the Government to carry out measures to remove "long existing abuses," so as to give the people in Canada as cheap a service as that in other countries where a national telephone service is maintained. This resolution was prompted by the popular idea that telephone rates on nationally owned telephone systems are lower than on systems operated by private enterprise, and was due principally to the fact that the Government of Manitoba had recently reduced telephone rates after working the telephones in Manitoba for rather less than a year in succession to a company. The mover of the resolution relied on the evidence of "an eminent expert," a Mr. DAGGER, who had given evidence to a Committee of the House to the effect that present rates in Canada could be "cut in two" and still leave a satisfactory profit on the working, state ownership being the natural and only way to demonstrate the truth of such an assertion. Of course many figures were given in support of this idea, and from these it would seem at first sight that Canada is in a very unenviable position. IN the discussion which ensued it was, however, pointed out that the question of depreciation, which is so often forgotten by advocates of low rates in dealing with these matters, had been entirely omitted, and that if a proper figure had been included the profit shown by the Manitoban Government would have been converted into a loss. A telephone business is peculiarly susceptible to depreciation, and is probably more liable to "scrapping" than any other electrical business. Five per cent. per annum of the capital seems to be a minimum figure, and 10 per cent. is not unreasonable. What a large percentage of the revenue is swallowed up in this way is emphasised by the fact that the Bell Telephone Co. wrote off for depreciation between the years 1899 and 1905 percentages of revenue varying from 34 to 42 per annum. Moreover, comparative figures of telephone rates are more or less worthless. The telephone business is characterised by the unusual property that an increase of business does not necessarily lead to an increase of profit. An increase in the number of subscribers means that more work is entailed for each subscriber and also a greater capital cost. Consequently, it is useless to compare a small system with one that is large. Moreover, the cost of staff must vary enormously with the locality; for example, an operator at Stockholm receives £36 per annum as compared with £110 in Australia. Such points are not appreciated by the lay mind, which expects as cheap a service in London as in Finland, and in addition very much greater facilities.

The Insulation of Cables.

FOR low-tension lead-covered cables most central station engineers at the present time choose an insulation of paper impregnated with oil; in fact, such insulation has been used for probably 90 per cent. of the underground cables installed in this country during recent years. Although bitumenised fibre or jute is a more expensive material than paper, its use for the insulation of low-tension cables does not add appreciably to their cost; for high-tension cables, however, where the insulation becomes a much more important factor in the total cost of the cable, paper is almost universally used, the extra cost of bitumenised fibre being then rather prohibitive. The reason for the marked preference in favour of paper insulation for low-tension cables, however, is a little difficult to explain, for the advantages of bitumenised fibre can by no means be disregarded, and, on the other hand, oils are not uniform in character. Thus, the oil used for impregnating a paper cable must be carefully chosen, since it should not be too fluid, nor, on the

other hand, too viscous, as the layers of paper will in the latter case not slide freely over one another, resulting in a likelihood of the insulation tearing or cracking whenever the cable is bent. In fact, this cracking is always a more likely occurrence with paper than with bitumenised fibre.

Again, the process of jointing is more difficult if the paper is well impregnated with oil, since cleanliness is not so easily secured; and another point, also in favour of fibre, is that moisture can travel more easily along a paper insulated cable. The most important consideration, however, is the life of the cable, and as this is not easily ascertained it must be largely a question of opinion. It cannot be too strongly emphasised, however, that only the very best Manila paper obtainable should be used, and any saving in the cost of the insulation of a cable is dearly purchased if obtained at the expense of the life of the cable, for the latter is certainly largely determined by the durability of the insulation. Information upon this subject is, however, rather scarce, so that our readers will no doubt welcome the article by Messrs. Clayton Beadle and Henry P. Stevens, the first instalment of which appears in our present issue. In this article the composition and durability of the papers employed in the manufacture of cables are discussed, mainly from the chemical point of view, and as the article is the result of wide experience, we do not doubt that the authors' conclusions will be of value to those concerned with this important branch of the industry.

Personal.—It is announced that the Royal Academy of Sciences of Sweden has awarded a gold medal to Mr. T. A. Edison for his inventions in connection with the phonograph.

Motor Omnibus Regulations.—We are informed by the London Electrobus Co. that the limit of $3\frac{1}{2}$ tons proposed by the Commissioner of the Police for motor omnibuses does not include fuel, water or accumulators, so that such a regulation will not interfere with the present design of the electrobus.

The Faraday Society.—The following nominations for the Officers and Council of this Society to be elected at the forthcoming annual general meeting were announced at the last ordinary meeting of the Society: *President:* Mr. J. Swinburne, F.R.S. *Vice-Presidents:* Mr. G. T. Beilby, F.R.S., Sir R. A. Hadfield, F.R.S., Prof. A. K. Huntington, Dr. Ludwig Mond, F.R.S., Lord Rayleigh, O.M., F.R.S., Prof. A. Schuster, F.R.S., and Mr. E. Solvay. *Treasurer:* Dr. F. Mollwo Perkin. *Council:* Messrs. E. J. Bevan, Bertram Blount, A. C. Claudet, W. R. Cooper, S. Z. de Ferranti, F. W. Harbord, W. Murray Morrison, H. F. K. Picard, J. L. F. Vogel, and Dr. N. T. M. Wilsmore.

Electric Power Supply in Bombay.—A very large hydro-electric scheme, whereby it will be possible to supply Bombay as well as a number of local mills and other power users, is now under consideration. It is proposed to erect three large reservoirs by constructing dams across the Shirawta, Walwhan and Lanonla valleys, which will collect water from the Ghat mountains. From these reservoirs the water will be conveyed through a penstock to the power station near Khopoli, the total fall being 1,730 ft. Power will be transmitted at 45,000 volts by overhead lines to Bombay, some 43 miles away. Here it will be stepped down to various pressures and distributed to consumers.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Pontianak—Saigon	Sep. 16, 1908	—
Tourane—Amoy	Jan. 19, 1909	—
Malta—Zante	Apr. 6, 1909	Apr. 11, 1909
Hong Kong—Macao	Apr. 13, 1909	—

German Bunsen Society.—The annual meeting of this society will be held at Aix-la-Chapelle from May 23rd to 26th, immediately before the International Congress of Applied Chemistry in London.

Institution of Colliery and Mining Electrical Engineers.—We are informed that the Inaugural Meeting of this Institution will be held at the Grand Hotel, Manchester, on April 24th at 5 p.m. The chair will be taken by Mr. Wm. Maurice, of the Hucknall Colliery Co. A cordial invitation is extended to all interested in electrical and mining matters.

New Submarine Cable to South America.—The Western Telegraph Co. has submitted a proposal to the Argentine Government for the construction and laying of a new submarine cable directly connecting Argentina and Europe, and touching at Ascension Island. The chief officials of the Argentine Posts and Telegraphs Department and the Ministry of the Interior have expressed themselves favourably towards the scheme, which is also well received in political and commercial circles in the Republic.

Birmingham Section of the Institution of Electrical Engineers.—The following list of officers to act on the council of this Section during the session 1909-10 has been prepared for circulation and presentation at the annual general meeting on May 5th: *Chairman,* Mr. R. K. Morcom. *Past-chairmen,* Messrs. R. Threlfall, F.R.S., R. A. Chattock and Dr. G. Kapp. *Vice-chairman,* Mr. M. Railing. *Ordinary members of committee* (*remaining in office*), Messrs. V. Bornand, A. R. Everest, A. Lindsay Forster, J. P. Kemp, J. F. Lister, A. Pearson, A. M. Taylor, and J. C. Vaudrey. *Ordinary members of committee* (*new nominations*), Messrs. J. H. Barker, M. Kloss, F. J. Moffett, and Dr. W. E. Sumpner. *Hon. secretary,* Mr. H. B. Matthews.

Iron and Steel Institute.—We are informed that the annual meeting of this Institute will be held at the Institution of Civil Engineers, Great George-street, Westminster, on Thursday and Friday, May 13th and 14th. Unfortunately the president-elect, Sir W. T. Lewis, may be prevented from occupying the chair, and in that event Sir Hugh Bell will preside. Among the Papers down for reading are the following:—"On the Production of Iron Sheet and Tubes in one Operation," by Mr. S. Cowper-Coles; "On High-tension Steels," by Mr. P. Longmuir, and "On the Roechling-Rodenhauser Electric Furnace," by Mr. W. Rodenhauser. The annual dinner of the Institute will be held at the Hotel Cecil on the evening of May 14th. The autumn meeting will also be held in London, on September 28th, 29th and 30th.

Electric Traction in the Congo.—A correspondent to "The Times" states that Mr. Sandys, who is responsible for the construction of the well-known railway from Mataeli to Leopoldsville, has gone to Africa to examine the rapids and falls of the Lower Congo in order to decide whether it would be possible to obtain sufficient hydraulic power to operate the railway electrically. It is reported, concerning the line now under construction from the Upper Congo to the Great Lakes, for which an additional capital of a million sterling has lately been raised, that the first section from Stanleyville to Ponthierville, 80 miles in length, has been completed, and the temporary bridges have been replaced by permanent structures. The second section, extending to a length of 210 miles, between Kindu and Kongolo has been fully surveyed and nearly laid out. About 125 miles of formation have been prepared, and the track is laid for a distance of 90 miles. As soon as Kongolo is reached, the further portion of the navigable Upper Congo for a distance of 400 miles—that is to say, reaching from Kongolo right up to Congo through Lake Kisale, as far as the falls of Kalengwe, in Katanga—will become available for navigation by boats of 500 tons burden. It is hoped that all will be ready by the end of 1910.

Electric Traction in Japan.—A railway which, when finished, will be the third longest in Japan, is now under construction and possesses the further distinction that it will be electrically worked throughout. It will connect Kyoto, a large town with nearly half a million inhabitants, with Osaka, an in-

dustrial centre, with a population of nearly one million. From an industrial point of view, therefore, the railway should prove of great importance. The total length of the line, which will be double-track throughout, is 30 miles. Current for working the line will be supplied from three 850 kw. three-phase steam turbo-alternators, the transmission voltage being 2,500 volts. Sub-stations are to be erected along the line, and will transform the three-phase current to continuous at 2,500 volts for use at the trolley wire. The equipment of the line is in the hands of English firms, among whom may be mentioned Messrs. Dick, Kerr & Co., Willans & Robinson and Babcock & Wilcox.

Electrically-Operated Fish Van.—An interesting application of electric traction to goods traffic is illustrated by the introduction of a combined parcel and fish van, which is now being employed on the electrified lines of the North Eastern Railway in the neighbourhood of Newcastle. The van has four compartments arranged to give a driver's cab at each end, with divisions in the centre for luggage and fish respectively. The van is 55 ft. long over the head-stocks, and is carried on pressed steel bogies with wheels 3 ft. in diameter. The couplings and buffers are so arranged that the van can be coupled to either a steam or electric train without delay. Hand and air brakes are both provided, the latter being supplied from an electrically-driven air compressor. The electrical equipment consists of four 125 H.P. B.T.-H. motors similar to those used on the North Eastern Railway Co.'s other electric trains. The Sprague system of multiple unit control is also fitted. Great care has been taken to make all the electrical equipment as safe as possible; all the cables are asbestos covered and are run in solid drawn steel conduits screwed into cast-iron connecting boxes. Where the cables leave the conduits the latter are bell-mouthed and are provided with rubber washers to render the whole air-tight. The van is lighted by six lamps connected in series, while duplicate sets of signal and route lamps are provided.

Investigations on the Electrical State of the Upper Atmosphere.—A Paper on this subject was read on Tuesday, March 23rd, by Mr. W. Makower, Miss Margaret White and Mr. E. Marsden before the Manchester Section of the Institution of Electrical Engineers. It contained the results of investigations made during July and August, 1908. These were chiefly concerned with the measurement of the electric currents flowing from a kite down a wire by which it was attached to the winding machine. In the first experiments different lengths of wire were let out with the kite, detached from the winding machine, and the free end of the wire attached to an ebonite insulator fixed to the ground. The kite was then connected to earth through a sensitive dead-beat galvanometer and the current measured. In these experiments the currents at considerable heights were so large that it was found necessary to reduce the sensitiveness of the galvanometer by shunting. The plan was therefore adopted in later experiments of using a portion of the kite wire when attached to the drum of the winding machine, which was earthed, as a shunt, and thus making use of the usual daily flights taking place at the Glossop Observatory. The mean currents obtained were as follows:—

Height of kite above ground.		*Current in amperes.*
2,000 ft.	....	5×10^{-5}
4,000 ft.	....	13×10^{-5}
6,000 ft.	....	23×10^{-5}

The current at any fixed height varied considerably from day to day. There seemed, however, to be a fairly close connection between the current and wind velocity, the currents being great when the wind was high. A few experiments were made on the potential of the air at different heights, but no very reliable results were obtained, on account of the difficulty of satisfactorily insulating the apparatus owing to the high potentials to be measured.

Electro-Analysis of Mercury Compounds with a Gold Cathode.—At the meeting of the Faraday Society held on March 30th, Dr. F. Mollwo Perkin read a Paper on this subject, in which he first showed that the results obtained were always slightly high—from 0·5 to 1 per cent. This was at first attributed to occluded hydrogen; but it was found that the gold electrode did not increase in weight when made the cathode in dilute sulphuric acid, the current being passed for 6 to 20 hours. When the electrode coated with mercury was treated in a similar manner it also showed no increase in weight. The increase in weight could hardly be due to oxidation since the electrode was cathode, and when a platinum electrode was run in series with it the mercury deposited upon the platinum was always slightly less than was theoretically required. The author was consequently unable to account for the results, but pointed out that a gold electrode could not be satisfactorily used for analytical purposes. A rotating silver electrode showed similar results—viz., the weight of mercury was too high. Usually the time required to deposit the mercury was from five to six hours, but by placing the cell and electrodes in a powerful magnetic field in such a way that the liquid was caused to swirl, the mercury was deposited in about 50 minutes. The results in this case, however, were again too high. The author also described two new quartz vessels which he had devised for depositing mercury or other metals upon a mercury cathode, one of them being fitted with a siphon side tube. In conclusion, the author said that undoubtedly the best electrode for depositing mercury upon was one of mercury, and that the deposition was extremely rapid if a rotating anode was employed.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, April 17th.

BIRMINGHAM & DISTRICT ELECTRIC CLUB.

7 p.m. Meeting in the Battery Room, Summer-lane Power Station, Birmingham. Paper on "Electric Welding," by Mr. V. D. Green.

TUESDAY, April 20th.

JUNIOR INSTITUTION OF ENGINEERS.

7:30 p.m. Meeting at Royal United Service Institution, Whitehall, S.W. Paper on "Systems of Electrical Power Distribution," by Mr. C. H. Smith.

THE INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Meeting at Great George-street, Westminster, S.W. Paper on "The 'New York Times' Building," by Mr. C. T. Purdy.

WEDNESDAY, April 21st.

BIRMINGHAM LOCAL SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

7:30 p.m. Meeting in the large Lecture Theatre, the University, Edmund-street. Papers on "Manipulation of Telephone Dry Core Cables," by Mr. F. G. C. Baldwin; and on "Improvement of Power Factor in A.C. Systems," by Mr. Miles Walker.

THURSDAY, April 22nd.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Meeting at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Paper on "The Electrical System of the London County Council Tramways," by Mr. J. H. Rider. Adjourned discussion.

FRIDAY, April 23rd.

PHYSICAL SOCIETY OF LONDON.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: (1) "On a Want of Symmetry Shown by Secondary X-Rays," by Prof. W. H. Bragg, F.R.S. (2) Transformations of X-Rays," by Mr. C. A. Sadler. (3) "Theory of the Alternate Current Generator," by Prof. T. R. Lyle.

THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's Gate, St. James Park, Westminster. S.W. Presidential address by Mr. J. A. F. Aspinall.

STUDENTS' SECTION OF THE INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Meeting at Great George-street, Westminster, S.W. Paper on "The Development of Hydro-Electric Power Schemes; with Special Reference to Works at Kinlochleven," by Mr. J. M. S. Culbertson.

ROYAL INSTITUTION OF GREAT BRITAIN.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Tantalum and its Industrial Applications," by Mr Alexander Siemens.

Corps of Electrical Engineers (London Division).
Commanding Officer, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, April 19th, "A" Company ...... Tuesday, April 20th, "B" Company	Infantry drill (Recruits), 6 p.m. to 7 p.m.
Thursday, April 22nd, "C" Company ...... Friday, April 23rd, "D" Company	Technical drill, 7 p.m. to 9:30 p.m.

THE INDUSTRIAL APPLICATION OF THE ELECTRIC MOTOR, AS ILLUSTRATED IN THE GARY PLANT OF THE INDIANA STEEL COMPANY.*

BY B. R. SHOVER.

Summary.—A description is here given of the main features of the electrical installation for the largest steel-making plant in the world. Blast furnace gas is used for a large gas engine power station. One of the most interesting features is the electrical equipment of the rail-mill, the roll-trains being direct coupled to the largest induction motors ever made, of 2,000 and 6,000 H.P. capacity.

A brief historical *résumé* of the application of electric power to the steel-mill industry is first given. While the United States has led in the application of electric drive to auxiliary machinery, Europe has pioneered the way in its use for driving roll trains. In the different European steel plants there are to-day about 230 motors with a normal capacity of 19,000 H.P. and a maximum capacity of 41,000 H.P. used for electric drive of non-reversing roll trains. In addition, one noteworthy installation is that of a 10,500 H.P. reversing outfit at the Hildegardehütte mine. In June, 1907, the Illinois Steel Co. put in the first and only reversing-mill drive that has been installed in America.

The increasing demand for steel has led to the recent installation of the Gary plant. The site chosen is at the extreme south end of Lake Michigan, about 26 miles from the centre of Chicago. The advantages of this location consist of lake transportation, splendid railroad facilities and cheap land. The governing feature in the design of the plant was economy, and to this end the blast-furnace gas was utilised in gas engines, driving electric generators to furnish electric power.

It was decided to stick to only well-tried apparatus, and the use of trolley wires for cranes, scale larries, &c., was abolished. For travelling apparatus up to and including travelling cranes of 50 tons' capacity a 2 in. by $\frac{3}{8}$ in. steel strip is used for main conductors. Apparatus of larger capacity uses a 60 lb. rail, while the unloaders and bridges have 100 lb. rails, reinforced by heavy copper cable, so as to get carrying capacity sufficient to avoid excessive drop. In the part of the works now complete there are installed 110 electric travelling cranes with an aggregate lifting capacity of 3,812 tons. The capacity is 22,025 H.P. in direct current and 5,312 H.P. in 440 volt alternating current motor; 27,000 H.P. in 6,600 volt alternating-current motors haa already been operated. About an equal aggregate number of horse-power will be required for the operation of that part of the plant now under construction, and still more for parts which are at present being designed.

Electric Power Station.—For this part of the plant it is intended to use the gas available from eight blast furnaces. On account of the large amount of current, the especially large number of circuits and units, and also to make the operation more reliable, this plant is divided into two sections, which are called power houses No. 2 and No. 3 respectively. The eight blast furnaces producing 3,600 tons of pig iron per 24 hours will give a total of 22,450,000 cubic ft. of gas per hour. Thirty per cent., or 6,750,000 cubic ft., of this gas is used for heating stoves; 7·5 per cent., or 1,700,000 cubic ft., are used under the boilers to furnish steam for spare steam engines, pumps and miscellaneous heating; 2·5 per cent., or 600,000 cubic ft., are necessary for operating the gas washers; 12·5 per cent., or 2,800,000 cubic ft., are used by the blast-furnace blowing engines; 2·5 per cent., or 600,000 cubic ft., for auxiliary use in connection with these engines. The remaining 45 per cent., or 10,000,000 cubic ft. per hour, are available for power purposes. If estimated at 90 B.Th.U. per cubic foot and 10,000 B.Th.U. per boiler horse-power, this gas is equal to 110,000 boiler horse-power in gas engines.

There are installed in No. 2 and No. 3 electric power stations a total of 17 gas engines, each rated at 3,000 H.P., but capable of about 50 per cent. overload. It will, therefore, be seen that only approximately 50 per cent. of the available power as calculated will be used in this station. The electrical equipment of power houses No. 2 and No. 3 comprises fifteen 2,000 kw. alternating-current units, two 2,000 kw. direct-current units—all driven by gas engines—and also two 2,000 kw. alternating-current turbo units.

Gas Engines.—The gas engines are horizontal twin tandem, double acting, running at 83$\frac{1}{3}$ revs. per min. The cylinders are 44 in. in diameter by 54 in. stroke. The floor space occupied by each engine and generator is 74 ft. by 39 ft., with total approximate weight of 1,700,000 lb. The largest piece in the engine is the bed plate, which weighs from 90 to 95 tons. The flywheel is 23 ft. in diameter and weighs 200,000 lb.

* Abstract of a Paper read before the American Institute of Electrical Engineers.

Turbines.—The two turbines are rated at 2,000 kw. each, and were installed primarily for use in the construction of the plant and to furnish power for starting up. It is also expected that they will assist materially in the regulation of the station by taking care, to a certain extent, of the sudden peak loads.

Storage Battery.—The installation of the storage battery was for the purpose of minimising the fluctuation of load on the generating station. The storage battery consists of two separate batteries of 125 cells, 73 plates per cell, each battery having a rating of 4,320 amperes, with a momentary rating of from two to three times that amount. They are installed in a two-storey building located directly north of the power station, the connection between the two buildings being through a tunnel.

The direct-current regulation is accomplished by means of two 2,500 ampere 35 volt boosters. The motors and generators of this booster are of the interpole type, controlled by a carbonpile regulator acting through a motor-driven exciter. The alternating-current regulation is accomplished by means of special 2,000 kw. split-pole converters. The regulating current for this converter is supplied by a series transformer in the leg of each generator lead. In turn, these transformers are connected to a totalising transformer of the compensator type, which supplies current to a synchronous motor-driven special synchronous converter. From the direct-current side of this converter is taken the regulating current for the split-pole converter. A special 10,000 ampere remote-control switch short-circuits the starting resistance.

The generator oil switches are arranged so that the regulating transformer of each generator is short-circuited when that generator is not in service. Connections are also made so that when stations No. 2 and No. 3 are connected together the battery will regulate on both, but should either tie switch be thrown out, thus disconnecting the two stations, no regulation is possible on station No. 2, and the current transformer in the legs of the generators in that station are at the same time short-circuited. In respect to the average load on the station the regulation of both direct current and alternating current is by remote control.

The transmission system is in duplicate, each section having sufficient capacity to carry the entire load in case of accident to the other sections. The lines are supported upon a steel tower construction made exceptionally heavy on account of the great height of the towers and heavy complement of feeders.

Sub-stations.—There are three sub-stations. Sub-station No. 1 is located in the rail mill and consists of four 500 kw. motor-generator sets. This sub-station normally supplies current for all the direct-current apparatus in the shop group, rail mill and billet mill. Sub-stations No. 2 and No. 3 each have two units, duplicates of those in sub-station No. 1. They normally supply current to the ore unloaders and bridges. The direct-current power furnished from the two 2,000 kw. gas engine driven units in the power station is used to supply the direct-current motors for the blast furnaces and open-hearth plants. When the mills are not in operation, and only the lights and a few cranes are needed, it will be possible to shut down the sub-station and furnish power direct from the power station. This method of operating will result in considerable saving in operating expense. A battery will probably be installed in the near future at this sub-station.

There are located at various parts of the plant nine installations of transformers for supplying 440 volt three-phase alternating current. In these stations there are a total of nine 800 kilovolt-ampere oil-insulated water-cooled transformers and 27 100 kilovolt-ampere oil-insulated self-cooling transformers.

Electric Power Applications.

Central Pumping Station.—All of the water for the works is taken from the lake at one point. At present there are installed four centrifugal pumps, each of 25,000,000 gallons capacity per 24 hours, pumping against a head of 100 ft. These pumps are driven by three-phase 440 volt 500 revs. per min. induction motors. In order to make this installation as free as possible from interruptions due to electrical troubles, there is a main feeder from each power station. Each feeder has its own oil switch, feeding three 800 kilovolt-ampere transformers, and two of the motor-driven pumps are operated from each set of transformers. The 'bus bars are provided with disconnecting switches, so that either set or both sets of transformers can be operated from either or both main feeders.

Gas-washing Plant.—There is one such plant for every group of four blast furnaces. Each gas-washing plant consists of eight washers, driven by 150 H.P. 440 volt 375 revs. per min. induction motors. These motors are fed from one of the transformer installations, but the secondaries of this transformer station can also be connected in parallel with the transformers in the pumping station, running both as a unit. In case of the failure of one of the stations,

a part of the pumps and the gas washers can be operated from the other station.

Repair Shops.—A total motor capacity of 2,440 H.P. is installed for operating these shops.

Ore Unloaders.—Located on the edge of the slip are five ore unloaders of 10 tons capacity each. The total weight of each machine is 890,000 lb. The motor equipment of each unloader consists of six direct-current motors, totalling 435 H.P., the hoisting being done by a 150 H.P. compound-wound motor (60 per cent. shunt and 40 per cent. compound), and a 100 H.P. series-wound motor being used for car haulage and bridge motion. With the exception of the car haulage and bridge motion, all motions of the unloader are controlled through distant-controlled automatic magnetic torque-limit controllers. The master controllers for operating these motors are located in the leg of the unloader, so that the operator who rides with the bucket not only has a clear view of everything he is doing, but has absolute control of all motions of the machine.

Ore Bridges.—The ore taken out of the boats is deposited in a huge concrete trough directly in the rear of the unloaders. From this point it is picked up by the ore bridges, of which there are five. These bridges are of the cantilever type, having a total over-all length of 459 ft. The lifting capacity of each bridge is 13 tons of ore, in addition to the weight of the bucket. The total weight of the bridge is 238,000 lb. The motor equipment of each bridge consists of 14 direct-current motors, totalling 618 H.P., comprising four 80 H.P. series motors for hoisting, four 40 H.P. for the trolley and four 30 H.P. for the bridge.

The ore picked from stock by the bridge is deposited in a transfer car of 100,000 lb. capacity, the electrical equipment of which consists of two 50 H.P. motors operated by means of an ordinary street-car controller, and an air compressor supplying air for opening and closing the doors and for air brakes. This car is used for transferring the ore from the bridge to the appropriate bin. Underneath the bins are the scale larries, driven by one 21 H.P. direct-current series motor, and carrying a similar motor for opening and closing the door of the bin. This larry is used for transferring ore, coke and limestone from the various bins in the appropriate quantities and depositing it in the blast-furnace skip., driven by a 150 H.P. compound-wound motor. The control of this skip is absolutely automatic; the operator simply starts it up, after which the accelerating, running, retarding and stopping is entirely automatic. The total travel of this skip is 163 ft. up an incline of 60 deg. to the horizontal. The time of making one trip is 60 seconds. The loads carried are approximately as follows: Ore 7,000 lb., coke 3,600 lb. and limestone 6,000 lb.

Pig-casting Machine.—For taking care of the material from the blast furnaces on Sundays, when the open-hearth plant is not in operation, there is provided a pig-casting machine. There is a main building in which are located two double-trolley ladle cranes; the main hoist is 75 tons, and the auxiliary hoist 15 tons. There are six strings of moulds and conveyors for disposing of the cast material. The ladle is handled by a 5 ton electrically operated jib crane. The moulds are driven by 40 H.P. 750 revs. per min. induction motors, and conveyed by 30 H.P. 750 revs. per min. induction motors.

Open Hearths.—Each open-hearth plant consists of 14 60 ton furnaces. The molten metal from the blast furnaces is poured into a 300 ton mixer by a 75 ton electric ladle crane of the same design as that in the pig-machine building. The metal is carried from the mixer to a point in front of the various furnaces by an electrically operated hot-metal car, whose equipment consists of two 25 H.P. 250 volt 290 revs. per min. series motor, operated by a standard series parallel controller. The ladle from this car is handled and the contents poured directly into the open-hearth furnaces by another 75 ton ladle crane.

The cold scrap for charging the furnace is stored and handled in the stock yard, which is entirely covered by two 5 ton electric travelling cranes. The stock is handled by means of electromagnets, each one capable of handling from 1,000 lb. to 2,000 lb. of scrap, according to the character of the material, or of lifting 10,000 lb. in large pieces. After this scrap is loaded the charging boxes are shifted in front of the open-hearth furnaces and the contents put in by means of a low-type charging machine. The equipment consists of a main hoist with a 30 H.P. series motor; bridge travel, two 30 H.P. series motors; trolley, 20 H.P. series motor; tilting, 11 H.P. series motor; rotate, 3·25 H.P. series motor

The steel is handled in 60 ton ladles by three 125 ton ladle cranes. The electric equipment is as follows: Main hoist, 110 H.P.; first auxiliary hoist, 50 H.P.; second auxiliary hoist, 30 H.P.; main trolley 30 H.P.; auxiliary trolley, 11 H.P.; bridge travel, two 50 H.P. motors. The controllers for this apparatus, except that for the main hoist on all ladle cranes (which is automatic magnetic control) are of the ordinary hand-operated lever type.

The electric equipment of the coal-handling apparatus in connection with the gas producers for these furnaces consists of a coal crusher driven by a 25 H.P. direct-current motor; a double-skip coal elevator driven by a motor similar to that on the coal crusher; and four hopper cranes, each driven by 7·5 H.P. series motors. The hopper cranes are used for distributing crushed coal in overhead bins directly into the producers.

The control of the skip is entirely automatic in its action. As the descending car approaches the bottom point of its travel it opens the door of the coal bin; in stopping it rests on a counterweighted lever. When the skip is nearly filled with coal the counterweight on this lever is overbalanced, the skip dropping down about 3 in. more. This actuates the switch which starts the skip on its upward travel, its first action being to close the door of the coal bin. The operation is repeated by the second skip, and continues, unless stopped, until the coal bin is entirely empty.

As part of the open-hearth plant there are two stripper buildings. One of these buildings contains one, and the other two, 200 ton electrically operated stripper cranes. These cranes are equipped with 100 H.P. 375 revs. per min. series motors on the main hoist; a duplicate to the above on the stripping hoist; 30 H.P. 500 revs. per min. trolley, and one 50 H.P. 480 revs. per min. on the bridge.

In the soaking pits are three 7·5 ton soaking-pit or ingot cranes. Each of these cranes has a 5 ton high-speed auxiliary hoist on the trolley for repairing the pits. The electrical equipment is as follows: Main hoist, 50 H.P.; auxiliary hoist, 30 H.P.; trolley, 7·5 H.P.; bridge, two 50 H.P.; tongs turning and opening, 5 H.P.

For delivering the ingots from the pit to the first table in the rolling mill two ingot buggies are used, for which a special control has been designed. Each buggy is intended to take care of six rows of four pits, which are located respectively north and south of the table. To prevent the two buggies colliding, should both happen to be coming toward the table at the same time, the trolley bars through which the current is transmitted to the motors on the buggies are in three sections, one section in front of the table and one long section on each end of that. Each controller has six points corresponding to the six rows of pits, one point corresponding to the table and one to the off position. The operator can throw his controller to the point representing the row of pits to which he desires to run, and when the buggy reaches this point it is automatically stopped. Return motion with controller on the table position will bring the buggy up to the table—where, however, on account of the great accuracy of the stop, the buggy is not stopped automatically, but at the will of the operator. When one buggy is at the table it is impossible for the other one to reach that point, as the two controllers are so interlocked as to prevent this occurrence.

(To be continued.)

THE COMPOSITION AND DURABILITY OF CABLE PAPERS.

BY CLAYTON BEADLE AND HENRY P. STEVENS.

Summary.—Information at present available upon the desirable properties of paper from the insulating point of view is very meagre. The authors attempt to fill this gap by giving the results of their experience in dealing with such papers from the chemical point of view. The composition of manila and other papers is briefly discussed. Tests to which papers should be subjected are considered, and a number of tables of results are given. The effect of moisture is dealt with at some length, and the authors finally express their opinions on changes taking place when papers are in contact with the atmosphere and when they are protected from it.

Manila papers have been used for cable insulation for 20 years and upwards and have stood the test of time; consequently cable manufacturers specify that paper used for cable insulation should be composed of "manila hemp of good quality." Whether the users of cables or their engineers are right in their choice as against all other available materials is another question. There are other materials that may be as durable or even more durable than manila and perhaps equally serviceable, except perhaps on the score of price.

We are frequently called upon to examine papers on behalf of cable manufacturers, as well as paper stripped from cables themselves on behalf of the users, in addition to which we are asked at times to assist the paper manufacturers in their endeavour to suit the requirements of the cable manufacturers.

We wish it to be understood that we are not electricians but

chemists who have devoted considerable attention to the subject of paper, and the chief object of this communication is to discuss the physical rather than the electrical qualities of paper used for the purpose. We think such a discussion may prove of some service both to the cable manufacturer and user as well as to the paper maker.

The maker of the paper is frequently not altogether acquainted with the requirements of the maker of the cable, as will be hereafter seen from papers submitted for the purpose, the greater number of which, to say the least of it, are quite unsuitable. On the other hand, the cable manufacturer being wholly unacquainted with the technicalities of paper making, cannot give full expression to his requirements, and consequently the paper maker is not wholly to blame because he submits unsuitable paper.

Granted for the time being that paper for cable insulation, or that most in favour, is to be a manila paper, we must point out to the cable manufacturer what must be comprised under the term manila paper. Manila, properly speaking, refers to the *musa textilis*, a fibre very largely grown in the Phillipine Islands for the purpose of rope making; and the chief source of manila fibre for paper making is from old ropes, butt ends and spinning waste, but such old ropes and their sources of supply do not consist only of manila, they include various aloe fibres, sisal, &c., and phoniun tenax, a rope-making fibre which comes from New Zealand. The original fibres of musa are about 6 mm. in length and have a diameter of 0·024 mm., showing a ratio of 250. The fibres when bleached are white and lustrous, the walls are uniform, and when seen in section they are round or polygonal with fusiform ends. The fibre as used in manila paper is only partially bleached and, of course, is materially reduced in length during the process of beating.

It is impossible to demonstrate in this article in what respect the manila fibre proper is to be distinguished from other fibres with which it is classed, as it requires a great deal of experience to distinguish between them. We wish merely to emphasise the fact that manila must be used in a generic sense to describe not only manila proper but other fibres, such as above mentioned. Furthermore, it is an anomaly to talk of manila hemp, —manila is not hemp at all—hemp belongs to a very different class of fibres—hemp fibre is the *cannabis sativa*. The ultimate fibres have a length of 22 mm. and a diameter of 0·022 mm., showing a ratio of 1,000. They are absolutely different microscopically from the manila fibre, the fibres show striæ and fissures and often fibrillæ. The ends of the fibres are large and flattened; in section they appear as concentric zones of irregular outlines. The sources to the papermaker are scutching refuse, spinning waste, threads, cuttings, and rope ends. If we were to speak of a paper consisting of real hemp we should signify the above fibre. Inasmuch as the rope ends and other sources of supply of manila to the paper maker may frequently contain hempen ropes, &c. (the more the better), manila papers may quite unintentionally contain hemp as well as the above-mentioned fibres so frequently associated with manila.

When fully bleached, and especially when it is beaten for the manufacture of paper, hemp fibre is difficult to distinguish from flax; in fact, the leading authorities declare that they are often unable to distinguish flax from hemp under the microscope. This fibre in its unbleached state, as well as the above fibres classed with manila, are found in manila papers as used for cables, and we think it would be quite fastidious of any cable manufacturer to reject the paper constituted of any of these fibres, including hemp proper, on the score that they are not real manila. The fact is that real manila or *musa textilis* is not superior to real hemp or *cannabis sativa*, in fact, we should prefer to see a paper made of real hemp rather than of real manila.

The microscope is useful as showing the condition of the fibres and the extent to which they are beaten, &c., but to form an adequate opinion of a paper it is advisable to make certain physical and chemical tests. The best cable manufacturers now fully realise that the care displayed in making the paper is as important as its fibrous composition.

We have had instances in which we have given the composition of papers to cable manufacturers, and they have told us that the paper specified is manila hemp. We have carefully examined the paper microscopically and we have reported a certain proportion of "hemp stock." We are purposely avoided giving in our certificates so much "manila hemp;" we call it "hempstock" or "rope stock." We have to bear in mind the condition of the raw materials as they reach the paper maker, and that it is practically impossible for him to procure raw material consisting only of *cannabis sativa* unless he is paid a higher price for his paper than the cable manufacturer could afford.

Furthermore, it must be borne in mind that there are other fibres which, as far as possible, should be excluded in the manufacture of manila paper, the chief of which is jute. The great source of this material is "bagging," but in the material used in the manufacture of cable papers the most scrupulously careful and conscientious papermaker is not always able to exclude jute entirely, therefore, a few jute fibres here and there may not be intentionally added, and provided that they are only present in small quantities we do not consider that they detract from the value of the paper, but the quantity should be small. Jute, however, belongs to what is known as lignocelluloses, and in the condition in which it is used for paper making, *i.e.*, an unbleached or only partially bleached condition, it contains a lot of lignin, and cannot be regarded as a permanent fibre. Many papers which we have examined for the cable manufacturers, however, contain notable quantities of jute, enough at least to warrant us in believing that the jute has been independently added. The jute fibre has a length of only 2 mm.; diameter 0·022; ratio 90. They exist in compact bundles of smooth fibres. It is available in three forms, threads, "butts" and bagging.

In America there is a class of paper known as "bogus manila," and many mills are scheduled as makers of this class of paper. "Bogus manila" does not contain manila at all but usually consists of mixtures of chemical wood and jute in varying proportions; such paper would be entirely unsuitable for the purpose of cables, and is largely used for strong bags, wrapping papers and large envelopes. It owes its strength to the presence of chemical wood and its yellow qualities to presence of jute. Jute has practically no strength-giving qualities. To cable manufacturers we say beware of "bogus manila." Some cable manufacturers use a considerable quantity of chemical wood pulp paper in place of manila for what may be called their second-class cables. It has one point of advantage over manila paper, although it has not been proved to possess the same duirability—it can be made of greater uniformity of texture. One can perhaps appreciate the excellent wearing qualities of Manila papers on bearing in mind that the bags as ordinarily used are largely composed of Manila, and noting the great amount of handling that they stand and the force required to tear them.

The general mode of treatment of fibres for the manufacture of cable papers is very briefly as follows: The fibres, whether manila, hemp, &c., if in the form of rope, are cut up into short lengths, opened up, placed in a cylindrical boiler together with lime or caustic soda, boiled under a pressure of 30 lb. to 50 lb. for from 5 to 10 hours, emptied out, washed free of alkali, put into a breaker, a machine consisting of an oblong trough provided with a roll with sharp knives, where the fibres are partially disintegrated, and at the same time washed with a continuous flow of water. If need be, the fibres are partially bleached with a chloride of lime solution, after which they are cleansed from the liquor by thoroughly washing and draining. The material is now put into the beater, where it is reduced to the condition necessary for the paper machine, and emptied into the chest. After the material is suitably dilute it is passed over sand tables, where gritty matter is deposited, and then through strainers, where any coarse particles are retained; it passes in a continuous flow on to the endless wire of the Fourdrinier machine, where the fibres are deposited in the form of a sheet, then through the couch rolls and the press rolls, where the water is squeezed

out, after which it passes over a series of steam drying cylinders, from whence it emerges dry, and is reeled. It is supplied in the form of rolls to the cable manufacturer, who requires to slit it into narrower widths suitable for lapping round the conductor. Such in the briefest outline are the processes to which these raw materials are subjected for their conversion into cable paper.

In giving some details of physical tests done by us on cable papers we will first refer to the tensile strength in the two directions.

All paper made on the Fourdrinier machine is greater in strength in the machine than in the cross direction in consequence of the fibres lying mostly in the machine direction, consequently it is easier to tear a sheet of paper along the direction of the web than across it. This gives the advantage required by the cable manufacturer; it is most important to him that the strength should be the greatest in the direction of the web.

The mode of testing paper for physical qualities depends upon the purpose to which the paper is to be put as well as its quality and mode of manufacture. Thus, in testing paper for physical strength, for fine qualities it is the custom to take a width of ⅝ in., which is specified in many of the Stationery Office contracts; whereas with papers of coarse texture, even although of the best quality, such as coarse wrapping papers, a width of 2 in. is taken. For the testing of cable papers we have adopted a 1 in. width as being, in our opinion, the most suitable. But whatever width we take, for the purposes of comparison we reduce the figure to pounds per inch width. With the papers of fine texture that are required to be free from any local variations of thickness, &c., a width of ⅝ in. will show any local weakness which would not be shown up on a width of 2 in. On the other hand, a paper used for wrapping purposes, but of necessity of a coarse texture, would show irregular tests on a width of ⅝ in., because a thin place might extend to this distance, but at the same time it would be of no practical consequence. This is the object, therefore, in choosing different widths of strips for different kinds of paper.

Cable papers are of a more or less coarse texture, but at the same time they require to be fairly uniform in thickness. One important consideration is the freedom from gritty metallic and other particles, which would break down the insulation. Of course this is guarded against by the numerous thicknesses of paper overlapping one another, or the simple spiral winding, which causes an overlapping of thicknesses, nullifying any irregularity which would be found in one thickness alone of the sheet. When only a small sample of the paper is available for the tests, lengths of only 50 mm. between the clamps of the testing machine are taken; but it is better where possible to employ 100 mm., in which case the elongation at break read off in millimetres gives the percentage stretch without calculation.

The length of the strip taken for the tensile strength is practically immaterial as regards the figure obtained, although the greater the length the greater the chance of meeting with a weak place, and, consequently, the lower the figure. With a good paper the increased length, however, shows very little difference on the figure. It is, therefore a point in favour of a paper if the same breaking strain is obtained for different lengths, as indicating its uniformity of texture.

The bursting strain of a paper may from time to time be employed for the purpose of rough comparison, but we do not make use of it in our certificates, as it does not give an absolute figure. For this test there are one or two standard machines. These are generally provided with a rubber diaphragm, which is made to expand with a pressure due to liquid glycerine against a clamped piece of paper, the pressure being indicated on a gauge. This we do not recommend for the testing of cable papers, except in a rough way.

Another and frequent test is the "folding test," which can be roughly performed by noting the number of times a paper can be folded backwards and forwards before it is worn out or breaks. The folding must be done in a regular manner. We do not think this has sufficient bearing upon the qualities of cable papers, as they are not subjected to this kind of wear. A further test is the crumbling test, which can be done by hand in a rough way, or by means of a machine which automatically crumples a paper until it wears holes in it. This, like the above mentioned, is of little moment to the cable manufacturer. Later we give some figures which show how high good cable papers stand on these tests.

The last physical test to which we wish to refer is the determination of "stretch." This is done simultaneously with the determination of the tensile strength at the moment of break. This figure is generally taken as representing the "stretch at break," and is expressed as a percentage on the initial length. The stretching qualities of a paper are of considerable consequence to the cable manufacturer, as will be hereafter seen. On examining the tests hereinafter given (Table A) it will be noticed that the strength is greatest in the machine direction (*i.e.*, the direction of the web or reel), and least in the cross direction (*i.e.*, at right angles to the machine direction), and that the stretch varies inversely as the strength, being greatest in the cross direction and least in the machine direction. The importance of a good stretch to a strong paper cannot be over estimated, particularly for such purposes as cable manufacture. A paper may have a high tensile strength, but be of little utility because it may be lacking in stretch—in other words, it would be a brittle paper. A brittle paper is a thing to be avoided. The stretch of a paper as well as the strength depends upon its texture—that is, the mode of its manufacture—as well as the direction of the fibres. The strength is greatest if the paper is pulled in the prevailing direction in which the fibres are placed, and least in the direction at right angles to that in which the fibres are placed. At other angles to these two directions the paper shows intermediate qualities, which qualities have been very carefully investigated by one of us * and recorded for different kinds of papers, both machine and hand made, in the form of diagrams, which diagrams show very interesting relationships. This question is well worth the study of those who wish to go closer into the subject. However, we are not here concerned with these matters, and only wish to record results on "strength" and "stretch" in the two directions at right angles to one another.

When the paper is made in the first instance, in the course of drying it undergoes contraction as a whole—that is, it occupies less volume and covers less superficial area. As a pull is put upon it in the direction of its web the contraction may be nil in this direction, or it even may result in an elongation, the greater the pull put upon the paper in the machine direction in the course of drying the greater the tendency to contract in the opposite direction. This affects the stretch of the paper when tested for strength. If a paper is lapped round a cable a pull is put upon it; this pull may be sufficient to stretch it somewhat, although not to the limits of its elasticity. To wrap a paper round an object so as to fit compactly it is important that the paper should be able to stretch without fear of breaking, and if the wrap is to be tight there is a slight permanent pull which holds the paper tightly in its position.

There is a considerable difference, however, in the qualities of paper when the paper is used *per se* in comparison with that of paper that is impregnated with hydro-carbons or other dielectrics. Thus, with paper as used for certain kinds of insulation, the paper itself has to be an insulating material. But when the paper is impregnated it acts rather as a medium for the dielectric rather than the dielectric itself. As is well known, bone-dry paper stands very high as an insulating material, and is greatly reduced in insulation, as it takes up moisture, a point which has to be guarded against in electric mains. This point is briefly referred to here, as the condition of paper to moisture determines to a large extent its physical qualities.

Now, if one records the conductivity of paper under different atmospheric conditions it will be noticed how rapidly the conductivity rises with the slight absorption of atmospheric moisture; consequently, with paper used *per se*, we have to consider not only its physical qualities in its normal condition —*i.e.*, as supplied by the paper maker to the cable manufac-

* Beadle, "Technics" (George Newnes, Ltd.) Vol. II., pp. 64, 254, 348, 586.

turers—but its physical qualities in its bone-dry condition—*i.e.*, after it has been subjected to warm treatment in vacuo. The strength, as well as the stretch, are modified, and remain so until the moisture and temperature are restored to the original. The effect of heat *per se* on paper makes a considerable difference on its physical qualities; one cannot apply heat to paper without depriving it of moisture, but, by the use of vacuum drying the moisture can be removed with only a moderate application of heat. Reels of paper subjected to vacuum drying undergo a certain amount of shrinkage. If the paper is to be impregnated with hydro-carbons, &c., it is first of all necessary to have it bone-dry, so that a proper penetration of hydro-carbons may be insured, and at a sufficient temperature to ensure proper penetration. In fact, the moisture in the paper should be, if possible, reduced to nil or within ½ per cent.

The absorption of ordinary papers is generally judged in their relation to moisture, but an impregnated cable paper has to be judged from quite a different standpoint—namely, that of absorption of greasy materials. It has to be just the opposite to a grease proof, for it requires to be a grease absorbent.

In our physical tests, among other things, we have instituted a system of determining the volume percentage of the ingredients. Thus, we can tell the amount of air space as well as the amount of space occupied by the fibres, and we have demonstrated that the grease absorbent qualities of a paper are directly proportional to the air space. It is the custom to "size" most papers. The commoner writing papers, as well as printing papers, are sized with rosin (precipitated from resinate of soda by means of alum), this rosin rendering the paper resistant to moisture and to ink. A great many papers would have very little strength if there were no rosin added to them; but although such papers are said to be sized and shine resistance they mop up grease as freely as blotting paper mops up ink.

The question has been raised with us by one or two cable manufacturers whether the paper should be sized with a moderate amount of rosin or not. The amount of rosin is generally 1 or 2 per cent. on the weight of the paper. The presence of the rosin need not detract from the insulating qualities of the paper, provided that only just sufficient chemicals are used for its precipitation. Furthermore, it usually adds adds to the difficulties of the paper maker if he is called upon to supply paper containing no rosin; and, lastly, we have no proof whatever that a certain amount of rosin size detracts from the hydro-carbon absorbent qualities, therefore we pronounce rather in favour of a certain amount of sizing. At any rate, we should not consider it a matter of any consequence or a reason for rejection if a paper contains a small amount of size. It was formerly thought that the hydroscopic moisture of paper is diminished by rosin sizing. Recent researches have rather disproved this theory. It would appear, therefore, that in papers as used for Post Office insulation the liability to take up moisture from the atmosphere is not diminished by rosin sizing, consequently unless there is any other reason against it such papers might just as well be waterleaf papers.

(To be continued.)

THE USE OF THE POTENTIOMETER ON ALTERNATE-CURRENT CIRCUITS.*

BY CHARLES V. DRYSDALE, D.SC.

Summary.—After discussing the application of the potentiometer principle to alternate-current measurements, the use of the author's phase-shifting transformer with a potentiometer is described. A universal potentiometer has been designed on this principle, which serves both for direct and alternate current measurements, and for testing P.D., current, phase, power, inductance, capacity, &c.

Owing to the small range of instruments for the direct measurement of alternate currents or P.D.s, since these operate on the square law, there is need for an instrument capable of measuring P.D.s and currents of any range with accuracy, and also, if possible, of indicating the phase.

In attempting to apply the potentiometer principle to alternate current measurements, two processes seem to be possible—(*a*) the balancing of the alternate current P.D. against an equal direct-current P.D. by the employment of some differential balancing device preferably of an electrostatic character, or (*b*) the balancing of two alternate-current P.D.s against one another. Previous propositions have always been based on the former idea. An obvious device being that shown in Fig. 1, in which the P.D. to be measured is applied between the needle and one pair of quadrants, while that derived from the potentiometer is connected between the needle and the other pair of quadrants, and through a considerable resistance. The sole difficulty lies in the electrometer.

In view of such difficulty the author has turned his attention to the second method, *i.e.*, of balancing the alternate current P.D. to be measured against a known alternate-current P.D., by the interposition of a sensitive alternate current detector, such as a telephone or vibration galvanometer. This, of course, implies that the two voltages under comparison must have the same magnitude, frequency, and phase, and, approximately, the same wave-form.*

The equality of frequency is of course secured by deriving the test and comparison voltages from the same source of supply, but some special device is needed for bringing the phases into coincidence. In some experiments recently made with the writer's phase-shifting transformer,† however, the accuracy of the phase variation was found to be so good that it was thought worth while to introduce it into potentiometer work; and Fig. 2 shows the diagram of the connections which have been employed. The phase-shifter is here

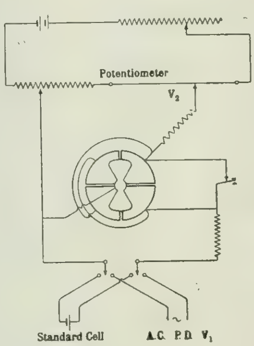


FIG. 1.

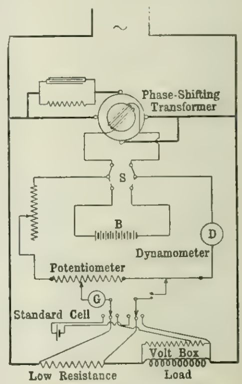


FIG. 2.

shown supplied with single-phase current through a phase-splitting device, which can be built up with it so that it merely requires connecting straight on to the mains. The current derived from the secondary of this transformer traverses the rheostat coils, and slide-wire of an ordinary potentiometer, such as the Crompton form; and also some form of dynamometer current measuring device. The writer has found a Weston alternating-current voltmeter excellent for this purpose, as it gives a very good reading with the current (0·05 ampere) employed with the Crompton potentiometer. The remainder of the potentiometer is connected up precisely as for ordinary direct current working, except that a vibration galvanometer is substituted for the ordinary form. By having an auxiliary battery B and throw-over switch S, the arrangement is always ready for either direct-current or alternate-current comparisons.

The procedure is as follows:—The throw-over switch is first arranged to supply direct current from the battery B, and the rheostat altered until the standard cell is balanced at its nominal value, as in ordinary direct-current working. The dynamometer reading is then carefully noted, or a fiducial mark is made, which always represents the exact 0·05 ampere. On now throwing over to alternate current, the rheostat is altered to reproduce the same R.M.S. current as indicated by the dynamometer D; and the position of the potentiometer contact is shifted and the phase-shifter

* Abstract of a Paper read before the Physical Society. A brief account of the discussion following the reading of this Paper appeared in THE ELECTRICIAN, Feb. 19, p. 724.

* Since this was written the writer has been informed that Dr. Sumpner has somewhere suggested that an alternating-current potentiometer could be made, if any means were available for bringing the phase of the current in the slide-wire into coincidence with that of the P.D. to be measured.

† THE ELECTRICIAN, Dec. 11, 1908.

turned, until the vibration galvanometer shows no vibration. The adjustment is very similar to that of the two resistances in an Anderson's bridge, and presents no difficulties. The voltage and phase are then read off on the potentiometer and phase-shifter respectively. In the illustration a low resistance is connected in series with the load, and a volt-box in parallel with it, and the current and P.D. can be determined directly in the ordinary way. Of course, the phase-shifting transformer must always be connected to the same source of supply as the load.

Instead of the vibration galvanometer, a dynamometer or electrometer in which one pair of terminals is connected to the supply so as to be "separately excited," and the other to the ordinary galvanometer terminals, has been employed with good results. The deflections are then to left or to right, as in an ordinary galvanometer. But it must not be forgotten in this case that balance will be obtained not only when the vectors of the two P.D.s compared are coincident, but also when their vector difference is in quadrature with the P.D. of the supply. For this purpose, if such an instrument is used it must have its "exciting terminals" changed over from one phase to the other, and balance secured in both cases.

It is obvious that this device does not indicate the effective or R.M.S. value of the P.D., except when the supply and tested waveforms are both sinusoidal or of identical form. When a vibration galvanometer is employed, its sensitiveness to the fundamental wave is so great in comparison with that to the harmonics, that we shall be practically correct in assuming that it is the fundamental wave only which is measured, and the comparison is really between the mean and not the R.M.S. values. On the other hand, if there is any serious difference of wave-form, the sensitiveness to the upper harmonics should be sufficient to prevent an exact balance being secured, and this warns us when great accuracy is not to be expected. The author shows that if care is taken to have a supply of fairly sinusoidal wave-form, the measurements may be considered sufficiently accurate for the majority of purposes.

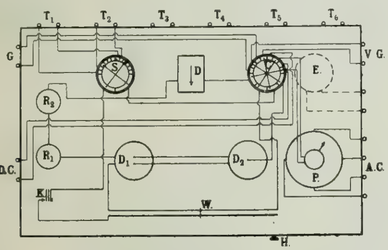


FIG. 3.

Measurements.—The results of two experiments are given to show the possibilities of the method. There seems no reason to doubt that 0·0002 volt can be easily detected, or that a drop of 0·1 volt could be measured to an accuracy of 0·2 per cent. or closer. The readings of the phase angle repeated themselves constantly to within 0·1 deg.

The author has designed a potentiometer in which a small phase-shifting transformer and dynamometer are included in the case, with a throw-over switch, permitting the instrument to be used as either a direct or alternate-current potentiometer. Fig. 3 shows the connections, which need little explanation. The main circuit of the potentiometer, consisting of the rheostats R_1 and R_2, the two dials D_1 and D_2, the slide-wire W, and the dynamometer D, is connected to two of the blocks of the change-over switch C, which is similar in form to the well-known selector switch used in the Crompton potentiometer. The derived P.D. from the Dial D_2 and slide-wire contact is led by the key K and the selector switch S to two more of the contacts on C. The remaining eight contacts on C are connected in pairs to the phase-shifting transformer P, the battery terminals D C, the ordinary galvanometer terminals G, and the vibration galvanometer terminals V G. The phase-shifter primary is excited from the terminals A C, which are here shown, four in number, for two-phase or split-phase. A single motion of the switch C to right or left connects the main circuit of the potentiometer on to the battery or secondary of the transformer, and simultaneously connects the sliding contacts through the selector switch to the appropriate galvanometer. The key K being provided with a holding-down cam, leaves the hands free to move the potentiometer contacts and rotate the phase-shifter simultaneously. A frequency meter F of the vibrating reed type may be fixed on the base if desired, in which case the instrument is available for inductance and capacity measurements. The dynamometer D is not provided with a scale, but with a fiducial mark which can be slightly adjusted to suit the standard cell check. It will also be made astatic to avoid risk of error from stray fields.

The results already obtained appear to justify the belief that this method is capable of being used with considerable accuracy and convenience for all P.D., current and phase measurements. One of the most valuable applications is to search coil work with alternate currents, whereby the distribution of main and leakage fluxes in cores, and the propagation of magnetic impulses can be studied. The variation of current and P.D. along a cable fed with alternate currents could also be obtained.

ELECTRIC TRACTION ON RAILWAYS.*

XIV.—PRACTICAL CONSIDERATION OF OVERHEAD CONDUCTORS.

BY PHILIP DAWSON.

(Continued from page 925.)

Summary.—In this article the author first considers the many objections which have been raised against the use of the third rail for main line railway electrification, and then proceeds to discuss the use of overhead conductors, dividing the latter system into those where two overhead conductors per track are necessary and those where only one conductor per track is required. The construction of the overhead work is also considered in detail.

In a previous section of this work, when dealing with the third rail conductor, it was pointed out that, whilst third rails had originally been used with electric traction in the very early days, this system was soon dropped in favour of the overhead conductor, as soon as the satisfactory system of overhead contact shoe, collector or trolley had been devised. The only early heavy electric locomotives in America such as those constructed for the Baltimore & Ohio Railway were equipped at first with the overhead system, although the difficulties connected with collecting very large currents in this way were found so great that eventually the overhead system had to be dropped and the third rail again resorted to.

The American railway engineers had fully realised at this time that for ordinary main line operation the overhead system was preferable, as many troubles were to be anticipated by the use of the third rail. This, of course, is not the case with purely local lines, such as tube, elevated or branch lines of main line railways over which little, if any, goods traffic and few steam hauled trains have to circulate. Thus the City & South London and the Liverpool Overhead Railway adopted the third rail from their inception; but these two lines evidently form part of the last category and not of the first.

Before going into any detail regarding the methods of overhead construction adopted in connection with railway work, it may be of interest to consider some of the many objections which have been raised by British and foreign railway engineers against the use of the third rail for general main line railway electrification. The following objections to the third rail system are extracted from a report made after most careful investigation by the chief engineer of one of our important railways:—

In the event of the derailment of the train the third rail would almost certainly be disturbed and thus add to the consequent dislocation of traffic.

The line could not properly be packed and maintained without great risk to the platelayers; or, as an alternative, this work would have to be done during the short time at night when the passenger trains had ceased running and the current cut off, but this could not be done on most of our railways if goods were also worked by electricity, as the largest portion of our goods traffic is worked at night.

Damage would be certain to arise with consequent dislocation of traffic in unloading materials at night for repairs and renewals.

The third rail cannot be fixed in station yards and for through crossings without being foul of gauge, but if so fixed it would be a source of great danger to the staff engaged in shunting and marshalling operations.

In case of a heavy fall of snow considerable interruption of traffic would probably ensue.

In many cases structural alterations to and probable reconstructions of station platforms would become necessary to allow of a third rail being kept clear of gauge.

Considerable expenditure would become necessary in alterations to and diversions of point rodding and signal connections, and on the viaducts this would apply to water and gas mains.

In the case of joint lines, where the company only have running powers, it would be difficult to get the necessary sanction to lay down the third rail.

Mr. A. D. Williams, an American engineer, has very clearly stated the case in connection with the form of conductor to be chosen when general railway electrification is under consideration. and some of the points he makes are condensed in the following paragraphs :—

For goods yards and sidings it is essential that the electric conductor should add as little as possible to the ordinary complications and dangers inseparable from present methods of working. In such places trains must be made up and handled frequently with urgent haste by night as well as by day, and an electrical conductor so placed that it interferes with or increases the hazard of operations is not admissible.

The track must be continually lined in and levelled up. This work must be carried on under traffic conditions which must be slowed up or stopped for a gang of men to get their tools out of the way, and can never be absolutely suspended. On a one or two-track road, with infrequent trains, this is one thing ; on a four-track line with 700 or 800 train movements or more a day, the problem is not a simple one.

The operation of a line dealing with all classes of traffic and handling hundreds of trains a day is a vastly different problem from that met in the handling of a dense traffic of a single class, as on the elevated or underground lines of large cities. In the application of electric traction to an existing railway designed for steam operation, there are many obstacles to overcome. The electric equipment itself may not cost as much as the alterations necessary to permit the use of electricity. The steam lines were laid out many years ago, and the gradual growth in the size of rolling stock and locomotives has encroached on the originally ample clearances, until to-day there are many lines that are unable to admit extra heavy goods wagons or large saloon or dining cars to certain portions of their system ; the clearance between tracks has been shaved to the limit and equipment is frequently damaged at tight places.

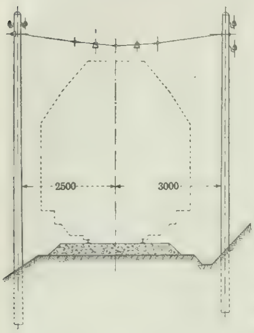


Fig. 11.—Contact Line Ordinary Section. Burgdorf-Thun Three-Phase Line.

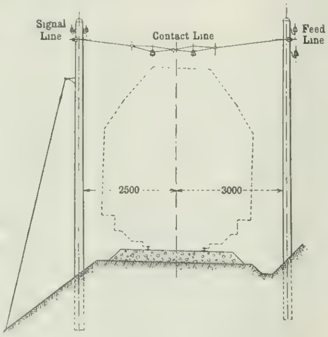


Fig. 12.—Contact Line on Embankment and Curves. Burgdorf-Thun Three-Phase Line.

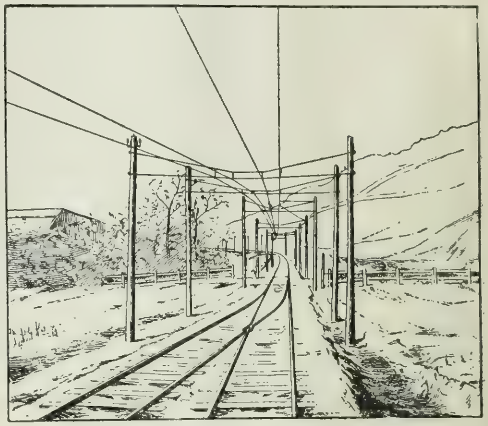


Fig. 14.—Contact Line Arrangement Over Single Switch. Burgdorf-Thun Three-Phase Line.

In the location of the electric conductor several things must be considered, particularly clearances. The clearance question is one of the most difficult problems the railway engineer is called upon to solve. Clearances which were ample for the equipment of fifty years ago are inadequate for the equipment of to-day, and on most English lines the maximum loading gauge is so close to existing structures that further encroachment, by additions to either structures or equipment, is practically impossible.

The maximum loading gauge line is supposed to represent the composite cross-section of the largest locomotive,

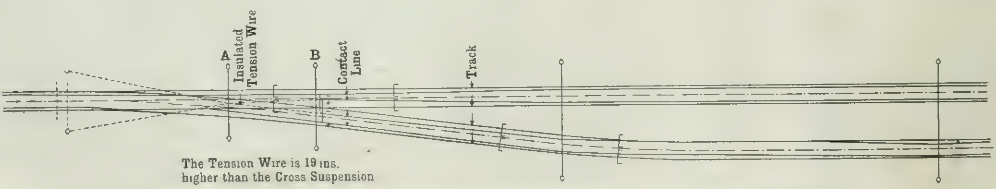


Fig. 13.—Aerial Switches. Plan of Single Turn-out. Burgdorf Thun Three-Phase Line

the largest freight car, the largest passenger coach, the largest wrecking crane, in running condition; this cross-section being increased by a sufficient amount to cover the side sway and lopsidedness due to a broken spring, eccentric loading bringing the car down on its side bearings, journal play and wear. The effect of curvature of the line must also be considered. Necessarily, any conductor conveying current to a locomotive or car must be outside of this line by an amount sufficient to provide a working clearance. The current collectors must be capable of reaching this conductor and of being housed within the maximum loading gauge.

In connection with maintenance of way, the third rail adds not a little to the trouble of keeping the track in line, as it obstructs one side. In addition it reduces the efficiency of the track gangs and adds to the expense, and the incidental fireworks it furnishes demoralise the labour gangs.

From an operating standpoint, the third rail is a menace and a constant source of danger to the railway staff, particularly at night. Circumstances often require that a guard should go back with a red light to protect the rear of his train. Without the third rail there was a certain amount of risk; with it there is a positive danger, and this danger is a vivid reality to all experienced railway men who have had the opportunity to observe working conditions on a third-rail line.

In connection with wrecking operations the third rail presents considerable difficulty. The first result of an accident is a short-circuit cutting off all current in that block until the third rail has been cleared or re-established. This is a good point, but it makes it absolutely necessary to depend upon steam for handling the wrecking equipment. In addition, extra plant must be got out to handle the third rail. The third rail weighs from 60 lb. to 100 lb. per yard, and cannot be put in until the track has been placed. Brackets and insulators are required about every 10 ft., and it takes considerable time to line the third rail in and get it covered. In the meantime traffic will have to be towed past the gap by steam locomotives, which will mean keeping a number of such machines on hand for emergency use. It may be necessary to handle all passing traffic on one track; this would be troublesome on a four-track road and worse on a double-track line. Any attempt to run a track round the wreck would be handicapped by the necessary third-rail construction; it would not be impossible, but it would require so much time that it would not be feasible. During the entire time the wreck was being cleared up current would have to be kept off that section of the road, as it would be impracticable to run the risk of stampeding the large labour gangs required by any spectacular electrical displays.

In dealing with the gaps at switches it has been frequently necessary to use an overhead conductor. When this is of the low-tension variety, and the supports have to span several tracks, supporting a conductor over each of them, it is extremely difficult to devise such a support as will not obstruct all views of signals. These overhead conductors must overlap the third rail at each end of the gap in order to guard against all possible chances of a train becoming stalled at such a point, for, though the ordinary operating speeds at such switches and cross-overs may be ample to carry a train over the gaps, there is always the possibility of an emergency arising when trains must be under absolute control. In railway parlance this means the ability to stop immediately and to start from such a stop, as well as the ability to increase the speed. The necessity of the overhead conductor has been recognised in the largest installation of third rail handling standard railway equipment.

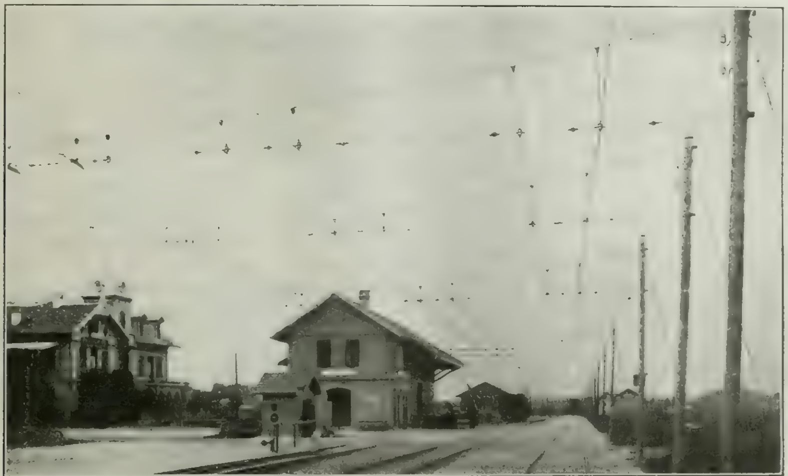


Fig. 5.—Burgdorf-Thun Three-Phase Line, Showing Overhead Construction at a Railway Station.

A feature not heretofore mentioned is the fact that at certain points it is necessary to locate derails and dwarf signals; the latter are rendered nearly invisible by the third rail. The derail cannot be done away with, as it is an absolute necessity at many points, and should it be over-run it will naturally result in a tearing out of a third rail.

In connection with bridge work the third rail will cut many of the floor beams and bracket, plates particularly on through plate girder bridges, and the further it is located from the gauge line of the track the further into these brackets it will cut. This causes considerable trouble in the design of new structures, and necessitates extensive remodelling in existing structures. Where cross-overs occur on curves considerable care must be used in order to prevent the contact shoes coming into contact with a running rail in passing from one track to another. The mechanism boxes for signals and points and derails, fogging machines, &c., must also be very

carefully placed in order to avoid all danger of their being touched by these shoes. These troubles are aggravated by the fact that the under-running shoe is held in position by a spring, and the failure of this spring is liable to let the shoe drop sufficiently to ground on any metal object close to the running rail.

A consideration of the foregoing disadvantages will certainly indicate that the third rail, either over or under contact, leaves much to be desired in regard to its assistance in the introduction of electric traction for ordinary main-line railway work.

These and other considerations have resulted in the development of systems using such high pressures as 3,000 to 20,000 volts, so as to enable the maximum energy required to be collected from a comparatively small overhead conductor. For the purposes of this article we can divide them into two groups—namely, those systems requiring, beside the rail return, two overhead conductors insulated from each other, as well as earth, as is necessary when three-phase traction is used, and those requiring one conductor per track, such as the high-tension direct current and the single-phase methods of traction.

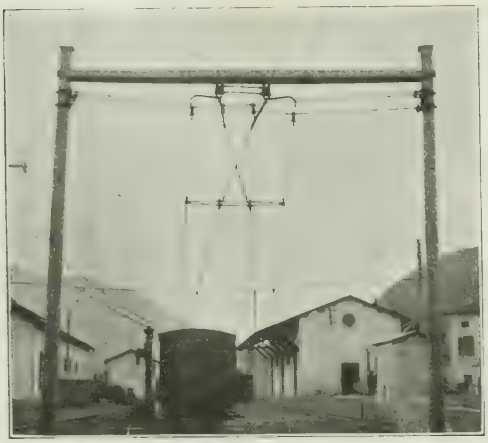


Fig. 6.—View of Station, showing Section Insulator at Cross-over Roads. Valtellina Railway.

Overhead Conductors Generally Considered.

The first overhead conductor for main-line railway work was that at first adopted in the Baltimore & Ohio Railway, now superseded by the third rail.

For overhead work involving the use of very high pressures up to 20,000 volts or so great care has to be taken as regards insulation and safety devices, so as to obviate possible loss of life through a broken wire. The form of construction to be adopted will depend upon the class of service to be undertaken. Thus, on a line running but a few trains in each direction every day a much simpler and cheaper construction can be provided than will become necessary if a line is equipped, say, into a terminal station dealing with 700 or 800 or more trains a day. In the former case, a large amount of time is available for inspection and maintenance repairs, whereas in the latter practically no time can be spared for this purpose, except possibly an hour or two every night, and then only at great inconvenience to the traffic. It will also be evident that the form of suspension adopted will depend also upon whether low or high speeds will have to be dealt with.

It will also be apparent that the form of collector adopted will depend upon the intensity of the traffic, and the speed as well as weight of train to be propelled. Thus, for long country lines with infrequent trains and not excessive speeds, and running single motor cars with possibly one trailer, the ordinary trolley and wheel, similar to that in general use with electric tramways, can be used with advantage, although the size of trolley wheel and similar details may have to be slightly different from usual tramway practice. If trolleys of this description are adopted, it is possible to utilise an overhead construction of the simplest form, the only difference between such a construction and the ordinary tramway overhead construction consisting in the use of insulators capable of dealing with the high pressure involved,

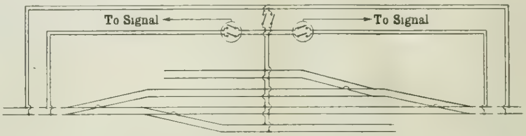


Fig. 7.—Diagram of Connections at Station, Valtellina Three-Phase Line.

and the safeguarding of the railway employés and passengers in the case of a breakage of a wire. It is a problem of this nature which presented itself for solution in Sweden, where it is intended to electrify long-distance country lines having very infrequent service, and on which very high rates of speed need not be attained.

As regards the section adopted for the conductor wire, this varies to a very large extent both as regards the area and the form of the section. The wires, adopting the classification for round wires, vary from 1/0 L.S.W.G. to 7/0 L.S.W.G. The choice of section depends on many factors, such as frequency of feeding points and mechanical strength, although it is, as a rule, the latter factor which

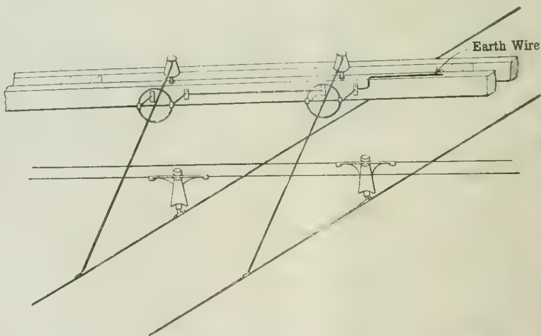


Fig. 8.—Trolley Lines at Level Crossing, Safety Device. Valtellina-Lecco-Sondrio (Ganz) Three-Phase Railway.

carries the greatest weight in the final decision. As a rule, copper is used for the contact wire, although in the case of the New York, New Haven & Hartford Railway steel wire has now been adopted for this purpose. Single wires supported only at long intervals, either from cross structures or bracket arms, have also been used in connection with the two three-phase railways, the Burgdorf-Thun line and the Valtellina system, both being long-distance country lines. In the case of the Burgdorf-Thun line, the contact line consists of two hard-drawn copper wires, 8 mm. (0·31 in.) in diameter, suspended from transverse steel wires; the latter

are fitted to wood posts (Figs. 1 and 2) placed on each side of the railway line. In the main stations the posts are of iron. The trolley line is divided by section insulators into 15 independent sections, as a means of safety and to facilitate the detection of defects in the insulation. The transverse suspension wires are generally 115 ft. apart, but this distance is reduced where the railway crosses main roads, at curves and in stations. At the points of suspension the height of the contact wires above the rails is 17 ft. $\frac{11}{16}$ in., the deflection never exceeding $13\frac{3}{4}$ in. The lowest part of the contact line is 4·850 metres (15 ft. $10\frac{7}{8}$ in.) above the rails. Fig. 3 shows the arrangement of the contact lines at a three-track intermediate station. In tunnels, the height available being limited, the deflection has been reduced by placing the suspension wires closer. Taking current in passing the points is effected as follows: When a car is coming from the left of the point (shown in Fig. 3) to continue its journey in a straight line, the current is first taken by the four contact bows at a time; then the first double-contact bow gets engaged in the space contained between the carrying wires A and B and the right-hand single bow in front, leaving the contact wire, marked +, and sliding on to the auxiliary tension wires, shown in dotted lines, and which are isolated from the other wires. The rear contact bow has not yet reached the transverse wire A; the current is, therefore, taken by three single bows, which are the left-hand front and left-hand rear contact bows on the —wire and the right-hand rear single contact bow on the +wire. Thus there is never any interruption of current. As soon as the front double contact has crossed the transverse support B its two parts come again in contact with the corresponding wire, and the rear bow, which then rises between A and B, can, in its turn, leave one of the +contact wires. In order to prevent an interruption in the current it is only necessary that the distance measured on the centre line of the car between the two double bows be slightly greater than that between the two suspension points A and B.

Fig. 9.—Simplon Tunnel, showing Three Phase Overhead Construction at Brieg (Brown, Boveri & Co.)

The auxiliary tension wires have a double action; they first guide the bow, when out of contact between A and B, and they relieve the transverse wire B by helping the tension of the contact wires. Crossing is effected noiselessly and without sparking. There is no difficulty in stopping the car or in changing the direction of travel under a switch. Fig. 4 shows a set of points in perspective and Fig. 5 the overhead construction at a station.

A similar form of construction was adopted in the case of the Valtellina line. The pressure between the two overhead wires used in this case is 3,000 volts, which, in consequence of insulation difficulties, both of the collector and of the two wires themselves at points and crossings, is the highest pressure hitherto used or recommended to be adopted for three-phase work.

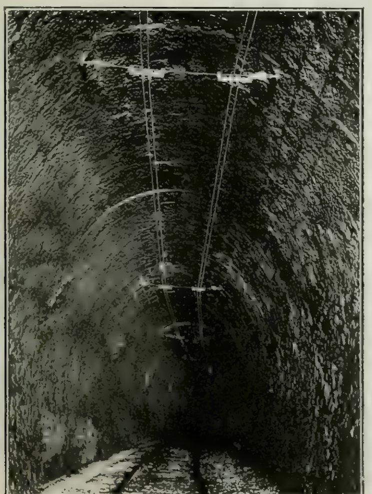


Fig. 10.—Simplon Tunnel Three-Phase Construction (Brown, Boveri & Co.)

Fig. 11.—Simplon Tunnel, showing Construction of Poles used (Brown, Boveri & Co.)

The number of wires at points and crossings is double, thus making four overhead wires per single track, as shown in Fig. 6. For points the two corresponding wires of one phase are held 660 mm. apart (26 in.) until the frog is reached, after which they diverge gradually with the tracks. At crossings one phase is insulated for about 6 metres (19 ft. 8 in.) by means of the creosoted wooden insulators whilst the other phase carries the current.

At level crossings safety devices, to act in case of broken trolley wire, are provided, as shown in Fig. 8, which is self-explanatory, the wire if broken being immediately connected to earth, as shown. At all the stations signals are interlocked with the line switches.

At both ends of a station there is an insulated section of overhead line 300 metres long, as shown in Fig. 7. This section can only be switched on if the signal is lowered for the train to proceed. A through cable or by-pass is carried round the station, thus enabling the whole overhead system, excepting the station, to be interconnected, as shown in the diagram Fig. 7.

Figs. 9, 10 and 11 show the very light form of overhead construction adopted in the case of the three-phase installation of the Simplon tunnel, equipped by Messrs. Brown & Boveri, and are so clear that they require no detailed description.

With this we will conclude the consideration of what may be called the plain trolley wire construction of the tramway type, the only difference being that, in consequence of the high pressures used, experience has shown that porcelain is practically, for the present at least, the only insulation available. This being the case, and before we proceed to consider more closely the construction of single-phase lines or any high-tension overhead construction requiring only one working conductor per track, involving more complicated forms of construction, which have been resorted to for reason of safety and otherwise, we will briefly examine the question of insulation.

(*To be continued.*)

ALUMINIUM WELDING.

The reduced cost of aluminium has contributed greatly to the rapidly increasing use of this metal in competition with copper for electrical purposes. One of the greatest obstacles to its extended use has been the difficulty of obtaining a sound mechanical joint.

FIG. 1.—A JOINT AFTER WELDING.

In the United States, metal sleeves have been used to hold together the cable ends, but they do not give a sound electrical joint owing to the oxidation of the aluminium surface where in contact with the metal sleeve. Attempts have been made to weld aluminium electrically, but the weld when made was found to be brittle and the strength of metal considerably reduced, in some cases as much as 10 per cent.

As is well known the difficulty—if not impossibility—of soldering aluminium is due to the formation of an imperceptible, but very persistent, film of oxide on the surface of the metal. This film of oxide cannot be reduced by the use of flux, nor can it be mechanically removed, for, however rapid the removal, a fresh film is instantaneously formed on the new surface which prevents the permanent adhesion of the solder.

Mr. Sherard Cowper-Coles has made a large number of experiments on the welding of aluminium, extending over eight or nine years, and has now perfected a compact welding machine, making use of the fact that aluminium readily becomes coated with a film of oxide.

The principle underlying the process is as follows:—The ends of the rod to be jointed are butted, after facing square, and heat from a gas blowpipe or benzine lamp is applied at the joint, which rapidly produces an oxide skin, and the fused metal is retained within this skin of oxide. When the ends of the rods are molten, they are brought rapidly together by releasing a spring catch; the oxide skin, bursting at the point of contact, is driven out by the pressure of the spring and the clean molten metal unites and makes a perfect joint.

FIG. 2.—VIEW SHOWING SKIN OF OXIDE.

Fig. 2 shows clearly the skin of oxide containing the molten aluminium, the weight of which causes the flexible skin of oxide to sag, the skin when pierced allows the molten metal to run out leaving a loose skin as shown in the illustration. Fig. 1 shows a joint after welding; the ring of the metal which has been squeezed out is largely composed of aluminium oxide. It is necessary to remove the collar only when it is desired to obtain a uniform diameter.

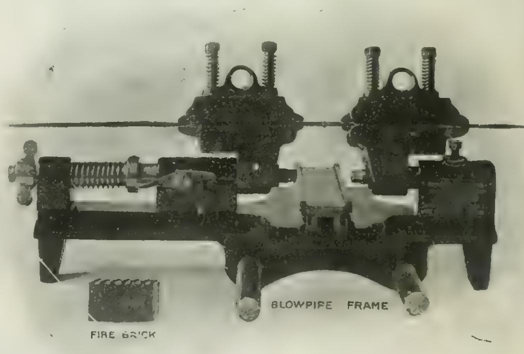


FIG. 3.—MACHINE FOR ALUMINIUM WELDING.

The machine illustrated in Figs. 3 and 4 is operated by a blowpipe from coal gas. The adjustable spring jaws, A, are lined with a refractory holder, so as to insulate the aluminium. The compressed spring and spring release B can be clearly seen; the adjustable stop C regulates the movement of the spindle. The blowpipe D is fitted with a spring universal joint E, and can be adjusted in position along the rods F. These rods are detachable, so that the machine packs up very closely. The flame plays on the grooved firebrick G which is

supported on an adjustable inclined plane K, thus regulating the height to a nicety, by means of the screw.

The machine can be supplied with coal gas or Dowson producer gas blowpipe (made of iron), or with benzoline lamp for field work, in which case it can be packed in a box 18 in. by 7 in. by 7 in., weighing only 19 lb.; the complete outfit costs from £10 upwards, according to the size of the welds to be made.

Tests for tensile strength on 12 consecutive welds (not picked specimens) made by this welding machine showed that the fractures occurred at a considerable distance from the weld, indicating there-

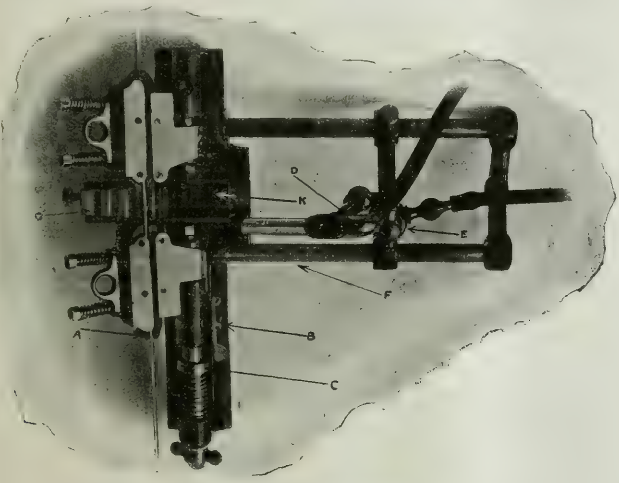


FIG. 4.—COWPER-COLES MACHINE.

fore that the metal had not deteriorated during the process of welding. The extension, on 4 in., in the 12 tests referred to varied from 8·0 to 14·0 per cent., the elastic limit from about 4 to 7 tons per square inch, and the maximum stress from 6·3 to 10·85 tons per square inch, none of the specimens breaking in the welded portion.

NON-INDUCTIVE, WATER-COOLED STANDARD RESISTANCES FOR PRECISION ALTERNATING-CURRENT MEASUREMENTS.*

BY C. C. PATERSON AND E. H. RAYNER, M.A.

Summary.—The authors show that by applying a potential sheath lead in close proximity to the outside of a tube of resistance alloy, standard resistances of low value and up to any current capacity can be constructed, whose effective self-induction is as low as two or three thousandths of a microhenry.

In the measurement of power in alternating-current networks when the highest accuracy is desired, it is difficult to obtain standard resistances in which the time constant (the inductance divided by the resistance) is sufficiently low to render the effect of inductance negligible, and at the same time the resistance of which does not vary with the temperature or the frequency. This is especially the case when large currents are to be dealt with, for in this instance the comparatively large amount of energy to be dissipated renders it almost impossible to get rid of the heat by natural radiation sufficiently rapidly to prevent a rise in temperature beyond the limit at which even the best material will maintain its resistance sufficiently constant. In dealing with the question of alternating-current measurement at the National Physical Laboratory, we have had to aim at an accuracy considerably higher than 1 part in 1,000, and not the least difficult part of this problem has been to construct a series of resistances ranging from 0·04 to 0·001 ohm, and capable of operating at from 50 to upwards of 2,000 amperes.

It is generally recognised that for laboratory purposes it is not desirable to try to limit the amount of power used in the measuring apparatus (provided the heat can be effectually dissipated) if extra torque and increased accuracy and reliability can be secured in the standard instruments. In the resistances in question we have been able, without difficulty, to use a drop of 2 volts and more, across the potential points, for standard resistances up to 2,000 amperes, and we have adopted this figure as a basis for alternating current and power measurements.

It will be readily appreciated that the only practicable method of dealing with this amount of power (4 kw. in the 2,000 ampere resistance) is by some artificial method of cooling. The device adopted by Messrs. Crompton many years ago, of tubular resistances cooled by water constantly flowing through them, suggests itself at once as the most convenient form for the purpose.* Attempts were first made to draw Eureka tubes, and the London Electric Wire Co. went to considerable trouble in an endeavour to make some seamless tubes of this material; but the attempt had eventually to be abandoned in favour of manganin. This alloy, although more troublesome on account of the necessity of hard soldering all joints, appears to lend itself better to the drawing of seamless and uniform tubes. The tubes used have been obtained from Messrs. Goliasch, of Berlin, and have proved most satisfactory in every way.

In order to be able to obtain high wattmeter readings at low power factors it is desirable to be able to use each resistance at a current considerably in excess of that for which it is normally rated, and the maximum value is such that a greater change than 2 parts in 10,000 does not take place in the value of the resistance due to rise of temperature. Thus, the maximum current for the 0·040 ohm resistance is 115 amperes, for the 0·002 ohm 260 amperes, for the 0·010 ohm 450 amperes, for the 0·002 ohm 1,300 amperes, and for the 0·001 ohm 2,500 amperes, the normal drop of 2 volts being, in consequence, increased in each case. It is possible, of course, by applying a correction to use the tubes for higher currents than these. A flow of cooling water equal to 15 litres per minute was used, but the exact amount is of little consequence. A smaller amount could be used if arrangements were made for churning the water.

The watts (per square centimetre) which are dissipated in these tubes under the "maximum" load conditions vary from $7\frac{1}{2}$ to 12. An upper limit of 10 watts may be taken as an average value for the design of manganin tubes up to 1·5 mm. thickness of wall. This corresponds to a current density of about 25 amperes per square millimetre (16,000 amperes per square inch) in tubes 0·3 mm. thick. From considerations of self-induction, a thin-walled tube of large diameter, working at a high current density, has great advantages.

An experiment with tap water in the 0·002 ohm tube showed that the resistance of the column of water was about 40,000 ohms, and its shunting effect, therefore, negligible.

Fig. 1 illustrates the change in resistance of the 0·001 ohm manganin tube as the current increases from 0 to 4,000 amperes. The shape of this curve may be taken as typical of the curves obtained by experiment on all the standards, which exhibit the well-known characteristic of manganin alloy for variation of the temperature coefficient. In good manganin there is a total rise in the resistance of about 2/10,000 from 8°C. to 35 or 40°C., after which, as the temperature increases, the resistance tends to fall with greater rapidity than the original rate of increase.

Construction.—The cross-section of each tube is proportioned so that a length of about 40 cm. ($15\frac{1}{2}$ in.) has the desired resistance. Five sizes have been made up to the present, and three resistances of each size except of the largest. The approximate dimensions of the tubes are given in the Paper. These tubes are silver soldered into heavy copper ends, which form the potential points, and which serve to lead the current into the tube. Each copper end has a hole through it equal to the bore of the tube, so that a stream of cooling water can pass continuously through the tube.

Fig. 2 shows one of the complete resistances (0·002 ohm for 1,000 amperes). It will be seen that the current is led in from the two terminal posts in a way which maintains a well-closed circuit, and thus avoids giving rise to fields which may affect other apparatus in the neighbourhood. The narrow ring soldered to the centre of the tube forms the common point for the volt and current circuits in wattmeter measurements with the quadrant electrometer. The manganin tubes are seamless, and the first treatment is to anneal them thoroughly at a red heat, in order, as far as possible, to secure subsequent constancy in their resistance. The heavy copper cylindrical ends and centre rings are then sweated on with silver solder, care

* Abstract of an original communication to the Institution of Electrical Engineers, accepted by the Council for publication in the Journal.

* See "The Potentiometer and its Adjuncts," by Clark Fisher, p. 77; also THE ELECTRICIAN, Vol. XXXVIII., p. 22.

being taken to ensure that the resistances are a few per cent. lower than the values which are finally required. It is then necessary, especially with the very thin walled tubes, to wash over all the inner surfaces with acid, so as to remove the scale. If this is not done the tubes will have a comparatively large temperature coefficient. After removing all traces of acid, the inner surface is coated with enamel, which is hardened in the usual way by stoving. This prevents subsequent oxidation of the surface. The tubes are then ready for closer resistance adjustment, which is best done by sand papering their outer surfaces in a lathe. When the resistance is within ½ per cent. of the final value the tube is soft soldered into the brass or copper end castings and mounted up. The final adjustment is then made and the outer surface lacquered to prevent oxidation.

Self-induction.—The method usually adopted for rendering a low sheet resistance as non-inductive as possible is to double the sheet back upon itself. Dr. Orlich (of the Reichsanstalt) has recently

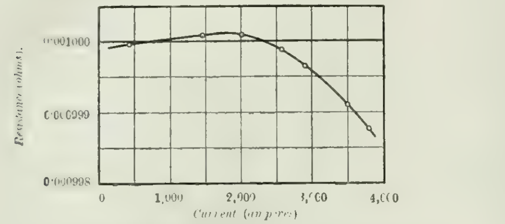


FIG. 1.—0·001 OHM STANDARD RESISTANCE. CURVE OF CHANGE OF RESISTANCE WITH CURRENT.

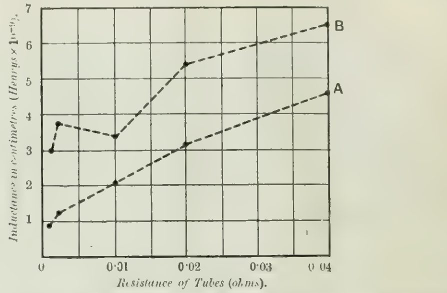
constructed a set of oil-cooled standards on this principle, with very active mechanical stirring of the oil. In order to bring the volt drop across the terminals of the water tube standards into phase with the currents passing through them, a device has been adopted which was suggested by Mr. Albert Campbell,* in connection with non-inductive resistances. It consists in leading the potential wires back along the resistances in such a way that the magnetic flux, which causes the back E.M.F. of self-induction in the resistance, will also give rise to a practically equal back E.M.F. in the lead of the potential circuit, and so neutralise the induction effect. In order to make this elimination more complete, and also to render the calculation of the inductance possible, it is necessary that the potential lead shall take the form of a closely fitting cylindrical sheath running the whole length of the tube and insulated from it at all points except at one end. In the tubes in question the thickness of this insulation is 0·2 mm.

The cross-section of one of the tubes with its sheath clamp is shown in the top right-hand of Fig. 2. Underneath this is shown a section (to a very much magnified scale) of a small part of the tube, insulation, and sheath, in order to illustrate their relative proportions. On account of its closeness to the tube it has not been possible to draw the sheath in the elevation, only its clamp being shown. The magnified section, as reproduced, is 20 times the scale of the remainder of the drawing.

The only flux which can cause a self-inductive effect which is not eliminated by the sheath is that which cuts the manganin tube while it does not cut the sheath. Of these linkages those outside the sheath are completely eliminated by it, and those inside it can be divided into two classes—namely, the linkages of the flux in the insulating material with the whole current, and the linkages of the flux in the tube itself with part of the current. It will be seen how the concentration of all the current in a very thin tube of large radius assists the non-inductive quality of the resistance as compared with the case in which it is distributed over a solid conductor.

A table in the Paper gives the values of the effective inductances and time constants of the various resistances, the value of the time constants varies from $1{\cdot}6\times10^{-7}$ for the 0·040 ohm resistance to $30{\cdot}0\times10^{-7}$ for the 0·001 ohm resistance. Fig. 3 has been drawn from the calculated values in order to indicate graphically the relative effect of the two linkages. With the data and experience gained with the tubes already constructed, the authors are now designing standards to work with 5,000 and 10,000 amperes in which the inductances will be even more favourable.

The necessity of reducing the value of the inductances of low resistances to the lowest possible limit is illustrated by a diagram. This shows that for standards up to 2,000 or 3,000 amperes, at 50 frequency, although the inductances may be as low as three thousandths of a microhenry, the low value of the resistance and consequent high time constant makes it necessary to use a correction, if a closer accuracy than 1 per cent. is desired at power factors of 0·1. With



Curve A shows the proportion of the inductance which is due to a thickness of insulation of 0·2 mm. Curve B gives the total inductance.

FIG. 3.—DIAGRAM SHOWING THE RELATIVE PROPORTION OF THE SELF-INDUCTION OF TUBE RESISTANCES CAUSED BY THE THICKNESS OF INSULATION BETWEEN TUBE AND SHEATH.

resistances for 200 and 300 amperes the correction is only 0·1 per cent. at 0·1 power factor.

For calculating the effect of a variation of frequency on the resistance of the tubes the authors used Dr. Heaviside's formula. It was found that owing to the thinness of the tubes and the high volume resistivity of manganin the variation of resistance with frequencies of 100 or less only affected the hundredth thousandth place, and was absolutely negligible.

The authors are not aware of any method of measuring the low values of effective inductance of such resistances as these to anything approaching the accuracy with which they can be calculated. The following experiment embodies a method which has been found of great value in measuring small differences of phase in current transformers and similar apparatus. It is similar in principle to that which has been utilised and described by E. and W. H. Wilson in connection with some interesting tests on commercial shunts.*

R and R_1, Fig. 4, are two similar water-tube resistances supplied with current by one of two alternators coupled together. The quadrants of a sensitive electrometer are connected across one of the resistances, while the needle is connected to the other alternator whose voltage is displaced 90 deg. with relation to the phase of the machine which supplies the current. The phase difference is adjusted till the deflection of the electrometer is zero, the quadrants being connected to one of the resistances. If these are now changed

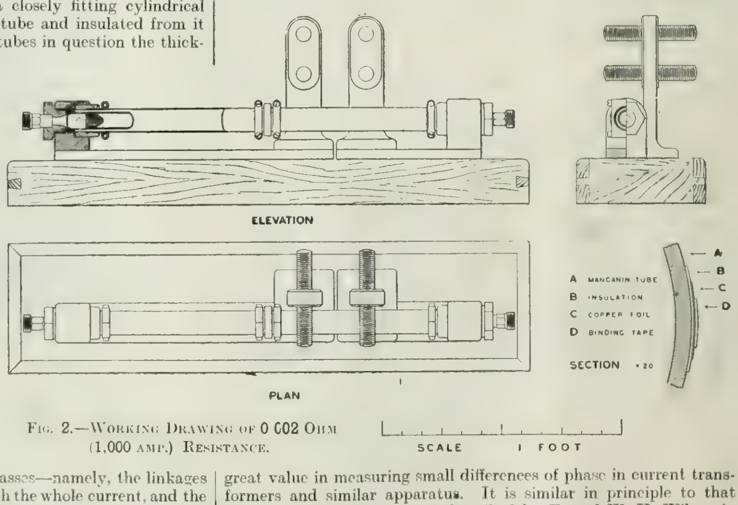


FIG. 2.—WORKING DRAWING OF 0·002 OHM (1,000 AMP.) RESISTANCE.

* THE ELECTRICIAN, Vol. LXI., pp. 1000-1001.

* THE ELECTRICIAN, Vol. LVI., p. 464.

over to the other one, any deflection will be proportional to the sine of the phase angle between the E.M.F.s on the two resistances.

In the tests two similar standards were used, one with its sheath and the other without, and it is possible thus to test the difference of effective inductances of the two tubes and to illustrate the screening action of the sheaths. Measured in this way, the change of phase angle of the 0·002 ohm resistance with and without its sheath was 0·67 deg. at 50 ∿ per second. It will thus be seen that the sheath corrects for over 90 per cent. of the inductance of this tube.

Comparison with other Apparatus.—It is interesting to compare the relative advantages of the authors' tube type of non-inductive resistance with the more usual strip type. A comparison cannot be made on the basis of inductance alone, since the capacity of the tube resistances to dissipate energy may be said to be roughly 300 times that of air-cooled standards. This gives them a great advantage from the points of view of overload capacity and constancy of resistance at all loads. The authors are of opinion that the water-tube type of resistance must compare very favourably with any other similar standards from the points of view of cooling efficiency, compactness, general convenience and low self-inductance.

The following data are given for the purpose of indicating the magnitude of the inductances found in commercial apparatus. Messrs. E. and H. Wilson (*ref. cit.*) give the value of a commercial corrugated straight manganin shunt for use with a hot wire ammeter as 160 cms. Its value was 0·0045 ohm, being constructed for 200 amperes. The phase displacement of this shunt at 50 ∿ is of the order of 0·6 deg. Messrs. Siemens & Halske publish the results

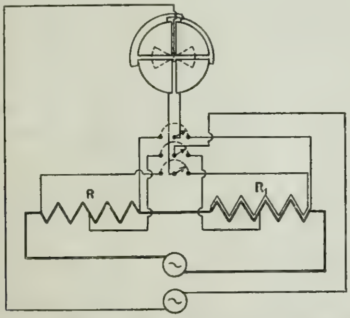


Fig. 4.—Diagram of Connections for Test to Demonstrate the Screening Action of the Potential Sheaths.

of phase displacement tests between the primary and secondary of one of their high-grade current transformers, ratio 1,200 15, 50 ∿. These tests show phase displacements varying from 0·5 deg. at one-tenth load to 0·2 deg. at full load. Our own measurements on the phase differences in current transformers also give values of this order.

A NEW STANDARD OF LIGHT.*

BY W. A. HARWOOD.

The ideal qualities of a standard of light—viz., absolute constancy, exact reproducibility, simplicity and utility under any ordinary conditions are found in practice to be antagonistic. For instance, the Violle molten platinum standard is satisfactory so far as constancy and reproducibility are concerned, but it is too expensive and complicated for everyday use, and on the other hand, the simple self-contained and portable flame standards are subject to considerable irregularities due to varying atmospheric conditions.

The difficulty has been in great part overcome by adopting three types of standards—viz., standards for ultimate reference, intermediate standards and working standards, known respectively as "primary," "secondary" and "working" standards. The Violle standard has been shown to fulfil satisfactorily the requirements of a "primary" standard. The Fleming Ediswan large bulb glow lamps fulfil most of the conditions of a "secondary" standard. Flame standards possess decided advantages in their simplicity and portability, and in the fact that they are self-contained for use as working standards outside the region of electric lighting.

The most serious objection to the Fleming Ediswan glow lamp is the possible considerable cumulative error introduced by multiplying the number of photometer readings. The proposed new standard is intended as a "secondary" standard, which may be stamped once and for all with a given candle-power and will retain its value for an indefinite period, thus obviating the necessity of more than two sets of photometer readings.

The new standard consists of the light emitted by a fixed area of an incandescent metal strip heated electrically. Of various metals tried pure platinum has proved most suitable for the purpose. The method of adjustment depends on the different absorbing qualities of black fluorspar and water for waves of heat and light. Of the total radiation emitted by a heated platinum strip, the percentage which is absorbed by black fluorspar is found to increase as the temperature of the strip is raised, while the percentage absorbed by water diminishes. At one particular temperature of the strip these two percentages are equal and their equality fixes the conditions of the strip uniquely. In the actual apparatus two parts of the radiation from the strip pass through a plate of black fluorspar and a layer of water respectively, and fall on two sensitive thermopiles which are connected in opposition through a galvanometer. The adjustment consists in regulating the current so that the galvanometer deflection is zero.

Up to the present the strip has been photometered against an incandescent lamp run at constant voltage, with very satisfactory results.

* Abstract of a Lecture delivered before the Manchester Local Section of the Institution of Electrical Engineers.

THE COMBINED EFFICIENCY OF A SMALL GAS ENGINE AND PRODUCER PLANT.

BY A. H. GIBSON, M.SC.

A series of experiments have recently been carried out on a suction gas producer coupled to a gas engine in the Engineering Laboratories of the Manchester University. The plant, which was supplied by the National Gas Engine Co., is capable of developing approximately 24 B.H.P., and was run at approximately full load over the whole series of experiments. The object of the latter was to determine the efficiency of producer and engine under different conditions of working. The fuel used throughout was gas coke containing 81·75 per cent. of carbon, and 1·19 per cent. of hydrogen, and had a net calorific value of 12,635 B.Th.U. per pound dry. The general conclusions to which the experiments led are as follows:—

The composition and calorific value of the gas varies greatly with the quantity of water vapour supplied to the vaporiser, as does the thermal efficiency of the producer, the latter attaining its maximum value—viz., 78·6 per cent. when the gas produced has its highest calorific value—viz., 127·1 B.Th.U. per cubic feet at 32°F. under a pressure of 29·921 in. of mercury. The efficiency of the engine, however, falls off as the gas becomes richer, the reduction of thermal efficiency being accompanied by a reduction in the percentage of heat rejected to the jackets, and in an increase in the percentage rejected in the exhaust gases. The engine has a maximum thermal efficiency of 26·9 per cent. and a minimum efficiency of 22·8 per cent., measured on the brake horse-power.

The overall thermal efficiency of the plant has a maximum value of 18·16 per cent., measured on the brake horse-power, this occurring with a slightly greater vapour supply than that (0·4 lb. per pound of dry fuel) giving the maximum producer efficiency. This value coincides very fairly with that obtained by Drs. Bone and Wheeler in a series of trials on a large pressure producer developing approximately 3,000 H.P. and burning bituminous coal as fuel.

Under conditions of maximum efficiency in the small producer the consumption of dry fuel amounted to 1·11 lb. per brake horse power per hour.

BOOKS RECEIVED.

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"English Prices with German Equivalents." By St. Koezorowski. (London: E. & F. N. Spon.) 1s. net.

"The Cultivation and Preparation of Para Rubber." By W. H. Johnson. 2nd edition. (London: Crosby, Lockwood & Son.) 7s. 6d. net.

"The Gas Engine." By Cecil P. Poole. (New York: Hill Publishing Co.) 4s. 6d. net.

"L'Allumage des Moteurs à Explosion." By G. Yseboodt (Paris: Dunod & Pinat.) Fr. 3.50.

* Abstract of a lecture delivered before the Manchester Local Section of the Institution of Electrical Engineers.

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With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The thirty-fifth issue of the Supplement will be published (Gratis) with the number of "THE ELECTRICIAN" for April 30.

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THE HIRING OF ELECTRICAL APPARATUS.

At the present time the expansion of domestic power supply is such an important question that no apology is necessary for the frequent reference to the subject in our columns. In fact, we believe that the future welfare of many electricity supply undertakings where a motor load is practically unobtainable is largely bound up in the development of the use of electricity for household purposes. In the majority of houses the greatest possibility of such development lies in the use of electricity for heating and cooking, and in order to popularise this branch it is necessary, firstly, that suitable and well-designed apparatus at a reasonable price should be on the market; secondly, that the apparatus should be brought to the notice of the public by means of well-equipped showrooms; thirdly, that electric supply undertakers should be in a position to let apparatus on hire to would-be consumers; and lastly, that a suitable tariff should be offered. In regard to the last item, much has already been written, and in this connection it is only necessary to draw attention to recent Papers read before the Institution of Electrical Engineers, in the present session by Mr. W. R. COOPER, and last year by Messrs. HANDCOCK and DYKES, and to the discussions which ensued. These showed the difficulties which have to be faced in the way of tariffs. An inspection of our annual Electric Supply Tables will show that in many cases current is offered at a low rate—at about 1d. per unit—for heating and cooking, so that the

slow progress made in the sale of current for these purposes cannot be solely attributed to the present scales of charges, though the accompanying stipulations may be at fault.

In regard to the other requirements, the question of the design of suitable apparatus and also the unsatisfactory organisation of existing showrooms (which, unfortunately, are not numerous) have been discussed quite recently in these columns, so that further reference is here unnecessary. The fact should not be overlooked, however, that the third requirement mentioned above—the letting on hire of apparatus—is very closely connected with the organisation of the showroom, and much can be learnt by careful study of the systems adopted by the gas companies. In this connection it is interesting to notice that within the last few weeks many electricity undertakings have decided to make arrangements for obtaining and equipping showrooms, so that the need for greater publicity is evidently being more appreciated.

In the eyes of the general public, electrical appliances are surrounded with mystery; and since the cause of any failure of such apparatus is frequently not apparent, except to a technical person, the consumer is inclined to attribute all failures to faulty apparatus, although in many instances they may be due to unskilful or careless handling. The possibility of such failures, however, can be reduced to a minimum; but, nevertheless, the average consumer naturally shows a good deal of hesitation before purchasing what he regards as experimental apparatus. There is, however, little difficulty in interesting such consumers in the subject of electric cooking, for the advantages of electrical appliances, particularly as regards cleanliness, appeal to the minds of all except gas enthusiasts; and the distribution of instructive pamphlets, with an invitation to call at the showrooms where the apparatus will be shown in use, will usually result in many inquiries. If the best results are to be obtained from the latter, it is essential that, where necessary, inquirers should have the opportunity of obtaining any apparatus on hire or hire-purchase.

Hitherto electric supply undertakings have been rather reluctant to take up the letting on hire of electrical cooking and heating appliances, although much has been done in the way of letting motors on hire, but that some such arrangement is essential for the satisfactory development of the electric supply industry there is little doubt. The public has become so accustomed to the hiring of gas ovens and gas fires that they naturally expect the same facilities to be placed at their disposal in the case of electrical apparatus, and in the latter case the necessity is considerably greater, owing to the higher price of electrical appliances, the fact that its capabilities are largely unknown, and the desirability of competing with gas apparatus on equal terms.

During the past year much more attention has been paid to this subject, and as recently as January the Blackpool Corporation decided to adopt an experimental scheme for hiring out electric heaters, cookers, &c. The rental has been fixed at 10 per cent. on the cost of the apparatus, and as the charge for energy is only 1d. per unit we shall await the result of this experiment with no little interest. In the meantime we desire to draw the attention of other central station engineers to what is being done, and we hope that some of them may be encouraged to adopt schemes of a similar character. Although the rental mentioned above may prove to be insufficient to cover maintenance and depreciation for the time being, it is desirable that the consumer should not be called upon to pay a large sum for the hire of apparatus, which later on, it may be noted, is likely to be much reduced in price when a considerably increased demand has been brought about. With an increased demand competition will be stimulated, the efficiency and design of the apparatus improved, and the percentage charge may be increased without raising the actual sum for rental.

It will be remembered that some years ago the Local Government Board were opposed to the raising of loans by municipal authorities for the purpose of purchasing electrical apparatus for hiring without special statutory authority. This attitude restricted to some extent the growth of the business, as the promotion of a special bill is a costly method of procedure.

Moreover, many Councils encountered considerable opposition from wiring contractors and the electrical trade by their desire to undertake, not only the hiring of the apparatus, but also the complete equipment of the necessary installation. The point should not be overlooked that the letting on hire or hire-purchase can be, and should be, distinct from the ordinary business carried on by electrical contractors, who would usually be unwilling to undertake business on hire-purchase terms. The electric supply undertakers have been authorised to supply electricity, and it is only fair that they should be allowed to encourage its use by all possible means. In fact, it is not only desirable, but imperative, that in this respect they should be placed on an equality with the gas undertakers, so that they may bring electrical apparatus more prominently to the notice of likely consumers.

In this connection it will be remembered that the Electric Lighting Acts (Amendment) Bill, which is now being considered by Parliament, contains a clause giving powers to all electric supply authorities to undertake, under certain conditions, the letting on hire of electrical apparatus. Such a clause would greatly facilitate matters if the Bill became law. Even now, many large undertakings already possess the necessary statutory powers, and those who are not so fortunately placed might well consider the possibility of utilising reserve funds for purchasing apparatus to let on hire, as has been done at Blackpool.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

The Life Story of Sir Charles Tilston Bright, C.E. By CHARLES BRIGHT, F.R.S.E. (London: A. Constable & Co.) Pp. xiv.—478. 12s. 6d. net.

This book is so full of interest that it requires no effort to read, and it is well that it should be published in revised and abridged form, because there is, perhaps, some danger of the valuable work done by Sir Charles Bright, in the earliest days of long-distance submarine telegraphy, being overlooked by later generations.

One, of course, hardly expects a nice sense of historical perspective in a biography by a son, and if the part played by its subject in regard to the introduction of many electrical

advances does not lose in the telling, allowance will be made for filial partiality. Even to those who are not without knowledge of the history and literature of the subject, the strenuous work and undaunted spirit of Sir Charles come with a sense of freshness, and revive admiration for the qualities displayed by him at a relatively very early age. In reviewing Bright's life, however, it seems clear that he spread even his abundant energies and great persistence over too wide a field, and that he would have accomplished more enduring work in his later years if he had circumscribed his engineering interests. There is here, perhaps, a lesson for our own day.

That he was at least one of the first to grasp the essential factors in submarine cable work, both from the engineering and electrical points of view, is abundantly manifest. And it would have been well had his advice been followed in important particulars, such as the weight of copper and gutta-percha in the first Atlantic cable, and the battery power used in working it. He was, perhaps, not always sufficiently critical in regard to enterprises submitted for his advice. For instance, the approval he gave to the "North Atlantic Telegraph Project," involving cables via Iceland and Greenland, has not been borne out by history and experience. The slow speed of the early long cables has been greatly improved by other means than dividing the route up into short sections.

In any case, Sir Charles Bright has left his impress on cable and land telegraphy, and there is inspiration in his courageous dealing with new conditions and great untried engineering and electrical problems, involving huge risks. His is the credit of proving the possibility of laying long cables in deep water, as to Sir James Anderson belongs that of making these cables a property by showing that they could be picked up from great depths and repaired.

Mr. Charles Bright is to be congratulated on his latest publication. The subject of the biography, and the book itself, are well presented, and the illustrations are excellent and well chosen. Some judicious pruning and editing might be an improvement; while the too frequent use of footnotes, many of which could very properly be incorporated in the text, is irritating to the reader. But the work is illuminative, and possesses distinct value in an age of biographies in its outstanding representation of a vigorous and able personality, whose life work was and still is of high importance in the world's progress.

GEO. R. NEILSON.

The Elementary Theory of Direct Current Dynamo Electric Machinery. By C. E. ASHFORD and E. W. E. KEMPSON. (Cambridge: University Press.) Pp. viii.—120. 3s. net.

This little book discusses the direct current dynamo and motor from an elementary point of view, and the beginner will find the main principles involved explained in a very simple and clear manner. The authors follow generally accepted lines and so the treatment calls for little comment, yet there are a few points that may be criticised. No reason is given, nor does one actually exist, for the warning that shunt motors should be allowed to reach full speed before load is put on; furthermore, exception may be taken to the statement that the armature field of dynamos is always small in comparison with the field produced by the magnets, as the number of ampere-turns per pole on the armature and field is very often about the same. In the formula given for the E.M.F. of an armature it would be preferable to let "b" represent the number of parallel circuits in the armature rather than the number of brush-studs, as otherwise the formula will give incorrect results for series windings, in which the number of parallel circuits is not necessarily equal to the number of brushes.

The sentence "There are no lost volts in the field circuit" appears in the discussion of the characteristic curves of the shunt dynamo; this statement is not intelligible and as it has no apparent connection with the context, in which it occurs, its omission in a future edition would be desirable.

The development of the calculation of magnetic circuits is perhaps the best feature of the book, but it is unusual to define permeability as the ratio of B to H as obtained from points on a hysteresis loop. The result of such a definition is, as is pointed out in the text, to give negative values of the permeability for points on certain parts of the loop. The reviewer would point out that this method of defining permeability will lead to infinite and zero values for those points of the curve at which the magnetising force and the magnetisation are zero and also two values for the permeability for each value of the induction density.

It would be an improvement if the armature of figure 37 were shown laminated, and if the directions of the currents and fluxes were indicated in figures 69 and 70, and if the letters N and S used in these figures for the neutral axis, and the axis of symmetry were replaced by other letters, as they give rise to confusion if they are taken in their ordinary meaning to denote North and South poles.

Throughout the book "D.P." is used for difference of potential in place of the almost universally adopted abbreviation "P.D.," and this change seems undesirable in the interest of uniformity of notation.

Notwithstanding the presence of such slight inaccuracies as have been indicated above this book may be recommended for the use of elementary students owing to its conciseness and freedom from mathematical difficulties.

A. J. M.

THE E.M.F.s INDUCED IN THE EXCITING WINDING OF SINGLE-PHASE ALTERNATORS.*

BY H. BRÜHN.

Summary.—The author examines the reaction of the stator current on the rotor winding in a single-phase generator, and shows how the E.M.F. induced in the several turns depends on their position, which becomes of importance in machines having cylindrical rotors with distributed windings. The result of the investigation shows that, in addition to the E.M.F. which appears at the slip-rings, other E.M.F.s exist inside the winding. Although these latter pressures neutralise one another, and therefore set up no pulsating currents in the exciting circuit, yet owing to their possible magnitude, they may become dangerous to the insulation.

In the present article the E.M.F.s set up in the rotor (or exciter) circuits of single-phase alternating current generators will be investigated, and their shape and distribution examined. For the sake of simplicity a two-pole alternator will be assumed with a cylindrical rotor carrying a uniformly distributed drum winding. The number of slots is $2k$, and the winding pitch is taken equal to the pole pitch. There are $2k$ turns on the rotor, and the latter is opened at the two opposite ends of a diameter, whilst the two halves are joined in series, consequently the flux due to the exciting current will be triangle-shaped, with its axis of symmetry along the diameter where the winding is opened. We will denote the turn connected immediately to slip-ring I as the first turn of the rotor winding, and this is the turn which lies in the peak of the field. Further, the pressure between the two points of the winding lying in the neutral zone of the field we shall call the pressure perpendicular to the slip rings.

First, we shall only investigate the action of the fictitious stator flux and for the time being neglect the fictitious rotor field—*i.e.*, the field produced by the exciting ampere-turns—since the latter field does not alter its strength and consequently cannot induce anything in the rotor turns with which it is interlinked and relatively at rest. The exciting winding, therefore, is assumed open, and only the stator is traversed by an alternating current of frequency $\frac{\omega}{2\pi}$. This current, i_s, can be expressed as a function of the time t—

$$i_s = a_1 \sin \omega t + a_3 \sin 3\omega t + a_5 \sin 5\omega t + \ldots$$
$$= \Sigma_m a_m \sin m\omega t,$$

where m is an odd number and a_1, a_3, &c., are constants.

If we further assume that the stator flux is sinusoidally distributed over the circumference, then the radial component of the induction B in the gap at the position x and instant t is

$$B = \Sigma_m a_m \sin m\omega t \times A \sin x.$$

where A is the constant expressing the relation between the stator current and the field and x is the distance, measured along the periphery, of the point considered from the middle of the stator coil side. The flux passing through an area of the rotor of axial length 1 and breadth dx is $d\Phi = Bdx$. The flux interlinked with the first rotor turn, when occupying any particular position $x = a$, is

* Abstracted from "Elektrotechnik und Maschinenbau."

found by integrating the expression for B with respect to x between the limits a and $a+\pi$. Thus

$$\Phi_a = \Sigma_m a_m \sin m\omega t \int_a^{a+\pi} \mathrm{A} \sin x dx$$
$$= \Sigma_m a_m \sin m\omega t \times 2\mathrm{A} \cos a.$$

Remembering now that the frequency of the stator current is equal to the number of revolutions per second of the rotor, we can write $\gamma+\omega t$ for the angle a, where γ is a constant angle giving the position of the first rotor turn at the instant $t=0$. At short-circuit, or with a pure wattless load, the first rotor turn will lie in the plane of the centre of the stator coil side at the moment $t=0$ (*i.e.*, stator current $=0$), thus $a=0$, and therefore $\gamma=0$ also. With a non-inductive load the first rotor turn has its plane at right angles to that of the stator coil, so that when $t=0$, $a=\gamma=\pi/2$. If the generator is working on a load of power factor $\cos\phi$, the corresponding value of $\gamma=\pi/2-\phi$.

Coming now from the first turn to the $(n+1)$th, which is displaced from the first turn by an angle, $n\delta$, where δ denotes the angular distance between two adjacent turns, then we must write $a=\gamma+\omega t+n\delta$, and the flux embraced by the $(n+1)$th turn is

$$\Phi_{n+1} = 2\mathrm{A}\Sigma_m a_m \sin m\omega t \cos\{\gamma+n\delta+\omega t\}$$
$$= \mathrm{A}\Sigma_m a_m \{\sin[(m+1)\omega t+\gamma+n\delta] + \sin[(m-1)\omega t-\gamma-n\delta]\},$$

since $\sin\omega\cos v = \frac{1}{2}\sin(\omega+v)+\frac{1}{2}\sin(\omega-v)$.

By differentiating this expression with respect to the time t we get the pressure induced in the $(n+1)$th turn of the rotor winding

$$e_{n+1} = -\frac{d\Phi_{n+1}}{dt} = -\mathrm{A}\omega\Sigma_m a_m\{(m+1)\cos[(m+1)\omega t+\gamma+n\delta]$$
$$+(m-1)\cos[(m-1)\omega t-\gamma-n\delta]\}$$
$$= -\mathrm{A}\omega\Sigma_m a_m(m+1)\{\cos(m+1)\omega t\,.\cos(\gamma+n\delta)$$
$$-\sin(m+1)\omega t\sin(\gamma+n\delta)\}$$
$$-\mathrm{A}\omega\Sigma_m a_m(m-1)\{\cos(m-1)\omega t\cos(\gamma+n\delta)$$
$$+\sin(m-1)\omega t\sin(\gamma+n\delta)\};$$

or $e_{n+1} = -\mathrm{A}\omega\Sigma_m a_m\{(m+1)\cos(m+1)\omega t+(m-1)\cos(m-1)\omega t\}$ $\cos(\gamma+n\delta) + \mathrm{A}\omega\Sigma_m a_m\{(m+1)\sin(m+1)\omega t-(m-1)$ $\sin(m-1)\omega t\}\sin(\gamma+n\delta)$.

This expression gives us an insight into the E.M.F.s induced in the several turns and in the whole winding. In the first place we see that the pressures set up in the several rotor turns are represented by the algebraic summation of a series of cosines and a series of sines, which combine in a certain ratio, determined by sin $(\gamma+n\delta)$ and cos $(\gamma+n\delta)$, and is different for the several turns. In the first turn, where $n=0$ only cosine pulsations occur when $\gamma=0$—*i.e.*, on short-circuit, for in this case the second term equals zero. On the other hand, only sine pulsations are set up in a coil lying in the neutral zone $(n\delta=\pi/2)$, for now the first term becomes zero. Thus the pressures in the different turns have different phase relations. With non-inductive loads the converse of the above occurs. Of course, by short-circuit, &c., we assume the rotor to occupy these positions with respect to the stator field, although in the above the rotor winding is taken to be open.

If the above expression for e_{n+1} is evaluated for a few positions for a given wave-shape of stator current, it will be found that the E.M.F.'s induced in the turns lying in the peak of the fictitious rotor field (*i.e.*, $n\delta=0$ and $n\delta=\pi$) deviate mostly from a sine wave. Further, the expression for e_{n+1} shows that this deviation increases the more the stator current differs from a sine wave. For a purely sinusoidal stator current, the rotor pressures will also be sine waves —*i.e.*, putting $m=1$, we get

$$e_{n+1} = -2\mathrm{A}\omega a_1\cos 2\omega t\cos(\gamma+n\delta)$$
$$+2\mathrm{A}\omega a_1\sin 2\omega t\sin(\gamma+n\delta)$$
$$= -2\mathrm{A}\omega a_1\cos\{2\omega t+(\gamma+n\delta)\},$$

which is a sinusoidal pressure with twice the frequency of the stator current.

In order to find the pressure between the ends of the rotor winding—*i.e.*, between the slip-rings I. and II.—we must take the sum of all the pressures from $n=0$ to $n=2k-1$. Since the turns 2 to k have the same E.M.F.s induced in them as the turns $2k$ to $k+2$, the slip-ring pressure is obtained by subtracting from twice the pressure induced in the half winding $n=0$ to $n=k-1$ the pressure induced in the first turn and adding the pressure induced in the $(k+1)$th turn. For the sake of simplicity we will denote the sine and cosine series by $\mathrm{R}_{\sin}$ and $\mathrm{R}_{\cos}$ respectively, so that the pressure in the $(n+1)$th turn is

$$e_{n+1} = -\mathrm{A}\omega\mathrm{R}_{\cos}\cos(\gamma+n\delta)+\mathrm{A}\omega\mathrm{R}_{\sin}\sin(\gamma+n\delta).$$

The pressures in the first and $(k+1)$th turns are

$$e_1 = -\mathrm{A}\omega\mathrm{R}_{\cos}\cos\gamma+\mathrm{A}\omega\mathrm{R}_{\sin}\sin\gamma,$$
$$e_{k+1} = \mathrm{A}\omega\mathrm{R}_{\cos}\cos\gamma-\mathrm{A}\omega\mathrm{R}_{\sin}\sin\gamma.$$

The pressure e_{sr} at the slip rings is then

$$e_{sr} = -2\mathrm{A}\omega\mathrm{R}_{\cos}\Sigma_0^{k-1}\cos(\gamma+n\delta)$$
$$+2\mathrm{A}\omega\mathrm{R}_{\sin}\Sigma_0^{k-1}\sin(\gamma+n\delta)$$
$$+2\mathrm{A}\omega\mathrm{R}_{\cos}\cos\gamma-2\mathrm{A}\omega\mathrm{R}_{\sin}\sin\gamma.$$

Summing up the above from the relation

$$\Sigma_0^{k-1}\sin(a+n2\beta) = \frac{\sin k\beta}{\sin\beta}\sin(a+\overline{k-1}\beta),$$

and substituting $\delta=\pi/k$, we get

$$e_{sr} = 2\mathrm{A}\omega\cot\frac{\pi}{2k}\{\mathrm{R}_{\cos}\sin\gamma+\mathrm{R}_{\sin}\cos\gamma\}.$$

In a precisely similar manner, the pressure $e_\perp$ at right angles to the slip rings is given by the expression

$$e_\perp = -\mathrm{A}\omega\mathrm{R}_{\cos}\{(\sin\gamma+\cos\gamma)\cot\frac{\pi}{2k}-\sin\gamma\}$$

$$+\mathrm{A}\omega\mathrm{R}_{\sin}\{(\cos\gamma-\sin\gamma)\cot\frac{\pi}{2k}+\cos\gamma\}.$$

Comparing the two last expressions with one another, it is seen that for the case of short-circuit $(\gamma=0)$, the cosine series vanishes from the slip ring pressure, whilst it remains in the second equation. Similarly with non-inductive load $(\gamma=\pi/2)$.

This remarkable circumstance can only be explained by the fact that inside the winding pressures are opposed to one another. That this actually is the case can be more clearly seen when—starting from one slipring—we consider the effective pressures of the several turns along the winding. This is found in the usual way

$$\mathrm{E}^2_{n+1} = \frac{1}{\mathrm{T}}\int_0^{\mathrm{T}} e^2_{n+1}dt = \mathrm{A}^2\omega^2\cos^2(\gamma+n\delta)\frac{1}{\mathrm{T}}\int_0^{\mathrm{T}}\mathrm{R}^2_{\cos}dt$$
$$+\mathrm{A}^2\omega^2\sin^2(\gamma+n\delta)\frac{1}{\mathrm{T}}\int_0^{\mathrm{T}}\mathrm{R}^2_{\sin}dt$$
$$-2\mathrm{A}^2\omega^2\cos(\gamma+n\delta)\sin(\gamma+n\delta)\frac{1}{\mathrm{T}}\int_0^{\mathrm{T}}\mathrm{R}_{\cos}\mathrm{R}_{\sin}dt.$$

Since in this expression $\sin(\gamma+n\delta)$ and $\cos(\gamma+n\delta)$ can be regarded as constants, in the first two terms we get the squares of the effective values of the cosine and the sine series, which can be denoted by $\mathrm{E}^2_{\cos}$ and $\mathrm{E}^2_{\sin}$. The third term is zero, since the mean value of a sine or cosine curve over a whole period is zero. We then get

$$\mathrm{E}^2_{n+1} = \mathrm{A}^2\omega^2\{\mathrm{E}^2_{\cos}\cos^2(\gamma+n\delta)+\mathrm{E}^2_{\sin}\sin^2(\gamma+n\delta)\}.$$

If we insert in this equation various values of $n=0$ to $n=k-1$, for the case of the short-circuited generator $(\gamma=0)$, we get the effective pressure of the several turns as the hypotenuse of right angled triangles whose other sides depend on $\cos n\delta$ and $\sin n\delta$. Since $n\delta$ has all values from 0° to 180°, the side representing $\mathrm{E}_{\sin}\sin n\delta$ will always be positive, but the other side, for $n\delta>90°$ becomes negative—*i.e.*, it changes its direction. This can be shown still more clearly when $\mathrm{E}_{\sin}\sin n\delta$ and $\mathrm{E}_{\cos}\cos n\delta$ are plotted as functions of $n\delta$, whence it will be at once seen that in the case of the cosine curve the values $n\delta=0$ to $n\delta=90°$ are equal and opposite to those of $n\delta=180°$ to $n\delta=90°$, whilst for all values of $n\delta$ the sine terms have the same direction. The same happens in the second half of the winding, since the $(k-1-l)$th and the $(k+1+l)$th turns have the same pressures.

The sum of all the pressures induced in the $2k$ turns—*i.e.*, the effective slip-ring pressure—is

$$\mathrm{E}_{sr}{}^2 = \mathrm{A}^2\omega^2\{\mathrm{E}^2_{\cos}[2\Sigma_0^{k-1}\cos n\delta-2]^2+\mathrm{E}^2_{\sin}[2\Sigma_0^{k-1}\sin n\delta]^2\}.$$

But the sum of all the cosines, as seen above, is zero, whence

$$\mathrm{E}_{sr} = 2\mathrm{A}\omega\mathrm{E}_{\sin}\cot\pi/2k.$$

That is, at short-circuit only the sum of the sine pressures occur at the slip rings.

A similar relation holds for the other limiting case $\gamma=\pi/2$—*i.e.*, non-inductive load—for then

$$\mathrm{E}^2_{n+1} = \mathrm{A}^2\omega^2\{\mathrm{E}^2_{\cos}\sin^2 n\delta+\mathrm{E}^2_{\sin}\cos^2 n\delta\}.$$

whence $$\mathrm{E}_{sr} = 2\mathrm{A}\omega\mathrm{E}_{\cos}\cot\frac{\pi}{2k}.$$

The pressure distribution throughout the winding has the same character as before, for only the amplitudes of the several individual pressures have altered. At the slip-rings only the sum of the sine terms appears, although its magnitude and shape are different than before.

If the stator current has a phase displacement ϕ, then γ assumes some value between 0° and 90°, and in addition to the sine pressures, cosine pressures will also occur.

It now remains to consider how the above conditions are affected when the rotor winding is short-circuited through the exciter, as actually happens in practice. Taking first the case of the short-

circuited generator, it is obvious that the sine pressures (e_{sin}) at the slip rings will be consumed by sending a current lagging practically 90° through the rotor circuit, so that the fictitious rotor field—which we have hitherto neglected as constant—will be transformed into a pulsating field. The reaction of these flux pulsations on the stator current gives the latter a peaked shape. Thus, whilst the sine pressures in the exciting winding are consumed, the opposing cosine pressures are not affected by the closed circuit, but their maximum value will be further increased owing to the deformation of the stator current caused by the pulsating current set up by the sine pressures.

A similar state of things exists when the stator current has any other phase relation—one part of the induced pressures will always be consumed and one part, composed of the pressures which oppose one another, still exist. These latter pressures are by no means to be neglected, for in certain cases they may well assume dangerous proportions. As shown by Rezelmann, the same sinusoidal pressure is induced in the rotor as in the stator when the number of turns is the same in each. When the stator wave shape is strongly distorted, the maximum value of the rotor pressure can be considerably increased.

A NEW ELECTRICAL HARDENING FURNACE.*

BY E. SABERSKY AND E. ADLER.

Summary.—A description is here given of a new furnace heated by electricity and mainly intended for hardening steels. Particulars are also given of the comparative cost of hardening with the electric furnace and with a gas furnace.

The illustration herewith shows a vertical section across the furnace. A bath is formed by metal salts, or mixtures of same, contained in a fireclay crucible. The best composition of the bath depends mainly on the temperature to be attained for industrial purposes. It usually consists of a mixture of KaCl and $BaCl_2$, and current is transmitted to the bath by two electrodes made of Swedish ingot iron, which is characterised by a particularly low percentage of carbon, possessing a melting point of 1,500 to 1,600°C. These electrodes end in iron terminals sweated in turn to copper conductors. The crucible is surrounded by asbestos and a layer of insulating lagging, the whole being contained in a cast-iron case. This construction greatly reduces the radiation losses, in fact, after 10 hours' operation of the furnace at about 1,350°C., the cast-iron case has a temperature of 30 to 40 deg. only. Over the bath a sheet-iron hood is placed, fitted with chimney and damper.

Like the filament of the Nernst lamp, the salts are conductors of the second class; their conductivity at normal temperature is therefore very small, while at high temperatures they offer to the electric current a comparatively low resistance. Assuming that the mixture is sufficiently hot, the bath forms virtually an electric conductor, the cross-section of which is determined by the breadth of the iron electrodes and the level of the liquid, while its length is fixed by the distance between the electrodes. Thus each part of the bath produces its own heat. This feature distinguishes the furnace from all others.

The heating of the salts prior to their becoming conductive is done by means of an auxiliary electrode. A piece of arc lamp carbon is pressed against one main electrode, when it soon reaches a white glow and melts the salts in its immediate vicinity. The auxiliary electrode, which consists of an iron stick fitted with wooden handle, is then drawn towards the other main electrode, the molten salt trailing behind it until a bridge is established between the two electrodes, which in itself is a conductor. The current which now passes continues to raise the temperature of the bath until the desired limit is eventually attained. The articles to be heated are then dipped into the bath, suspended from thin iron wires or held with tongs. They are allowed to remain in the bath until they are uniformly heated throughout and have attained the same temperature as the bath itself—that is, until they show its colour.

The most striking feature of this furnace compared with others is the uniformity of the temperature throughout the whole bath. This is mainly due to the fact that the heat is produced in each part of the bath, and that the radiation losses are not only very low but are nearly equal for each unit of outside surface except the upper. Careful measurements with a pyrometer of the thermo-couple type over the whole surface and immersed to different depths have shown that the temperature in the bath varies only by 2 to 3°C., except in an upper layer of 10 to 15 mm., in which, due to radiation, the temperature is 10 to 20°C. lower.

* Abstract of a Paper read before the Faraday Society.

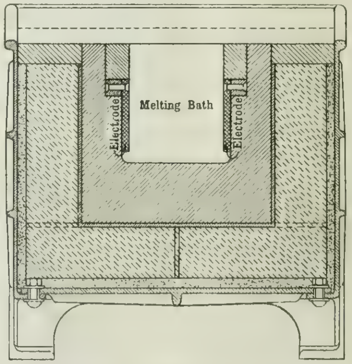
Electrolytic influences must be prevented, and, therefore, alternating and not continuous current should be used. All frequencies between 25 and, say, 60 cycles may be applied; with less than 25 cycles electrolytic phenomena would appear. For three-phase systems a special type of furnace has been constructed, which has four electrodes. A stationary transformer converts the three-phase supply into two-phase, and to each phase one pair of electrodes belongs.

When the salts have become melted the voltage necessary for maintaining the temperature is about 5 to 30 volts, while the heating-up voltage reaches about 70 volts. Such low voltages are not available from ordinary supply systems, and consequently a transformer has to be used.

The heat developed, and thus the temperature of the bath, are dependent on the voltage impressed on the furnace; if it is desired to alter the temperature, this can therefore be done by a variation of the voltage, which is easily done with a transformer.

An important part of the hardening installation is the pyrometer. For the temperatures in question the thermo-couple type of pyrometer seems to give the most reliable results, but it also had to be assimilated to the trying influence of the salt bath. In its latest shape it forms an angle, the upper limb of which carries the terminals, these being thus outside the destructive influence of the heat. The thermo-couple used is platinum—platinum-rhodium protected by different protecting sheaths of Marquardt composition and steel.

The characteristics of the hardening process are then discussed, and from these the following are put forward as the features an ideal hardening furnace should possess: (1) It should be possible to obtain all hardening temperatures required in industrial practice—



VERTICAL SECTION OF ELECTRICAL HARDENING FURNACE.

that is, the range between 750 and 1,350°C. (2) It should be possible to heat the steel to the required hardening temperature simply, easily and rapidly. (3) The temperature of the steel should be easily ascertainable, kept constant with a margin of, say, ±30 deg. and well under control. (4) The steel must be equally heated all over, notwithstanding the different cross-sections the tool may possess, thus preventing the overheating and burning of edges and points. The realisation of this condition also prevents the redistribution stresses due to unequal temperatures. (5) During the heating process foreign matter must not come into contact with the steel, otherwise its carbon percentage will be altered or it may be affected in other respects. (6) It should be possible to place the cooling tank close to the furnace in order to minimise the loss of heat during the transfer and to avoid the oxidising influence of the air. (7) The furnace should not give off obnoxious or poisonous vapours (lead, potassium, cyanide, &c.). (8) The total operating cost incidental to the hardening process should be low.

It is then shown how far these conditions have been fulfilled by the electric furnace just described, a comparison being made with the non-electric furnaces on the market. The resistance type of electric furnace, consisting of a muffle fitted with a platinum resistance, is in its working principle and performance more or less similar to other muffle furnaces—for instance, gas-fired ones. It possesses some advantages and has successfully been applied for heating small articles, but is of inconsiderable industrial importance and will therefore not be further discussed. (1) and (2) A great advantage of the electric furnace is that it is possible to cover a wide range of temperatures with one equipment by changing only the composition of the bath. Also the steel is heated by dipping it into a bath, which is certainly the simplest operation possible. The temperature of the

bath is adjusted to the exact value of hardening temperature desired, unlike other heating processes, where the bath is heated up to a higher temperature, and the tools must be removed before it has assumed the temperature of its surroundings. By dipping the cold steel into the heating chamber, the temperature of the latter must drop. In the electric furnace, when the tool is dipped into the salt the level rises, the resistance of the bath drops, and current and heat increase automatically.

In all types of furnaces, except the electric, the thermal conductivity of the heating medium plays an important part. This medium fills the space between the tool and the heat producer, and has to transmit the heat from producer to tool. In the electric furnace the heat is produced in the salt, not only conducted by it, and by increasing the voltage more heat can be produced than the steel can take up. The speed with which the heating process can be performed is, therefore, not limited by the thermal conductivity of the heating medium, and is in actual practice 6 to 10 times higher than obtainable with other types of furnaces.

(3) The number of hardening plants in which pyrometers are to be found is surprisingly small. From inquiries made it appears that this is due less to the cost of such apparatus, or the skill necessary in handling it, than to the alleged unreliability of these instruments. The reason for this prejudice is apparently the fact that in all existing furnaces, be they of the muffle or bath type, the temperature is unevenly distributed, and in general is much higher near the walls than in the centre—that is, the position where the pyrometer is placed.

(4) In the electric furnace the smaller cross-sections of the tool will also heat up more quickly than the larger ones, but will not overheat, because they cannot assume a higher temperature than that of the bath itself. The bath equalises all difference in temperature and in a very short time heats the whole mass up uniformly. This point, together with others already referred to, explains the very small percentage of waste in electric furnace plants compared with others.

(5) While the tool is in the bath, air is, of course, prevented from coming into contact with it, but a thin coating of salt protects it still further on its way from the furnace to the cooling tank, and falls away only when placed in the cooling liquid. This is a great advantage over all types of open fires or muffles, but it is common to all bath-type furnaces. Metal salts, however, offer the additional advantage that they do not give off poisonous gases, and that, unlike lead, they can be obtained comparatively pure at reasonable cost. Furthermore, a salt coating breaks up entirely in the cooling liquid, while with lead, sometimes small particles stick to the steel, leaving soft points underneath them.

(7) During the heating-up period, or when a certain temperature is exceeded, the metal salts give off a small amount of vapour, and therefore hood and chimney are provided. During the normal operation there is scarcely any vapour at all produced. The hood offers the further advantage that the radiation of the bath surface is somewhat diminished, and can be made use of for preheating the articles to be hardened. For this purpose a grate is fixed in the hood, on which the articles are placed prior to their being dipped into the bath. An interesting case, in which the freedom of the electric furnace from smoke or vapour has been found valuable, is the hardening of rock drills in a South African mine. Here the furnace is placed in a working, the drills are sharpened and rehardened underground, and a considerable saving effected all round.

(8) Before discussing the question of operating costs in detail, we wish to emphasise that it is only fair to compare costs for different systems on the basis of the performance of a given hardening operation, but not on the cost of operating a furnace per hour, irrespective of its production, as has been suggested in some cases. The operating expenses of the electric furnace are made up of the following items: Cost of current (the current consumption of different sizes of furnace are given in the Paper), maintenance, salt, labour and preheating (coke oven, or the like).

The parts subject to wear are crucible and electrodes. The crucible has been found to have a life of 1,200 to 1,800 hours at a temperature of 1,300°C., and up to 3,000 hours at lower temperatures. This is much longer than with muffle furnaces, which is probably due to the absence of the destructive influence of the gases of combustion and to the fact that the crucible does not transmit the heat. The most sensitive part of the electrodes is that which projects over the level, which is protected by exchangeable tips. These tips have a life of about 400 to 800 hours, and the cost of their replacement is as low as the renewal of the fireclay.

The cost of the salt is comparatively low, and the amount lost by evaporation and wastage need only be allowed for. This amounts, for instance, in a furnace, length 200 mm., breadth 200 mm. and depth 270 mm., under ordinary working conditions to little more than 1 lb. for 10 hours' continuous operation. As to labour, it is claimed that the ease with which the electric furnace can be handled makes it possible to use cheaper labour than that employed in plants where the success of the work is dependent on the skill of the operator. On the other hand, it must not be forgotten that the speed at which the process is performed is much greater, and that therefore a larger number of pieces can be handled.

Some actual figures, showing the output of which the electric furnace is capable, are given in an appendix. A comparison of the operating costs between an electric and gas furnace, obtained from a test made in a large tool factory, is also given in an appendix, and bears out some of the remarks just made.

The scope of application for this furnace is a very wide one; it is mostly used for hardening tools, drills, cutters, millers, &c., and also dies, printing rollers, or similar devices. Another important field is the manufacture of small articles produced in large numbers, like needles, pens, sword blades, cutlery, surgical instruments, chains, projectiles, &c. The furnace is also considerably used for work of a more scientific character, as, for instance, for metallography, for melting small quantities of metal in a muffle placed in the bath or in connection with the testing of engineering material. The great value of the furnace for scientific work lies, in the authors' opinion, mainly in the possibility of making reliable tests and of reproducing a given set of conditions. In some cases the furnace with a special bath has been successfully used for tempering, and it may be of interest in this connection to mention that tempering colours duly appear in the electric furnace, although they do not show in an oil bath of equal temperature. The electric furnace here described is the invention of Mr. H. Krautschneider, and is manufactured by the Allgemeine Elektricitäts-Gesellschaft of Berlin, while the British rights are in the possession of the Electrical Co. Since it has been placed on the market (about three years ago) about 200 installations have been executed in various factories.

COMPARISON OF OPERATING COSTS FOR HARDENING FURNACES.

Material to be hardened: 100 mullers; weight of each, 5·25 kg. Process: (*a*) Preheating period, from atmospheric temperature to 400°C. (*b*) Main heating period, 400 to 1,150°C. (*c*) Cooling.

Gas Furnace (time required 50 hours).

12,300 cubic ft. of gas at 3s. 6d. per 1,000 cubic ft. ...	£2	3	3
Motive power for air-blast ...	0	5	0
Labour, 50 hours at 8½d. ...	1	15	5
Total ...	£4	3	8

Electric Furnace (time required 10 hours).

200 kw.-hours at 1·2d. ...	£1	0	0
Coke for preheating ...	0	1	0
Salt ...	0	0	6
Labour, 10 hours at 8½d. ...	0	7	0
Total ...	£1	8	6

DISCUSSION.

Mr. W. C. PREBBLE remarked on the danger of suddenly heating complicated tools.

Dr. J. A. HARKER thought that the amount of energy consumed in the furnace could be greatly reduced by improved lagging. The method of heating up the bath initially with a carbon rod seemed liable to difficulties. He asked if fused fluoride salts had been actually used.

Dr. C. H. DESCH considered that the furnace did away with the old difficulty of judging hardening by means of skill acquired with the eye. A pyrometer was of no use in an ordinary muffle.

Mr. C. WEISS thought that the authors had somewhat penalised gas in their estimates of cost.

The CHAIRMAN (Dr. H. Borns) said the amount of electrolysis would depend on the form of the current wave. It might be advantageous in some cases.

Mr. F. W. HARBORD (communicated) described some of his experiences with the furnace in heating a large number of steel bars from 800°C. to 1,230°C., and keeping them at a high and fairly constant temperature for some time; this he was able to do without difficulty. If a furnace could be designed to compete with the present large heating furnaces, its possibilities should be very great.

Mr. W. ROSENHAIN (communicated) thought the furnace had decided advantages for the hardening and tempering of tool steels. He thought some care would be required in the selection of the fused salts; nitrates, for example, would have an oxidising effect on steel. Too rapid heating of a piece of metal of uneven cross-section might be undesirable, as expansion stresses would be set up. The uniformity of temperature attained was probably largely due to lagging. He hoped that the use of the furnace would throw light on such questions as whether heating to what are excessive temperatures when the metal is exposed to furnace atmospheres is also injurious when the metal is submerged in fused salts.

Mr. C. R. DARLING (communicated) criticised the authors' figures for costs of working. In works in which producer gas was available for the gas furnace, the financial superiority of the electric furnace would di-

appear. He suggested the use of an optical pyrometer for temperatures above 1,100°C.

Mr. T. Vaughan Hughes (communicated) considered that the electric furnace had many drawbacks compared with producer gas-fired equipments, such as too sudden heating, the trouble in dealing with fused salts, and the difficulties of handling large quantities of goods. He was of opinion, too, that its efficiency was low compared with existing furnaces, especially for maintaining comparatively low temperatures. He added some particulars of such gas-heated furnaces, which, he stated, easily realised the advantages claimed for the electric furnace. The latter, excepting for very precise and scientific investigations, could not compete with a properly designed producer gas-fired furnace.

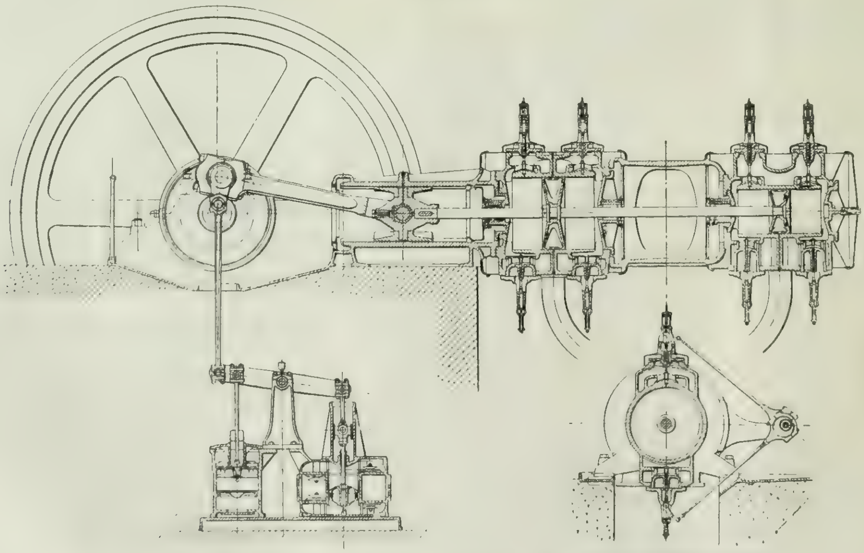
Mr. E. Adler replied to the various points raised. The rate of heating depended on the voltage and was under control. No action of the fused salts on steel had been observed. Mr. Hughes admitted the scientific value of the furnace, but appeared to consider that scientific accuracy was unnecessary for scientific work. Of course, much larger furnaces than those now made could be built, and their efficiencies would increase accordingly. Optical pryometers might perhaps be used above 1,400°C.; for ordinary purposes thermo-couples were preferable. There was no difficulty in starting the furnace, which took some 15 to 20 minutes Fluoride salts had only been used experimentally.

THE LENTZ STEAM ENGINE.

Although the steam turbine has come largely into favour in this country for driving electric generators, it must not be supposed that the reciprocating steam engine is undergoing no further development. There are many engineers at the present day who would prefer the older type if prime cost could be overlooked.

An engine which has achieved an excellent reputation on the Continent is that known as the "Lentz," the features of which are low steam consumption, the stability of its construction and the small number of parts subject to wear. Owing to the high speed at which these engines run, they are particularly suitable for direct coupling to electric generators. In this country Messrs. Davey, Paxman & Co. have the sole right to manufacture these engines, which are due to Herr Lentz, and they have already many engines of this type on order, whilst several have been supplied.

Fig. 1 shows a section through a compound horizontal condensing engine with circulating and air pump, and also a cross-section through the cylinder in which the valve gear is plainly indicated. The latter, which is probably the most interesting part of the engine, is actuated by eccentrics on a side shaft, driven by bevel



Cross-section through Cylinder.

Fig. 1.—Section through a Horizontal "Lentz" Engine.

wheels from the main shafts. For this purpose friction cones are used, pressed hard together, but to prevent slip shallow teeth are provided, the points being also turned off. A feature of the gear is its quiet and smooth running. A roller at the end of each valve spindle bears on a curved lever actuated by the eccentric rod. This curved lever in its motion lifts and closes the valve rapidly and silently, hammering being impossible, since the roller is kept in close connection with the cam by a spring during the motion of the

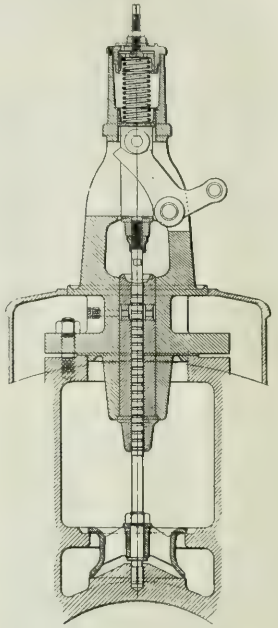


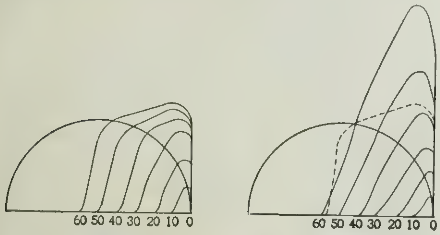
Fig. 2.—Admission Valve.

valve. While the valve is closed, the cam moves clear of the roller. The action will be more evident from Fig. 2, which shows an admission valve.

To each cylinder there are two steam and two exhaust valves, which are lifted and closed by four independent eccentrics and rods. The valves are double seated, and the steam valves are so arranged as to be free to lift easily to any pressure coming from the inside of

the cylinder; water shock is thus safely avoided, and cylinder relief valves are not required. The valve spindles are grooved and work in cast-iron sleeves, and by means of the "Lentz" system of draining the valves, stuffing boxes are rendered unnecessary. This, of course, reduces friction to a minimum, and allows the governor to be extremely sensitive while having great stability.

The cut-off obtained with these valves is sharp, as is shown by indicator diagrams taken from the engines, and it is interesting to note that the valves open and close rapidly without wire-drawing,



Lentz Valves. Ordinary Valves.

Fig. 3.—Valve Opening Diagram.

there being no dash-pots to retard the motion of the valves. The diagram, Fig. 3, shows the amount of lift of Lentz valves, as compared with ordinary drop valves.

The governor is of the inertia type and is placed on the side shaft. It is directly connected to the two high-pressure steam eccentrics by two pins. These eccentrics are movable on a slide block keyed to the shaft; thus the governor can alter their eccentricity, and conse-

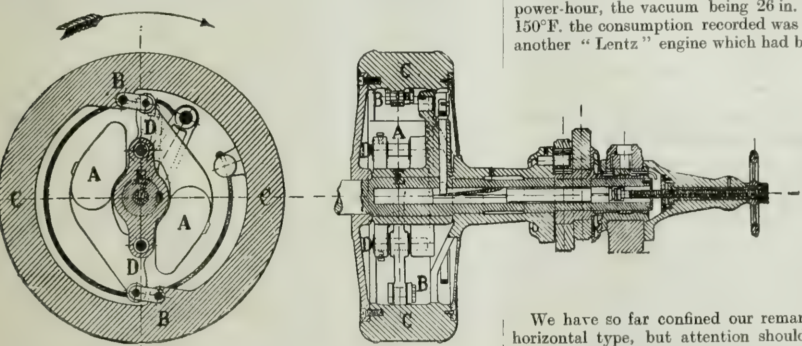


Fig. 4.—Governor of "Lentz" Engine.

quently the cut-offs. Sectional views of the governor are given in Fig. 4, and it will be seen to consist of two weights A pivoted on a carrier. E, keyed to the side shaft; these two weights and the carrier are attached to an outer ring C, the carrier by a spring and the weights by a knee joint formed by D and B. This ring C performs the action of a flywheel. When the least change of load, and consequently of speed, takes place, the inertia of the outer ring, which tends to keep its speed constant, causes it to move relatively to the carrier, and by moving the eccentrics, the cut-off is altered to suit the change of load. With the new speed, the weights are balanced by the spring in the new position, and so maintain the new cut-off. A hand wheel is provided at the end of the shaft to enable the driver to change the speed of the engine by altering the tension of the governor spring while the engine is running. The governor is quick in action and the momentary change in speed, due to alteration of the load, is only slightly greater than the permanent change.

The packing of the piston-rod stuffing boxes is of interest, as it consists merely of a series of cast-iron rings (see Fig. 5), which fit over the rod and are held in cast-iron boxes, allowing them to follow any irregular motion of the rod. Owing to the absence of springs friction losses are very small. There is no gland bush and steam has direct access to the packing, but it returns to the cylinder during the period of expansion instead of leaking through the packing. As seen from Fig. 5, the rings form a series of chambers, which are efficiently drained; any steam escaping from the front chamber enters the second chamber and there expands. A portion will, perhaps, escape to the third chamber, undergoing a further expansion, and so on. It will be found, however, that the last ring does not show the slightest signs of leakage of steam.

Messrs. Davey, Paxman & Co. have supplied us with the following particulars of tests on a 366 I.H.P. tandem compound horizontal

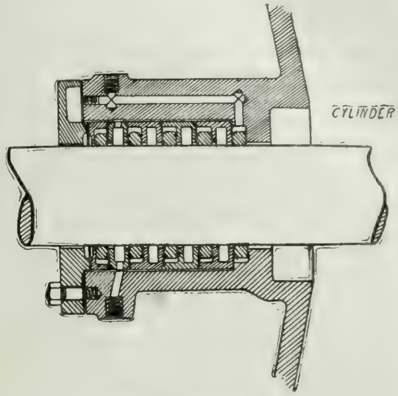


Fig. 5.—Stuffing Box.

"Lentz" engine. With saturated steam and a boiler pressure of 170 lb., the steam consumption was 12·3 lb. per indicated horse-power-hour, the vacuum being 26 in.; whilst with a superheat of 150°F. the consumption recorded was only 10·4 lb. In the case of another "Lentz" engine which had been working continuously for 10 months in a flour mill, the steam consumption, when tested at the end of that period, worked out at 10·35 lb. per indicated horse-power-hour, the superheat being 150°F. and the vacuum 27 in.

From what has been said, it will be seen that the Lentz engine has been designed with a view to the use of superheated steam.

We have so far confined our remarks mainly to engines of the horizontal type, but attention should be drawn to the fact that these "Lentz" engines are also made in the vertical type, in which case they run at a higher speed than the horizontal engines, and are particularly adapted for coupling to electric generators. In this connection we may mention that a vertical compound "Lentz" engine, developing 2,050 I.H.P. and coupled to two dynamos, is in use in the power station of the City & South London Railway Co.

PHYSICAL SOCIETY.

At the meeting held on March 26th, at the Imperial College of Science, Dr. C. Chree, F.R.S., president, in the chair, a Paper by Dr. J. A. Fleming and Mr. G. B. Dyke on

"The Production of Steady Electrical Oscillations in Closed Circuits and a Method of Testing Radiotelegraphic Receivers"

was read by the authors. It was pointed out that at the present time a very large number of oscillation detectors have been invented for use as receivers in radio-telegraphy; but that there is great difficulty in obtaining quantitative and qualitative tests of these in actual radio-telegraphic stations, partly on account of difficulty of access and partly on account of the varying conditions incidental to practical radio-telegraphic work which are unfavourable to quantitative tests. Availing themselves, however, of the small radiative property of closed circuits, the authors pointed out that, by the use of two such nearly closed oscillatory circuits, one being employed as a transmitting station and the other as a receiving station, these

being placed at a distance of a few hundred yards from each other, what is practically equivalent to radio-telegraphic stations with open oscillators at very large distances can be constructed. Methods were then described for producing in one of the closed circuits extremely constant damped oscillations by means of an induction coil or transformer, a spark-gap on which a steady jet of air is allowed to impinge, and a suitable mercury break. Means were described for ascertaining when the current in this transmitting circuit is constant. The receiving circuit consists of a square circuit of insulated wire which is pivoted in such a manner that it can be turned in any direction, the angular deviations being measurable on scales. This circuit is joined in series with a condenser of variable capacity and with the oscillator detector to be tested. If the oscillation detector is of the current-actuated type, it is placed in series with the condenser, if of the potential-actuated type it is placed across the terminals of the condenser, being associated with a shunted cell and telephone if necessary, or with a telephone simply, if a magnetic detector. It is then possible to set this receiving circuit in such a position that it has no current induced in it by the oscillations in the transmitting circuit; but on turning it through a certain angle sounds are heard in the telephone indicating the production of oscillations in the secondary circuit. The angle through which it is to be turned is a measure or indication of the sensibility of the detector. Instances were given of the ease with which detectors of various types, such as a magnetic detector, electrolytic detector, crystal detector and ionised gas detector could be compared for relative sensibility. The instrument has been found to be of great use in investigations on ionised gas detectors now being conducted at the Pender Electrical Laboratory. It was also pointed out that such an arrangement permits the effect of various types of oscillations to be investigated, as the transmitting circuit can be made the seat of damped oscillations of various degrees of damping or of undamped oscillations. This method of testing with closed circuits has the advantage that it can be conducted entirely within a large building and by one person. A self-acting apparatus was also exhibited for sending messages or signals by a punched tape.

A Paper was also read by Dr. J. A. FLEMING and Mr. H. W. RICHARDSON on

"The Effect of an Air Blast upon the Spark Discharge of a Condenser charged by an Induction Coil or Transformer."

When an oscillatory discharge of a condenser takes place across the spark-gap in the usual manner by charging the condenser by an induction coil or transformer, the intermittent spark which takes place is a complex effect. It consists partly of a true condenser discharge and partly of an alternating-current arc due to current coming directly out of the induction coil or transformer. This arc discharge is a source of difficulty in making accurate quantitative measurements with electrical oscillations, and to produce a uniform oscillatory discharge this true arc discharge must be prevented or arrested. It was shown in the Paper that this can be done by a regulated air blast produced in any convenient manner, thrown upon the spark-gap, provided that the spark-gap is small. As a proof of the advantages to be obtained from this arrangement a number of measurements were given of the decrement and spark-gap resistances of various circuits measured with the Fleming cymometer both with and without the air blast upon the spark-gap. It was shown that the observations were more regular and the resonance more accurately delineated when the spark-gap was so treated with an air blast.

The Paper also described experiments made to investigate the effect of breaking up the spark-gap into smaller spark-gaps in series, both when the gaps were subjected to an air blast and also without the air blast. It was shown, up to a certain length of gap, about 2 mm. in the case of this experiment, that the air blast had a very decided effect in increasing the mean square value of the discharge current, and also that a similar effect was produced by dividing up the spark-gap into smaller spark-gaps in series, provided that the total spark-gap was not increased beyond a certain limit. This increase appears to be due to the suppression of the arc discharge, as shown by the appearance of the image of the spark in a revolving mirror. With regard to multiple spark-gaps, the general result, however, appears to be that beyond a small limit in length, about 3 mm., nothing is gained by breaking up the spark-gap into spark-gaps in series or by subjecting the spark-gap to an air blast.

Mr. W. DUDDELL congratulated the authors and remarked that the Papers contained a great deal of useful material. The use of the earth inductor for testing receivers was a feature of the first Paper. He asked Dr. Fleming to what extent the effects obtained in the receiving circuit were due to true radiation, and why they had used coal-gas instead of alcohol in their interrupter. Referring to the authors' method of determining the current in the transmitter, he asked if there was any objection to putting an ammeter in the circuit and reading the current directly. He should also like some more information about the cases in which it was found impossible to obtain a position of the earth inductor giving silence in the telephone. Was it because the distance apart was not sufficiently great or was some physical impossibility involved? With regard to the second Paper he had always found it possible to get a uniform discharge by using an alternating current of suitable frequency in the primary. He asked the authors if it was the arc or the spark which was blown out by the air and whether the part blown out had a spectrum different from the rest.

Dr. W. H. ECCLES asked how much of the energy absorbed by the receiver was due to radiation and how much to electromagnetic induction. He had obtained results, depending on electromagnetic induction, similar to those described by the authors by using very much smaller apparatus, but he had discontinued his experiments, because in practice the whole of the energy received was due to true radiation. He pointed out that a receiver adjusted and tested in a laboratory was never in proper adjustment for actual work. He suggested that the reason it was sometimes impossible to get a position of silence arose from stray radiation falling upon the receiver.

Dr. ERSKINE-MURRAY pointed out that detectors varied greatly in resistance, and that therefore a telephone of suitable resistance should be selected in each test.

Dr. A. RUSSELL thought that Prof. Fleming and Mr. Dyke's method of testing radio-telegraphic receivers would be a great help in judging their relative values. He much appreciated the clear distinction drawn between the function of the spark and the arc as this cleared up some of his difficulties. Although the air-blast of the Lennox blower was doubtless beneficial by preventing arcing, he thought that the fact that the dielectric coefficient of the glass nozzle used was greater than unity might have accelerated the sparking. He mentioned some of the difficulties encountered in computing sparking voltages when there were two gaps in the circuit. In this case it had to be remembered that the sparking voltages at the moment of the discharge were not equal and opposite. When the potentials of the electrodes were known, however, and they were spherical in shape, the sparking voltages with two gaps in series could be calculated with fair accuracy.

Dr. R. S. WILLOWS pointed out that by blowing out the spark the resistance of the path was increased and the rate of change of energy thereby altered. The fact that greater regularity and greater energy could be obtained could be easily demonstrated by using an electrodeless discharge-bulb. Referring to the fact that it was necessary to know the self-induction of one of the circuits, he asked the authors what form of circuit had been chosen and how its self-induction had been calculated. In one of the experiments a resistance r had been added, and he remarked that attention should be directed to its effective resistance under rapidly alternating currents, as this might depend upon whether the added resistance was a pure metal or an alloy.

Mr. L. H. WALTER agreed with Dr. Erskine-Murray that it was necessary to choose a suitable telephone when making a test. Although the electrolytic detector was supposed to be more sensitive than the magnetic form, it was possible to choose a telephone of such a resistance as to make the magnetic detector appear the more sensitive.

Dr. FLEMING, in reply, said that it was impossible to state precisely what proportion of the current produced in the receiving circuit was due to true radiation from the closed transmitting circuit, and how much was due to electromagnetic radiation, but from his point of view it did not matter. All that was necessary was that a feeble oscillatory current should be produced in the receiving circuit which should be capable of being varied by turning the receiving circuit through a certain angle, and whether this was due to actual detachment of energy from the transmitting circuit, or to the mere movement of lines of magnetic force backwards and forwards through space, seemed immaterial. The oscillation detector in any case was a mere detector of oscillations. In reply to Mr. Duddell, he said that there was no objection to putting an ammeter in the transmitting circuit provided it was a low resistance instrument and did not produce any sensible damping of the oscillations. As regards the existence of an exact zero point, this seemed to be a question of distance from the transmitter. It had been usual at University College to work with two coils about 60 ft. apart, and at that distance some very sensitive oscillation valves detected sounds which might be due to the action directly upon the valve or upon the connecting wires, but by going to larger distance, it was possible to get complete silence at the telephone. With respect to the use of coal-gas or alcohol in the interrupter, coal-gas had proved itself to be incontestably superior to alcohol. As regards the action of the air-blast, it appeared tolerably certain that the part of the discharge which was blown away was that due to energy coming directly out of the induction coil or transformer. In reply to Dr. Eccles, he said that they had found it necessary to work at a certain distance from the transmitter, but that when this was done the order of sensitiveness in which oscillation-detectors were arranged by the apparatus shown was also the order in which they were found to be sensitive when employed in actual radio-telegraphic work. It was necessary not to work the transmitter and receiver too near to one another, otherwise there were direct effects on wire connections, rheostats, &c., which obscured the real effects. In reply to Dr. Willows, the reason for choosing the rectangular form of circuit was because the inductance could be readily calculated from formulæ given in well-known text-books. With respect to the remarks of Mr. Walter and Dr. Erskine-Murray, he agreed that it was necessary to choose a telephone of suitable resistance, and that the results taken with different telephones would not be the same.

Dr. S. W. J. Smith read a Paper

"On the Action between Metals and Acids and the Conditions under which Mercury causes Evolution of Hydrogen."

The action between an acid and a metal, which results in the replacement of hydrogen, can be formulated without the aid of any hypothesis beyond the assumption that it is approximately reversible. The mode of formulation suggests a kinetic picture of the process by which equilibrium is in certain cases attained. This was described by the author, and it was pointed out that if a steady state is reached, after a certain quantity of hydrogen has been evolved, it will be defined by an equation of the form $ahM=bmH$. In this, a and b are constants at a given temperature, h and m are the concentrations of the hydrogen ions and of the metal ions respectively in solution, and H and M are specific constants of hydrogen and of the metal.

The experiments described in the Paper may be regarded as an attempt to justify the above equation when the metal is mercury. It is shown that hydrogen can be made to appear after equilibrium has been reached, either by reducing the value of m or by increasing the value of h. The effects produced by HCl and H_2SO_4 are nearly alike (except for secondary effects with concentrated sulphuric acid), and it is probable that other acids would act in the same way. It would, therefore, appear to be justified for this case at least that the action between metals and acids can be formulated in a purely physical way. Referring to the action with concentrated sulphuric acid, the author described and explained how sulphuretted hydrogen only, or mixtures of sulphuretted hydrogen and hydrogen, could be obtained at will by varying the rate of removal of the mercury salt from the solution in contact with the metal.

Dr. W. Watson congratulated the author and remarked that in physical chemistry hypotheses were often used which were not based on experimental evidence. Dr. Smith had shown that his hypothesis corresponded with actual physical facts, and his theory could be looked upon with satisfaction.

In reply to a question by Mr. F. E. Smith, the Author explained that the process by which the concentration of the mercury salt in solution was reduced below the amount necessary to prevent evolution of hydrogen was endothermic.

THE UTILISATION OF SMALL WATERFALLS.*

BY H. J. S. HEATHER.

In connection with the utilisation of its small waterfalls, South Africa labours under three disadvantages. These are: (1) The length of the dry season in ordinary years; (2) the high rate of wages prevalent; (3) the frequent unhealthiness of the localities in which waterfalls are usually found. For the first of these drawbacks the writer has no remedy to offer. Water storage may generally be a commercially feasible proposition in countries where three weeks without rain constitute a drought, but where, as in many parts of South Africa, a normal dry season of six months has to be reckoned with, the cost of an adequate reservoir will almost always be quite prohibitive. The second and third of the drawbacks can be minimised by a proposal which the writer first made about 10 years ago, and of which he now finds some portions have been recently applied by the Siemens-Schuckertwerke, in some linked-up power stations they have built on some low falls on the Rhine.

It has long been known that the ordinary three-phase induction motor, when driven at a speed higher than that of synchronism, and when supplied with a wattless current of synchronous frequency, will operate as a non-synchronous generator, the load it takes up depending upon the speed at which it is driven and nothing else. With such a generator, therefore, paralleling is unnecessary, and no regulation is required in any respect except that of speed. The same three wires that carry away the power output serve also to bring in the wattless exciting current. There is no complication whatever, the ordinary motor switchboard being used, no starting switch is required, and the rotor of the generator can be of the extremely simple and mechanical type, known as the "squirrel cage."

It is of some or all of these facts that the Siemens-Schuckertwerke have taken advantage in the installation to which reference is above made. They have interlinked three turbine-driven stations, of which two are non-synchronous, as described, and the third is equipped with the ordinary synchronous generator, exciter and regulating switches. It is only, therefore, in this third controlling station that any skilled electrical attendance is required, the other two being placed in charge of men who only need look after the turbines and put on or take off water when instructed to do so by telephone from the controlling station. The saving in expense results from the employment of one set of skilled, and two sets of unskilled shiftsmen instead of three sets of skilled attendants.

* Abstract from the "South African Mining Journal," of a Paper read before the South African Association of Engineers.

The writer's proposal goes somewhat further in the same direction. In most of the waterfalls in South Africa the head available is sufficiently high to warrant the use of an impulse wheel, such as the Pelton. The mechanism of this is so exceedingly simple that it, together with a squirrel cage induction generator, can perfectly well be trusted to look after itself, particularly when arrangements are made by which it is always under constant load. The latter condition is secured by the use at the control station of an automatic load, which adjusts itself so that the total load on the system remains constant, in spite of motors being started or stopped.

The control station would contain (*a*) a synchronous generator, with exciter and regulating switchboard, and large enough to supply the wattless current required by all the induction generators and induction motors connected to the system. (*b*) A prime mover, large enough to bring this machine up to speed and make up its no-load losses when fully excited. As soon as one of the power stations is at work, the prime mover can be thrown out of gear and the synchronous generator can be run as a motor, or, rather, as a converter, taking a small watt current from the mains and returning to them a comparatively large wattless one. Of course, if a waterfall or other cheap source of power is available at the control station, it would be advisable to utilise it and allow the synchronous machine to supply both power and wattless current, thus saving capital outlay. (*c*) A resistance capable of absorbing the whole power output of the system, and which operates automatically, absorbing more or less power as external load is thrown off or on, so that the sum remains constant. The resistance can take the form of an ordinary three-phase liquid-starting switch.

The power stations would each contain a Pelton wheel, direct-coupled to a squirrel cage induction generator, and a switch with automatic time relay overload release. Under ordinary circumstances no attendance beyond, perhaps, a weekly visit of inspection would be required.

The synchronous generator, non-synchronous generators, and motors would all be connected in the usual way to the same set of three wires, and the author points out that there is nothing experimental about any part of the scheme. The provision of a special machine to provide wattless current would never add 20 per cent. to the capital outlay. Taking it, however, at this figure, we might get for the total capital outlay per kilowatt, £20 in the case of the ordinary synchronous power stations, and £24 for the mainly non-synchronous combination proposed. On the basis of a load factor of 100 per cent., and allowing 20 per cent. per annum to cover interest, redemption and maintenance, the hourly charges per kilowatt of output would be, in the case of synchronous stations, 0·1095d.; and in the case of non-synchronous stations, 0·1315d. Wages for each synchronous station would, within the limits of size being considered, be independent of size and amount to about 36d. per hour.

Now, suppose three waterfalls were available, each capable of producing 100 kw. The wages in the case of synchronous stations would amount to 0·36d. per kilowatt-hour of output. The wages for one synchronous and two non-synchronous stations, which would all three be looked after by one staff of men, would only amount to 0·12d. per kilowatt-hour. The comparative total costs are therefore 0·4695d. per kilowatt-hour for the synchronous system and 0·2515d. for the non-synchronous system.

The author finally shows that the consequences of a breakdown in such a power station left to itself are not serious, and he hopes that the suggestion may lead to its adoption to the benefit of small power users in the remoter parts of the country.

LEGAL INTELLIGENCE.

Workmen's Compensation.

In the Salford County Court, last week, application was made on behalf of the General Electric Co., to terminate or reduce an award in favour of Lewis Kaiser, one of the company's former workmen. It appeared that Kaiser sustained an accident involving the loss of some of his finger ends, and it was stated that the healing process was such as to enable the man to perform the work he had been previously engaged upon, viz., stamping out metal discs and rings under a power press.

His Honour Judge Shiress Will asked if the company were prepared to take the man back at his old job.

Mr. Acton (for applicants): We have not a vacancy at present, but we are prepared to take him on as soon as we have.

Mr. Frank Dalby, works manager of the company, said he did not know that the man applied for work as soon as he came from hospital and was refused. He would not take on a man with a maimed hand if he applied for work while there were men with two hands availabe.

His Honour declined to alter the award, and gave judgment for respondent with costs.

PARLIAMENTARY INTELLIGENCE.

London Electricity Supply Legislation.—The second reading of the Bill introduced by the Board of Trade to constitute the L.C.C. the purchasing authority in respect of the undertakings of the companies which promoted the London (Westminster and Kensington) Electric Supply Companies Act, 1908, has been postponed until 19th inst.

X-Ray Research Work.—In the House of Commons last week, Mr. Hobhouse stated, in reply to a question by Mr. Bowerman, that a grant had been made from the Royal Bounty Fund to Mr. Harry W. Cox, who recently sustained serious and permanent injuries in connection with X-ray research work.

Electric Lighting Acts (Amendment) Bill.—A petition in favour of this bill has been presented by Sheffield Corporation.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A pupil is wanted for a l.t. three-wire station in the South London area. Preference given to those having technical training. No premium and no salary.

An armature winder is wanted by a railway company in London. See advertisement.

A lecturer in chemistry and physics is required at the L.C.C. Paddington Technical Institute. Commencing salary £150, rising by annual increments of £10 to £200 per annum. Applications, on forms, to be obtained from the Education Officer, L.C.C. Education Offices, Victoria Embankment, W.C., by 11 a.m., April 26.

Mr. G. F. Nayler has been appointed chief assistant at the Nelson electricity works, Mr. W. M. Thomson engineer-in-charge and Mr. W. G. Coates shift engineer.

Mr. J. S. Beddoc, Pembroke, has been appointed second assistant electrical engineer to the Admiralty, and Mr. A. E. Frankling to a similar position at Portsmouth naval establishment.

Gillingham Council have appointed Mr. F. T. Woodward commercial assistant and canvasser at £104 per annum, and Mr. Parker shift engineer.

EDUCATIONAL.

Sir John Cass Technical Institute.—Special courses of instruction will be given during the summer term at this Institute in Practical Physical Chemistry, by Mr. G. Senter, B.Sc., Ph.D., and on Conduction in Gases and Radio-activity by Mr. R. S. Willows, M.A., D.Sc. Detailed syllabus of the courses may be obtained from the offices of the Institute, Jewry-street, Aldgate, London, E.C., or by letter to the Principal.

Crystal Palace Engineering School.—The "Wilson" premium for the best Paper read before the Crystal Palace Engineering Society during the present session has been awarded to C. J. Allen for his Paper on "Ferro-Concrete as applied to Buildings."

Other Papers read during the session were "Sea Coast Defences," by D. H. Whyte, and "The Mechanical Testing of Iron and Steel," by A. N. Lucey. The Premium was presented to Mr. Allen by Sir Wm. H. White, K.C.B., on the occasion of the 109th distribution of certificates at the above school on April 7.

Aberdeen.—A lengthy report has been prepared for the Electricity committee by the city electrical engineer (Mr. J. Alex. Bell), on the charges made for electrical energy.

Mr. Bell states, in his report, that, in considering a new method of charging, it was essential to have one sufficiently flexible to meet in competition the various other forms of power and light. Their present system of charging had the objection, from a consumer's point of view, of being complicated, and the simpler one could make tariffs the better. It had been said that the prices charged at Aberdeen would not compare favourably with those charged in other towns, but the returns submitted by him satisfactorily met that allegation. In regard to municipal tramway undertakings receiving their supply from combined lighting and traction stations, it had been urged that the price charged for their tramways was too high. Out of 76 municipalities owning tramways 14 had separate stations, and five out of these 14 municipalities did not own the lighting and power supply undertaking. The uninitiated were given to making the mistake of comparing the works costs of these separate stations with the price charged by combined stations. The lowest price charged for ordinary power consumers in most cases was considerably less than that charged for tramways. Of the 211 municipal electricity works in the United Kingdom Aberdeen was 25th in size of output, and as regards works costs it ranked 26th in order of merit. In regard to total costs (exclusive of capital charges) it only ranked 45th. That was mainly due to the excessive sum paid for rates and taxes in comparison with other undertakings, and was partly due to paying rates on the full value of their underground works, whereas other undertakings paid only on a quarter of their value. They paid 12·07 per cent. of their revenue from electricity supply in rates and taxes, whereas other undertakings paid, on an average, between 1 per cent. and 5 per cent., only one being over 10 per cent. Their capital charges were high, due to their cautious policy of depreciation, which made Aberdeen one of the financially soundest electricity undertakings in the country. Mr. Bell thought that unless the Council were prepared to quote for large factory supplies on the lines of other municipal undertakings, the department could hardly be considered to be fulfilling the part of an electricity supply undertaking, and doing what it could for the industries in their midst, and it might even be necessary to consider carefully the question of future depreciation, or (as he preferred to call it) an antiquation fund. The future reduction in cost of supply all round could only be obtained in a limited number of ways. The works costs were down to a low figure, the plant installed being highly economical; the use of steam turbines in future extensions would slightly improve that figure. He was already considering the question of exhaust steam turbines. A speedy relief from excessive taxation would help the undertaking; that the capital charges be kept down to the lowest possible figure compatible with sound work and with due regard to the expansion of the business was also essential. The increase of the output of the station, with improved load factor, was the point the committee should, in his opinion, continue to devote the most attention to. The load factor worked out last year at 18·46 per cent. During the past year the number of units sold was 5,104,036. Though the committee had not yet had under consideration the charges to be made for large factory supplies—and it might be mentioned that in most cases those were better dealt with under agreement for a term of years—still, the smaller power business had increased most satisfactorily. He had worked out and submitted particulars of the revenue that would have been derived from their power consumers had they adopted the tariffs for that class of business in other large towns. When dealing with the matter the committee should, in his opinion, consider the use of slot meters for certain classes of lighting consumers, and as regards power rates, rearrange them to include the large power users and the daylight undertakings, such as the granite industry. A low rate for heating and cooking would also be of benefit to the undertaking, and public lighting should be put on a fixed rate per lamp per annum.

Argentina.—The "Review of the River Plate" says the Government has approved the statutes of the Cia. General de Electricidad de Cordoba, which is to have an authorised capital of $1,500,000 gold.

Santa Fé Municipality have received offers from Mr. Donald Tiblon, Messrs. Fleming & Co. and Messrs. R. Smiles and J. Wall for the purchase of their existing tramway undertaking and the conversion of the system to electric traction. It is probable that if either proposal is accepted an arrangement will also be made for supplying electricity for lighting part of the town.

Australasia.—The Cobar Electric Supply Co. has been formed to take over from Mr. E. M. Grant the right to supply electricity for power and lighting in Cobar, N.S.W. The generating plant will consist of two 40 kw. three-phase alternators, belt driven from two 54 B.H.P. suction gas driven engines, and the estimated cost is put at £4,600. For street lighting there will be 60 lamps, some of 25 c.p., and the remainder of 50 c.p., and later on it is proposed to supply current to the adjoining municipality of Wrightville.

Korumburra (Vic.) Shire Council recently decided to raise a loan of £2,500 for additional electric lighting plant.

The power plant of the tin mines of the Mount Bischoff Co., at Waratah (Tasmania), is a mile from the main distribution point, and water from the river Waratah is conveyed thereto by a race 100 chains in length, and consisting partly of a ground race of 13·5 sq. ft. sectional area, and partly of an iron flume of 2 ft. radius. The race ends above the power station, to which the water is conducted by a steel pipe column 1,350 ft. in length and 18 in. inside diameter. The power plant includes two 150 kw. 50 cycle 2,300 volt British Westinghouse three-phase alternators, coupled by flexible coupling to impulse wheel type Escher Wyss turbines, the buckets of which have been specially designed to stand the stresses due to the working head of 560 ft. A contract has been recently placed for an A.E.G. 300 kw. three-phase alternator and a 450 H.P. Voith turbine, also for switchgear and a Tirrill regulator. This new plant is expected to be working by June next.

Bacup.—The Council have obtained sanction to a loan of £27,770 for the electrification and reconstruction of the tramways in the borough. When the lines are completed there will be a through tramway connection from the Rossendale Valley to Blackburn.

Bath.—Last week the Council decided to apply for sanction to a loan of £11,700 for the electricity supply department. viz. £5,200 for excess expenditure, £6,000 for mains extensions during the next three years, and £500 for a mechanical stoker.

The Chairman of the Electric Lighting committee, in moving the adoption of the minutes of the committee, stated that a special sub-committee had been constituted to consider and report upon a scheme of advertising with a view to increasing the revenue of the undertaking. He explained at some length the committee's relations with Mr. Schenk, who had asked whether the Council would, on any terms, including the dropping of his bill, be prepared to negotiate for a new agreement for the sale of the undertaking. A letter had been received from his solicitors suggesting a joint conference between the Board of Trade, the

committee and himself, for the purpose of reducing the objections of the Board to a minimum, and stating his (Mr. Schenk's) willingness to withdraw the present bill on terms. The committee, however, recommended that it was undesirable to re-open the negotiations and declined the offer for a conference.

The report was adopted.

Belfast.—It is evident that the electricity undertaking is making good progress in this city for the chairman of the Gas committee considers that "the Electricity committee is unfairly cutting rates to obtain customers," and the Gas committee have actually passed a resolution infavour of the "electricity undertaking being placed under the Gas committee." Fortunately, there are many hard-headed, business men on the Council, and there is little likelihood of this ingenuous recommendation being adopted.

Bexhill.—Sanction to a loan of £2,120 for additional plant at the electricity works has been applied for by the Council.

Bray (Ireland).—The Council recently resolved to apply for sanction to a loan of £2,600 for additional plant at the electricity works. An engineer is to be called in to overhaul the engine at the station.

Brussels International Exhibition.—Notice is given that sections 45 and 59 of the Patents and Designs Act, 1907 (which provide that the exhibition of inventions and designs at international exhibitions shall not prejudice the right to apply for patents or for the registration of designs, &c.), will apply to the Brussels International Exhibition, 1910, and exhibitors will be relieved from the proviso in the said sections that notice of intention to exhibit must be given to the Controller of Patents.

Buxton.—An unopposed inquiry was held last week into the Council's application for sanction to a loan of £724 for extensions at the electricity works.

Chichester.—The electricity works, which have been designed by Mr. Horace Boot, consulting engineer, Westminster, for the supply of electricity for lighting and power in Chichester and district, are nearing completion, and it is hoped that supply will be given in a few weeks' time. This is one of the first electricity works relying entirely on Diesel oil engines for its prime movers, these engines having been supplied by Mirrless, Bickerton & Day. The contractors for the whole of the works are Messrs. Johnson & Phillips, and Mr. Boot has had as his clerk of the works Mr. R. V. Weare.

Colchester.—The action, brought against the Council by Messrs. Hollington Bros. for an injunction to restrain a nuisance, alleged to have been caused by vibration at the electricity works, has been settled by the payment of £300 to Messrs. Hollington for costs and in final settlement of all claims.

East Lothian Tramways.—The Western District Committee of East Lothian County Council have been notified by the Musselburgh & District Light & Traction Co, that they propose to proceed with the construction of the tramway, proposed to be laid from Levenhall to Port Seton, and a committee has been appointed to watch the construction of the line.

Electricity in Agriculture and Horticulture.—The "Dundee Advertiser," of the 6th April, contained a lengthy account of the installation of electrical apparatus on the farm of Mr. William Low, of Balmakewan, N.B. Prof. Greig (of the North of Scotland College of Agriculture, Aberdeen), who worked for a long time with the late Prof. S. Lemström, and who very kindly overlooked Prof. Lemström's proofs before the publication of his famous book on this subject, was the primarily cause of the important application under practical working conditions on Mr. Low's extensive farm. Having carefully read the literature on the subject, Mr. Low, in view of Prof. Greig's descriptions, upon whose estate there is, we understand, every possible use made of electrical application of a practical character, decided to have an experiment made on an adequate scale to test its merits. We learn that Mr. Low

Has decided to introduce the requisite electrical plant, and, in conjunction with the Directors of the North of Scotland College of Agriculture, to engage in experimental work. Five fields have been set apart, one each of barley, oats, potatoes, first year's grass and second year's grass. Half of these crops, covering some 23 acres of land, are to be electrically treated, while the remainder of the plots will be unelectrified. It is Sir Oliver Lodge's process, or system, which is being installed at Balmakewan. The plant necessary to generate electricity at Mr. Low's place is small. A turbine is being erected on the banks of the Luther, 1¼ miles from the Home Farm. Current is conveyed by overhead wires to the area of experiment. Here a weather-tight hut contains the transforming and rectifying apparatus.

The expenses incurred in installing such a system are pretty considerable. The cost to Mr. Low will be something like £200, and he is already provided with the necessary generating plant. Electrical treatment of soil apart, Balmakewan is an interesting estate. There are two farms on it—the Home Farm, extending to 330 acres, and the Mains of Luther Farm, some 170 acres in extent—and each is perfectly appointed. The laird is head of the engineering firm of Low & Duff, Monifieth, and the hand of the engineer-agriculturist is evident on all sides. The plant installed on the Luther burn supplies the electrical energy that drives the thrashing mill at the Home Farm 1¼ miles distant, the mansion house is electrically lighted, electric power is used in the laundry, and the machinery in the sawmill is worked by electricity, as also is the Broadbent stone crusher. Mr. Low has recently had fitted up a small motor to drive an ice refrigerator plant. Altogether, Balmakewan, thanks to its enterprising proprietor, is probably the most up-to-date estate in the north-east of Scotland.

Electricity in Gold Mining.—The "Australian Mining and Engineering Review" states that Mr. Parham has applied, on behalf of a syndicate, for permission to utilise the water power of the Toaroha river to generate electrical energy for working the terraces and Rimu Flat, near Hokitika, New Zealand.

By means of 150 sluice heads it is estimated that about 10,000 B.H.P. would be obtained, and it is calculated that a head of about 700 ft. can be obtained by constructing a tunnel and a pipe line to the site of the power station. It is proposed to use 2,500 kw. h.t. three-phase generators driven by 3,600 H.P. Pelton water wheels and the current would be stepped up to 20,000 volts and transmitted 17 miles to the pumping station. Mr. Parham's estimate for the first two pumping units is £51,500.

Epsom.—The Council propose to introduce a system of "free" wiring in co-operation with local contractors.

Frome.—Negotiations are proceeding for the transfer of the electricity works to Edmundson's Electricity Corpn. At present the company is working the station under agreement with the Council.

Glasgow.—The Joint Committee on the Production of Electrical Energy report that in their opinion the existing arrangements for the generation of electrical energy by the Corporation should be continued.

Hanley.—The borough electrical engineer (Mr. C. H. Yeaman) has been instructed to report as to the advisability of giving a supply of electricity in Milton.

Hornsey.—The Council have applied for sanction to borrow £6,000 for extensions of the electricity supply mains and house services. An electrical exhibition is to be held in the Muswell Hill Athenæum.

India.—Messrs. Siemens Bros. Dynamo Works are installing two 30 H.P. Campbell gas engines, gas producer plant, and two 50 amp. 500 volt dynamos, for the electric lighting of Pondicherry. For street lighting 324 25 c.p. Tantalum lamps will be used.

Infirmary Lifts.—Before entering into a contract for the electric lifts required at the new infirmary, Edmonton Guardians have decided to obtain a report from an electrical engineer at a fee of 20 guineas.

Kirkcaldy.—The Council have received a communication from a firm of solicitors intimating that clients of theirs were prepared to construct an electric tramway from Kirkcaldy to Inverkeithing, and asking for an appointment to discuss the scheme. The Tramway committee were instructed to meet the promoters and report to the Council.

Light Railways in Germany.—In a bill recently introduced into the Prussian Diet provision is made for the extension of the light railway system at a cost of £11,366,000. This amount includes £4,000,000 for the construction of new lines, over £200,000 for doubling of track of seven existing lines, and about £5,000,000 for new rolling stock. Though most of the lines are worked by steam, £80,000 is provided for the electrification of the Dessau–Bielefeld line, and it is reported that if this should prove a success many of the new lines will be similarly equipped.

London Fire Brigade.—The annual report of the London Fire Brigade states that of the 3,238 fires in 1908 only 101 had their origin in electric lighting, &c., against 355 directly attributable to gas lighting and heating.

Of the electric fires 91 are stated to have been caused by defective electric circuits. Of the gas fires 108 were caused by escapes of gas, 84 by curtains, &c., coming into contact with gas light, 22 by overheating of gas stoves, 20 by gas stoves, 15 through seeking with light for gas escape, 14 by overheat of gaslight, &c.

Maidenhead.—The Council have applied for sanction to a loan of £3,500 for extensions of the electric generating plant.

Middlesbrough.—The electrical engineer (Mr. H. M. Taylor) has reported to the Electric Light committee that there will be a substantial profit on the past year's working of the electricity undertaking, and therefore it has been decided that £1,482 is to be contributed in relief of rates.

Municipal Tramways Association.—At the meetings of the managers' section of this Association, which will be held in the Town Hall, Newcastle-on-Tyne, on June 3 and 4 next, the following subjects will be introduced for discussion :—

"Description of Newcastle Tramways," by Mr. E. Hatton : "Charges

for Energy for Traction Purposes," by Mr. J. M. McElroy; "Transfer Tickets," by Mr. A. Ellis; "Medical Examination of Motormen and Conductors: What the Standard of same should be," by Mr. J. B. Hamilton; "Time Meters," by Mr. H. Mozley; and "Maintenance of Track and Roadway," by Mr. W. M. Rogerson.

Newcastle-under-Lyme.—Sanction has been received to a loan of £700 for extensions of mains and house services.

Newport (Mon.)—Sanction has been received to a loan of £2,578 for additional generating plant. On Tuesday the Council authorised the purchase of three additional tramcars.

Obituary.—The death is announced of Mr. John Wilson, manager of Leith Corporation tramways. Deceased was in the service of the Edinburgh Street Tramways Co. for many years, but when the Corporation took over the tramways he was appointed manager.

We regret to record the death, in his 63rd year, of Mr. Charles Edward Stuart at Kew. Mr. Stuart had been in the service of the Associated Telegraph Companies 39 years, and was from 1881 until the time of his death registrar of the Globe Telegraph & Trust Co.

Presentation.—Southend tramway and electricity staff have presented a diamond ring to Mr. Andrews, tramway traffic manager, who is leaving for Malta.

St. Anne's-on-the-Sea.—The Council recently decided to allocate £700 out of the profits on the electricity undertaking to the relief of rates.

Councillor Cooper objected to the proposal, and said there were only two reasons which could justify the appropriation of the profits to relief of rates: one was that the price of electricity should have been reduced to a very low point, and the other that the use should be practically universal. Neither of those existed in St. Anne's, where the price was 7d. and 2d. per unit, or a flat rate of 5¼d.; and at the end of 1908 only 665 householders out of 1,937 were users of electricity. The soundest policy was to devote any surplus to a reduction in the price of electricity.

South Africa.—East London Town Council recently offered to take a lease for 20 years of the Government power station at the Harbour, at £520 per annum, to purchase the cables in the Buffalo river and the plant for £5,000, and to supply current to the Government at 3d. per unit.

Of the loan proposed to be raised by Pretoria Municipality £75,000 is included for electric tramways.

Southampton.—The Manager of the tramways reported recently to the Council on the increased energy consumption per car-mile during the last year or two.

The report stated that in some towns the units per car-mile had gone up enormously, although Southampton's increase was not very great. Among the towns he had prepared a schedule of there were only four (Reading, Bradford, Aberdeen and Leeds) in which the returns showed a decrease of units per car-mile. The decreased consumption in Reading was attributed to strict supervision over drivers; Bradford stated that about 100 of their cars had been fitted with meters and returns showed that these had a powerful influence in stopping waste; and Aberdeen also recommended close supervision of the men to prevent "rushing and abuse of the controller." The chief reasons given for the increased consumption per car-mile were careless driving, increased age and consequent wear of track, cars and equipment and general increased speed of running on most tramway systems. In the manager's opinion a likely cause of increase was that the iron cores of the field coils and armatures had aged from constant use. That was especially noticeable in transformers, but was probably due to the use of alternating current. With direct current the deterioration was not so noticeable. It was found that owing to the iron ageing a greater amount of current was required to energise the magnets, and thereby propel the car. The wear and tear of the gear wheels and pinions was an important factor, and if an axle got bent it immediately increased the consumption of current. However, it was probable that the chief factor of increase was careless handling by motor men. As regards the wear and tear of gear wheels it was a moot point as to the proper time to replace these. From tests he had made he found that worn gears used more current than new ones, but if new gears "mesh" too deeply the result would be the opposite. Gears that had been in use about two years were working at their best efficiency. It was possible that those which had been in use for a much longer period were using more current than at some prior time, but as the total cost of replacement was about £12 per car, one hesitated to scrap them too soon, as it took a long time to save £12 of current. As regards electrical equipment he did not think the small amount of money saved in current would warrant expenditure on more efficient apparatus. The increased number of passengers per car-mile would contribute to an increased consumption of current. In conclusion the manager drew attention to a controller regulator, which made it impossible to rush the controller handle round too quickly. The cost of installing this would be about £4 10s. per car.

Southwark (London).—In our issue for April 2 (p. 983) we stated that Mr. F. T. Wright had been temporarily appointed manager of the electricity supply works. We learn that this is inaccurate, as the Electric Light committee withdrew their recommendation, and at a subsequent meeting it was decided to request Mr. D. M. Kinghorn to continue in the service of the Council for the time being.

SPECIAL NOTICE.

Swansea.—The Electricity committee anticipate a profit of about £2,000 on the working of the electricity undertaking during the current year.

Torquay.—Last week the Council decided to adopt, in place of the present maximum demand system, a flat rate of 4½d. per unit for electric current as from the 25th ult.

Watford.—The Council are to undertake (through contractors) the wiring of St. John's Church, at an estimated cost of £200. The amount is to be repaid by 28 quarterly instalments.

Wigan.—The Electricity committee have approved plans for the extension of the generating station, and tenders are to be invited.

Wimbledon.—The Electricity undertaking has been assessed at £9,926 for income tax purposes.

The borough electrical engineer has been instructed to prepare a scale of charges for the supply of energy for power.

An agreement is to be entered into with Merton Council for supplying energy to the sewage disposal works at West Barnes-lane at 1½d. per unit for power and lighting.

Wireless Telegraph Notes.—It is reported that further experiments are being carried out by Lieut. Loring, on behalf of the Postmaster-General, having particular relation to islands laying off the mainland and other places where natural difficulties make the cost of communication under the regular telegraphic system very heavy or prohibitive.

The "Standard's" Genoa correspondent states that the official opening on the Molo Vecchio of the wireless telegraph offices, laboratory, school, &c. (which are arranged on the Liverpool model), has just taken place. Messages can now be sent from Genoa to a distance of 320 miles direct, and the office is in touch with the Italian stations, Rome, Naples, Palermo, Bari, Anconza and Venice.

Wireless Telephone Notes.—In the presence of the Minister of Marine, M. Picard, on Monday, interesting experiments in wireless telephony were made by two naval officers (Lieuts. Colin and Jeance), between the Eiffel Tower and Mélun, a distance of 50 kms. (30 miles). Successful attempts were made in August and November last to establish wireless telephonic communication between Paris and Mélun and Paris and Dieppe. Yesterday's trials with improved apparatus amply confirmed the practical value of the earlier results. The representatives of the press were enabled to overhear the conversations engaged in at the offices of the Radio-telegraph Mfg. Co. in the Boulevard Grenelle, where everything was heard very distinctly.

Woking.—Three additional schools are to be wired for the electric light.

Worcester.—A special committee has been appointed to consider and report upon the charge made by the Electricity committee for pumping at the water works.

Workhouse Lighting.—Haslingden Guardians are negotiating with Rawtenstall Corporation for the supply of electricity for lighting the Haslingden workhouse.

Wrexham.—The Council have obtained sanction to a loan of £6,850 for mains, house services, &c.

York.—Last week a special meeting of the Council was held to consider tenders for the construction of new, and the reconstruction of the existing, tramways.

Ald. Meyer, vice-chairman of the Tramways committee, said that the committee had decided to recommend the adoption of the overhead system, mainly on account of economy. They had come to the conclusion that the conduit system was prohibitive owing to cost, and the tenders they had received for the surface-contact system amounted to nearly £20,000 more than those for the overhead system. That represented about a ½d. per car-mile for sinking fund and interest, and it seemed to him that that expenditure was greater than the benefits they would derive from the adoption of that system. He moved that the Council decide upon the overhead system. He gave particulars of some of the 21 tenders received; one was for the "G.B." and one for the Lorain surface-contact system, and the Railless Electric TractionCo. had also tendered. The lowest tender was for £86,000.

A long discussion ensued, but ultimately, owing to a tie on a division, the further consideration of the matter was adjourned.

At a public meeting on Wednesday a resolution against the municipalisation of the tramways was carried.

Dinner.—Mr. J. Eaton-Shore, shop superintendent, presided at the second annual dinner of the shop officials and foremen at Siemens Bros. Dynamo Works at the Institute, Tipping-street, Stafford.

This was the first function of its kind attempted at the institute, but the arrangements were admirably carried out by the committee (Messrs. Briggs, Rathbone and Saunders, with Mr. F. E. Read as hon. sec.). There were about 100 present. The toast of "The Firm" was given by Mr. Kilpatrick and supported by Dr. Kloss. Mr. Koettgen (managing director, London) responded, and spoke very encouragingly of the future prospects of the Stafford works. Mr. Palairet proposed "The Guests," and Mr. Kieffer, the Stafford manager, received a cordial reception in responding to the toast. "Siemens Institute" was proposed by Mr. C. N. Toplis, and Mr. Read replied. During dinner the institute orchestra rendered selections of music.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Metropolitan Asylums Board invite tenders for the installation of telephones and fire alarms at the South Western Fever Hospital, Stockwell, S.W., in accordance with the plan and specifications prepared by the engineer-in-chief (Mr. T. W. Hatch, M.Inst.C.E., M.I.Mech.E.), and which may be obtained at the offices of the Board, Embankment, London, E.C. Tenders by noon April 23.

Chevington East Parish Council will receive provisional estimates and offers, accompanied with plans, drawings and specifications, for the installation of a street lighting scheme by electricity for the district. The scheme will provide for aerial wiring upon creosoted poles, for about 80 up-to-date lamps. Current will be supplied from the local colliery. Mr. W. Gibson, the Council's surveyor, will meet intending contractors at 94, Queen-street, Amble, by arrangement.

Amble Urban District Council are prepared to receive provisional estimates and offers, accompanied with plans, drawings and specifications such as will meet Board of Trade requirements (free of charge to the Council) for the installation of a gas suction plant, and, alternatively, for steam plant, to supply electricity for public and private lighting in the town. Mr. W. Gibson, the Council's surveyor, will meet intending contractors at 94, Queen-street, Amble, by arrangement.

Stepney (London) Electricity Supply Committee invite tenders for supply and erection of steam, feed, circulating, water, and other pipe work, valves, hot well tank, motor-driven centrifugal pumps, &c. Copies of specification, &c., from the borough electrical engineer and manager (Mr. Wm. C. P. Tapper, A.M.I.E.E.), 27, Osborn-street, Whitechapel, E. Tenders to the chairman of the committee by noon April 22.

Woodbridge Urban Council, who are desirous that a company should establish electricity works in the district, announced that they would support a company in an application for a provisional order and would enter into a contract for public lighting from April 1, 1912. The population is 4,600 and gas is 4s. 6d. per 1,000 ft. Tenders by June 1.

Belfast Tramways and Electricity committee invite tenders for supply, delivery and erection of one circulating pump, with motor and pipes, for the pump house, Laganbank-road. Specification, &c., from the city electrical engineer, Mr. Thomas W. Bloxam, M.I.E.E. Tenders to the town clerk, City Hall, Belfast, by noon April 24.

London County Council require tenders by May 4 for supply of about 4,000 tons of girder tramway track rails and fastenings and 3,000 tons slot rails and conductor tees. Particulars from the County Hall.

London County Council also want tenders by May 4 for roadwork and platelaying required for various tramways ($2\frac{1}{2}$ miles single track). Particulars from the County Hall.

The Metropolitan Asylums Board want tenders by 10 a.m. April 28 for supply of four ambulance tramcars at the Smallpox Hospitals, near Dartford. Specifications, &c., from the Board's offices, Embankment, E.C.

Manchester Tramways committee want tenders by 10 a.m., April 20, for electrical equipments for cars, arc lamps, cable, wheel tyres, tubing, bolts and nuts, &c. Specifications, &c., from Mr. J. M. McElroy, 55, Piccadilly, Manchester.

TENDERS RECEIVED AND ACCEPTED.

Cardiff Corporation have received the following tenders:—

Switchboard.

Siemens Bros. Dynamo Works (*accepted*) **£475**

Morris & Lister	£910	Electric Construction Co.	£570
General Electric Co.	871	Walsall Electrical Co.	564
Union Electric Co.	741	Spagnoletti (Ltd.)	558
Sanders & Co.	653	British Thomson-Houston Co.	549
Tetley & Co.	630	Cox-Walkers	535
Bertram Thomas	628	Switchgear Co.	525
British Westinghouse Co.	619	Johnson & Phillips	490
Elec. & Ordnance Access. Co.	596	Cowans (Ltd.)	485
Ferranti (Ltd.)	593	Whipp & Bourne	483

Cables.

British Insulated & Helsby Cables (*accepted*) **£1,824**

W. T. Glover & Co.	£1,950	Lahmeyer Electrical Co.	£1,874
Callender's Co	1,907	W. T. Henley's Co.	1,866
Siemens Bros. & Co.	1,884	Johnson & Phillips	1,859
Western Electric Co.	1,878		

Pipework.

Aiton & Co. (*accepted*)	**£595**	W. T. Towler & Son	£730
Cross Bros.	1,002	John Spencer (Ltd.)	714
Stewart & Lloyds	800	Foster Bros.	673
Babcock & Wilcox	795	J. Wilson & Co.	640
J. H. Nicholson & Co.	765		

Wimbledon Council have accepted the following tenders for annual supplies for the electricity undertaking:—

Brunner, Mond & Co., alkali; Pryke & Palmer, F. Bird & Co., and J. Harvey, tools, engine room stores, &c.; Western Electric Co., h. and l.-t. cables, public lighting cables, &c.; Doulton & Co. and Albion Clay Co., conduits; Callender's Co., joint boxes and jointing materials, &c.; W. Lucy & Co., house cut-outs; British Insulated & Helsby Cables, all other cable items; British Westinghouse Co., transformers and meters; A. Duckham & Co., lubricating oils; W. H. Willcox & Co., other oils; General Electric Co., metallic filament lamps and electrical accessories; W. Geipel & Co., carbons; Siemens Bros. Dynamo Works, V.I.R. cables; E. J. Shaw & Co., arc lamp globes; Union Electric Co., flame arc lamp carbons; F. Bird & Co., castings; Hall & Co., firebricks and fireclay.

Colchester Corporation have accepted the following tenders for annual stores:—

Joslins Limited, prepayment meter installations, ironmongery, tools, and oilmen's sundries; Stanford & Co., castings; Valveline Oil Co., oils; W. Lucy & Co., fuse boxes; Reason Mfg. Co., slot meters (1d. meters), and Ferranti Limited, slot meters (1s. meters).

For tramway stores the following tenders have been accepted:—

Joslins Limited, rubber and fibre material, oils, and lighting cables; Williams & Co., ironmongery; Lubroleine Oil Co., axle grease; Watlington & Co., carbon brushes, pinions and trolley head fittings, overhead equipment, &c.; Dick, Kerr & Co., various car fittings; Jackson & Co., armature coils; and Brackett & Co., castings.

Stepney (London) Council has accepted the tender of the City Glass Co. for annual supply of arc lamp globes of the estimated value of £58. 2s. 6d. Conditional upon a trial being satisfactory, an order has been placed with H. Bennett at £120 for "Fumicide" smoke prevention apparatus. The Council is to have the option of ordering three additional sets at an inclusive sum for the four of £450.

Glasgow Corporation recently accepted the following tenders for the tramways department:—

British Westinghouse Co., armature coils; Lorain Steel Co., spare points, special track work, steel rails and fishplates; Wm. Jessop & Son, high speed steel; British Insulated & Helsby Cables, copper bonds; Hughes Label Co., labels for ticket boxes.

A contract for the supply and erection of electric haulage and pumping plant for the pits of the Thrislington Coal Co., Ferryhill, co. Durham, has been placed with the General Electric Co. The British Westinghouse Co. are also supplying a three-phase alternator (2,750 volts, 40 periods) for the Thrislington collieries.

Stockport Council have accepted the following tenders :—

Ed. Bennis & Co., elevator (including rotary filler); Babcock & Wilcox, weldless steel tubes; Stewart & Lloyd, electrically-welded piping; Lorain Steel Co., tramway cross-over.

Bury (Lancs.) Electricity committee have accepted the tender of Baxendale Bros. for the supply and erection of the steel work for their new power station.

The D.P. Battery Co. have received orders (amongst others) during the past week for 15 storage batteries of their country house type for various installations in the British Isles.

Wigan Council have placed contracts with the Universal Mill Furnishing Co. and R. Burland & Sons for cylinder and dynamo oil, &c.

Walsall Corporation have accepted the tender of Youngs Limited for the supply of 56 jacks for the tramway department at £1. 12s. 6d. each.

Yarmouth Council have accepted the tender of the Brush Co. for 18 gear wheels at 55s. each, and that of John Baker & Co. for 60 steel tyres at 34s. 6d. each.

Derby Town Council have accepted the tender of Aiton & Co. for pipework at £320.

Brighton Lighting committee have accepted the tender of the Phœnix Dynamo Co. for a 300 kw. motor generator at £978.

Accrington Electricity committee have accepted the tender of the Brush Co. for two double-deck and one single-deck cars.

Nelson Council have placed an order with J. Carter & Co. for wiring the fire station.

Watford Council have placed an order with the Lea Recorder Co. for a CO_2 recorder.

Maidenhead Council have accepted the tender of Callender's Cable & Construction Co. for the supply of cable at £397.

Gosport Council have accepted the tender of Manlove, Alliott & Co. for the extension of the refuse destructor at £3,946.

Llandudno Council have accepted the tender of J. K. & R. Lord for supply and erection of a Lancashire boiler at £430.

Warrington Council have accepted the tender of H. Bibby (at £25) for electrical work at Garven House.

Oldbury Council have accepted the tender of the Worthington Pump Co. for an electric motor for the sewage works at £39. 10s.

The Postmaster-General's Department, Melbourne, Victoria, have placed an order with Richard Johnson, Clapham & Morris for g.i. wire at £319.

The Oriental Timber Corpn., Geelong, Victoria, recently placed an order with the Australian General Electric Co. for electric lighting and power plant, including a 750 kw. three-phase alternator (480 volts, 50 cycles) and a Curtis steam turbine, 15 induction motors (including one of 300 H.P.), with switchboard, Tirril regulator, &c. The plant will be manufactured by the British Thomson-Houston Co., of Rugby.

BUSINESS NOTICES.

Messrs. W. H. Allen, Son & Co., of Queen's Engineering Works, Bedford, and London, have decided to undertake the manufacture of water turbines under the patents of Messrs. Piccard, Pietet & Co., of Geneva.

Messrs. J. & H. Grevener have taken over the sole agency in the United Kingdom and the British Colonies for the sale of the well-known manufactures of the Land & Sea Cable Works. Stocks of wires and cables of every description will be held in London and also in the chief provincial towns. Messrs. Grevener have appointed Messrs. Davies Bros., Swansea, to represent them in Wales and the West of England, and Messrs. Hamilton Bros., of Glasgow, in Scotland.

Messrs. R. Easton & Son, who recently removed to 28 and 30, Southwark Bridge-road, London, S.E., announce that they are now able to offer much quicker delivery of their lifts and cranes.

Joseph Richardson Norris and John Henderson, jun. (trading as J. R. Norris & Co.), electrical engineers, 5B, Manchester-street, Oldham, have dissolved partnership. Debts by J. R. Norris, who continues under the old style.

Sales by Auction.—Messrs. Fuller, Horsey, Sons & Cassell will sell by auction on the premises, 33, Endell-street, Long-acre, London, W.C., on Tuesday, April 27 at 11 a.m., high-class machine tools, including a No. 1½ "Cincinnati" Universal milling machine, a plain milling machine, seven screw-cutting lathes, four radial and pillar drilling machines, slotting and shaping machines, &c., a 10 B.H.P. motor, shafting and belting, parallel vices, loose tools, &c. Catalogues of Messrs. Gadsden & Pennefather, solicitors, 28, Bedford-row W.C., and of the Auctioneers, 11, Billiter-square, London, E.C.

Messrs. Fuller, Horsey, Sons & Cassell have been instructed to sell by auction at the works of the Motogear Engineering Co., Emerald-street, Theobalds-road, London, W.C., on Friday, April 30, at 11 a.m., modern machine tools, including nine screw-cutting and other lathes, four milling and four drilling machines, Hendey shaping machine, &c., also a 5 B.H.P. National gas engine, shafting and belting, &c.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane, Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in advertisements.

The Coatbridge & Airdrie Electric Supply Co., Moorgate-court, Moorgate-place, London, E.C., have two d.c. direct-coupled steam dynamos (Browett, Lindley-Brush sets) for sale.

Premises to Let.—Premises in Westbourne-road, Barnsbury, N. (suitable for motor garage or factory) are advertised to be let by the Dennis Estate Office, 1, Warner-street, Roman-road, Barnsbury, London, N.

Messrs. A. J. Cayley & Son, Chenies-street, London, W.C., advertise to be let premises for showrooms, workshops and warehouses.

Patents Development.—The proprietors of the following British Patents desire to make arrangements for their development and practical working in this country :—

No. 7,942/1906, for "Improvements relating to Wireless Telegraphic and Telephonic Systems." Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

No. 2,274/1904, relating to "Improvements in Telegraphic Transmitters," and No. 5,944/1902, relating to "Improved Telegraphic Systems." Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

Directory of the Engineers and Metal Trades.—We have received from Messrs. Kellys (Ltd.) a copy of the eleventh edition of Kelly's Directory of the Engineers and Iron and Metal Trades and Colliery Proprietors. This useful work of reference, which was first issued 40 years ago, is published at intervals of four years, and the information contained in the present edition extends to no less than 1864 pages, an increase of 32 pages over its immediate predecessor. The Directory comprises every calling connected with the profession and the industries specified and connected with metal, or having any connection with, or affinity to, engineering. The preface contains interesting statistics on the exports from, and imports into, this country of the various raw materials and manufactured articles, which are followed by an index to the towns and places dealt with in the Directory—nearly 7,500 in number. It is stated by the publishers that all the places in this list have been specially visited, and the particulars relating to each firm have been personally taken by their agents, the information thus collected having been subsequently compiled and arranged in the form in which it appears in the Directory. The published price is 30s. nett.

Metropolitan Railways and Tramways Map.—From Mr. Edward Stanford we have received a copy of a new and useful map of Metropolitan railways, tramways and miscellaneous improvements, which was deposited with the London County Council for the 1909 session. The map, which is drawn to a scale of one inch to the mile, gives a list of the plans deposited. The published price is 2s. nett, or 4s. mounted in case.

CATALOGUES, &c.

Galvanic Batteries.—In these days of extra high-tension power transmission, wireless telegraphy and other electric wonders, it is often forgotten that the primary battery still possesses a considerable sphere of usefulness. We are reminded that this is the case by a list of galvanic batteries which has just been issued by the India Rubber, Gutta Percha & Telegraph Works Co. This contains full details of the well-known Silvertown Leclanché cells and batteries for all purposes. These cells are made in a number of different types and sizes, and are adapted for a great variety of uses. Poggendorff, bichromate, Bunsen, Grove and Daniell batteries also find a place. The Silvertown improved low resistance battery, which is specially adapted for driving small motors for dental and similar purposes, as well as for charging small accumulators and lighting rooms at night, is also described.

"General" Electrical Progress.—We have received from the General Electric Co. a copy of their March "Progress Pamphlet." This contains some details of the high-tension consumer's equipment which we have already described in The Electrician, as well as of Osram fittings, radiators, cooking outfits, circuit-breakers, ironclad switches, lamp holders, ceiling roses and similar apparatus are also included. A leaflet issued with the pamphlet gives the latest prices for Osram lamps.

Plunger Pumps.—From Messrs. W. H. Willcox & Co., Southwark-street, London, S.E., we have received a leaflet illustrating their "Willcox-Turner" patent triple acting plunger pumps. Among these is the "Twin-type" pattern which is specially suitable for work where a considerable quantity of water is to be delivered. The pumps seem admirably fitted for the work they have to do.

The O.S. Wiring System.—This new system of wiring (described in The Electrician for April 9), which is designed to provide for modern requirements in regard to elasticity of application, as well as inexpensiveness of material and erection, perfect electrical continuity and simplicity, is being exploited by the Sun Electrical Co. They are now supplying two kinds of patent semi-flexible wires which are metal-cased throughout, and are known as "Kuhlos" and "Stannos" metacase conductors. These, combined with the company's well known "Kalkos" conduits form the O.S. wiring system. These "Metacase" conductors offer, it is claimed, many advantages over the so-called "surface flexible" system as they are watertight, electrically continuous and mechanically protected. By using the O.S. wiring system in one form or another, low cost is no longer inconsistent with efficiency and durability. The catalogue illustrates and describes the various details of the wires themselves, together with the accessories required by the systems.

Tantalum Lamps.—We have received from Siemens Brothers Dynamo Works (Ltd.), Tyssen-street, Dalston, N.E., a new catalogue dealing with "Tantalum" lamps and fittings specially designed for ship and harbour lighting. In general arrangement it is original and contains a good selection of cheap and handsome fittings. The list, which also deals with metal and carbon filament lamps of convenient voltage and candle power, must prove a very useful publication to all interested in ship lighting installations. Copies will be supplied to bona fide trade applicants.

Bells and Telephones.—Messrs. Falk, Stadelmann & Co. have recently issued a "Bells and Telephones" catalogue, and although it contains details of bells and telephones, the title by no means indicates its full scope, for we notice that such widely different articles as induction coils and gimlets are listed. This catalogue is supplied free to bona fide contractors, and they should find it a distinct acquisition to their library.

Single-Phase Motors.—The single-phase E.B.H. motor is a speciality of Messrs. E. Brook (Ltd.), Huddersfield. Their latest list contains full details of these motors which are made up to a standard pressure of 100 to 110 and 200 to 220 volts, with frequencies of 50, 60, 80 and 100. These motors can be supplied from stock on the same day as ordered.

Pick-Quick Coal-Cutters.—Messrs. Mavor & Coulson's artistic calendar for April contains some interesting details of the operation of their well-known pick-quick electric coal-cutter. From tests made with this machine it has been found that the average output of coal per month is 2,300 tons, which is, it would seem, a very satisfactory result. A pamphlet dealing with the firm's generating plant is also to hand.

Rotary Scraper.—Mr. O. N. Beck has issued a pamphlet dealing with a rotary scraper for cleaning colliery tubs. This scraper is electrically-driven, and forms a quick and easy method of getting rid of the dirt from tubs.

Self-Sustaining Winch.—The London Electric Firm send us their latest pamphlet of electric winches, which includes details of their $2\frac{1}{2}$ cwt. and 5 cwt. sizes. These winches are, it is claimed, self-sustaining, and are made without ratchets, pulleys or worm gearing.

Lightning Conductors.—The Nationalen Elektrizitats Gesellschaft, of Munich, send us a pamphlet in English and French, dealing with their system of protection from lightning. The pamphlet is excellently illustrated and gives full details of this Company's well-known lightning conductors.

Imports.—The following are official values of electrical machinery, material, and apparatus imported into this country (*a*) during March, 1909, and (*b*) during the current year from Jan. 1 to March 31, with the increases or decreases compared with the corresponding periods of 1908:—

Electrical machinery (*a*) £54,597 (decrease £13,110); (*b*) £119,337 (decrease £61,676); telegraph and telephone cables (*a*) £9,963 (increase £112), (*b*) £24,805 (decrease £9,894); telegraph and telephone apparatus (*a*) £19,584 (increase £1,096), (*b*) £44,322 (decrease £15,674); other electrical wires and cables, rubber insulated (*a*) £4,233 (decrease £1,575), (*b*) £13,949 (decrease £4,880); with other insulations (*a*) £12,664 (increase £4,340), (*b*) £29,888 (increase £2,175); carbons (*a*) £11,401 (decrease £6,044), (*b*) £36,178 (decrease £11,855); glow lamps (*a*) £28,298 (increase £12,443), (*b*) £118,603 (increase £58,646); arc lamps and electric searchlights (*a*) £315 (increase £4), (*b*) £7,362 (increase £6,226; parts of arc lamps and searchlights (other than carbons) (*a*) £4,462 (increase £125), (*b*) £12,363 (decrease £2,004); primary and secondary batteries (*a*) £4,391 (decrease £848), (*b*) £14,207 (increase £3,833). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £105,149 (increase £7,294), (*b*) £328,329 (increase £26,264).

Exports.—The exports of electrical machinery, material, &c. (*a*) during March, 1909, and (*b*) during the current year from Jan. 1 to March 31, and the increases and decreases compared with the corresponding periods of 1908, are as follows:—

Electrical machinery (*a*) £111,699 (decrease £2,900), (*b*) £334,598 (decrease £21,373); telegraph and telephone cables (*a*) £45,126 (decrease £4,547), (*b*) £98,244 (decrease £68,606); telegraph and telephone apparatus (*a*) £15,283 (increase £4,904), (*b*) £49,950 (increase £9,817); other electrical wires and cables, rubber insulated (*a*) £21,709 (decrease £1,241), (*b*) £62,615 (decrease £12,732); with other insulations (*a*) £19,384 (increase £1,380), (*b*) £59,906 (increase £281); carbons (*a*) £596 (decrease £452), (*b*) £2,067 (increase £446); glow lamps (*a*) £7,401 (increase £3,932), (*b*) £17,409 (increase £7,536); arc lamps and searchlights (*a*) £2,981 (increase £1,634), (*b*) £6,089 (increase £2,559); parts of arc lamps and searchlights (other than carbons) (*a*) £2,361 (increase £1,319), (*b*) £5,069 (increase £1,367); primary and secondary batteries (*a*) £11,731 (increase £5,135), (*b*) £30,433 (increase £21,832). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £160,644 (increase £18,056), (*b*) £423,484 (decrease £36,122).

BANKRUPTCIES, LIQUIDATIONS, &c.

A meeting of the creditors of the Buenos Ayres Grand National Tramways Co. (Ltd.) (in voluntary liquidation), will be held at 62, London Wall, E.C., on 19th inst., and creditors are required to send particulars of their claims to Mr. Fortescue Thursby, one of the liquidators, by May 1.

A dividend is to be paid to the creditors of Thos. Ernest Evans (trading as T. Arthur Evans & Co.), electrical and mechanical engineers, 14, Heathfield-street, Swansea, and claims are to be sent by April 26 to Mr. Hy. Rees, Government-buildings, Swansea.

A supplemental dividend of $2\frac{1}{4}$d. is payable at Bankruptcy-buildings, London, W.C., to the creditors of Thos. Hodgkinson (trading as Electro-Neurotone), 186, Goldhawk-road, London, W.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

December 7, 1908.

26,408 Rogerson. Sanding tram and other lines.
26,441 Wilcox. Trolley guards.
26,449 & 26,450 Hartmann & Braun Actien Ges. Hot-wire electric current measuring instruments. (Date applied for, 6/3/08.)*†
26,453 Hale. Emergency or secondary lighting.
26,485 Mayer. Trolley wire suspenders. (Date applied for, 21/12/07.)*†

December 8, 1908.

26,507 Johnsen & Walleen. Conducting current to or from continuous-current electrical machines.*
26,533 Wild & Lister. Circuit-breaker action.
26,555 Conrad. Transformers for operating vapour electric devices. (Date applied for, 10/1/08.)*†
26,572 Walker. Electric lighting installations where high-voltage currents are transformed.
26,588 Marconi's Wireless Telegraph Co. & Round. Measuring electromagnetic wave lengths.
26,592 Ellinger. Heat-resisting electric lamp protector.
26,620 Job. Switching devices.

December 9, 1908.

26,630 Baker. Rotary switch.
26,665 Norman & Reader. Driving a centrifugal pump blower by means of rotating field electric motor in such a manner that no glands or stuffing boxes are required.
26,666 Norman & Reader. Electrical converter for converting direct current to alternating current or vice versa, and transforming voltage as required.
26,674 Stevens. Charging several batteries in parallel, and regulating the voltage on electric feeders.
26,709 Ferranti. Current collectors.*
26,739 Kearney. Overhead guide rail for mono railway and tramway systems.

December 10, 1908.

26,752 Fennell & Perry. Electric lamp-holders.
26,796 Stratton & Claremont. Mechanical connectors for electric cables.*
26,808 Meirowsky. Electrical condensers. (Date applied for, 18/5/08.)*†
26,822 Read. Electrically heated geysers.
26,825 B.T.-H. Co. & Gray. Production of coherent conductors of refractory material.
26,826 B.T.-H. Co. (G.E. Co., U.S.) Silicon alloys.
26,832 Fleming. Detecting electric oscillations.
26,836 Black. Electric traction contact boxes. (Addition to No. 10,636/07.)
26,844 Buchler. Electrical conductors.
26,862 Jacob & Tudor Accumulator Co. Devices for steadying the load on connected generating plants.
26,867 Davis, Graham & Cox. Combined telephone and electric light or other equipment.

December 11, 1908.

26,881 Electric Control, Macmillan & Rattenbury. Mechanisms for operating and controlling the movements of members.
26,894 Bird & Thomson-Bennett. Electric ignition apparatus for internal-combustion engines.
26,915 Murray. Keyboard transmitter for printing telegraph systems.
26,916 Murray. Tape transmitter for multiplex telegraph systems.
26,917 Murray. Synchronising arrangement for a multiplex printing telegraph.
26,918 Murray. Printer for a multiplex printing telegraph system.
26,929 Julius Sax & Co. & Wheat. Cluster lamp-holders for electric incandescent lights.

December 12, 1908.

26,967 Timar & Ziegler. Time relay for electric currents.*
26,973 Hookham. Electrical contacts.
26,984 Hall & Robertson. Dynamo-electric machines.
27,021 Smith. Preventing telephone or telegraph wires, when broken, making contact with other wires carrying higher voltages.
27,034 Vollert. Chemical electrolytic process.
27,036 Ottley & Harrison. Electric incandescent lamps.
27,043 Höing. Devices for suspending pipes, cables and the like.*

December 14, 1908.

27,064 Ardagh & Ardagh. Renewing the life of tram rails in situ.
27,075 Schröter. Devices for attaching wire conductors to insulators. (Date applied for, 12/12/07.)*†
27,097 Siemens-Schuckertwerke G.m.b. [H.Securing thin covering to fine single wires. (Date applied for, 14/12/07.)*†
27,138 Bonbright. Electric speedometers and odometers.*
27,139 Clement. Telephone exchange system.*
27,140 Drysdale. Potentiometer for measurements on alternate-current and direct-current circuits.*
27,143 Timar & Dreger. Arc lamp with pairs of carbon.*
27,145 Highfield. Electrical wiring.
27,149 Leitner. Driving mechanism for dynamos.
27,156 Ross. Electric heaters.

December 15, 1908.

27,163 Baker. Switch for closing and opening an electric circuit.
27,207 Raasch. Time switches.*
27,212 Cecil & Bronsdon. Electric ignition regulator.
27,213 Sweetser. Electric switches.
27,236 Justice. (Alfred W. Kiddle & Amalie Mathilde Baumann, U.S.) Electric generators.*
27,242 Crouch & Etchells. Electrical distribution systems.
27,244 Marshall. Electric switch mechanism.
27,283 Landis & Gyr. Alternating-current meter.*

December 16, 1908.

27,303 Gilbert. Feeding mechanism for arc lamps.
27,310 Chambers. Telephony and telegraphy by means of "Hertzian waves."
27,343 Siemens-Schuckertwerke G.m.b.H. Alternating-current meters (Date applied for, 17/12/07.)*†

December 17, 1908.

27,436 Blackall & Jacobs. Electric signalling apparatus.
27,462 Tanaka, Wanibuchi & Peacock. Generating electric currents.*
27,470 Smith & Granville. Insulated line wire cables.
27,477 Justice. (Essex Co., U.S.) Third rail insulators.*
27,491 Barta & French. Electrical machines.

December 18, 1908.

27,504 Zumpt. Electrical fuse-boxes.
27,536 Holman. Arc lamps. (Date applied for, 1/9/08. Comprised in No. 2,261/08, dated 1/2/08.)*
27,538 Rawlings, Handcock & Dykes. Severing the hard metal sheathing of electric conductors.
27,539 Rawlings, Handcock & Dykes. Sheathing electrical wires.
27,577 Wigley, Redpath & Petrie. Fuse-setting machines.
27,585 Good & Davies. Incandescent electric lamps.

December 19, 1908.

27,616 Priestley & Priestley. Electric tramway cars, locomotives, motor cars, &c.
27,626 Walton & Bell. Showing variation of temperatures, with electrical alarm attachment.
27,639 Dawson. Attaching shades and reflectors to incandescent electric lamps.
27,664 Wilkinson. Devices for electric heating.*

SPECIFICATIONS PUBLISHED.

1907 Specifications.

26,294 Harrison. Supporting filaments in incandescent electric lamps. (Post-dated, 27/6/08.)
27,034 Davy. Arc lamps.
27,038 B.T.-H. Co. (G.E. Co., U.S.) Electric motor-starting devices.
27,095 Ryan. Electrical welding machines.
27,559 Murphy. Electrode for use in the purification of water and other liquids.
27,675 Hatfield. Electromagnetically operated apparatus.
27,830 Gibbs. Electrolytic cells.

1908 Specifications.

2,153 Buckton. Incandescent electric lamp caps and couplings.
4,372 Felten & Guilleaume-Lahmeyerwerke Akt.-Ges. Regulation of pressure of electric machines. (Date applied for, 27/2/07.)
7,328 Allgemeine Elektricitats Ges. Arc lamps. (Date applied for, 2/8/07.)
8,101 Siemens Bros & Co. & Toplis. Cooling the commutator of a dynamo-electric machine. (Addition to No. 7,255/06.)
8,255 Dickinson. Brake operating mechanism for tramway cars and other vehicles.
8,522 Berg. Turbo-electric generator systems. (Date applied for, 20/4/07.)
9,237 Allgemeine Elektricitats Ges. Protecting transformers, cables and other electrical apparatus. (Date applied for, 29/4/07.)
9,636 Siemens-Schuckertwerke Ges. Fittings for electric glow lamps. (Date applied for, 25/6/07.)
9,762 & 9,763 Ruzicka. Manufacture of electrical resistances.
9,832 Peters. Safety fuses for switchboards.
9,850 Boult. (Union Switch & Signal Co.) Electric signalling systems for railways and the like.
9,876 De Sainte-Clare. Variable-speed gear for electric automobiles. (Date applied for, 7/11/07.)
10,171 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Reducing the reflex action at the points of connection of electrical conductors or circuits differing in the values of their electrical properties. (Addition to No. 9,273/06.)
10,269 Ruzicka. Arc lamp.
10,317 Mershon. Insulating supports for high-tension conductors. (Date applied for, 21/5/07.)
10,632 Paterson & Dark. Clamping device for electric contacts or brushes.
10,764, 10,767 and 10,768 Tate. Storage battery plates. (Date applied for, 20/12/07.)
11,064 Timar & Von Dreger. Starting switches for electric motors. (Date applied for, 5/6/1907.)
11,068 Routin. Electro-mechanical regulators or governors for electric generators. (Date applied for, 24/5/07.)
11,710 Siemens & Halske Akt.-Ges. Plastic mass from tungsten compounds. (Date applied for, 3/8/07. Addition to 16,489/07.)
12,411 Mozingo. Electric railway system for collecting and delivering mail. (Date applied for, 10/6/07.)
12,420 Paulin & Fortune. Telemotor apparatus for ships' steering gear.
12,644 Girdlestone & Thorkelin. Arc lamps.
12,682 Allgemeine Elektricitats Ges. Arc lamps. (Date applied for, 15/7/07.)
13,136 Schulze. Measuring instruments having an electromagnetic brake. (Date applied for, 29/2/08.)
13,539 Haack. Mercury vapour lamp.
13,661 Bloxam. (Siemens Schuckertwerke Ges.) Fittings for incandescence electric lamps.
14,259 Diaz & Azarola y Gresillon. Preventing the theft of electrical energy.
14,425 Graham. Telephonic systems.
14,538 Berg. Turbo-electric generator systems. (Addition to No. 8,522/08.)
14,554 Allman & Leeson. Electrical vulcanising apparatus.
14,776 Schwenke. Electric projectile igniters.
15,289 Hall. Magneto machines for use in connection with the ignition systems of internal combustion engines.
15,376 Rains. Electrical water heaters.
15,818 Aitken. Telephone cordless switchboards.
15,819 Aitken. Telephone cordless switchboards.
15,949 Rorke & Rorke. Electric make-and-break devices. (Post-dated, 27/4/08.)
16,096 Siemens & Halske Akt.-Ges. Telephone installations. (Date applied for, 2/8/07.)
16,849 Hall. Safety spark-gap devices for use in connection with the ignition systems of internal combustion engines. (Date applied for, 20/7/08.)
16,910 Schattner & Amberton. Prepayment electric meters. (Date applied for, 17/3/08.)
17,114 London Electron Works Co. & Kardos. Elevated tracks or run-ways and trolleys therefor.
17,205 Bradburn. Telepone apparatus. (Date applied for, 25/1/08.)
17,410 Lundberg, Lundberg & Lundberg. Electric switches.
17,414 Siemens Bros. Dynamo Works & Kieffer. Ventilating rotors of dynamoelectric machines.
17,417 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Commutators for electrical machinery.

10,552 HENSHAW & SWINDELLS. Controlling the trolley poles of electric cars and the like. (Addition to No. 25,415/05.)
11,517 SIEMENS-SCHUCKERT WERKE GES. Continuous-current machines. (Date applied for, 27/7/07.)
12,296 EVERSHED & VIGNOLES & VIGNOLES. Electrical resistances adapted to measure currents by the fall of potential method.
14,080 ROTH. Switch-holders for electric incandescent lamps.
15,330 WEISSE. Electric fuses.
16,766 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke Ges.) Electro-magnetic clutches.
16,797 RENSING. Arc lamps.
16,848 HALL. Magneto machines. (Date applied for, 20/7/1908.)
17,416 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke Ges.) Cooling of the end windings of dynamo-electric machines.
17,493 WOLHAUPTER. Insulated joints for railway rails and the like.
17,509 REGINA-BOGENLAMPENFABRIK GES. & HANISCH. Arc lamp.
17,535 ALLGEMEINE ELEKTRICITATS GES. Arc lamps. (Date applied for, 21/8/07.)
17,730 KENNEDY. Alternating-current electric energy integrating meters.
17,809 BERGMANN. Magneto-electric igniting device with asymmetric polar pieces.
17,841 PAGE. (Telegraph Transmitting Instrument Co.) Keyboard telegraphic transmitters.
17,934 PALMBORG. Telephone exchanges. (Date applied for, 3/9/07.)
17,936 REINEKE. Producing electric energy.
18,216 S.P. (SUCHOSTAWER PATENTS) SYND. & SAYERS. Surface contact system of electric traction.
18,458 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.
18,461 B.T.-H. Co. (G.E. Co., U.S.) Commutating poles for dynamo-electric machines. (Addition to No. 5,741/07.)
18,713 S.P. (SUCHOSTAWER PATENTS) SYND. & SAYERS. Electric traction on the surface contact system.
18,880 STEPHENS. Manufacture of magnetos.
19,265 MARSH. Electric furnaces. (Date applied for, 19/9/07.)
19,311 SIEMENS & HALSKE AKT.-GES. Electric incandescence bodies of tungsten. (Date applied for, 26/9/07.)
19,388 EBNER. Interrupter for electric ignition apparatus of explosion motors.
19,889 SIEMENS-SCHUCKERTWERKE GES. Repulsion electric motors. (Date applied for, 28/9/07.)
20,179 SERAGNOLI. Electro-pneumatic device.
20,288 ROBERT BOSCH. Terminal for magneto-electric ignition apparatus. (Date applied for, 15/11/07.)
20,352 HANKIN & WOLFF. Resistances in electric circuits.
20,601 SIEMENS BROS. & CO., & FERREIRA. Electrically-controlled railway signals.
21,075 KINGSBURY. (Western Electric Co.) Switching apparatus for interconnecting the lines of a telephone exchange system. (Date applied for, 3/1/08.)
21,603 ALLEGEMEINE ELEKTRICITATS GES. Devices for protecting transformers, cables and other electrical apparatus. (Date applied for, 29/4/07. Included in 9,237/08.)
21,628 S.P. (SUCHOSTAWER PATENTS) SYND. & SAYERS. Electric traction on the surface-contact system.
21,741 KELLER. Electric furnaces.
22,516 MIESS. Incandescence vapour lamps. (Date applied for, 22/11/07.)
25,029 EISENSTEIN. Wireless telegraph systems or the like. (Additions to No. 20,128/07.)

COMPANIES' MEETINGS AND REPORTS.

Cuba Submarine Telegraph Co.

The seventy-fifth ordinary general meeting was held on Wednesday, Mr. GEORGE KEITH presiding.

The SECRETARY (Mr. James Scott) read the notice convening the meeting and the auditors' report.

The CHAIRMAN then said: Gentlemen, Mr. Parish, our Chairman, is unable to be present to-day. He is not well, and his doctor enjoins quiet. He has asked me to read his speech. "Gentlemen:—When we held our half-yearly meeting last October I explained that the receipts for the six months from January to June had been adversely affected by the failure to a serious extent of the sugar crop in the island of Cuba, and that consequently they compared unfavourably with those of the previous year. From past records we find that the second half of the year always shows smaller receipts than the first half. It was, therefore, to be expected that our traffic receipts from July to December would be less than those for the previous half-year; and as you will see from the comparative statement which is attached to the report they amounted to £12,909, against £16,158 received from January to June. They also compare badly with the previous year, for during July to December, 1907, we received £15,715, or nearly £3,000 more than in the six months we are dealing with, and this falling off reflects to a large extent the general bad state of trade throughout the West Indies. This year the sugar crop is much larger, the mills are working away at full swing, and the general trade of the island is in consequence much better, and we estimate that our earnings for the first three months of this year are fairly satisfactory. have only alluded to the sugar crop, as that is the most important one in the island, but there is also the tobacco growing, which is of great value, especially in the western part of the island, and I am glad to say that the latest advices encourage the expectation of a fairly good crop. The American occupation of the island came to an end last January, and since then the new president has been in power; it is hoped that the present Government will fulfill the expectations which have been formed of it, and that a term of peace and prosperity is now being entered upon. Our cables have worked well, and there has been no difficulty in dealing with the traffic with which we have been entrusted. In regard to the present accounts, I will first call your attention to the revenue account; our receipts are £12,909 from traffic, and from interest on investments, &c., £1,948, making together £14,857. The expenses are £6,025, thus leaving a balance of £8,832, which enables us to place £1,000 to reserve fund, pay the dividend on our preference shares, which amounts to £3,000, and to ask you to agree to a dividend at the rate of 6 per cent. per annum on on our ordinary shares, thus maintaining the same rate as we have paid for the past three half-years. A contribution of only £1,000 to the reserve fund is not so large as we have been accustomed to; but we recognise that our present reserve of £111,000 is a good, solid amount, and you Board felt that as we had made the 6 per cent. dividend we might fairly pay it. The details of our expenses are very similar to those of the corresponding half of 1907; the total then was £6,177, or £152 more than this year. Our capital expenditure shows an increase of about £2,400, which is accounted for by our having bought the freehold house at Santiago, in which our office is situated; it is a very suitable house, in the best position for our business, which we have rented for a good many years. Now our offices at Santiago and Cienfuegos are in our own houses, which may be regarded as a good investment. I regret that our claims against the American and Spanish Governments still remain unpaid, but I still have hopes that we may yet receive them." I now move the adoption of the report and accounts.

Mr. R. K. GRAY seconded the motion, which was carried unanimously.

Resolutions approving the dividends recommended by the directors and according a very hearty vote of thanks to the chairman, directors and staff brought the proceedings to a close.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—Mr. J. B. Concanon stated at the meeting last week that, in regard to the companies which they had absorbed, the Grand National and La Capital Traction & Electric Companies' systems were being worked by the Anglo Company as from the 1st inst. As regards the results they were likely to arrive at when the necessary junctions and additions to track were constructed to allow of the entire combination being run systematically and economically as one complete whole, he thought they might safely rely upon the experience gained so far, as an indication of what they might look for in the future. Although they were working the Belgrano systems from July 1, 1907, the Buenos Ayres Electric and the Belga-Argentine systems from July 1, 1908, they were only able to run new services in combination with the Anglo as from Oct. 1 last, and the result had been that for the quarter ended Dec. 31 the total combined receipts showed an increase of 10·72 per cent., and the working expenses came down from 57·09 per cent. to 55·46 per cent., while for the months of January and February this year the net profit amounted to £95,249, an increase of £11,009, or 13 per cent., so that he thought it was reasonable to expect further large increases in net receipts when they were in a position to work new services over the Grand National and La Capital Traction Co.'s lines in combination with their present system, especially as those systems were far larger and more important than those of the Belgrano, Buenos Ayres Electric and Belga-Argentine. They anticipated that the results for the current year, although one of transition, would, after providing for all prior charges, leave a balance sufficient to pay a satisfactory dividend on the ordinary shares, while they look for a further substantial improvement in the net revenue in 1910 and subsequent years.

BABCOCK & WILLCOX (LTD.)—The net profit during the year 1908 was £301,614. 16s. 5d., and, with £38,664. 3s. 4d. brought forward, the balance was £340,278. 19s. 9d. The interim dividends of 3 per cent. on the preference and of 8 per cent. on the ordinary shares absorbed £69,400, and out of the balance (£270,878. 19s. 9d.) the directors recommend that the following dividends be paid for the half-year ended Dec. 31, 1908, viz.:—3 per cent. on the preference shares, less tax (£3,000) and 8 per cent. on the ordinary shares, tax free (£66,400), and a bonus of 4 per cent. on the ordinary shares, tax free (£33,200). £100,000 is to be placed to reserve and £25,000 to the dividend equalisation fund, leaving a balance to be carried forward of £43,278. 19s. 9d. Although, in common with all other engineering firms, the company is affected by the general depression in trade, the works are fairly well occupied, and the works, buildings, machinery, &c., have been well maintained, and additions and improvements carried out.

BATH ELECTRIC TRAMWAYS (LTD.)—At the meeting last week Sir James Sivewright said that, like other tramway undertakings, their earnings for 1908 compared unfavourably with those for the preceding year. Probably there was no business that was more affected by climatic causes than a tramway system, and in Bath the general trade depression had prevented people from spending money to the same extent as they did in good times. The diminution in earnings had been largely compensated by the savings effected in expenditure. The loss on their omnibuses had been reduced from £792 in 1907 to £31 in 1908. The omnibuses were an indirect source of revenue, for they brought passengers to the tramways that they otherwise would not have.

BRISBANE ELECTRIC TRAMWAYS INVESTMENT CO. (LTD.)—Including £2,130 brought forward, the profit for 1908 was £61,220, and after paying debenture interest, preference dividend and interim dividend of 2s. 6d. per share on the ordinary shares the available balance is £14,795, and the directors recommend that a balance dividend of 3s. 6d. per share (tax free) be paid on the ordinary shares (making a total dividend for the year of 6 per cent.), and that £1,670 be carried forward.

BRITISH ALUMINIUM CO. (LTD.)—At a meeting of the debenture stockholders last week it was decided to increase the nominal mortgage debenture stock from £1,000,000 to £1,100,000, and to create and issue £240,000 5 per cent. redeemable mortgage debentures of the Loch Leven Water & Electric Power Co. Mr. G. A. Touche stated that owing to the enormous change which had come over the industry during the past 18 months it had been found necessary to press forward the completion of the Kinlochleven works and the manufacture of aluminium was begun there last month. The cost would be £1,000,000. The scheme at Kinlochleven included the building of an electric railway and a village for housing the employees. The increase of output thereby assured would be of immense advantage to the company, as the company would in future have to rely upon the greatly increased sales for satisfactory results.

CALCUTTA TRAMWAYS CO. (LTD.)—The receipts for 1908 were £165,547, and working expenses £106,800, leaving a balance of £58,747, and after adding balance forward, &c., the disposable balance is £60,592. Interest on debenture stock, &c., and the dividends on preference and ordinary shares absorbed £41,498, leaving £19,094. The directors propose to pay a final dividend of 2s. per share, making 4 per cent. for the year, to add £5,000 to depreciation and to carry forward £333.

CANADIAN GENERAL ELECTRIC CO.—The directors' report for 1908 states that the profit was $753,088. Depreciation, &c., and interest absorbed $242,720, and dividends paid (7 per cent.) amount to $439,042, leaving $71,325, which, with the balance from 1907 made $145,231 for carrying forward. Notwithstanding the continued industrial depression, the company secured several important contracts, which, added to current business, will keep the company fairly busy during the year. During the past three months more orders were secured than during the previous six months, and as indications pointed to a material improvement in trade conditions the future is looked forward to with more confidence than at any time during the preceding year.

HAVANA ELECTRIC RAILWAY CO.—The gross earnings in 1908 were $2,276,807, an increase of $133,684 over 1907. After deducting expenses and 6 per cent. dividend on the preferred and 1 per cent. dividend on the common stock, the balance was $200,967. The gross earnings per track mile were $38,448, against $36,217, and net earnings $19,168, against $16,923. During the year a decree was issued by the Provisional Government giving authority to the company [to construct about 30 miles of extensions or new lines.

INDO-EUROPEAN TELEGRAPH CO. (LTD.)—The directors, in their report for 1908, announce that they have been successful in obtaining an extension of the Persian Concession for 20 years from January, 1925. Tariff modifications decided upon at the International Telegraph Conference at Lisbon will not materially affect the Company's receipts. Direct Wheatstone working (without intermediate retransmission), hitherto in operation between London (Manchester and Liverpool) and Teheran, has been extended to Karachi by the co-operation of the Indo-European Telegraph Department of the India Office, and is in daily use for telegrams exchanged with India and the Far East. The former retransmission at Teheran has thus been eliminated, with consequent gain to the telegraphing public in respect both of speed and of accuracy. Revenue from message account and other sources amounted to £132,837. 4s. 4d., compared with £136,579. 2s. 2d. for 1907, a decrease of £3,741. 17s. 10d. Expenses on commercial and general account were £49,926. 4s., and on maintenance account £25,807. 11s. 8d., making £75,733. 15s. 8d., against £73,052. 19s. 8d., an increase of £2,680. 16s. The balance is £57,103. 8s. 8d., which is reduced to £53,601. 4s. 11d. by deduction of income-tax. Adding balance brought forward (£8,558. 7s. 10d.) and £549. 9s. profit on realisation of investments, the total is £62,709. 1s. 9d. The directors have set aside £5,000 to meet line repair contingencies. Deducting this sum and interim dividend (£10,625) there remains £47,084. 1s. 9d. The directors propose a dividend for the six months to Dec. 31, 1908, of 17s. 6d. per share (making 6 per cent. for the year) and a bonus of 20s. per share, both tax free, and to make a special distribution (tax free) to the shareholders of £12,750 (equivalent to 15s. per share) out of interest upon certain investments. They also propose to hand over to the trustees of the retirement trust fund a further sum of £5,000, carrying forward £10,209. 1s. 9d.

A shareholder (Mr. G. von Chauvin) has notified that he will at the forthcoming meeting move a resolution "That a special sum of £3,000 be voted to the directors in recognition of their past services to the company, to be divided among them in such manner as they may determine."

ISLE OF WIGHT ELECTRIC LIGHT & POWER CO. (LTD.)—The result of the trading for 1908 including £190. 1s. 10d. brought forward) is a profit of £11,391. 10s. 9d. After paying interest on debentures and loans (£5,097. 17s. 7d.) and a dividend on preference shares (£2,500) there remains £3,793. 13s. 2d. The directors recommend that £2,500 be placed to a renewal account and £1,000 to reserve, leaving £293. 13s. 2d. to be carried forward. At the end of the year the equivalent of 94,905 8 c.p. lamps was connected (against 89,300 in 1907)—at Ventnor and Bonchurch 21,074 (against 20,655), Sandown and Shanklin 19,392 (18,479), Newport and Cowes 34,435 (31,710), and Ryde and St. Helens 19,904 (18,456).

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

BROWNE ENGINEERING CO. (LTD.) (102,382.)—Reg. April 5, capital £30,000 in £1 shares (5,000 preference), to adopt an agreement with H. J. S. Mackay, W. J. W. Bullock and H. A. Harvey, and to carry on the business of electrical engineers, electricians, suppliers of electricity, &c. Private company. First directors are H. J. S. Mackay, W. J. W. Bullock, H. A. Harvey and J. A. Smeeton.

POWER ENGINEERS (LTD.) (102,302)—Reg. March 30, capital £2,000 in £1 shares, to carry on the business of electrical, mechanical and civil engineers, manufacturers of and dealers in electrical and other machinery and appliances, &c. Private company. First directors, W. B. Esson and R. B. Matthews. Reg. office, Bank-buildings, Kingsway, London, W.C.

SIR JOHN JACKSON (SOUTH AMERICA) (LTD.) (102,452)—Reg. April 7, capital £100,000 in £100 shares, to carry on the business of contractors for public works, including railways, tramways, docks, electric light, telegraphic and telephonic works, &c., in South America. Private company.

STATUTORY RETURN.

WASTE HEAT & GAS ELECTRICAL GENERATING STATIONS (LTD.)—Return to March 3 gives capital as £150,000 in £1 shares, all of which have been taken up. £1 per share has been called up on 68,402, 15s. per share on 16,598 and 5s. per share on 65,000 and £97,100. 10s. has been received. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

J. DEFRIES & SONS (LTD.)—Charge on a book debt due from the Midland Railway Co., dated March 13, 1909, to secure £174. 17s. 1d. Holders, Messrs. Gedge & Feeny.

GRATZE LIMITED. — Particulars of £2,500 debentures, created March 19, 1909, filed pursuant to sec. 10 (3) of the Companies Act, 1907, the whole amount being now issued. Property charged, company's undertaking and property, present and future. No trustees.

COMPANY INCORPORATED OUTSIDE THE U.K.

ELECTRICAL ENGINEER INSTITUTE OF CORRESPONDENCE INSTRUCTION (821F)—Particulars filed March 30. Capital $50,000 in shares of $100. Reg. in U.S.A. on March 7, 1898. British address: 13, Southampton-street, Holborn, W.C., where Mr. J. Wetzler is authorised to accept service.

CITY NOTES.

MEMORANDA (April 15).—Bank rate 2½ per cent. (since April 1, 1909). Price of silver, 23 9/16d. per oz. Consols 85½—85¾ for money and account. Consols Pay Day, May 5; Stock and Shares Continuation Day, April 27; Ticket Day, April 28; Pay Days, April 16 and 29. Mining Shares Carry Over Day, April 26.

PRICES OF METALS (London).—*Copper*, cash, 57½; three months 58¼. *Lead*, English, 13⅝—13⅞; foreign, cash, 13 5/16; three months, 13⅝. *Spelter*, cash, 21⅜—21½; two months, 21½—21⅝. *Tin*, English, 133½—135½; foreign, cash, 133¼—133½, three months, 134—134¼. *Iron*, Cleveland, cash, 47/6½, and three months, 48/2. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

EVERED & CO. (LTD.)—The accounts for 1908 show a loss of £6,081, against a loss of £4,074 for 1907. From this has been deducted the credit balance of £3,071 brought forward, leaving a debit balance of £3,010.

FLEMING, BIRKBY & GOODALL (LTD.)—At the recent meeting a dividend of 9 per cent. on the ordinary shares was declared, £9,589 being carried forward.

MEXICO TRAMWAYS CO.—A dividend of 1½ per cent. for the quarter ended 31st ult. has been declared.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have been asked to appoint special settling days in and grant quotations to scrip, fully paid, for £1,250,000 6 per cent. 50 year mortgage bonds of the *Mexico Tramways Co.* and £75,000 4½ per cent. £100 prior lien gold bonds (registered) of the *Montreal Water & Power Co.*, and also to grant quotations to £357,100 4½ per cent. prior lien gold bonds (registered) (in lieu of 4 per cent. bonds now quoted) of the latter company; a further issue of 1,240 £10 fully paid 6 per cent. cumulative preference shares of the *County of London Electric Supply Co. (Ltd.)*; 35,704 £10 fully paid 4 per cent. guaranteed preference shares (in lieu of ordinary shares now quoted) of the *Gt. Northern, Piccadilly & Brompton Railway Co.* and $50,000,000 additional 4 per cent. $1,000 convertible bonds of the *American Telephone & Telegraph Co.*

TELEPHONE COMPANY OF EGYPT (LTD.)—The directors recommend a dividend of 4 per cent. (4s. per share), less tax, on both the preferred and deferred shares for the past half-year, making 10 per cent. for the year, placing £500 to reserve for contemplated pension scheme, and carrying £25,782 forward.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	April 7	1,241	+ 18	45	60,751	– 244
Airdrie	,, 2	205	– 8	13	2,769	– 66
Anglo-Argentine	,, 8	42,216	+ 2,248	11	556,883	+ 35,187
Ayr Corporation	,, 10	230	+ 18	47	13,176	– 323
Baker St. & Waterloo Ry.	,, 10	2,870	– 110	14	47,490	+ 4,475
Barnsley	,, 2	162	– 15	13	2,074	– 43
Barrow	,, 2	202	– 23	13	2,553	– 225
Bath Electric Trams, Ltd.	,, 7	674	+ 22	14	8,253	+ 191
Birkenhead Corporation	...	...	...	...	...	...
Birmingham Corporation	,, 10	6,518	+ 253	§1	9,777	+ 420
Birmingham & Mid.	Mar. 26	827	+ 51	12	9,318	– 38
Blackburn Corporation	April 7	961	– 69	2	1,848	– 53
Blackpool and Fleetwood	,, 10	740	+ 478	14	3,968	+ 777
Bolton Corporation	,, 11	3,256	+ 1,012	2	1,601	+ 707
Bombay	Mar. 11	R38,478	+ R3,411	10	R382,721	+ R26,616
Bournemouth Corporation	April 7	1,430	– 59	1	1,430	– 59
Bradford Corporation	...	...	...	...	...	...
Brighton Corporation	,, 11	1,115	+ 359	2	1,564	+ 303
Bristol Trams & Carriage	,, 9	5,576	+ 994	20	96,749	+ 8,551
Burnley Corporation	,, 10	1,760	+ 583	2	2,974	+ 693
Burton Corporation	,, 11	231	+ 36	2	428	– 5
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	,, 10	R46,364	+ R2,264	14	R712,738	+ R27,152
Camborne-Redruth	,, 10	133	+ 3	15	1,619	– 124
Cardiff Corporation	,, 3	2,017	+ 3	...	...	...
Cavehill	,, 2	52	– 2	13	701	– 44
Central London Railway	,, 10	4,474	– 1,440	14	77,703	– 7,455
Charing C., Euston & H'stead	,, 10	3,810	+ 710	14	53,475	+ 9,436
Chatham & Dist. Lt. Rys.	...	...	...	...	...	...
City & South London Rly.	,, 11	2,789	– 348	14	46,925	+ 413
City of Birmingham	,, 2	2,686	– 47	13	33,927	– 879
Colchester Corporation	,, 7	140	– 23	1	140	– 23
Cork Electric Trams Co.	,, 8	454	+ 15	14	5,734	+ 190
Croydon Corporation	,, 9	1,587	+ 317	§1	1,958	+ 156
Devonport & Dist. Trams	,, 2	313	– 88	13	4,719	– 630
Dover Corporation	,, 10	222	+ 60	2	309	+ 30
Dublin & Lucan Railway	,, 9	122	+ 14	14	1,609	+ 132
Dublin United	,, 9	4,872	+ 60	14	67,297	– 146
Dudley-Stourbridge	,, 2	768	– 24	13	9,095	– 272
Dundee Corporation	,, 7	1,157	+ 12	‡47	55,394	+ 1,975
East Ham Council	,, 10	1,019	+ 235	§1	1,480	+ 333
Exeter Corporation	,, 9	307	+ 45	2	395	+ 16
Gateshead & Dist. Trams	,, 2	978	– 26	13	12,527	– 178
Glasgow Corporation	,, 10	17,471	+ 12	45	760,505	– 17,174
Glossop Trams	April 3	113	– 2	14	1,570	– 72
Gravesend—Northfleet	,, 2	172	– 29	13	2,241	– 174
Great Northern & City Rly.	,, 10	1,331	– 312	14	21,979	– 2,786
Gt. Northern, Piccadilly, &c.	,, 10	5,075	– 310	14	81,780	+ 5,895
Greenock & Port Glasgow	,, 2	467	– 2	13	5,684	– 272
Hartlepool Tramways	,, 2	217	+ 24	13	2,503	– 215
Hastings Elec. Trams Co.	,, 8	868	+ 56	14	10,025	– 638
Hong Kong	,, 10	$3,196	+ $916	14	$116,046	+ $9,596
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation	,, 10	2,657	+ 281	§1	3,879	– 72
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 7	123	– 6	1	123	– 6
Ipswich Corporation	,, 10	423	+ 105	§1	578	+ 116
Isle of Thanet Co.	,, 10	489	+ 221	§27	7,493	+ 191
Jarrow	,, 2	100	+ 5	13	1,314	+ 81
Keighley Corporation	,, 8	168	+ 1	1	168	+ 1
Kidderminster & District	,, 2	79	– 8	13	1,015	– 57
Kilmarnock Corporation	,, 10	143	– 1	47	6,991	– 351
Lanarkshire Trams Co.	,, 8	1,139	– 136	14	16,412	– 1,102
Lancashire United	,, 7	1,196	– 26	14	16,211	+ 91
Leamington	,, 2	173	+ 48	13	1,811	+ 157
Leeds Corporation	,, 10	6,909	+ 786	2	9,988	+ 1,374
Leicester Corporation	...	...	...	...	...	...
Leith Corporation	...	...	...	...	...	...
Lincoln Corporation	,, 10	135	+ 33	2	244	+ 37
Liverpool Corporation	,, 3	10,364	– 437	‖13	136,284	– 1,229
Liverpool Overhead Rly.	,, 11	1,327	– 35	15	19,243	– 1,449
¶London County Council	...	...	...	...	...	...
London United*	,, 10	7,033	+ 1,454	‖17	71,558	– 3,334
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 10	194	+ 35	1	267	– 2
Manchester Corporation	...	...	...	...	...	...
Mersey Railway	,, 10	2,018	– 36	14	27,323	+ 624
Merthyr	,, 2	206	+ 6	13	2,520	+ 6
Metropolitan Dist. Railway	,, 10	8,934	+ 279	14	136,177	+ 10,883
Metropolitan Elec. Trams	,, 2	5,450	+ 270	13	67,406	+ 5,986
Middleton	,, 2	290	– 43	13	3,669	– 235
Nelson Corporation	...	...	...	...	...	...
Newcastle-on-Tyne Corp.	,, 10	3,904	+ 232	2	5,825	– 247
Newport (Mon.)	,, 10	726	+ 97	2	1,345	+ 110
Northampton Corporation	,, 9	450	+ 52	§1	553	– 4
Oldham, Ashton & Hyde	,, 2	520	– 73	13	6,670	– 571
Oldham Corporation	,, 11	2,272	+ 403	§1	5,187	– 22
Perth (N.B.) Corporation	,, 7	139	– 2	47	7,130	– 135
Perth (W.A.) Elec. Trams	,, 9	1,370	– 33	14	20,878	+ 128
Peterborough	,, 2	107	– 3	13	1,211	– 125
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 2	1,788	– 83	13	22,301	– 1,123
Preston Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 8	585	– 1	1	585	– 54
Rothesay	,, 2	48	– 1	13	573	– 30
Salford Corporation	,, 12	5,534	+ 1,357	2	8,631	+ 1,219
Sheerness	,, 2	40	– 7	13	543	– 78
Sheffield Corporation	,, 11	5,656	+ 204	§2	13,531	– 104
Singapore Trams	,, 10	$10,271	+ $415	14	$135,771	+ $3,241
South Metropolitan	,, 2	700	– 17	13	8,269	– 124
South Staffs	,, 2	784	– 101	13	10,225	– 827
Southend Corporation	,, 7	335	+ 40	1	336	+ 1
Southport Tramways	,, 2	221	– 15	13	2,784	+ 71
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 10	1,189	+ 509	§1	1,525	+ 419
Sunderland Corporation	,, 11	1,203	+ 121	2	1,820	– 73
Sunderland District	,, 7	403	– 44	23	9,910	– 290
Swansea Trams	,, 2	871	+ 1	13	11,079	+ 293
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 2	36	– 6	13	427	– 50
Tynemouth and District	,, 2	134	– 12	13	1,646	– 152
Tyneside Trams Co.	,, 7	392	+ 52	14	5,174	+ 265
Wallasey District Council	,, 10	967	+ 211	§1	1,370	+ 116
Walsall Corpn.	,, 10	530	...	14	6,910	– 590
Warrington Corpn.	,, 1	353	– 18	52	19,363	– 475
West Ham Corporation	,, 1	2,115	– 50	53	114,944	– 4,952
Weston-super-Mare	,, 2	25	– 2	13	314	– 4
Wolverhampton Co.	,, 2	398	– 51	13	4,953	– 621
Wolverhampton Corpn.	,, 7	742	– 27	14	9,979	– 698
Worcester	,, 2	238	– 1	13	2,930	– 62
Wrexham	,, 2	93	...	13	1,121	– 19
Yorkshire W.R. Trams	,, 11	1,335	+ 232	15	16,267	...
Yorkshire Woollen District	,, 2	841	– 94	13	10,686	– 392

ELECTRICAL COMPANIES' SHARE LIST

Share.	Last Dividend	Name.	Price Wed. April 14.	Rate % Yielded. £ s. d.	Dividend Due.	Business 5 Days to April 14. Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7 0	†Bournemouth & Poole Elec. Sup. Ord.	9⅞ –10⅜	5 19 0	Mar, Sept,	..	–
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞ –10⅛	4 9 0	Feb, Aug	..	
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10½ –10⅞	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 –105	4 5 6	Jan, July	..	..
5	2/0	Bromley (Kent) El. Lt. & Power Shares	4½ –5	5 10 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	95 –98	4 12 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8⅜ –8⅞	5 13 0	March....	8½	8
5	3/6	Do. 7 per Cent. Pref.	8 –8½	4 2 0	Mar, Sept	.	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	99 –102	8 18 0	June, Dec	..	–
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅞ –4⅛	5 19 0	Feb, Aug	3⅞	..
5	2/8	Do. 4½ per Cent. Pref.	4 –4½	5 0 0	Feb, Aug	4⅛	1½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93 –98	4 4 0	Jan, July	97½	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	98 –100	4 10 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ –4½	5 0 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜ –3⅞	5 13 0	March ..	3¾	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 –105	4 7 6	June, Dec	..	..
10	7/0	†City of London Electric Lighting Ord.	10½ –10⅞	5 11 6	Feb, Aug	10⅝	10⅛
10	6/0	†Do. 6 per Cent. Cum. Pref.	11¾ –12¼	4 18 0	Jan, July	12⅛	17⅛
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 –123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 –104	4 6 6	Jan, July	..	..
5	2%	County of Durham Elec. P.D. Ord.	1 –2	6 13 1	April, Oct	–	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3½ –3¾	6 17 10	April, Oct	..	..
10	6/0	†County of London Elec. Supply Ord.	8¼ –8¾	5 14 0	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. Pref.	10½ –11	5 9 0	Mar, Sept	10⅞	10½
St.	4½%	Do. 4½% Deb. Stock (red.)	106 –109	4 2 6	Jan, July	107½	..
St.	4½%	Do. Second Deb. Stock	101 –104	4 6 6	May, Nov	..	..
5	3/6	†Folkestone Electricity Supply Co. Ord.	4½ –5	5 10 0	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	95 –98	4 12 0	Feb, Aug	..	..
5	4/6	†Hove Electric Lighting Ord.	7⅛ –7⅝	5 11 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7¼ –7¾	5 16 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝ –6⅞	4 14 6	Jan, July	..	–
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93 –96	4 3 6	..	–	–
St.	4%	†Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 –100	4 0 0	April, Oct	..	–
St.	4½%	Kent Elec. Power Co.	85 –89	5 1 0	Jan, July	..	–
3	1/9⅜	London Electric Supply Ord.	1⅞ –2¼	3 6 8	Mar, Sept	2⅛	–
5	3/0	Do. 6 per Cent. Pref.	5 –5⅜	5 11 6	Mar, Sept	..	–
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92 –96	4 3 6	Jan, July	93	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅝ –5⅛	5 17 6	April, Oct	4⅞	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝ –5⅛	4 8 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	103 –109	4 2 6	June, Dec	–	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85 –88	3 19 6	Jan, July	87	–
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98	4 12 0	June, Dec	–	..
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	5 –5½	3 13 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	88 –90	5 0 7	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	3⅞ –4⅛	10 0 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 –5⅜	4 18 9	Feb, Aug	–	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	94 –96	4 1 3	Jan, July	–	–
100	..	North Metro. Elec. Power Sup. 5 Morts	100 –102	..	..	..	..
1	3%	Northern Counties Elec. Sup.	–	..	Mar, Aug	..	–
100	4½%	Do. 4½ per Cent. Deb.	91 –93	4 17 10	Jan, July	–	..
10	8/0	Notting Hill Electric Ord.	11 –12	5 16 6	March ..	–	..
5	4/6	Oxford Electric Ord.	6 –6½	5 8 0	March ..	6⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 –97	4 2 6	Jan, July	..	–
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅞ –9⅜	5 7 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 –7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	88 –90	3 18 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	5/16 –11/16	..	Feb	–	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 –70	5 14 0	Feb, Aug	..	..
5	4/0	†South London Electric Supply Ord.	2⅜ –2¾	7 5 0	April	2 11/16	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	¼ –½	5 0 0	..	..	–
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	1 1/16 –1 3/16	5 11 6	Feb, Aug	..	..
St.	4½%	†Do. 4½ 1st Db. Stk. Red.	100 –103	4 7 6	April, Oct	100½	–
5	2/6	†Urban Electric Supply Ord.	½ –1	–	April, Oct	..	–
5	2/6	†Do. 5 per Cent. Cum. Pref.	1½ –2	11 15 6	April, Oct	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	78 –82	5 10 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9½ –9¾	5 2 6	Mar, Sept	9⅝	9 7/16
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛ –5½	4 2 0	Jan, July	5¼	.
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	96 –98	4 2 0	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.	⅛ –¼	..	April	..	–
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ –⅝	6 13 0	Jan, July	..	–
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	88 –92	4 18 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 –92	4 18 6	Jan, July	90½	89½
10	6%	Bristol Tramways & Carriage Ord.	9½ –9¾	6 2 6	Feb, Aug	..	–
10	4%	Do. Cum. Pref. (fully paid)	8½ –9	4 9 0	..	..	–
St.	4%	Do. 4 per Cent. Debs.	99 –100	4 1 0	Feb, Aug	..	–
10	..	British Electric Traction Ord.	[illegible]	..	June, Dec	⅞	⅞
10	8/0	Do. 6 per Cent. Cum. Pref.	2⅝ –2⅞	11 8 0	Feb, Aug	2⅞	2
St.	5%	†Do. 5 per Cent. Perpetual Debs.	81 –85	5 14 0	April, Oct	85	85½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 –73	6 3 0	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	65 –67	5 3 0	Feb, Aug	67	65½
St.	4%	Do. 4 per Cent. Pref. Stock	83 –85	4 14 0	Feb, Aug	85	84
St.	2½%	Do. Deferred Stock	49 –51	4 18 0	Feb	–	..
100	4%	Do. 4 per Cent. Debs.	102 –104	3 16 6	Jan, July	103½	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 –94	4 5 0	Jan, July	93½	93½
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ –4¾	5 5 0	April, Oct	..	–
100	4%	Do. 4 per Cent. 1st Mort. Debs.	99 –103	3 17 6	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31 –32	4 14 0	Feb, Aug	3.	29½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 –112	4 9 0	Feb, Aug	–	..
St.	5%	Do. (1896)	103 –109	4 11 0	Feb, Aug	–	..
St.	5%	Do. (1901)	102 –105	4 15 0	Feb, Aug	..	–
St.	5%	Do. (1903)	90 –95	5 4 6	Feb, Aug	94	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 –102	3 18 0	May, Nov	..	–
10	6/0	Dublin United Trams. Ord	11½ –12½	4 16 0	Feb, Aug	..	–
10	6/0	Do. 6 per Cent. Pref.	12½ –13½	4 9 0	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	⅜ –⅝	..	Feb, Aug	..	–
10	4/0	G. Northern, Piccadilly & Brompton Ord.	..	–	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 –94	4 5 0	Jan, July	93½	9.½
5	2/0	Hast. & Dis. E. Trs. 6% C. P. ex 2, -ooac. ofa rs.	2 –3	..	Mar, Sept	..	–
St.	4½%	†Do. 4½ Db. St.	78 –83	5 8 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	7 –8	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	7 –7½	8 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	85 –90	5 0 0	Jan, July	..	–
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ –1⅜	..	Mar, Sept	..	–
St.	4%	Do. 4 per Cent. Deb. Stock	54 –59	6 18 0	Jan, July	.	–
10	6/0	Lanarkshire Tramways	9¼ –10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 –93	5 7 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1 –1½	..	Feb, Aug	–	–
10	5%	Do. 5 per Cent. Pref.	4¼ –5¼	9 10 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82 –4	4 15 3	Jan, July	–	..
10	2/6	London United Trams. 5% Cum. Pref.	3 –4	12 10 0	Jan, July	3⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	69 –74	5 8 0	Jan, July	7½	..
St.	–	Mersey Con. Ord. Stock	1 –2	–	Feb, Aug.	–	–
St.	–	Do. 3 per Cent. Perp. Pref.	2 –3	–	..	..	..
1	..	Metropolitan Elec. Tramways Ord.	[illegible]	–	..	..	–
1	–	Do. Deferred	[illegible]	..	April.. .	.	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 –97	4 13 0	Jan, July	96½	96
St.	½%	Metropolitan Railway Consolidated	36 –37	1 7 0	Feb, Aug	36½	36
St.	3%	Do. Surplus Lands Stocks	69 –71	4 4 6	Feb, Aug	69½	69½
St.	3½%	Do. 3½ per Cent. Preference	87 –89	3 18 6	Feb, Aug	88½	88
St.	3½%	Do. 3½ per Cent. "A" Preference	78 –80	4 7 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	75 –77	4 11 0	Feb, Aug	76	75½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 –94	3 14 6	Jan, July	93½	..

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., April 14.	Rate % Yielded (£ s. d.)	Dividend Due	Business 8 Days to April 14 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	90 —92	3 16 0	Jan, July	91½	91½
St.	..	Metropolitan District Railway Ord.	14½—15	—	Feb, Aug	15	14½
St	..	Do. Extension Pref. (5 per Cent.)	30 —33	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	63 —66	5 6 0	Feb, Aug	..	..
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	77 —79	3 16 0	Jan, July	78¼	77¾
St.	4%	Do. 4 per Cent. Midland Rent-charge	103 —105	3 16 0	Jan, July	103	..
St.	4%	Do. Guar. Stock 4 per Cent.	81 —84	4 15 0	Mar, Sept	83	82½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	135 —138	4 7 0	Jan, July	136¾	136½
St.	4%	Do. 4 per Cent. Ditto	89 —92	4 7 0	Jan, July	90⅜	90⅛
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—¾	—	May	..	—
1	0/9⅗	Potteries Electric Traction Ord.	¼—¾	8 0 0	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—⅝	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	88 —91	4 19 0	May, Nov	..	..
1	0/7⅕	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	73 —77	5 3 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5%1stMt.Db.	80 —84	5 19 0	Jan, July	..	..
..	...	UndergdE.Rys.Lon.6% In.bds.with coup.3	34 —36	..	June, Dec	35¼	35
..	21/11	Do. 5% Prior Lien Bonds	102 —103	4 17 0	..	103	102¾
—	4½%	Do. 4½% Bonds with coup. 2	84 —86	5 4 6	..	—	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	—	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	84 —88	5 2 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	9/32—13/32	..	..	..	..
1	0/7⅕	Do. 6% Cum. Pf.	23/32—27/32	6 12 0	April, Oct	..	..
1	1/7⅕	Babcock & Wilcox Ord.	4⅛—4¼	4 14 0	April, Oct	4¼	4⅛
1	0/7⅕	Do. Pref.	1 1/16—1 3/16	3 15 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¾—7¼	7 0 0	July, Feb	7 1/16	7
5	3/0	Do. 6 per Cent. Pref.	6 —6⅜	4 14 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	5/16—9/16	..	Feb, Aug	—	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	94 —96	6 5 0	..	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock‡	38 —43	9 4 0	Jan, July	..	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	56 —61	7 7 6	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	33 —38	11 16 0	Jan, July	—	—
5	5/0	Callender's Cable Con. Ord.	9½—10½	6 13 6	Jan, July	10	—
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5¾	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	..	..
1	1/6	Castner-Kellner Alkali Co.	1⅝ —1¾	7 7 0	May, Nov	1¾	1 11/16
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —107	4 4 0	Feb, Aug	..	..
1	0/7⅕	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	7 11 6	March ..	..	—
	0/7⅕	† Do. 6 per Cent. Cum. Pref.	15/16—1 1/16	5 13 0	April, Oct	..	..
1	0/8⅖	Consolidated Electrical Co.	5/16—7/16	8 5 0	August ...	...	..
1	1/0	Consolidated Signal Co.	1⅛—1¼	8 0 0	April, Oct	..	..
1	0/7⅕	Do. 6 per Cent. Cum. Pref.	29/32—31/32	6 4 0	April, Oct	1 3/16	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	1 —1¼	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	95 —98	5 2 0	Jan, July	..	—
1	0/7⅕	†Davis & Timmins	⅞—1⅛	..	Mar, Sept	—	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1¼	8 0 0	Sept	—	—
5	0/7⅕	† Do. 6 per Cent. Cum. Pref.	1 3/32—1 7/32	4 16 9	Sept ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.)(£3 pd.)	⅜—⅝	..	Feb, Aug	—	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	76 —78	5 2 9	June, Dec	..	..
St.	5%	† Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	—	..
5	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	59 —62	7 5 0	Jan, July	61	..
2	..	Electric Construction Co.	¼—½	..	Jan, July	—	..
2	2/9⅗	Do. 7 per Cent. Cum. Pref.	1 —1½	9 6 9	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 —64	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—7¾	6 9 0	June, Dec	—	..
St.	4%	† Do. 4 per Cent. 1st Mort. Debs.	83 —87	4 10 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11½—12½	6 0 0	Feb, Aug	12	..
5	2/3	Do 4½ per Cent. Pref.	5 —5½	4 2 0	Feb, Aug	..	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 2 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Wrks.	15 —16	6 5 0	Feb, Aug	..	..
10	..	Do. 5 per Cent. Cum. Pref.	10¾—11	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	98 —100	4 0 0	April, Oct	—	—
1	.	National Elec. Construction Co.	⅜—⅝	..	April	..	..
1	.	Richardsons, Westgarth & Co., Ltd. Ord.	11/32—13/32	..	Nov	..	..
1	7½	Do. 6 per Cent. Cum. Pref.	9/16—11/16	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	—	—	83	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	..	—
12	24/0	Telegraph Construction & Maintenance	32 —34	5 9 0	Mar, July	33½	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.	2 3/32—2 5/32	4 15 9	..	2 3/32	2 1/16
1	0/6	† Do. 5 per Cent. non-Cum. Preference	1 1/16—1 3/16	4 8 0	..	1 3/32	1⅛
St.	5%	† Do. 5 per Cent. non-Cum. Preferred	106 —109	4 11 6	..	107	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	104 —106	3 14 6	June, Dec	105½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 6	June, Dec	105½	105
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 9	..	107¼	105½
10	6/0	J.G.White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	4 0 0	Apr, Oct	21/32	..
5	2/0	Do. 6 per Cent. Cum. Pref.	2⅛—2⅝	11 8 0	Apr, Oct	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	72 —76	5 5 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3¼	—	June, Dec	2 15/16	..
100	5%	Do. 5 per Cent. Debs. (red.)	92 —95	5 5 0	June, Dec	..	..
St.	19/0	Anglo-American	55 —58	5 13 6	F,My,Ag,N	55	..
St.	30/0	Do. Preferred	100 —102	3 18 0	F,My,Ag,N	101¾	100½
St.	3/0	Do. Deferred	14 —14¼	2 16 0	F,My,Ag,N	14 3/16	14⅛
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk.	86½—88½	4 10 6	Jn,Ap,Jy,O	86⅝	..
10	6/0	Cuba Submarine Ord.	7½—8½	6 17 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	6 11 0	Feb, Aug	..	..
5	2/0	†Direct Spanish Ord.	3 —3½	[illegible] 15 0	April, Oct	—	..
5	5/0	† Do. 10 per Cent. Cum. Pref.	8½—9½	5 8 0	April, Oct	—	..
50	4½%	Do. 4½ per Cent. Deb.	100% 102%	4 8 0	Jan, July	..	..
20	4/0	†Direct United States Cable	12¼—12¾	6 15 3	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St	[illegible]	Eastern Ordinary	129½—132½	5 6 0	Ja,My,JyO	130½	130
St	17/6	Do. 3½ per Cent. Pref. Stock	85 —87	4 0 6	Ja,My,JyO	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104 —106	3 15 6	May, Nov	..	..
St	2/6	Eastern Extension	11¾—12⅜	5 11 6	Ja,Ap,Jy,O	12 3/16	12⅛
100	4%	Do. 4 per Cent. Deb. Stock	100 —102	3 18 0	Feb, Aug	..	..
25	4%	Eastern & S.Af. 4% Mauritius Sub. Debs.	101 —103	3 17 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 75	29 —31	6 9 0	Jan, July	30½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
25	12/6	Indo-European	62 —65	3 18 6	May, Nov	64	..
100	$1	Mackay Companies Common	72 —77	5 4	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	71 —76	5 5 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	¾—⅞	..	April		13/16
100	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	100 —102	3 18 0	June, Dec	—	—
2½	1/3	West Coast of America	1⅜ —1⅝	3 15 6	May	..	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
10	..	West India & Panama	[illegible]	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	7⅝—8⅜	7 2 6	May, Nov	8½	..
10	12/0	Do. 6% 2nd Pref.	7½—8½	—	May, Nov	7¾	..
100	6%	Do. 6 per Cent. Debs.	100 —102	4 18 0	Jan, July	7¾	..
10	3/0	†Western Telegraph	13 —13½	5 4 0	Mr,Jn,O,D	13½	13 1/16
St	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	102½	101½
...	4%	Western Union Telegh. $1,000 4% Bonds	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Share	Last Dividend	Name	Price Wed., April 14.	Rate % Yielded (£ s. d.)	Dividend Due	Business 8 Days to April 14 Highest	Lowest
		TELEPHONES.					
100	2$	†Amer. Telephn. & Telegh. Cap. St.	139½—140½	5 14 0	..	141½	136½
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98 —100	4 0 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	98 —100	5 0 0	Mar, Sept	..	—
5	3/0	Chili Telephone	7⅞—8⅜	4 15 6	August ..	..	..
1	0/7⅕	Monte Video Telephone Ord.	27/32—31/32	6 4 0	Nov	..	—
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106 —108	5 11 0	Feb, Aug	107	106½
St.	6%	Do. Def. Stock	121 —123	4 17 6	Feb, Aug	122½	120½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11½	5 6 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11½	5 6 6	Feb, Aug	..	...
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5⅝	4 9 0	Feb, Aug	5 9/16	[illegible]
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	98⅜	98
St.	4%	Do 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	..
1	0/7⅕	Oriental	1 5/16—1 7/16	5 9 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	April, Oct	—	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	..
5	3/0	United River Plate	6¾—7	5 14 0	July	6 13/16	6¾
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅜	4 13 0	June, Dec	5¼	—
St.	4½%	Do. 4½ Deb. St. Red.	103 —105	4 5 6	Jan, July	..	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜—3⅞	7 14 0	Jan, July	..	..
10	2/0	†Globe Telegraph & Trust	10⅛—10⅜	5 5 0	SpDcMrJu	10¼	10 3/16
10	3/0	† Do. 6 per Cent. Pref.	12⅞—13⅜	4 9 9	SpDcMrJu	13 3/16	12 15/16
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	8/0	Anglo-Argentine 6% Cum. 1st Pref.	6 1/16—6 5/16	4 15 3	April, Oct	6¼	5¾
5	5/0	Do. 10% Non-cum. 2nd Pref.	9 1/16—9 5/16	5 8 0	Jan, July	9 3/16	9 1/32
St.	4%	Do. 4% Deb. Stock	91 —93	4 6 0	June, Dec	92	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 0	Jan, July	..	..
5	2/6	Brisbane Electric Trams. Invest. Ord.	5½ —5¾	3 9 0	May	5⅝	5 9/16
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5 3/16	4 16 9	May, Nov	..	—
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	101 —105	4 5 9	Jan, July	..	..
St.	8%	British Columbia El.Ry.Df. Ord.	142 —146	5 9 6	Mar, Sept	..	..
St.	6%	Do. Pref. Ord. Stock	121 —125	4 16 0	May, Nov	122¾	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	107 —109	4 12 0	Jan, July	105½	107¼
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102½—104½	4 6 0	April, Oct	...	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 6 8	Jan, July	..	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	98½—100½	4 4 6	—	..	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	96 —98	5 2 0	Mar, Sept	96½	93¼
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	89 —93	6 9 0	Feb, Aug	..	..
5	2/0	Calcutta Tramways (1 to 137,610)	4½—5	4 10 0	Mar, Sept	5¼	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅜	4 16 6	Jan, July	..	—
1	4½%	Do. 4½% 1st Deb. Stock (red.)	99 —102	4 8 0	Jan, July	100	..
St.	..	Cape Electric Tram Shares	⅛—⅜	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904)Sh.	5⅝—5⅞	4 5 6	F,My,A,N	5 13/16	5¾
St.	4%	Do. 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	89 —92	5 8 6	May, Nov	—	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 —88	5 18 9	June, Dec	..	—
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	88 —93	5 7 6	Feb, Aug	90½	90½
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	84 —88	5 14 0	Jan, July	..	—
5	6%	Do. 6 per Cent. "B" Ditto	58 —63	9 10 0	Jan, July	..	—
5	1/0	Lisbon Elec. Trams. Ord.	1 —1⅛	4 9 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	95 —100	5 0 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	90 —93	5 7 6	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	92 —96	5 4 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	141 —143	4 5 6	..	141½	[illegible]
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	93½—94½	5 5 6	..	94⅜	94
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	102 —104	4 6 6	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	103 —106	..	..	..	..
1	1/0	Perth Elec. Trams Ord	21/32—23/32	6 12 6	May	..	—
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	—	—
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅝	5 6 6	..	5 11/32	5 5/16
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..	—
100	..	Rio Janeiro Tram, Lt. & P. Co.	100½—102½	..	..	101⅞	101
..	5%	Do. 30 yr. Gold Bnds.	93¾—94¾	5 5 6	..	91⅜	93¼
100	5%	† Do. 10 yr. Mt. Bnds	84½—85½	..	..	85½	84¼
—	$1½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	157 —158	6 0 0	..	158	157
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100 —101	4 19 0	June, Dec	101	100¼
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	9¾	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	90 —91	4 16 0	Jan, July	..	..
5	3/3	Calcutta Elec. Supply Ord.	6½—7	5 14 0	April, Oct	..	..
100	$1¾	†Canadian Gen. Elec. Co. Com. St.	114½—115½	6 1 0	..	114½	114¼
100	$3½	† Do. 7% Cm. Pt. Stock	116 —117	..	..	116½	115
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —102	4 13 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	85 —87	5 15 0	..	85¾	85¼
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1¾—2¼	..	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Deb Stock	90 —94	5 6 6	Jan, July	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½—90½	5 10 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	..
10s	0/3	Kalgoorlie Elec. Power & Ltg. Ord.	3/16—5/16	..	..	..	..
1	0/7⅕	Do. 6 per Cent. Cum. Pref.	⅝—⅞	7 10 0	April, Oct	21/32	..
St.	6%	Madras E.S. Corp. 5 per Cent. Constn. Deb. St.	73 —82	6 2 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	[illegible]	5 13 0	..	83½	87½
St.	$1½	Mexican Lt. & Power Co. Com. St.	[illegible] —79	7 13 6	—	74¾	78
500	5%	Do. 5% 1st Mort. Gold Bnds.	91½—92½	5 8 0	..	92⅜	91½
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	116 —118	5 2 0	F,My,A,N	..	..
1	[illegible]	River Plate Electricity Co. Ord.	[illegible]	4 2 6	April	1⅜	[illegible]
1	1/2⅖	Do. 6 per Cent. non-Cum. Pref	[illegible]	6 6 3	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	101 —104	4 16 0	Jan, July	..	—
5	8/0	†Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5¼	5 14 0	April, Oct	..	..
100	$1	Shawinigan Water & Power Co. Ca	96½—98½	4 1 6	—	98	97
..	5%	Do. 5 per Cent. Bds.	106 —108	4 12 6	Jan, July	107	..
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 — 99	..	..	99	98½
[illegible]	[illegible]	[illegible] Falls Power Co. Pref.	[illegible]	5 0 0	Jan, July	[illegible]	[illegible]

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NOTES.

The Institution of Electrical Engineers.

THE following nominations for the new Council of the Institution of Electrical Engineers were announced at the meeting yesterday evening:—

President.
Dr. Gisbert Kapp.

Vice-Presidents.

Sir H. H. Cunynghame, K.C.B.	*S. Evershed.*
W. Duddell, F.R.S.	Col. H. C. L. Holden, F.R.S.

Members of Council.

W. W. Cook.	Major W. A. J. O'Meara, C.M.G.
G. K. B. Elphinstone.	W. H. Patchell.
Dr. E. Hopkinson.	*J. H. Rider.*
J. W. Jacomb-Hood.	W. Rutherford.
W. Judd.	J. F. C. Snell.
T. Mather, F.R.S.	G. Stoney.
W. M. Morrison.	A. H. Walton.

C. H. Wordingham.

Associate Members of Council.

E. Russell Clarke.	H. Human.

J. E. Taylor.

Hon. Treasurer.
Robert Hammond.

The names printed in italics are new nominations. The hon. treasurer retires annually, and is eligible for immediate re-election.

No engineer was more closely associated with the early days of electrical engineering than Dr. GISBERT KAPP, who was welcomed back to this country, after an absence of a few years in Germany (where he occupied conspicuous positions as Editor of the "E. T. Z.," and as secretary of the Verband Deutscher Electrotechniker), to fill the chair of electrical engineering at Birmingham University. Of the vice-presidents, Sir HENRY CUNYNGHAME has already served on the Council, and is well known in connection with patent law; but in recent years he has been connected more particularly with the legal restrictions which in this country become necessary to a growing industry, being at the present time one of the Assistant Under-Secretaries at the Home Office Mr. DUDDELL and Mr. EVERSHED have served on the Council on previous occasions and their careers are well known to our readers. Of the new ordinary members of Council, Mr. W. W. COOK is assistant chief engineer of the National Telephone Co., Mr. G. K. B. ELPHINSTONE, we need scarcely say, is identified with Messrs. Elliott Bros., and was formerly associated with the firm of M. Theiler & Sons; Mr. WALTER JUDD, electrician-in-chief of the Eastern & Associated Telegraph Companies, has served on a previous occasion, as have also Mr. J. H. RIDER and Mr. C. H. WORDINGHAM. On the other hand, the Council are introducing some new blood by the selection of Mr. W. M. MORRISON, engineer and managing director of the British Aluminium Co. Among the associate members of Council, Mr. E. RUSSELL CLARKE is an entirely new nominee, and is well known in that section of the Bar dealing with patent actions.

Another Solution of the Wiring Problem.

AT present it may be said that there are two schools of thought in regard to the wiring problem, or the problem of wiring houses at a reasonably low cost. One school prefers the device of giving the cable a metallic covering sufficiently strong to afford mechanical protection, but at the same time not so stiff as to prevent easy flexibility. The Stannos system, which we described a week or two ago, is an example of this kind. Such a system presents a satisfactory solution, and one that can be applied to work not only upon the surface, but equally well to work that is concealed beneath the plaster. The second school of thought is concerned with surface work exclusively. In this connection we have pointed out on previous occasions that although ordinary "flexible" may not be so suitable for the purpose in this country as abroad, a special kind of cable might very well be evolved for the purpose. The ordinary "flexible" stands a good deal of everyday wear, and little exception is taken to it. Therefore, a more hardy variety should surely be suitable for surface wiring where no very great wear would be experienced. We are glad to

note that Simplex Conduits, Limited, have taken the matter up, and, as will be seen in another column, three grades of flexible twin wire are now available for surface work of this kind. The first grade is armoured with tinned-iron wire, the second grade is covered with flame-proof material in place of such armouring, and is weather-proofed beneath the flame-proofing, and the third grade is simply covered with cotton, the covering beneath this cotton also being weather-proofed. We do not doubt that cables of this class will meet a very distinct want, and we trust that this kind of surface wiring will receive more careful attention now that the desired material is at hand.

The Electric Supply Industry in America.

Some idea of the progress made by the electricity supply industry in America is afforded by the central station statistics contained in the half-yearly electrical directory issued by the publishers of our contemporary, the "Electrical World." The most recent publication contains particulars of 5,740 plants on the North American continent, of which 5,264 are in the United States. The corresponding figures a year ago were 5,464 and 5,015 respectively, and the number of new plants is really much greater than is indicated by these figures, since a large number were last year absorbed or consolidated; actually, during the last six months alone, 195 new stations in the United States have been entered in the directory. When these figures are compared with the returns contained in our recent Electric Supply Tables the difference in the development of electricity supply in the smaller towns in this country and America becomes most marked, for it is probably in the number of these small plants that the difference between the returns for the two countries must be sought. One factor that helps such a movement is that in America the small town of to-day is a large town to-morrow, whilst, in this country, no such rapid development can be looked for to aid electrical enterprise. Another feature encouraging the adoption of electric power is the extensive system of inter-urban electric railways, which has been so far developed that it will probably be possible, at an early date, to travel from New York to Chicago, a distance of about 900 miles, by such means. Since no less than 4,154 of the plants give an alternating current supply, there seems every inducement for the adoption of metallic filament lamps. The great preponderance of these plants is certainly interesting when compared with the tendency to favour continuous current for small stations in this country.

Royal Society.—Among the Papers read at the meeting yesterday afternoon was one on "Dynamic Osmotic Pressures," by the Earl of Berkeley, F.R.S., and Mr. E. G. J. Hartley.

Imperial College of Science and Technology.—At a recent meeting of the Governors it was decided, subject to the approval of the King in Council, to recognise the association of the College with the metallurgical department of the Sheffield University for the subject of advanced metallurgy in iron and steel. It was felt that this course would provide greater facilities than would be obtained by organising a new department.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Pontianak—Saigon	Sep. 16, 1908 ...	Apr. 16, 1909
Tourane—Amoy	Jan. 19, 1909 ...	Apr. 19, 1909
Hong Kong—Macao............	Apr. 13, 1909 ...	—
Obock—Djibouti	Apr. 15, 1909 ...	—

Fatal Accident to Prof. Tufts.—A recent Central News telegram states that Mr. F. L. Tufts, professor of physics in Columbia University, was recently killed while engaged in some electrical testing work.

Iron and Steel Institute.—We announced in our last issue that Sir Wm. Lewis, president of this Institute, might be unable to preside at the forthcoming annual meeting in London. Sir William has now intimated that he will be unable to hold office, thus placing the council in a position of some difficulty. Under these circumstances Sir Hugh Bell has consented to hold office for a further term of twelve months.

Junior Institution of Engineers.—The twenty-fifth annual dinner of this Institution will be held at the Hotel Cecil on Saturday, May 1st, at 7 for 7:30 p.m. Mr. James Swinburne, F.R.S., president of the Institution, will occupy the chair, and Mr. R. B. Haldane, M.P., will be the guest of the evening.

The visit of the Institution to inspect s.s. "Otaki" has been postponed till April 28th.

Victorian Institute of Engineers.—The annual general meeting of this Institute was held in Melbourne on March 10. The report of the Council stated that the increase in the number of members was the largest in any one year since the early days of the Institute, and a promising feature was the establishment of a student grade. A salaried secretary (Mr. D. L. Stirling) has been appointed, and Mr. J. A. Smith has been re-elected president, Mr. H. R. Harper becoming vice-president.

Leeds Section of the Institution of Electrical Engineers.—The following are the nominees put forward by the council of this section for election to the committee during the session 1909-10. The election will take place at the annual general meeting on May 5th: *Chairman*, Mr. W. M. Rogerson; *vice-chairman*, Mr. T. Harding Churton; *committee*, Messrs. A. B. Mountain, W. Hartnell, A. J. Cridge, H. H. Wright and S. W. Schofield; *hon. sec.*, Mr. H. Dickinson.

Power Generation by the Tides.—According to the "Elektrotechnik und Maschinenbau" the idea of utilising the force of the tides for the generation of electric power has not been altogether abandoned in Germany. With this end in view a station of an original kind is to be constructed on a branch of the Elbe. The promoters of this scheme are endeavouring to get users of light or power in the neighbourhood to take advantage of this method of utilising the movement of the North Sea.

New Type of Tantalum Lamp Filament.—According to the "Electrical World" a patent recently issued to Werner von Bolton, of Charlottenburg, describes a new type of incandescent-lamp filament, consisting of a homogeneous mixture of metallic tantalum intimately commingled with a carbide of tantalum or of a metal of the vanadium group. The most advantageous form of the invention is stated to be a mixture of tantalum and tantalum carbide, and is secured by heating tantalum powder, held in a plastic mass by a binder which is carbonised by heat, thus giving rise to the carbide of the metal.

Personal.—The Marylebone Electric Supply committee recently received 128 applications for the position of engineer and manager of the electricity undertaking, and this number was reduced to four. After interviewing these the committee recommended Mr. A. Hugh Seabrook, of West Ham, for the appointment, to which a commencing salary of £800 per annum is attached. Mr. Seabrook, who has been engineer and manager at West Ham for 3½ years, served his apprenticeship with Messrs. Crompton & Co. He was assistant at Great Yarmouth for three years, and spent a similar term at Hampstead, after which he became engineer and manager at Barking, from which place he migrated to West Ham. Mr. Seabrook has proved a most energetic and progressive chief of the West Ham electricity undertaking.

Aluminium Direct from Bauxite.—The difficulties and cost attendant on the reduction of aluminium by the usual method, which requires that the alumina shall be free from impurities before reduction, has led a German inventor to propose a process whereby the purification of the alumina and the reduction of the aluminium go on together, while a valuable by-product is also obtained. In this method, according to the

"Engineering and Mining Journal," the crude bauxite is mixed with carbon and a boron compound, and treated in the electric furnace. The iron and silica go into combination with the boron, forming an exceedingly hard material, which has a commercial value as an abrasive, while the pure alumina passes to another part of the same furnace, or to another furnace, if desired, for reduction into aluminium in the usual way.

Electric Heating and Cooking in Hotels.—According to the "Electrical Review and Western Electrician," the Stantley Hotel, at Estes Park, Colorado, is to be operated by electricity. Mr. F. O. Stantley, the proprietor, has acquired his own water-power, which, at a distance of four miles, will provide enough electric power to supply not only all the electricity for use in the hotel, but for his own private residence and for the cottages in Estes Park. Street lighting will also be supplied from the same source. The owner is determined to make his hotel representative of the latest ideas in applications of electricity, and has ordered a complete electric-cooking equipment for his kitchen; electric water heaters for supplying hot water for the baths, kitchen and laundry; also electrically-heated mangle and flat-irons for the laundry. When open for regular service this summer the hotel will be "up to the minute" in all its electrical appointments.

Héroult Electric Furnace in California.—The "Electrical World" states that the Noble Electric Steel Co., of Héroult, California, is about to start up an electrical process for smelting iron. The cost of electrical energy at Héroult is £2. 8s. per horse-power year, or £3. 4s. per kw.-year. In an experimental furnace, which made several test runs last year, it is stated that $1\frac{1}{2}$ tons of iron were produced per day at a cost of 17s. per ton of pig iron for electric energy. With the larger furnace, now nearing completion, from 15 to 20 tons of pig iron a day will be produced for an expenditure, it is believed, of 16s. per ton for electrical energy. It is claimed that iron can be made at the furnace for £3. 4s. a ton. The electric smelting furnace for iron ore consists of a concrete stack 20 ft. high, with electrodes fixed in the walls of the crucible, the charging being done from the top, so that a long column of charge is pre-heated before it reaches the fusion zone between the electrodes. The electrodes are 24 in. apart.

Magnetite Arc Lamps.—A patent recently issued in the United States to Dr. C. P. Steinmetz describes the use of arc-lamp electrodes composed wholly or largely of magnetite. When the positive electrode is made of this material the arc gives off a brilliant white light having a spectrum like that of iron. The inventor states that the negative electrode need not be of magnetite, as the composition of the positive electrode determines the quality of the light. He suggests the use of certain impurities, such as magnesia, lime or alumina compounds, in the positive electrode for improving the performance of the lamp. In a patent issued to Dr. W. R. Whitney the use of copper for the negative electrode is described. This electrode is so constructed that the heat generated by the arc will maintain it at a certain temperature which is below that of oxidation of the copper, but which is high enough to prevent the products of combustion of the arc from condensing on the electrode.

Corps of Electrical Engineers.—A detachment of the Corps of Electrical Engineers visited Sheerness for an Easter training, under the command of Capt. H. E. Webb-Bowen and Sec.-Lieut. W. E. Hammerton. They returned to town on Saturday last. The weather during the training was on the whole favourable for carrying out the work of the corps, the detachment being engaged in running the searchlights installed at Sheerness for the defence of the Medway. On Wednesday morning there was an inspection by the officer commanding the Royal Engineers at Sheerness in company drill, and in the evening in technical work. Great satisfaction was expressed by the inspecting officer at the smartness of the detachment. On Friday afternoon, the 16th inst., a further drill inspection was held by the Chief Engineer from Chatham, who was accompanied by the Commanding Officer at Sheerness. A technical inspection was also held during the evening, when an attempt was made by several small torpedo craft to enter the river unobserved, which attempt, however, proved unsuccessful owing to the boats being in every case picked up by the searchlight beams. The Chief Engineer expressed great satisfaction at the manner in which the men carried out their various duties and complimented them on their smartness and general efficiency.

Incorporated Municipal Electrical Association.—The annual convention of the Association will this year be held in Manchester from June 21st to 26th, under the presidency of Mr. S. L. Pearce, city electrical engineer. The meeting will be opened by a conversazione at 7:30 p.m. in the Town Hall, when the Lord Mayor of Manchester, Ald. E. Holt, will welcome the members. The Lord Mayor will also open the proceedings on Tuesday at the Municipal School of Technology, in Whitworth-street, when the presidential address will be delivered and a number of Papers read. On the same day a luncheon will be held at the Town Hall, at the invitation of the chairman and members of the Manchester Electricity Committee, and several works in the vicinity will be visited. Wednesday is to be spent in Liverpool, where the members will be welcomed and entertained by Sir Charles Petrie and the members of the Tramways and Electric Power and Lighting committees in that city. Visits to the "Mauretania" and other "sights" will be paid in the afternoon. On Thursday papers at Manchester will again be the order of the day, the annual dinner taking place in the evening, while on Friday the annual general meeting will be held. The headquarters of the Association will be at the Midland Hotel, Manchester, and arrangements have been made for entertaining the ladies of the party while the male members are engaged in the more serious work of the convention.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, April 23rd (to-day).

PHYSICAL SOCIETY OF LONDON.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: (1) "On a Want of Symmetry shown by Secondary X-Rays," by Prof. W. H. Bragg, F.R.S. (2) "Transformations of X-Rays," by Mr. C. A. Sadler. (3) "Theory of the Alternate Current Generator," by Prof. T. R. Lyle.

THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's Gate, St. James's Park, Westminster, S.W. Presidential address by Mr. J. A. F. Aspinall.

STUDENTS' SECTION OF THE INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Meeting at Great George-street, Westminster, S.W. Paper on "The Development of Hydro-Electric Power Schemes; with Special Reference to Works at Kinlochleven," by Mr. J. M. S. Culbertson.

ROYAL INSTITUTION OF GREAT BRITAIN.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Tantalum and its Industrial Applications," by Mr. Alexander Siemens.

MONDAY, April 26th.

THE INSTITUTION of CIVIL ENGINEERS.

8 p.m. Meeting at Great George-street, Westminster, S.W. "James Forrest" Lecture on "Road Motors," by Col. H. C. L. Holden, F.R.S.

TUESDAY, April 27th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Annual General Meeting at Great George-street, Westminster, S.W.

THE FARADAY SOCIETY.

8 p.m. Meeting in the Library of the Institution of Electrical Engineers, 92, Victoria-street, S.W. Papers on (1) "Experiments on the Current and Energy Efficiencies of the Finlay Alkali Chlorine Cell," by Messrs. F. G. Donnan, J. T. Barker and B. P. Hill. (2) "On the Coefficients of Absorption of Nitrogen and Oxygen in Distilled Water and Sea Water, and of Atmospheric Carbonic Acid in Sea Water," by Dr. C. J. J. Fox. (3) "On the Electromotive Force of certain Platinum Compounds with Special Reference to the Oxygen-Hydrogen Gas Cell," by Mr. P. E. Spielmann.

Corps of Electrical Engineers (London Division).

Commanding Officer, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, April 26th, "A" Company	Infantry drill, 6:30 p.m.
Tuesday, April 27th, "B" Company	Infantry drill, 7 p.m.
Thursday, April 29th, "C" Company	Technical drill, 7 p.m. to 9:30 p.m.
Friday, April 30th, "D" Company	Technical drill, 7 p.m. to 9:30 p.m.

ELECTRICITY WORKS AND REFUSE DESTRUCTORS.*

BY J. A. ROBERTSON.

Summary.—After considering the nature of the problem involved in the use of a destructor with an electricity works, the author deals briefly with the most important points in destructor design. Finally, the results achieved at Greenock are given in detail.

Although combined electricity and destructor stations are now increasing at the rate of about 20 per annum, the value of the combination is still a matter of controversy.

Refuse disposal by cremation is primarily a sanitary measure, but the utilisation of what would otherwise be waste heat in the process naturally appeals to those responsible for municipal administration. Nevertheless any question of profit should be subservient to the requirements of cleanliness and public health.

It is proposed to show in this Paper that appreciable benefit can be obtained from the combination of electricity works and refuse destructors under certain conditions. The first is that there should be a fairly steady demand for energy on the electricity works.

The refuse must, of course, be collected daily, and it is desirable for sanitary reasons to transfer it from the collecting carts to the furnaces as quickly as circumstances permit. But unless the steam from the destructor can be utilised during the greater portion of the 24 hours, it will be necessary either to provide sufficient furnace capacity to burn a day's collection in a comparatively short period of time, storing the material as it is delivered, or to bye-pass the hot gases from the furnaces direct to the chimney. There are objections to such methods, and thus it follows that a continuous load must be available at the power station. In residential districts, where current is used chiefly for lighting purposes, it is questionable if any benefit is obtained from linking up the two undertakings, but where a power load exists, or where a tramway supply forms part of the output of the station, the refuse destructor and electricity works can be combined and operated with financial benefit to the community.

The refuse itself may be looked on as a low-grade fuel, which can be obtained free of cost, but requiring the employment of special plant for its combustion. From 15 cwt. to 1 ton of refuse is collected per 1,000 inhabitants per day. The chart (Fig. 1) shows the variation in delivery at Greenock during different periods of the year, and as the quantity of ash-pit refuse is less in summer, it will be seen that the value of the whole delivery is correspondingly reduced, so that while it is possible to obtain results as high as 86 units per ton in October, the figure in July falls as low as 24 units per ton. It has been suggested that in certain cases it would be profitable to reinforce the refuse with low-grade coal or coke dust in order to secure uniform steaming, and if a simple process of this kind could be devised which would enable the destructor boilers to be worked at or near their full capacity, irrespective of variations in the quality of the refuse, the steam-raising results could be enormously improved. There are difficulties, however, in designing a furnace to burn refuse and coal at the same time, and as matters stand the great difference in the quality of the refuse delivered from hour to hour, and throughout the year, constitutes the most serious drawback in combined installations, entailing the use of stand-by coal-fired boilers to ensure steady steam pressure at the engines.

The principal objection to combined installations by station engineers is the presence of dust or fine grit which finds its way into the engine room with bad results to the generating plant. The dust arises partly from the tipping of refuse—especially in dry weather—and in the operation of clinkering the fires, but is mostly due to the crushing and screening of clinker. It is only fair to point out that in most cases the dust objection might have been avoided, or at least obviated, by a better arrangement of buildings, and the author can affirm that in the Greenock installation no real trouble has been experienced from this cause.

The points which call for special attention in design are the charging or feeding of the refuse into the furnaces, the system of forced draught employed, the design of furnace and combustion chamber, and the position and type of boiler.

Charging.—The general practice hitherto has been to feed the refuse into the furnaces by manual labour. There are three systems of hand feeding, which may be classified as follows:—(*a*) The furnace is both fed and clinkered from the front. (*b*) The furnace is fed from the back, and clinkered from the front. (*c*) The refuse is tipped on top of the furnace, whence it is drawn or pushed through an opening in the furnace roof, where it falls on a drying hearth, and is then spread by manipulation through the clinkering door to a suitable thickness over the grate.

* Abstract of a Paper read before the Glasgow Local Section of the Institution of Electrical Engineers.

The great drawback to all hand-fed systems is the inrush of cold air which takes place during the time required for charging, and the consequent reduction in temperature of the furnace brickwork. Another serious objection is that the amount of labour, especially in front feeding, is very great, and the process of shovelling such difficult material is arduous and not clean. The chief recommendation of hand-fed systems is their simplicity, but it is also claimed that by selecting and feeding the refuse in small quantities better steaming results can be obtained than with automatic or mechanically fed systems. It would appear, however, that the cooling of the furnace during charging goes far to neutralise this advantage, which in any case is not sufficient to outweigh the sanitary objections to the system.

Mechanical Charging.—Having regard to the objections to hand feeding, it is not surprising that inventors have turned their attention to mechanical devices for feeding refuse into destructor furnaces. The earliest and best known of these is Bulnois & Brodie's system, in which movable iron trucks are employed. The apparatus is constructed in such a way that the movement of the charging truck opens and closes the furnace door so that the whole operation of depositing the refuse from the carts into the furnaces is carried out without the intervention of manual labour.

The system adopted in the Greenock installation is the automatic "tub-feed" system, which found favour chiefly on account of its sanitary advantages. In this system the refuse is tipped from the collecting carts into tubs or skips, each skip containing one load. The skips are then lifted by an electric crane and deposited on a storage platform, where they are kept till required for charging. This platform is erected over the clinkering floor, and is separated from the furnace brickwork to ensure cool storage. To charge a furnace, the skip is lifted from the platform by the crane and is placed on a movable cradle directly over the furnace opening, which is fitted with a

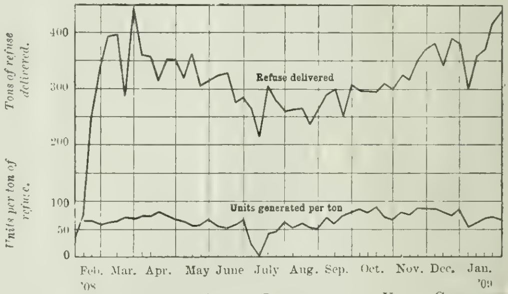


FIG. 1.—DIAGRAM SHOWING REFUSE DELIVERED AND UNITS GENERATED PER TON FOR YEAR ENDED JAN. 30, 1909.

water-sealed door. When released by the crane, the weight of the skip operates a system of levers and a balance weight in such a way as to lift the water-sealed door off the furnace and draw it to one side, so permitting the cradle to descend to the mouth of the charging door. The bottom of the skip consists of two hinged doors suspended so that when the skip reaches the proper position, the doors open outwards, and the contents of the skip are deposited directly into the furnace. The crane then lifts the empty skip, and the water-sealed door, actuated by the balance weight, is drawn back to its seat, the whole operation of opening the door, charging, and reclosing the door having occupied less than a minute.

The principal advantage of the system is, of course, its comparative cleanliness, and as the process of lifting the skips and charging the furnaces of an installation capable of cremating 100 tons in 18 hours can be performed entirely by one craneman, the saving in labour cost as compared with hand feeding is an important consideration. With this method of charging, the reduction of temperature which takes place during the slower operation of hand firing is largely overcome and the efficiency and capacity of the furnace is correspondingly increased. The disadvantage of the system is that it prevents any selection or proportioning of the charges, while the deposition of a whole cart-load of green refuse into the furnace at one charge is apt to cause fluctuations of temperature with consequent variation in steam pressure.

Furnaces and Boilers.—In modern destructor plants the following are essential features:—

1. Furnace chambers or cells designed so as to embody the principle of mutual assistance in operation.

2. A combustion chamber of sufficient capacity to maintain a high temperature under all conditions of working and designed to act as an sufficient dust trap.

3. A system of forced draught.

4. One or more boilers situated between the combustion chamber and the chimney.

Nearly all plants now in operation can be separated into two groups—*i.e.*, those in which the furnace chambers or cells are isolated from each other, the hot gases from two or more cells being led into a common combustion chamber, and those in which a number of grates are grouped in a common furnace. An advantage of the isolated system is that one unit can be shut down for repairs without affecting the operation of the others. In the common furnace system of construction only one of the sections, into which the grate is divided, is charged and clinkered at a time, and it is claimed that by charging frequently in small quantities a maximum temperature can be maintained in the cell itself. The smaller amount of brickwork exposed to high temperatures as compared with the isolated cell system is an undoubted advantage in keeping down the cost of repairs—a serious item in all destructor plants.

The object aimed at is the maintenance of high temperature in the products of combustion utilised for steam raising, and to obtain this it is essential with both types of construction that a large combustion chamber be provided *beyond* the furnaces, where all gases may be finally intermingled and cremated before coming in contact with the boiler. It is quite impossible to ensure that no green or partly burned gases will ever pass into the flues, and it is therefore essential that the chamber should be capable of storing sufficient heat in its brick walls to reduce the disturbance of temperature in the cells during charging and clinkering. The curve (Fig. 2) taken by an electrical pyrometer in the combustion chamber of one unit of the Greenock plant shows clearly the rise and fall of temperature during these operations. The second function of the combustion chamber is to trap as much as possible of the dust liberated from the furnaces.

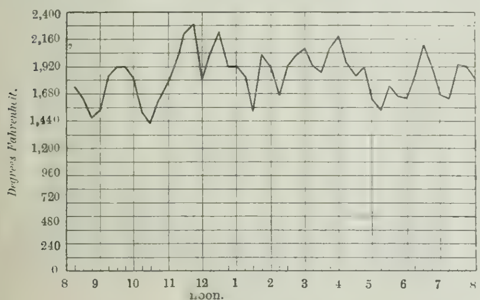


FIG. 2.—DAILY TEMPERATURE CHART, COMBUSTION CHAMBER.

The position of the boilers with relation to the cells is an importanc factor in the maintenance of high temperature. In some designs tht boiler is sandwiched between two cells, the gases from the fires passing through side openings into a combustion chamber directly beneath the boiler tubes. The better practice is to place the boiler beyond the combustion chamber, so that the green gases from newly charged refuse in passing through the chamber will combine with a large volume of higher temperature gases, thus becoming thoroughly mixed and cremated before they are brought into contact with the comparatively cooler surfaces of the boiler.

Draught and Combustion.—The possibility of utilising destructor heat for steam raising is undoubtedly due to the employment of forced draught for combustion. The large increase in the rates of burning through working at higher temperatures, and the fact that destructors can now be operated in populous districts without giving rise to nuisance, may also be credited to the same cause. Much controversy exists regarding the comparative merits of steam blowers and fan-produced draught for assisting combustion. It is claimed for the steam jet that it is less costly to instal, that the life of the fire-bars is more prolonged, and the process of clinkering the fires less arduous than with fan draught. Another claim, which is sometimes questioned, is that the steam jets in contact with the hot fuel produce a water gas which is of great value in raising the temperature of combustion. On the other hand, it is admitted that the amount of steam required for the steam jets is from 10 to 15 per cent. of the total steam generated in the destructor boilers, against 4 or 5 per cent. for steam-driven low-pressure fans, and that, although clinkering is easier, the quality of clinker is more fragile and not so suitable for building purposes.

The advantage of hot-air draught for all combustion processes is generally recognised, and the gain in efficiency by its use in destructor plant is beyond dispute, especially as the added temperature is usually obtained by heat which would otherwise be wasted. By placing a suitable heater in the main flue and passing the air through it before delivery to the furnaces, it is possible to add 300°F to 400°F. to its temperature, with a corresponding rise in the temperature of combustion. Another advantage of fan draught is that the air supply can be made to regulate itself to the requirements of the fuel. The amount of carbon in refuse may vary from 10 to 40 per cent., and to ensure complete combustion under all conditions the air supply should be capable of close regulation, and this can be easily attained with fan draught, either by hand-operated valves or by using a separate fan for each furnace driven by a shunt-regulated variable-speed motor. In most installations in this country the average draught pressure employed is from 1 in. to 2 in. of water column in the ash-pit, but much greater pressures can be employed with suitable fire-bars and thick fires. The Greenock plant was originally designed for a pressure of 9 in. to 12 in., and it was found possible with this pressure to work with fires from 18 in. to 2 ft. in thickness. The fire-grate is formed of solid iron bars perforated with numerous small holes through which the air is forced into the refuse. The experience gained after a few months' experimental working led finally to the adoption of an average pressure of 6 in., which appears to suit the varying conditions as efficiently as the higher pressure, with the advantage of economising the amount of power absorbed by the fans. The type of air heater usually employed consists of a battery of tubes built into the main flue, but in the Horsfall destructor the air is heated by passing it through side boxes in the furnace itself situated between the brickwork and the grate. It is found that their position here lessens the deterioration of the brickwork and assists the process of clinkering, but the author has found in practice that the comparatively small heating surface of the boxes and the rate at which the air must travel through them does not permit of a higher temperature than 180°F. being attained at the outlet, while a further disadvantage is that as the amount of heat imparted to the air depends on the temperature of the furnace, the draught is lowest immediately after charging, *i.e.*, just at the time when high temperature is most needed to dry the refuse and to commence combustion.

An ingenious system of superheating the air draught has been introduced by Messrs. Heenan & Froude in a destructor plant recently erected in Richmond, U.S.A. The furnaces are of this firm's standard hand-fed type, with four grates and divided ash-pits. A secondary chamber is provided below the furnace grate, and after the refuse has been cremated the hot clinker is manually withdrawn from the furnace and falls through an opening into the chamber beneath. A fresh charge is then fed into the furnace, and the air required for combustion—which has previously been drawn through an ordinary air-heater in the main flue—is passed through the hot clinker in the chamber before being delivered to the fires. Additional temperature is thus added to the air just when it is most required, and the clinker is also cooled down so that the process of withdrawing and barrowing away is rendered much easier than it would be in the ordinary way.

Boilers.—The two types of boilers in general use for destructor work are Lancashire and water-tube, the latter either of the marine or land type, although in one or two cases the tubular marine type has been successfully employed. It is usual to provide auxiliary coal-fired grates, with destructor boilers to increase the duty at times of abnormal demand ; but the author has found that the presence of hot gases from the destructor furnaces retards the process of coal combustion, and the actual benefit of the auxiliary coal-fired grate lies in the use which can be made of it when, through any reason, the destructor furnace is out of action. The experiment of forcing the boilers by mixing a charge of refuse with a smaller charge of coal in the destructor furnace was not a success, for on cleaning out the fires the coal was found only partially burned, the remainder being embedded in the clinker, which had apparently protected it from combustion.

The economy due to superheating steam is universally recognised with coal-fired boilers, and as the destructor boiler plant in combined works is generally situated some distance from the engine-room, the losses from steam-pipe radiation rae comparatively great. It is possible, by superheating, to ensure that at least dry steam only will be delivered at the engines, while the losses through drains and steam traps are materially reduced. At Greenock the steam at the boilers is at about 550°F., the temperature of the hot well is about 90°F., and that of the economiser outlet about 300°F. The distance between the destructor boilers and the engine stop-valve is about 100 ft., and it is found that in travelling through this distance the average temperature loss at normal full load is 40°F.

The high outlet temperature at the economiser gives the impression that full advantage is not being taken of the available heat in the boilers, and it might be possible by providing baffle walls in the boiler sections to absorb more heat in steam raising, and so reduce the temperature of the gases in the main flue ; but from experiments made in this direction it is doubtful whether any real advantage would

accrue. The reason appears to be that the dust which collects around the baffle plates and which can only be partially removed by cleaning while the boiler is under duty, reduces the available heating surface, with consequent reduction in the capacity and efficiency of the boiler. This question of dust in destructor flues and boilers has not always received the special attention by designers that its importance deserves, and the poor results obtained in many combined stations may generally be traced either to imperfect design of combustion chamber and flues or to insufficient space being allowed for dust settling.

However perfect the design of destructor furnaces, good results can only be attained if proper methods are employed in managing the installation. In coal-fired boilers, stoked by hand labour, we know that the efficiency may vary by as much as 20 or 25 per cent. with a change in the men employed. The importance of the stoker is, therefore, much greater when low-grade fuel such as town's refuse is dealt with, and to obtain continuity of temperature the most careful attention has to be given to the strength of air blast and the management and spreading of the fires. If the fires are allowed to blow into holes an immediate cooling effect takes place, and one reason for the difference between results obtained on trials and the average results over a longer period is probably the careful expert supervision —generally by the maker's representative—when test runs are being made. In burning refuse with heated air it is possible, if the fire is not carefully managed, to produce the appearance of perfect combustion on top of the fire, while the under side next the fire bars does not rise above the temperature of the incoming air. To overcome this the fire requires to be "managed," and so far the only method of doing this is by careful mixing and stirring of the refuse while it is burning.

It has been said that the best clinker is produced when the cells are also worked to the greatest advantage for steam-raising purposes; but the author's experience does not confirm this opinion, as he has found that with most classes of refuse a hard clinker cannot be produced unless the material is kept burning for some time after the maximum temperature has been attained, whereas for steam-raising purposes it is desirable that the maximum temperature should be attained as rapidly as possible, and the products of combustion withdrawn from the fire before the cell begins to cool down.

Supervision.—There have been differences of opinion in many cases, as to which department should supervise the working of the destructor, but from the experience already gained it is now generally admitted that if the best results are to be obtained the department which is responsible for utilising the steam should also control its production.

Financial Results.—The value of destructor steam to the electricity undertaking is a subject which has caused the widest difference of opinion. In Liverpool, where 600 tons of refuse are burned every day, no less than 9,209,369 units were generated from destructor steam during 1907, and this result has been obtained with non-condensing compound engines, using 50 lb. of steam per kilowatt-hour. In other towns, where the destructor is linked with the electricity undertaking, equally good results can be shown. In the Metropolitan districts the lowest fuel costs are claimed by Hackney, a combined station; while amongst smaller provincial towns another combined station—St. Helens—has long been noted for its low fuel cost per unit. The Liverpool undertaking, which returns 0·35d. per unit as its total fuel costs, only pays the cleansing department 0·2d. per unit for the 9,000,000 units generated at the destructor stations. At Partick, the first combined station in Scotland, the fuel costs were remarkably low for some years, the minimum figure of 0·20d. per unit sold being returned for 1905–6, when the bigger undertaking in Glasgow, with ten times the output, could only reach 0·23d. per unit. These facts give the impression that while in some cases the value of the destructor steam may be over-estimated there are others in which it does not receive its due share of credit.

The various methods employed in combined stations to determine the value of the destructor steam have been the subject of much contention. The only true valuation basis is, of course, the cost which would be incurred if the generating plant were run from coal alone under similar conditions as regards demand and output. To make the comparison accurate, any saving in capital cost to the electrical undertaking should be taken into account, and while it is rare to find any credit allowed to the destructor on account of saving in labour, there is no doubt that in most cases a saving does result to both departments due to combined supervision.

To take the saving in capital cost first, both departments will benefit from the obvious fact that the cost of a site for a combined undertaking is less than two separate sites. In buildings there is also an appreciable saving, and as one chimney will serve both undertakings, the cost will be halved to each. The saving in boilers is not so important as it appears, as it is necessary to provide a sufficient capacity of coal-fired boilers to guard against an interruption to the working of the destructor plant in winter, when snowfalls may interfere with the delivery of refuse, but the saving in maintenance and repairs should be considered. In feed pipes and piping there is a distinct gain through combination. In all these items the capital cost should be fairly apportioned between the departments, and any saving to the electricity department taken into account when adjusting the actual value of destructor steam.

In the combined installation at Greenock the difficulty of arriving at the steam value of the refuse was rendered easier through the generating station having been run exclusively by coal-fired boilers for three months before the destructor commenced working, and it was therefore possible to ascertain exactly the consumption of coal per unit generated and the efficiency of the boilers and generating plant. Separate water meters had been installed to register the evaporation in each set of boilers, and it was intended to apportion credit on this basis, but this method did not take into account the stand-by losses incurred through the irregular working of the destructor, and it was also found, on starting the destructor plant, that increased radiation losses from the steam pipes due to the position of the destructor boilers, brought up the consumption of steam per unit generated from 24 lb. to 26½ lb. It was considered only fair that the destructor should be debited with these losses, and it was therefore decided to apportion the units generated on the basis of the actual consumption of coal before the destructor commenced working, and the results given later may therefore be taken as the true value of the steam to the electricity undertaking under present conditions. The allocation is based on a consumption of 4½ lb. of coal per unit generated, and the weekly coal consumption divided by this figure gives the number of units to be apportioned to coal-firing, the remainder being credited to the destructor. The average price of coal has been taken at 10s. per ton, and after including an allowance for capital charges on boilers and pumps, the figure of 0·35d. per unit was arrived at as a fair payment to make to the cleansing department for steam.

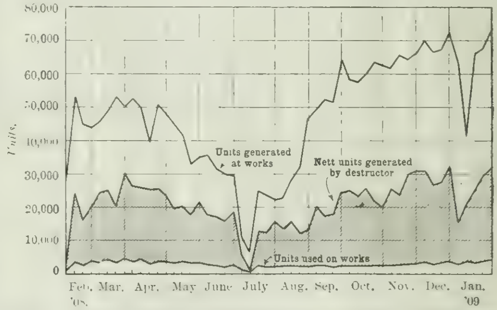


FIG. 3.—DIAGRAM SHOWING UNITS GENERATED AT WORKS. SHADED AREA REPRESENTS NETT UNITS GENERATED BY DESTRUCTOR.

In addition to the destructor plant the installation at the new Greenock works comprises:—Two double drum coal-fired boilers, each capable of evaporating 16,000 lb. of water per hour. These are fitted with close link chain grates and mechanical stokers. The generating plant consists of two 750 kw. and two 400 kw. direct-current Belliss-Westinghouse sets, one of these being arranged as a two-machine balancer and the others as single machines at 500 volts. The large sets on test with steam superheated to 500°F., and a vacuum of 26 in. at the condenser consumed 17·8 lb. of steam per kilowatt-hour, and the smaller sets 18·5 under the same conditions. Two surface condensers are employed, the cooling water being obtained by gravitation from a reservoir built on the course of an aqueduct which originally ran through the site, the water being then employed to operate a mill. Under normal working conditions the average consumption of steam is 26½ lb. per kilowatt-hour, this figure including all losses. All auxiliaries are electrically driven. The coal used has a calorific value of 11,600 B.Th.U., and the consumption, as already stated, averages 4½ lb. per kilowatt-hour. The units used on works for feed pumps, mechanical stokers, air pump and economiser (not including units used on destructor) amount to 1·9 per cent. of the generated units. The chart (Fig. 3) shows the total output of the works during twelve months ended January 31, 1909, the shaded portion representing the proportion generated by destructor steam, and the lowest line the amount of energy used by the destructor for power and light. The latter amounts to 12 per cent. of the destructor generated units divided, as follows:—

Fan draught	8·5	per cent.
Cranes	1·0	„
Clinker treatment	1·4	„
Lighting	1·1	„

The amount used for fan draught is unusually high, and is brought about by the abnormal pressure employed, but it is fully expected that this figure will be reduced by at least 10 per cent. in future.

The price to be charged to the destructor for energy supplied is a further point of contention, but the proper way is undoubtedly to treat the destructor in exactly the same way as another consumer with a similar load factor, due allowance being made for the absence of distribution costs. On this basis the price arrived at was 0·6d. per unit, the load factor being estimated at 35 per cent.

It has been mentioned already that tests over a short period of time are of little use to determine the true value of destructor steam. As an indication of the capacity of the destructor such tests are, however, of some importance. The average result of 67 units per ton over a whole year's working, although naturally a good deal lower than test results, is higher than any authenticated figure which has come under the author's notice up to the present, and, as it includes all stand-by losses on the station, may be considered extremely good. It is only fair to the makers to state that the installation was in some respects a new experiment, and that the results during the first part of the year were adversely affected by want of experience on the part of the workmen employed. It should further be explained that the repairs bill is chiefly made up of alterations and experiments carried out to improve the working of the plant after it had been taken over by the Corporation.

The cost of carting away unsaleable residue is at present a large item in the revenue account, and the labour charges for crushing and screening clinker compared with the return from clinker sold are abnormally high, owing to the difficulty of finding a market for these materials in the present depressed state of the building trade.

Some of the figures from the test report are as follows :—

Number, size, and type of boilers	2 Babcock & Wilcox, 2,070 sq. ft. H.S.
Economiser, No. of tubes (Green's)	240 tubes in two sections.
Total quantity of refuse burned	32 tons, 5 cwts.
Ditto per cell per 24 hours	24·72 tons.
Ditto per square foot of grate per hour	103 lb.
Total water per square foot of heating surface per hour	2·43 lb.
Total water per lb. of refuse burnt (actual)	1·11.
Total water per lb. of refuse from and at 212°F. or 100°C.	1·41.
Electrical units per ton of refuse	97 units per ton.

The capital cost of destructor, including one-half cost of site, one-half of chimney, buildings, furnaces, plant, economiser, proportion of steam and feed piping.
Total £19,800

FINANCIAL RESULTS AT GREENOCK DESTRUCTOR FOR 12 MONTHS ENDED JANUARY 31, 1909.

REVENUE ACCOUNT.		Per ton.	
Labour— *Expenditure.*	£	s.	d.
Operating destructor	936	1	1¼
Treatment of residue................................	134	0	2
Repairs—			
(a) Buildings	40	0	2¼
(b) Plant	120		
Disposal of unsaleable residue	135	0	2
Power and light	330	0	4½
Rates, taxes, insurance	83	0	1¼
Management	65	0	0¾
Total	£1,843	2	2
Credit.			
Sale of steam	1,665		
Sale of clinker...	65		
	£1,730	2	0¼
Balance to Net Revenue Account	113	0	1¾
Total	£1,843	2	2
NET REVENUE ACCOUNT.			
Interest on £19,800 at 3½ per cent..................	696	0	9¾
Sinking fund, $\frac{1}{30}$th of capital	663	0	9¼
Balance from Revenue Account	113	0	1¾
Net cost of disposal	£1,472	1	8¾

Technical Records.

Tons of refuse destroyed..	16,995
Units produced from destructor steam........................	1,142,064
Units used for power and light	132,006
Units generated per ton	67·2
Total clinker produced..	5,338
Total clinker sold	1,286

The author is aware that there are phases of the question which have not been dealt with in the Paper, but trusts that the arguments and figures submitted may elicit information from other engineers on this important subject.

DISCUSSION.

Mr. W. W. LACKIE (Glasgow Corporation Electricity Department), in opening the discussion, fully appreciated the value of the Paper, but was still of opinion that refuse destructors were refuse constructors, and that a combination of destructor plant and electricity supply was not practicable in Glasgow, where they had seven small destructors in which fully 50 per cent. of the available steam was used for driving auxiliary plant for refuse destruction alone. If it had been sufficiently early appreciated, perhaps their destructors would have been combined with the public baths, of which there were several about the town. To get over the difficulty of feeding, referred to by Mr. Robertson, why had they not some form of chain grate feed? He was also of opinion that the cost of condensing plant would far outweigh its advantages in the combination referred to. In Glasgow he emphasised the point that the cleansing department collected all the paper refuse separately, and thus made a considerable amount of money from its sale, whereas the paper would in the ordinary course be destroyed with the other refuse.

Prof. F. G. BAILY admitted he had no special knowledge of the subject, but it struck him that this was an instance where a special design of boiler might be further developed. Did the amount of £20,000 include boilers and economisers ?

Mr. F. A. NEWINGTON (Edinburgh) admitted he had no experience of the subject under discussion beyond knowing from experience that destructors were horribly dirty and smelly places. In a recent visit to Greenock he was agreeably surprised to find his former views in this respect upset. The arrangements for handling and tipping were an enormous improvement on anything he had previously seen. In fact, he thought the author was unnecessarily modest, as he (the speaker) understood it was Mr. Robertson's own idea. He quite agreed with the author in not drying the refuse before feeding the furnaces. He thought thermal storage should be a good thing. The Kensington and Knightsbridge system did not seem quite a success, but probably if used in a combined station it would be. He agreed with Mr. Lackie that such a combination of destructor and electricity supply was of great use for large and steady supply. For comparison purposes he would like to know the cost of carting to original tipping place.

Mr. S. MAVOR thought cremation was the ideal method of getting rid of refuse. He agreed that combined destructor and electricity supply was quite impracticable for Glasgow, but for small towns it was quite the thing where carting was within reasonable limits. He was much struck with the fact that the refuse with the best calorific value came from the poorer districts. Why was the chain grate not used ? It seemed incredible to him, since it would get over the difficulties referred to in stoking.

Mr. EVANS asked for the calorific value of cabbage stumps and tin cans. He also asked if it was not the amount of unburnt cinder got from the poorer districts which gave the refuse the higher calorific value referred to.

Mr. WILLIS asked why there was such an abnormal slump in the demand for electricity in July. Was it due to no demand, or want of refuse ? He was of opinion that induced draught would get over the dust troubles referred to during firing operations.

Mr. ROBERTSON, in reply, said he was, like Mr. Lackie, originally prejudiced against combined destructor and electricity stations ; but by careful planning he had kept the furnaces away from the electrical plant as much as possible, and he had seen to proper precautions being taken during firing by suitably designed tubs. In Liverpool there were five such combined stations as he advocated, and they were used as feeding points for the tramway system. To him there was no reason why Glasgow should not give equally good results. Chain grate feed had been used, but the chief difficulty with it seemed to be on account of the material used, jamming and choking. With regard to boilers, so far as he knew no special boiler had been designed. The gases only passed once over the tubes, as it was found the best results were obtained in that way. The refuse was burned at a very high temperature, and the gases could not be passed direct from furnace to the chimney for this reason. In reply to Mr. Newington, he would say the improvements in the Greenock plant were the Horsfall Co.'s patents. The capital cost included cost of boilers, economisers and part of steam piping. The cost of carting and tipping previous to installation of destructor, taking it two miles out of town, was 1s. 3½d. per ton, as against 1s. 8d. for the present system of destruction. In reply to Mr. Evans, the average value of the refuse destroyed was about one-sixth the calorific value of good steam coal. During July, on account of the holidays, no steam could be used. He found forced draught the most desirable.

"Wireless" in Hotels.—According to the "Electrical World" the Waldorf-Astoria Hotel in New York has already a wireless telegraph installation, and this lead is to be followed by the Auditorium Annex Hotel at Chicago, where the United Wireless Telegraph Co. are to erect a plant. It is said that similar equipments will be placed in hotels at St. Paul and Duluth, Minn., and perhaps in Buffalo and other cities. In addition to the Waldorf-Astoria in New York, the Bellevue-Stratford in Philadelphia is also equipped with "wireless," and messages are exchanged satisfactorily between these stations and also with vessels on the Atlantic.

SIMPLEX FLEXIBLE SYSTEM OF ELECTRIC WIRING.

In the early days of electric lighting this form of illumination was considered, not without some reason, to be essentially for the rich man, and the general opinion was that the person not very well blessed with this world's riches ought still to stick to the older means of obtaining artificial light. Whatever truth there may be in this statement, there is no doubt that since the time when electric light was first introduced, and even up to only a few years ago, the installation of the necessary wiring in the house meant a rather larger capital expenditure than the small householder was able to afford. Our national character for stolidness has in this, as in other cases, given rise to the use of very sturdy systems of wiring, which, when erected, have a very high factor of safety. During the past few months, however, the question has been raised whether this craze for solidity has not been carried too far, and that while including all points which make for safety in a system of house wiring, we could not as well give up a large number of the more expensive items without any sacrifice of this safety. Attention has been called in this connection to the surface flexible systems used on the Continent, and a large number of engineers have expressed opinions favourable to this arrangement. Others, however, have stated that this method of wiring is scarcely suitable in this country owing to the climatic conditions and the more extended use of high pressures. The discussion of this matter, however, has led to certain firms making experiments on the subject, with the result that one or two systems, which certainly combine flexibility and cheapness with safety, have been put on the market. We described one of these, due to Messrs. Siemens Bros. & Co., in our issue of April 9th, and we have now been informed by Messrs. Simplex Conduits (Ltd.) that they are also putting on the market a flexible system which it is hoped will aid in the solution of the "six-light" man problem.

This company claim that their unique experience in electric wiring matters has brought home to them the fact that the adoption of cheap and unreliable methods of wiring and flimsy material will not be of benefit to any concerned; a statement which we feel sure will be endorsed by all those who have the well-being of the electrical industry at heart. To resort to such methods as unprotected flexible cords of the ordinary kind as a means of popularising electric lighting would doubtless re-raise the chimera of danger from electrical fires from its grave, while there can be no doubt that such a method, though convenient, is rather repugnant to British ideas of good workmanship. The Simplex flexible system of wiring possesses, it is claimed, none of the disadvantages inherent in the wholly flexible systems, while at the same time it is cheap to instal and is very efficient. The disadvantage of unsightliness is also considerably mitigated, as with the patent armoured flexible, to be described hereafter, the wiring can be so arranged that it is almost unnoticeable against light-coloured ceilings or wall papers, whilst the other systems can be adapted so that the same end is attained. The time has now come to expose the illusion that electric light is exclusively for the rich man, and with some such system as that introduced by the Simplex Company the wants of the "six-light" man, who is doubtless a near relation o the "man in the street," will be satisfied.

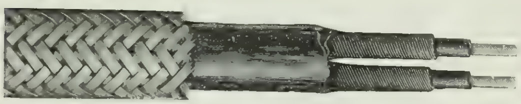


Fig. 1.—Sample of the Simplex Co.'s Cable for new Flexible Wiring System.

The Simplex armoured flexible wire, which forms a part of this new system, and which we illustrate in Fig. 1, has already been used to some extent in workshops in connection with radiator wiring. It consists of two 20/36 conductors, which are insulated with pure rubber and covered with cotton. These are formed into one circular strand, and are then armoured with 36 gauge iron wire, forming a cable having an overall diameter of 0·3125 in. A similar wire, covered with flame-proof cotton flexible and water-proofed can be used in cases where mechanical protection or electrical conductivity of the covering is not essential, while a third class of wire is covered with cotton in place of armouring and weather-proofed underneath the cotton covering.

The only accessory required with this system of wiring is a standard circular iron box. This box is so constructed that it will take a ceiling rose, a switch or a wall plug, and it may also be employed as an ordinary junction box. Four blank bosses are provided on this box, which allows it also to be used as a terminal or junction box. In providing the necessary outlets it should be noted that only one tool for drilling and tapping is used—*i.e.*, for drilling and screwing a standard Simplex ½ in. inlet. The internal dimensions of the box are 2⅜ in. by 1 in., and ample room is allowed for making the connections. The box is fitted with a porcelain interior, on which terminals are placed for connecting to the various circuits. For fixing wires to the face of walls a small brass clip, which we illustrate in Fig. 2, is used. By means of a special nipple, which is connected to the box mentioned above, a very good connection can be made to either lead-covered or cotton-covered flexible wire. These nipples depend upon a jambing action similar to that used in connection with the cord grip lamp-holder. The nipple consists of two parts: first, a tapped brass nipple of ½ in. exterior diameter, which is screwed into the inlet of the box. The wire is inserted into this, and by means of a lip on the interior of the nipple specially provided it is impossible to carry the armouring into the box itself, the smaller diameter only permitting the taped portion of the wire to pass through into the box. The second part of the grip nipple is a small screwed sleeve, as is used in an ordinary cord grip. This part screws over that portion of the small brass nipple which projects from the box, and by means of a lapping of soft lead wire, which is used in the case of the armoured flexible, the jambing action ensures a lasting connection between the box and wire, together with efficient electrical continuity. In the case of flame-proofed and cotton-covered wire this jambing effect is produced by means of a small rubber band. These nipples are made accurately to size to ensure an efficient gripping effect, and at the same time combining ease of erection. It is claimed by this means that an efficient lasting joint between the cable and box is obtained, and, if the wire be armoured, there is also good electrical continuity.

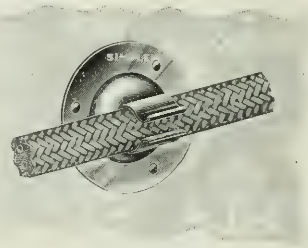


Fig. 2.—Clip for use with the Simplex Wiring System.

In erecting the new system the wire is measured and cut to the exact length, and the insulation is worked back, so that when inserted in the nipple it will butt up against the shoulder provided. After making connections to interiors, ceiling roses or other accessories, the connection to the box is completed by fitting the lead wire (or rubber ring in the case of flame-proof and cotton-covered flexible). The former should be lapped round the armouring, and in the latter case the rubber ring should be threaded on to the wire, together with the screwed sleeve, in an exactly similar manner as would be the case in wiring an ordinary lamp-holder. Provided these instructions are adhered to, we are informed that an efficient and lasting joint between the flexible lead and the box is obtained, and, in the case of the armoured grade, complete electrical continuity is assured.

Owing to the unsatisfactory results which are inevitable when a soldered connection is made in a flexible, due to the fact that the detrimental effect of the hot soldering iron results in fracture of many of the strands at the point where the wire ends into a sweating socket, a special form of connection has been adopted which is adapted to most types of accessories, and, whilst extending facilities for easy wiring, obviates breakages and ensures good electrical contact. On porcelain interiors a solid cheese head screw is used, together with heavy brass terminal, the upper portion being untapped and three washers being provided, so that at least three wires may be taken to the same connection. In nearly every case it will be found most convenient to carry out the wiring from corridors, making branch connection to lighting switch points by means of junction boxes with interiors; these junction boxes are available for light points in addition if desired. When running through walls, the flexible, whether armoured or otherwise, must be protected. This can easily be accomplished by a short length of "compo" tube, which can be made into an exceedingly neat job by chamfering away the ends after the wire has been run through, as would be done in the ordinary plumber's joint.

ELECTRIC CRANES.*

BY H. H. BROUGHTON.

(Continued from page 1003, Vol. LXII.)

Summary.—The author here deals with the design and construction of the mechanical equipment of cranes. The mechanism required for effecting the usual crane motions is treated in four sections. The first section relates to lifting mechanism. The article opens with a short discussion on the determination of the size of motor, and a simple expression is given suitable for most ordinary types of jib and overhead travelling cranes. Then follow notes on wire ropes, flat link-chains, the gear ratio, spur and worm gears, shafting, barrels, blocks and hooks, mechanical brakes, limit switches, and the "free-barrel" system. Lifting magnets and safety tongs are also described.

Mr. H. Spillman, chief engineer of the Maschinenfabrik Oerlikon, of Oerlikon, Switzerland, speaking in the discussion on Mr. Bruce's Paper on Worm Contact, read before the Institution of Mechanical Engineers,† stated that in order to give high efficiencies, a worm-gear must be designed, manufactured, and run under the following conditions :—

1. The particular conditions of service must be known to the designer in every case.
2. The form of the teeth must be as good as possible, and the teeth to be worked as accurately as possible.
3. Full care must be taken in choosing the material.
4. The lubrication must be excellent.
5. The construction of the worm-gear as a whole must be extremely careful and accurate in character.
6. The erection of the worm-gear at the site where it has to work must be given especial care, and should be done under close supervision.

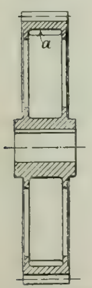


FIG. 80.—SPUR WHEEL CONSTRUCTION.

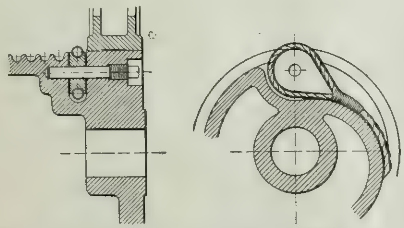


FIG. 81.—SHOWING METHOD OF SECURING ROPE TO BARREL.

Regarding the strength of worm-gear, on this question there is great difference of opinion. In designing worm-gears, the strength may safely be based on the same formula as for spur gear, but there are many other factors which must be taken into consideration. Messrs. D. Brown & Sons, of Huddersfield, whose wide experience in all classes of gearing is well known, state that the most efficient angle of the worm is from 27 deg. to 31 deg. This is a point to which engineers attach far too little importance. Many authorities give the most efficient angle as about 40 deg., but it is found when the worm angle is more than 30 deg. the side thrust is so great as to neutralise the efficiency to a considerable extent.

It is generally admitted that too much attention cannot be paid to the lubricating arrangements, and the author is of the opinion that the slight additional cost of an approved system of lubrication would be more than balanced by the higher overload capacity and reduced wear and tear of the gear.

When spur gearing is used, the wheels are made of the best open-hearth steel, hard and tough, and care is taken to secure a uniform grade, the best suited to resist the wear caused by the severe service to which crane gears are subjected. In the form of wheel shown in Fig. 80, the castings are practically free from shrinkage cracks, and blow-holes, and the roots of the teeth are not so liable to be spongy as with other designs.

The pinions are made from well-hammered blanks, cut from the very best high-carbon open-hearth steel billets.

The main spur wheel is frequently keyed direct to the lifting barrel in order to relieve the shaft of torsional stress, and to minimise the load on the key.

The slow-speed gearing is often cast, with spur or double-helical teeth, shrouded both sides, but owing to the roughness of steel castings, and the large amount of chipping and filing necessary to obtain a passable gear, it is open to

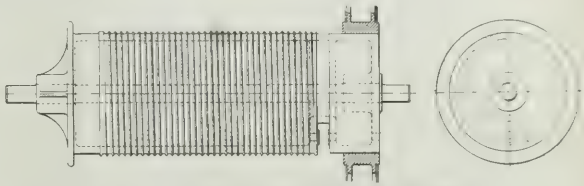


FIG. 82.—BARREL, WINDING ONE PART OF ROPE.

question whether cut gearing, of increased pitch and width to bring up the strength to that of the shrouded wheel, is not the cheaper in the long run, taking all the controlling factors into consideration.*

The teeth are short, and wherever possible the involute form should be used. The higher efficiency of the involute system generally, but especially where the wheel centres vary through wear, or other cause, favours this choice.

The high-speed gearing should be enclosed in dust-proof cast-iron or sheet steel cases made in two halves. Steel cases are only about one-quarter the weight of the corresponding cast-iron gear cases, and are easier to handle.

The shaft diameters are determined from the known torque and bending moment due to the wheels.

As far as possible all pedestals should be provided with caps and adjustable phosphor-bronze steps. They should

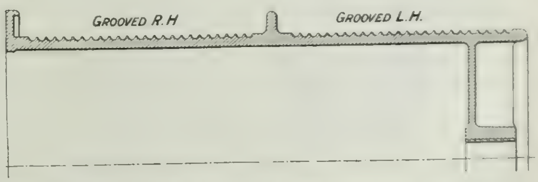


FIG. 83.—ANOTHER FORM OF BARREL, BY THE NUREMBERG CRANE CO.

be fitted with Kingfisher or Stauffer grease lubricators of ample capacity, properly fixed to prevent coming loose.

The construction of the barrels or rope drums will be inferred from Figs. 81 to 83. They should be grooved in the lathe to give a smooth bed for the rope, and as already stated must be made sufficiently large in diameter to take the entire length of rope, required for the maximum lift in one lap. In overhead travelling cranes, and other cranes of similar construction, the grooves are formed right and left-handedly from each end of the drum, so as to give a truly vertical and central lift.

† *Proceedings*, Inst. Mech. Engineers, Jan. 19, 1906.

* Generally speaking it is unnecessary to shroud the main spur wheel. The teeth unshrouded are stronger than the teeth on the mating pinion when shrouded to the pitch line on both sides.

The rope attachment depicted in Fig. 81, due to Adamson & Co., is such that if the whole length of rope is run off, as when working over a pit in the floor of the shop, the eye and its fastening will sustain the load, without assistance from frictional rope contact with the drum. A recess cast in the drum receives the eye, and the turned pin inserted through the drum-end fits into a hole in the steel eye-piece, around which the rope is bent.

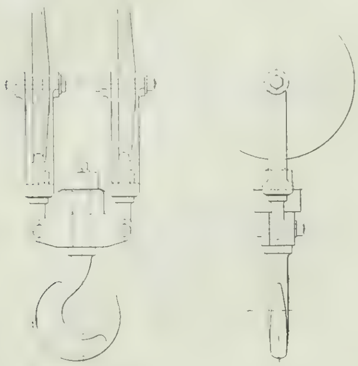


Fig. 84.—Block and Hook for Small Loads.

When the load is lifted at a high speed, or when the height of lift is small, there is a possibility of frequent overwinding taking place, and the limit switch, or overwinding device,* which interrupts the current may not prevent the blocks being brought into violent contact, particularly when light loads are being handled, as the momentum of the gearing is sufficient to cause a certain amount of running after the switch is opened. In such cases it is advisable to use taper barrels so that the load can be lifted at the

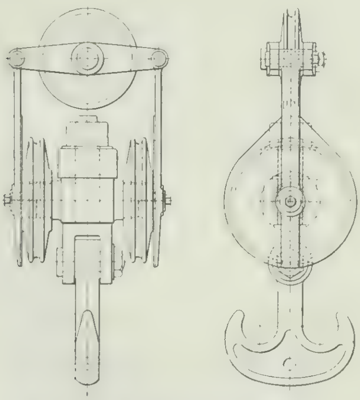


Fig. 85.—Block and Hook for Medium Loads.

maximum speed at the commencement of the lift, and, as the lift proceeds, the speed is decreased until the load nears the top of the lift, when the speed is very slow. In this way the load may be more easily handled and "nursed" near the top of the lift.

The top block fixing which carries the sheaves or compensating pulley is arranged with a universal joint, and is

* Limit switches will be described in a later section of the article.

suspended from a stiff cross-beam riveted to the sides of the trolley frame.

Typical designs of the block and hook are shown in Figs. 84 to 87 inclusive. The constructions (Figs. 84 and 85) by Broadbent & Sons are for light and medium loads respec-

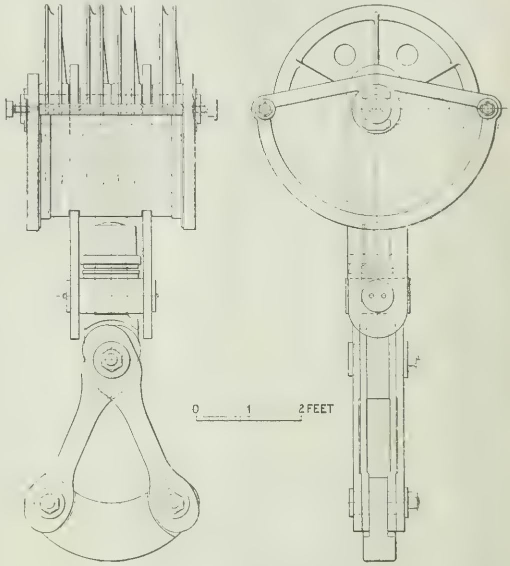


Fig. 86.—Block and Hook for Heavy Loads.

tively. It will be seen that the block pulleys are connected to the hook cross-head by double joints, so that they must hang truly in line with the rope no matter at what angle the rope may leave the barrel.

The block and hook (Fig. 86) by the Nuremberg Crane Co. is suitable for the heaviest cranes, and that shown in

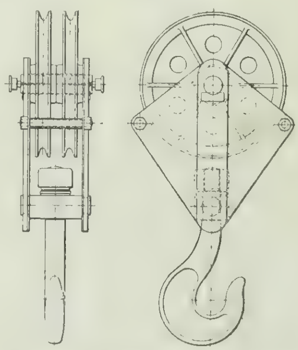


Fig. 87.—Usual Design of Block for Small and Medium Loads.

Fig. 87 by the same firm is suitable for cranes of small and medium capacity.

The details are shown so clearly in the several drawings as to require no elaboration.

In order to enable the hook and block safely to withstand the severe forces induced by the load slipping or surging, it is necessary to use the best material which can be obtained, and to proportion the parts in such a way as to keep the

working stresses low. Either the very best selected Yorkshire scrap iron or high quality mild steel should be used, and the working stresses adopted should not exceed 3 tons per square inch in tension, and 1·75 tons per square inch in shear. The bearings of the sheaves are proportioned to limit the pressure on the axle-pins to 0·5 ton per square inch, and care is taken to ensure thorough lubrication.

Table XVIII.—*Test Showing the Extra Strain upon a Hoisting Rope with a Few inches of Slack Chain.*

	Tons.	Cwt.
Load weighed by machine	2	17
Load lifted gently	3	0
Load lifted with 3 in. of slack chain	5	0
" " 6 " "	5	10
" " 12 " "	7	0

From the Impact Tests, by Cradock & Co., summarised in Table XVIII., we may conclude that an elastic connection should be provided between the hook and block in all cases where there is any likelihood of shock.

(*To be continued.*)

THE INDUSTRIAL APPLICATION OF THE ELECTRIC MOTOR, AS ILLUSTRATED IN THE GARY PLANT OF THE INDIANA STEEL COMPANY.*

BY B. R. SHOVER.

(*Concluded from page 5.*)

Summary.—A description is here given of the main features of the electrical installation for the largest steel-making plant in the world. Blast furnace gas is used for a large gas engine power station. One of the most interesting features is the electrical equipment of the rail-mill, the roll trains being direct coupled to the largest induction motors ever made, of 2,000 and 6,000 H.P. capacity.

Table and Transfer Motors.—In the rolling mill proper there are 21 tables and two transfers, all of which are controlled by automatic magnetic torque-limiting control. The eight operators stand on elevated platforms or pulpits. Some of the controllers are mounted on the operating pulpits and others on special platforms located near the motors which they control. These tables and transfer motors are all of the so-called mill type. Tables running constantly are equipped with shunt-wound motors. Those doing considerable amount of reversing or frequent starting and stopping have series-wound motors. The transfers are simple chain drive, having two sets of dogs for moving the rail sidewise, and the control is entirely automatic. When the operator throws his controller to the forward position, the transfer chain makes one-half revolution, depositing the rail in the proper place. Then the motor stops automatically. The next motion, for transferring the following rail, is made by the operator putting his controller to the " off " position and again throwing it to the " on " position.

An interesting feature of the auxiliary drive is the lifting table at the three-high 40 in. blooming mill. This table has a total weight of 256,000 lb., partly counter-balanced by means of a cylinder containing air at 500 lb. per square inch pressure, and is lifted or lowered 40 in. in three seconds. The operating motor is 250 H.P. 250 volt direct current, 100 revs. per min. compound wound. The control, like that of the table motors, is entirely automatic, and is manipulated by the operator simply throwing his master controller to the up or down position, the accelerating, running, retarding and stopping being taken care of automatically.

There is also a tilting table at the three-high roughing rolls similar to the lifting table, but of considerably less weight. This table gives one complete stroke of 26 in. either up or down in 1·5 seconds. It is driven by a 150 H.P. 250 volt 100 revs. per min. compound-wound motor, and is controlled like the lifting table.

The hot saws, five in number, are driven individually by 40 H.P. 750 revs. per min. induction motors. The saws are 40 in. in diameter and make 1,440 revs. per min. All five are raised and lowered at one time by a crankshaft operated by a 25 H.P. series shunt-wound mill-type motor. The control is similar to that of the lifting table, except that if the operator throws his control to the first point the saws lower and stop in that position. It is then necessary for him to bring his control to the first point on the reverse in order to raise the saws; then the latter come up to the top and again stop automatically. In regular operation, however, the operator throws to the second point; upon which the saws lower, cut the rail and again rise, stopping automatically in the upper position.

The cambering machine is driven by a 40 H.P. 750 revs. per min. induction motor. On the hot beds, four in number, there is a push-up for shoving the rails off the delivery table on to the beds, and a pull-up for dragging the rails from the beds on to the receiving table in the finishing mill. These " push-ups " and " pull-ups " are driven by 75 H.P. series mill-type motors, the controllers of which are also automatic. From the receiving table the rails are delivered in both directions to the finishing department by feed tables similar to those in the rail mill. Because of the continuous running of these feed tables the controllers are the ordinary hand-operated type.

For delivering the rails from this table to the straightening beds " kick-offs " are used. These are simply bars lying normally below the surface of the table, but raised at an angle so that rails are lifted and then slid off by means of a cam on a motor-operated shaft. The straightening presses, 18 in number, are driven by 10 H.P. 750 revs. per min. high-resistance rotor induction motors. The drill presses, 18 in number, are driven by 10 H.P. 750 revs. per min. induction motors with ordinary squirrel-cage rotors.

All of the induction motors in the finishing department are standard, and are controlled by means of a triple-pole double-throw switch, which is connected to a five-wire system. The two extra wires are taps taken off the main transformers, thus furnishing low

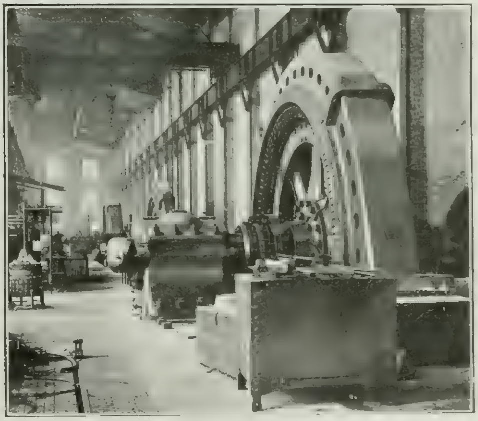


FIG. 1.—GENERAL ELECTRIC CO.'S 6,000 H.P. INDUCTION MOTOR IN RAIL MILL.

voltage for starting. This system does away entirely with the complication and trouble accompanying individual starting compensators.

The loading beds outside are covered by two special electric cranes which transfer the rails from one part to the other or load them in cars, the rails being handled by means of large special magnets. On the south side of the runway of these cranes is also a small monorail crane, whose sole purpose is to deliver rails to the cold-saw bed.

The cold saw, a tooth saw 42 in. in diameter making 1,800 revs. per min., is driven by a 100 H.P. 750 revs. per min. induction motor. This saw is capable of cutting an 85 lb. rail in 22 seconds, the load varying between 50 H.P. and 100 H.P., according to the part of the rail that is being cut.

Motors for driving the Rolls.—As mentioned earlier in the Paper, although electric motors have been used for some time to drive rolls, the motors used in this plant are several times larger than any motors of their type previously built. Their use for this purpose marks a new era in the industrial application of electric power. The main rolls of the mill are driven by six induction motors, having a combined capacity of 24,000 H.P., made up of the following units: Two of 2,000 H.P. at 214 revs. per min., one of 2,000 H.P at 68 revs. per min., one of 6,000 H.P. at 88 revs. per min., one of 6,000 H.P. at 83 revs. per min., and one of 6,000 H.P. at 75 revs. per min. One of the 6,000 H.P. motors is shown in Fig. 1 and 2,000 H.P. motors in Fig. 2.

In the construction of these motors the parts were made extremely heavy and rigid, following out as far as possible the practice which

* Abstract of a Paper read before the American Institute of Electrical Engineers.

has proved successful in the construction of steam engines for similar duty. The stator frame is of the box-type construction, and is split into four sections for ease in handling and transportation. The rotor spider is of cast steel, and is made up of four sections with two arms per section. The sections are bolted to disc hubs which are pressed on the shaft.

As the flywheel effect of the rotors necessary to overcome the excessive loads in rolling can only be determined accurately by actual trial, it was deemed advisable where possible to construct the motors so that the flywheel effect could be altered after the motors had been put in operation. This was accomplished in the 6,000 H.P. and the 2,000 H.P. motors at 68 revs. per min. by attaching to the rotor spiders heavy cast-steel rims which could easily be removed and exchanged for rims of different weights. On account of their triple speed, the two 2,000 H.P. 214 revs. per min. motors have separate flywheels weighing 100,000 lb. each. These flywheels are built up of riveted boiler plates, which do not permit of alteration.

The end thrust which may result from a diagonal fracture of a spindle or roll is frequently sufficient to wreck either the mill or the motor unless special precautions are taken. This problem, which is extremely difficult to solve when an engine is used for driving the rolls, is very easily solved when electric motors are used. A device termed a mechanical fuse is attached to the pedestal by two breakable rods. These rods are so proportional that they will break only when the end thrust exceeds 150 tons. When the rods give way under this pressure the rotor is free to move longitudinally away from the rolls, thereby relieving the thrust. To prevent injury to the brush rigging it is so arranged as to move freely with the brushes, always maintaining their proper position on the collector rings.

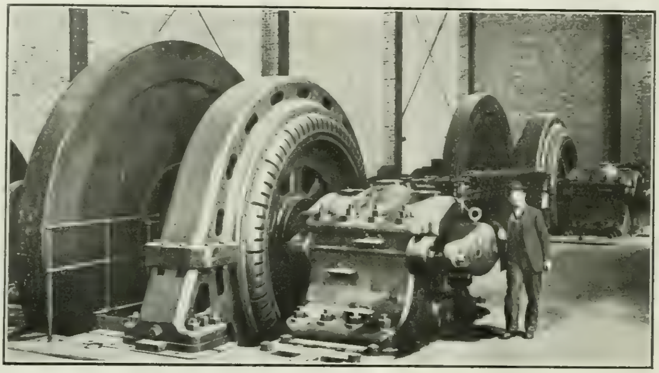


FIG. 2.—2,000 H.P. INDUCTION MOTORS IN RAIL MILL. (GENERAL ELECTRIC CO.)

The bearings are self aligning with oil-ring lubrication. They can also be lubricated from an independent oiling system. Provision is made for water cooling in case of emergency. The coils, which are assembled in open slots, are very rigid. In order, however, to prevent any possible vibration due to excessive fluctuations of the current, the coils are also firmly laced to a rigid supporting ring.

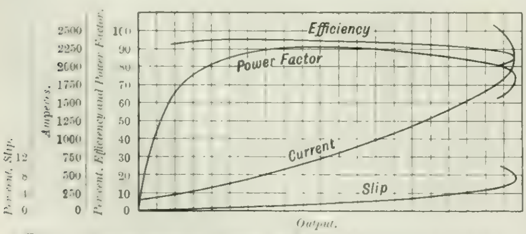


FIG. 3.—CHARACTERISTIC CURVES OF 6,000 H.P., 88 REVS. PER MIN. INDUCTION MOTOR.

The electrical characteristics of the motors are shown in Figs. 3 and 4, which represent the results of tests of the 2,000 H.P. motor at 214 revs. per min. and the 6,000 H.P. motor at 88 revs. per min. Reference to these curves shows that the power factor and efficiency are near their maximum at the rated output of the motors, and that high values are maintained throughout the complete operating range. Further particulars of the motors are given in the table.

H.P. (normal rating, 40 deg. rise)	2,000	2,000	6,000	6,000	6,000
Speed (r.p.m.)	214	68	83	88	75
No. of poles	14	36	44	34	40
Weight complete, lb.	396,000	578,000	749,000	749,000	783,000
Flywheel effect (lb. at 1 ft. radius) of rotor.	354,000	8,950,000	11,600,000	11,600,000	14,100,000
Air gap (total), in.	0·28	0·40	0·40	0·40	0·40
Breakdown torque, H.P.	6,800	5,100	18,500	20,600	16,400

The two 2,000 H.P. 214 revs. per min. motors were received at the Gary works complete except the flywheels, which were built up and turned after the installation of the motors. The three 6,000 H.P. and one 2,000 H.P. 68 revs. per min. motors were assembled and wound in position. The 2,000 H.P. 214 revs. per min. motor, with its controllers, was tested before shipment, but the controllers for the remaining four motors were first assembled at the works.

Only two minor troubles have developed so far in the entire installation. On starting up one of the 6,000 H.P. motors one section of the rotor resistance overheated, but investigation proved this trouble to be due to a stray piece of arc-lamp carbon. In starting up another of these motors trouble developed due to a broken grid in the rotor resistance.

Control for Roll-train Motors.—In designing the equipment for these 2,000 H.P. and 6,000 H.P. 6,600 volt induction motors, not only were the sizes of the motors to be controlled beyond anything previously attempted, but the specifications presented many novel features, for most of the motors the service required a very large flywheel effect. Because of the well-known characteristics of the induction motor, it was clearly recognised that there would necessarily be large fluctuations in current, even though the flywheels were very large, unless some means were employed for automatically introducing resistance into the motor circuit whenever the load was sufficient to cause even as small a change of speed as 2 or 3 per cent. It was desirable that the automatic features be adjusted so as to operate continuously, regulating the current taken by the motors so that the demands on the source of supply for any one motor would be uniform; the motor and its flywheel meanwhile accelerating and decelerating at a point just below synchronism to meet the power demands of the rail mill which it was driving.

The large current in the secondary circuits of the motors necessitated separate contactors. Rheostats were arranged in multiple

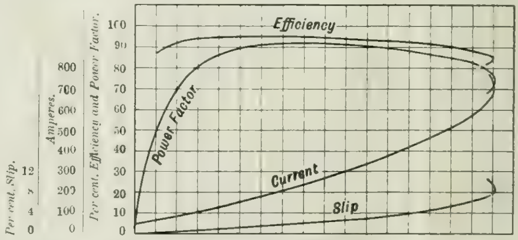


FIG. 4.—CHARACTERISTIC CURVES OF 2,000 H.P. 214 REVS. PER MIN. INDUCTION MOTOR.

delta, and the successive value of the resistance was made such that as each contactor closed the rush of current through it would be approximately one-fourth of the intake of the motor. This arrangement prevents the rheostats or contactors being called upon to carry anywhere near their full rated current, and gives the whole control system a conservative continuous rating.

The control apparatus for each motor consists of: Preliminary control apparatus, which includes the oil switches, reversing switches, series transformers, preliminary relays, &c. Secondary control (Fig. 5), comprising the rheostats, contactors, regulating panel, &c., and, thirdly, the master controller.

The motors and the controlling apparatus are placed in a separate room, which is separated from the rolling mill proper by a partition.

The master controller, however, is in the rolling mill. Under these conditions, therefore, the operator must depend chiefly on the automatic features of the control, which are so far away that he must judge of their correct working by the behaviour of the rolls while the steel is passing through them. In case of emergency, provision is made for the motor attendant to shut down the motors independently of the master controller.

The 6,600 volt current enters through the triple-pole main oil switch; from thence it passes through a number of oil switches which determine the direction of rotation. These switches are interlocked, making it impossible for them to be operated unless the main switch is open. Additional interlocks prevent them from being closed simultaneously. This group of preliminary control apparatus also includes the necessary relays to open the circuit in case of overload and to prevent the secondary control from being operated in an injurious manner.

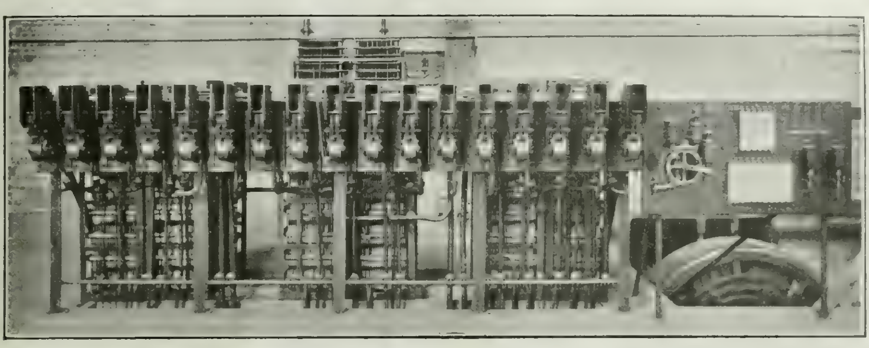


FIG. 5.—CONTROL EQUIPMENT FOR 6,000 H.P. MOTOR.

The arrangement of the secondary control rheostats in multiple delta is shown in Fig. 6. Direct current at 250 volts was adopted for the control of this secondary apparatus, and the voltages so arranged that each contactor coil is subjected to a pressure of only about 15 volts. This pressure is so small that the arcing is insignificant. To compensate for the different number of contactors in circuit at different speeds a balancing resistance equalling the resistance of the contactor is cut in or out of circuit inversely as the contactors. This keeps the current in the contactor circuit approximately constant at about 5 amperes, and results in a simple arrangement of contacts on the regulating device. The regulating device consists of two concentric groups of buttons, one connected to the contactor coils and the other group to the contactor resistances, the two groups being cross-connected step by step by a simple arm controlled automatically. Should the 250 volt supply fail, a weight attached to the grooved pulley on this arm serves to return the mechanism to the off position. The master controller, which operates both the preliminary control and secondary control apparatus, has two handles; one is a reversing handle and the other is for applying and shutting off the power.

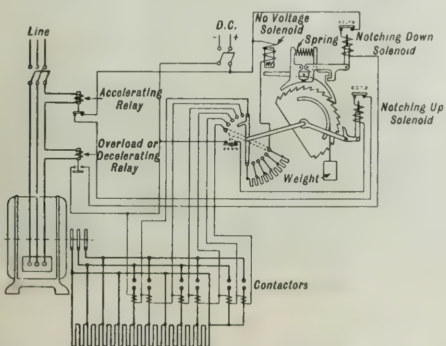


FIG. 6.—DIAGRAM OF SECONDARY CONTROL OF RAIL-MILL MOTORS.

Rail Mill.—The rail mill has a capacity of 4,000 tons of finished rails per 24 hours. It is not only the largest, but also the only motor-driven mill in the world rolling rails directly from the ingot without re-heating. There are nine passes in the blooming mill. The first two passes are two-high rolls 42 in. pitch diameter running at 6 revs. per min., and are connected to one of the 2,000 H.P. 214 revs. per min. motors through gear reductions. The next two passes are identical with passes one and two, except that the rolls are 40 in. in diameter and make 10 revs. per min. and are driven in the same manner. The next five passes are made in a 40 in. three-high train direct connected to a 6,000 H.P. 75 revs. per min. motor. The lifting table for this train has already been described. The bloom is then cut in two by means of the bloom shears, operated by a 75 H.P. induction motor.

The next train of rolls, which comprises a three-high roughing mill with passes 10, 11 and 12, is operated by means of the tilting table, the second edger or pass 16 and leader or pass 17. This train is 28 in. pitch diameter and direct connected to a 6,000 H.P. motor running at $63\frac{1}{3}$ revs. per min. The next pass is the 28 in. two-high former, direct connected to a 2,000 H.P. 68 revs. per min. motor.

The third roll train consists of the dummy, or pass 14, the first edger, or pass 15, and the finisher, or pass 18. These rolls also are 28 in. pitch diameter, and the train is direct connected to a 6,000 H.P. 88 revs. per min. motor.

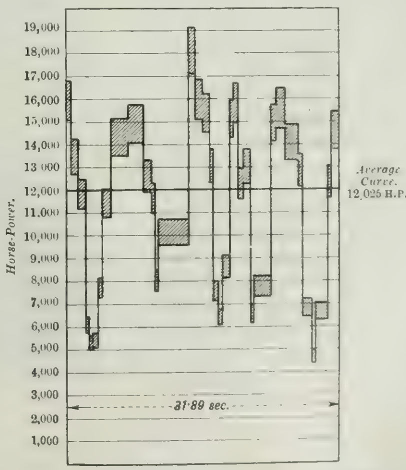


FIG. 7.—ESTIMATED COMBINED LOAD ON THE MILL.

A diagram of these passes, and particulars of the size, &c., of the pieces leaving the various passes, is given in the Paper. To supply power to the train motors of this mill there are two circuits, each of 10,000 kw. normal capacity at 6,600 volts. One circuit feeds the three blooming-mill motors; that is two 2,000 H.P. and one 6,000 H.P. The other circuit feeds the other three motors; that is, two 6,000 H.P. and one 2,000 H.P. The estimated combined load with the mill working at full capacity, with voltage and amperage of each of the circuits, is shown in Fig. 7. This cycle, which is 31·89 seconds,

indicates an exceedingly variable load, the total variations being from a minimum of 4,300 H.P. to a maximum of 19,010 H.P. with an average of 12,025 H.P., which makes the load factor on the six-train motors almost exactly 50 per cent. The curve was developed to provide a basis for estimating the size of the storage battery necessary to take care of the fluctuations and keep a constant load on the generating station.

Conclusions.—One of the most satisfactory conclusions, so far as the Indiana Steel Co. is concerned, that can be drawn at the present date is that, so far, all of the apparatus described in this Paper which has been tried has been practically a perfect success.

In the original design of the plant considerable attention was given to the question of underground versus overhead transmission. In view of some later developments, although it might have been possible to put in underground service, which would not have greatly exceeded the cost of overhead construction, yet the latter has given no trouble. All of the 6,600 volt feeders are protected by multigap lightning arresters, while the 22,000 volt has both multigap and electrolytic lightning arresters. The latter were not installed until after the former had been operated for some time, and since the installation of the electrolytic lightning arresters there has been no discharge over the multigap, nor have there been any bad effects from lightning either in the plant of the Indiana Steel Co. or at other points on the line, which are protected in like manner.

A comparison between the estimated horse-power and the observed horse-power required for the various passes in the rail mill shows some discrepancy; but because the steel rolled was colder than it would have been in actual practice, since all of the machinery is new and is not operating so quickly as it should, and because, also, of the lack of adjustment of the rolls, it is believed that the power required will be very little, if any, in excess of the original calculations.

After the roll-train motors had been started it was discovered that the stopping of them was an important feature. The 2,000 H.P. 214 revs. per min. motor, when disconnected from the rolls, required two hours to come to rest, while the 6,000 H.P. $83\frac{1}{3}$ revs. per min. motor required 1 hour 37 minutes to stop. This time consumed would mean corresponding delays in case of breaking of the main spindle, which, of course, could not be countenanced. In order to stop these motors within a reasonable length of time, direct current at 250 volts was introduced into one phase of the winding, through an external resistance, after the motor had been disconnected from the 6,600 volt line. By this device the 2,000 H.P. 214 revs. per min. motor was stopped in 2 minutes and 55 seconds, and the 6,000 H.P. motor in 1 minute and 42 seconds. During this time the first section only of the resistance of the rotor was closed. This device is being put in permanently, and a 6,600 volt switch connected to one phase, the other side of which will be connected to the 250 volt line through a permanent resistance, and this switch interlocked with the main 6,600 volt oil switch, so that both cannot be thrown in at the same time.

Probably no industrial application of electricity has been the result of more careful study on the part of the engineers in charge, or has marked a more general adoption of electric power than the one just described. Although many of the motor applications are not new, this plant is unique in respect to the number and variety of the applications and the size of many of its units. The rail mill now in operation, driven by induction motors with a combined capacity of 24,000 H.P., and having a normal output of 4,000 tons of steel rails per 24 hour day, is without a rival. The operation of the plant will, therefore, be watched with more than usual interest, both by steel mill engineers and electrical engineers. Its success will greatly accelerate the application of the electric motor in this industrial field.

Germano American Patent Treaty.—The United States Senate has ratified the new patent treaty between the United States and Germany, which provides for the reciprocal protection of patents taken out in Germany by Americans and in the United States by Germans. The existing law is also amended so that the obligation of manufacture in either country where the patent is obtained is abolished, and the patented article can be manufactured in another country and imported.

WIRELESS TELEGRAPHY IN THE TERRITORIAL FORCE.

This week we give some illustrations of work performed by the London Wireless Telegraph Company R.E. during the Easter holidays at Kneller Hall. When the Territorial force was created five wireless companies were formed—one for each army command. The function of these companies in war would be to keep up communications between the advanced posts of the army and the headquarters of the commander-in-chief. For this reason they must be

FIG. 1.—INTERIOR OF THE "WIRELESS" STATION USED BY THE TERRITORIALS DURING THE EASTER MANŒUVRES.

mobile, so that they can act with cavalry or horse artillery. Each company will consist, for the present, of two portable stations, each station being carried on a waggon which consists of a limber and main carriage. These waggons are horsed with a six-horse team and

FIG. 2.—VIEW OF THE EXTERIOR OF THE STATION, SHOWING THE ANTENNAE AND MAST EQUIPMENT.

carry four men on the boxes. The mast is in sections and is also carried on the waggons. None of the wireless companies are yet equipped with apparatus of any kind, although it is expected that some equipment will be issued before the end of this year.

The London company have been fortunate enough to get training in the stations of the Lepel Wireless Synd., these being situated at Slough and Twickenham. Further, one of the officers of the London Wireless Company R.E. is having a portable station made by the Lepel Wireless Synd. for the use of his company. The men will therefore have the advantage of learning the system, and the operators will be able to train for speed and efficiency.

In the German army the greatest importance is attached to the science of wireless telegraphy. There they have no less than 12 companies carrying portable apparatus, besides several fixed

stations at towns such as those of Metz and Strasburg. Up to the present they have used the Telefunken system, but in this year's manœuvres the Lepel system, which has many salient advantages, is to be tried in conjunction with the Telefunken system. The English regular army has only two companies carrying portable stations, and one fixed station at Aldershot. Up to now they have been using spark telegraphy, but lately they have purchased installations from the Lepel Wireless Synd. (continuous wave system), and there is every indication that the continuous waves will come into extensive use for military and shipping purposes, not only in this country but on the Continent.

There is no doubt that two companies are quite inadequate for the work of our regular army, and therefore it is one of the best points of Mr. Haldane's territorial scheme that five wireless companies are included. There is a great keenness in the ranks of the London Wireless Company, which is now over strength, and there are still a great number of applications for enlistment. As soon as the others are equipped no doubt the same keenness will be shown.

OERLIKON THREE-PHASE VARIABLE SPEED MOTORS.

The three-phase motor, although, of course, a very useful driving apparatus in many ways, for a long time suffered from the fact that to regulate its speed was no easy matter, and in consequence

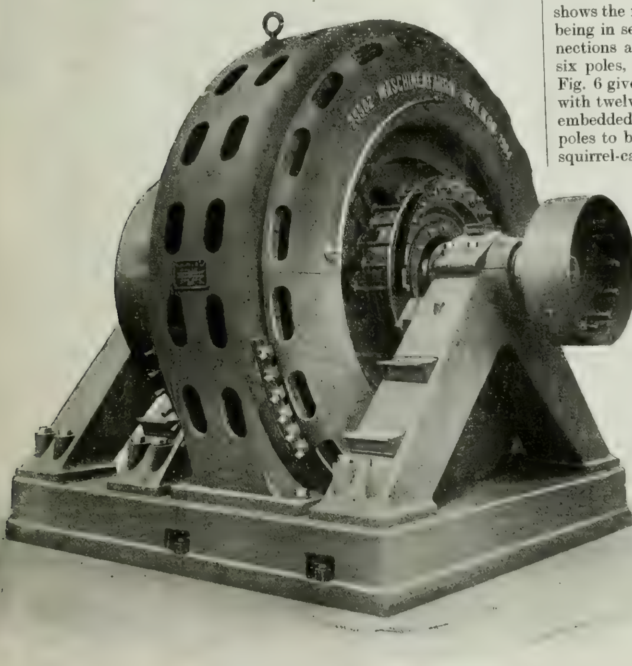


FIG. 1.—OERLIKON 500 H.P. THREE-PHASE VARIABLE SPEED MOTOR.

its employment for work in which a range of speed was desired was not possible. This in itself led to certain complications, for the current had often to be transformed from three-phase to continuous, so that the necessary speed regulation of the motor could be obtained.

In recent years, however, these difficulties have been overcome in several ways, one of the most successful being by altering the number of poles on the stator. The Maschinenfabrik Oerlikon were among the first to make motors of this type. Since their first introduction by this firm very considerable progress has been made, and in the following article we give a series of test curves which were obtained with one of the Oerlikon standard types of three-phase variable speed motor. We illustrate such a motor having an output of 500 H.P., which is installed at the Sandviken mines in Sweden, in Fig. 1.

The motor, on which the tests were made, had an output of 15 H.P., and was specially built for driving a large lathe. It was capable of running at four normal speeds—viz., 500, 750, 1,000 and 1,500 revs. per min. At all these speeds a constant output of 15 H.P. could be obtained, or a constant torque of 15 kg. on a brake lever 1 metre long. The motor was supplied with current at 500 volts, the frequency being 50 cycles.

The curves in Figs. 2 to 7 represent the characteristics of this motor for the six different positions of the speed regulator. Fig. 2

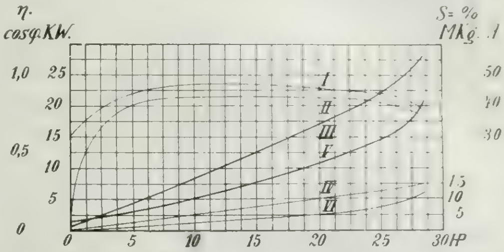


FIG. 2.—THREE-PHASE MOTOR CHARACTERISTIC. FOUR POLES. SERIES CONNECTIONS, 1,500 REVS. PER MIN.

NOTE.—In all figures: I.—Power factor; II.—Efficiency; III.—Input in watts; IV.—Torque; V.—Current; VI.—Slip.

shows the results obtained when there are four poles, the connections being in series. In Fig. 3 the motor also has four poles, but the connections are in parallel. Figs. 4 and 5 show the conditions with six poles, the connections being in series and parallel respectively. Fig. 6 gives the results obtained with eight poles, and Fig. 7 those with twelve poles. The stator has two separate windings, which are embedded in 72 slots, thus allowing four and eight or six and twelve poles to be respectively obtained. The rotor of this motor is of the squirrel-cage type.

The stator windings corresponding to a four or eight-pole arrangement consist of a set of four groups of coils per phase, which can be interconnected in three different ways. In two of these ways the speeds obtained correspond to a four-pole arrangement, the only difference between the two being that in one case the four groups of one phase are in series, while in the other case they are in parallel. The third way of combining the connections gives an eight-pole arrangement. The connections for six and twelve-pole conditions can be similarly arranged, the windings then having six groups of coils per phase. The test curves shown in Figs. 2 to 7 give all the electrical data obtainable by means of any of the connections referred to above over a range of load from no load to full load.

A comparison of the results obtained between no-load and full load for each stator winding, for both series or parallel connections, and when using either the smaller or greater number of poles, show that (1) the no-load current, when parallel connections are employed at the same speed with the smaller number of poles, does not differ considerably from the no-load current obtained with double the number of poles. Whilst with series connections the no-load currents with the smaller number of poles are only about a quarter those with the double number of poles. (2) The current at maximum output, and, in fact, the maximum output itself is nearly four times greater with the smaller number of poles when parallel connections are used than the current and corresponding output with double the number of poles. In the case of the series connections, however, the current and output is nearly the same with the smaller number of poles as with the double number of poles.

The corollary to this is that it is possible to do without the parallel connections with the lower number of poles—*i.e.*, with four and six poles, when the motor is being used for a constant output at the different speeds corresponding to the individual steps. This is particularly the case when the motor is used for driving tools, where a constant power gives a greater torque at lower speeds. On the other hand, the use of parallel connections with the smaller number of poles

—*i.e.*, four and six—is desirable when it is necessary to maintain a constant torque at all speeds.

The Oerlikon Co. recommend the use of parallel connections when this type of motor is used for driving pumps, printing presses, roll-

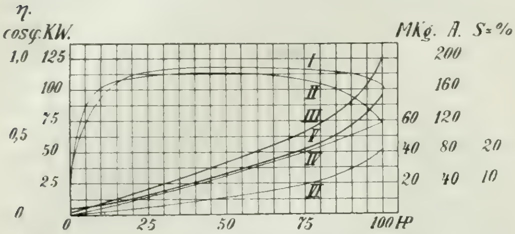


FIG. 3.—FOUR POLES. PARALLEL CONNECTIONS, 1,500 REVS PER MIN.

ing mills, hoisting gears or traction installations. The test results obtained with three-phase motors, either for a constant output or a constant torque, are given in the following tables for the machine under consideration—*i.e.*, for a motor of type 360 having an arbi-

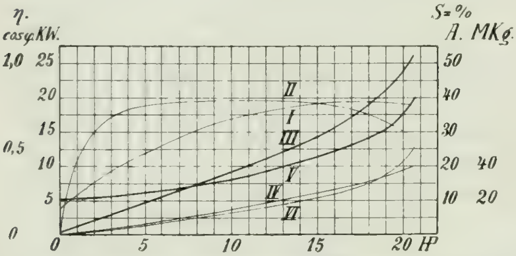


FIG. 4.—SIX POLES. SERIES CONNECTIONS, 1,000 REVS. PER MIN.

trarily chosen output of 15 H.P. and an arbitrarily chosen torque of 10 kgm. and 20 kgm. This constant output of 15 H.P. corresponds practically to the continuous output of the motor when it is running with the eight-pole arrangement of connections. If the connections are changed to a four or six-pole arrangement the output is proportionately increased, while a twelve-pole connection proportionately lowers the output. The outputs at each speed for which the motor is designed correspond to a constant torque of 10 m.kg. The starting

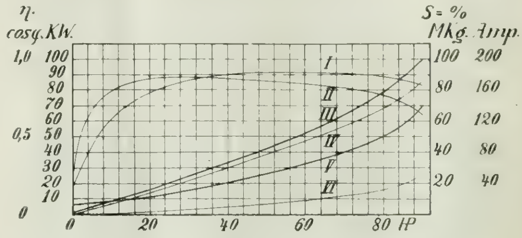


FIG. 5.—SIX POLES. PARALLEL CONNECTIONS, 1,000 REVS. PER MIN.

conditions of the motor are indicated in Table I., which shows the maximum starting moment for each pole arrangement and the corresponding current in amperes. The torque in kilogrammes when running on a brake lever of 1 metre length is shown, and the corresponding current in amperes is also given in the Table.

In this kind of work the proof of the utility of such a machine is

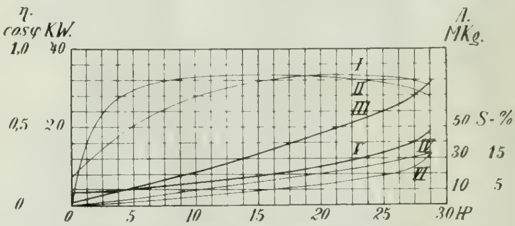


FIG. 6.—EIGHT POLES, 750 REVS. PER MIN.

given by the wideness of its application, and we understand that the excellence of three-phase motors for machine tool driving is being so recognised by one of the largest Swiss tool manufacturers that about 40 of these motors have already been installed in the

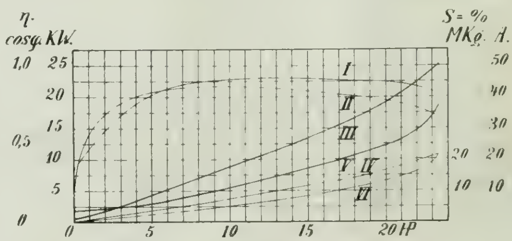


FIG. 7.—TWELVE POLES, 500 REVS. PER MIN.

works. The ironworks at Sandviken in Sweden, as mentioned above, are driving one of their rolling mills with an Oerlikon three-phase variable speed motor of 500 H.P., which is illustrated in Fig. 1. This motor works with a constant torque, and its outputs at four speeds are given in Table II. The efficiencies and power factors of a motor built to run on a circuit of 500 volts and a frequency of 50 cycles at four speeds are given in Table III.

Table I.—*Data for 15 h.p. Oerlikon Three-phase Variable Speed Motor running on a 500 volt circuit: frequency 50.*

A.—DATA WITH CONSTANT OUTPUT.

Grouping of poles.	Speed r.p.m.	Current amps.	Efficiency.	Power factor.	Starting torque m.kg.	Running torque. m.kg.	Starting current amps.
Four poles, parallel connections	1,475	18·0	86·0	0·84	7·3	36	260
Four poles, series connections	1,445	15·5	86·0	0 935	7·5	9	68
Six poles, parallel connections	978	20·5	85·0	0·72	10·8	65	245
Six poles, series connections	920	17·1	84·0	0·915	11·5	14	65
Eight poles	715	19·2	84·0	0·79	15·0	18	82
Twelve poles	447	23·0	77·0	0·77	24·0	30	70

B.—DATA WITH CONSTANT TORQUE.

I.—TORQUE 10 KGM.

Grouping of poles.	Speed, r.p.m.	Current amperes.	Efficiency.	Power factor.	Output.
Four poles, parallel connections	1,470	23·0	88·0	0·90	21·0
Four poles, series connections ...	1,425	21·0	86·0	0·92	20·0
Six poles, parallel connections...	980	20 0	84·0	0·69	13·6
Six poles, series connections ..	933	15·0	85 0	0·915	13·2
Eight poles	727	14·5	82·0	0 69	10·0
Twelve poles	455	12·5	76·5	0·55	6·0

II.—TORQUE 20 KGM.

Grouping of poles.	Speed, r.p.m.	Current amperes.	Efficiency.	Power factor.	Output.
Four poles, parallel connections	1,430	43 0	90·5	0·94	39·0
Four poles, series connections...	...	...	...	...	...
Six poles, parallel connections...	960	31 0	88.0	0·85	26·8
Six poles, series connections ...	830	31·0	72·0	0·86	23·4
Eight poles	700	25·5	82·0	0·82	20·0
Twelve poles..... ..	410	24·5	78·0	0·735	12·7

Table II.—*Data for 500 H.P. Oerlikon Three-phase Variable Speed Motor.*

Output.	r.p.m.	Output.	r.p.m.
500 H.P.	367	250 H.P.	183
400 H.P.	294	200 H.P.	147

Table III.—*Efficiencies and Power Factors of an Oerlikon Three-phase Variable Speed Motor running on a 500 Volt 50 Cycle Circuit.*

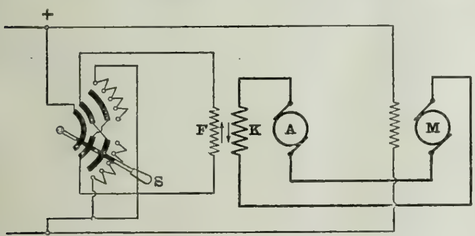
Speed, r.p.m.	367	294	183	147
Efficiency at full load	93%	90%	89%	88%
Efficiency at half load........	90%	87%	86%	85%
Power factor at full load	0·90	0 85	0·82	0·80
Power factor at half load	0·85	0·80	0·74	0 70

STARTING MACHINE WITH DEVICE FOR THE NEUTRALISATION OF REMANENCE.

The advantages of the operation of large motors with heavy fluctuations in load and especially of large haulage gear by means of a Ward-Leonard motor-generator set are in themselves sufficiently well known to account for the rapid introduction and extensive employment of the system. On the other hand, it may, however, perhaps be less familiar that this system possesses a distinct disadvantage, the surmounting of which has up to the present been attempted in vain.

With the Ward-Leonard system the motor is brought to rest by completely cutting out or short-circuiting the excitation of the starting machine which supplies current to the motor. As a rule, it is, however, not always possible to bring the motor completely to rest by this means owing to the presence of remanent magnetism in the starting machine, even after the excitation has been cut out or short-circuited. This remanence suffices to induce a small E.M.F., which, however small, is still sufficient to produce heavy currents, on account of the low resistance of the dynamo, motor and leads, thus imparting an undesired motion to the motor.

This circumstance signifies great unsafety of operation and also decreases the capacity of the plant owing to the difficulty experienced in effecting an accurate stopping. The controlling—*i.e.*, starting-gear of haulage—is, for example, on account of obvious reasons, mostly connected with the braking device in such a way that the braking or releasing of same can only take place when the control lever is in its middle position in which the excitation of the starting dynamo is cut out or short-circuited as the case may be. When the control lever is in this position, as already pointed out, sufficient remanent magnetism is still left in the starting dynamo to produce an E.M.F., which, in turn, causes a flow of current from the starting dynamo to the motor, so that the latter, instead of coming to rest when the brake is released, runs forwards or backwards in accordance with the preceding excitation. Should the motor further possess compensating poles, which is usual in the case of haulage motors, rolling-mill motors, &c., this phenomenon will become even more aggravated.



Device to remove remanent magnetism in Ward-Leonard Generator.

This difficulty has up to the present mostly been surmounted by leaving it to the discretion of the operator as to how far it is necessary to push back the control lever in order to counteract exactly the remanent magnetism in the starting dynamo, which prevents the motor from coming to rest when this lever has been brought to its "off" position. This procedure is naturally only a very incomplete and unsafe one, as it is entirely dependent upon the skill and attentiveness of the operator. Even if the operator has become perfectly initiated into this manipulation, he will, in each instance, still be in doubt again as to how far the control lever will have to be pushed back so as to neutralise exactly the remanence in the starting dynamo and bring the haulage motor completely to rest, owing to the fact that the density of the field due to the remanent magnetism depends upon the previous excitation, which varies considerably in accordance with the working conditions, thus even evading the operator's positive decision.

The Felten & Guilleaume-Lahmeyerwerke, A.-G., of Frankfort-on-Main, have now patented an invention (D.R.P. 208,285) which is found to remove completely the above discussed difficulty and at the same time is characterised by great simplicity. It consists, as shown in the diagram, of a winding, K, mounted on the field-magnet of the starting dynamo A, through which the armature current of the dynamo flows and which is connected up in such a way that it tends to remove the magnetic field still present, owing to the remanence. This winding has been rated in such a manner that upon cutting out or short-circuiting the main excitation F, the magnetism still present is just neutralised. If, then, the control lever for stopping the motor is put into its "off" position, by which means the main excitation F of the starting dynamo is cut out, the current generated by the remanent magnetism flows through the winding K in such a direction that a complete demagnetisation of the field is attained so that the motor positively comes to rest.

To attain the desired action this winding need only consist of a few turns, so that under normal working conditions of the generator it scarcely exercises any influence at all, and therefore only causes extremely low losses.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

The first annual report of the Governing Body has just been issued, and refers to the year ended July 31, 1908. A brief statement of the measures taken in the matter of the incorporation of the College, for which a Charter was granted on the 8th July, 1907, is first given, followed by a list of the members of the Governing Body. Four temporary sub-committees or Advisory Boards, consisting of certain members of the Organisation Committee, together with a limited number of persons, outside the Governing Body, have been formed. These committees made valuable reports on the matters committed to them, which are now receiving the careful consideration of the Governing Body.

The actual transfer of the Royal College of Science and the Royal School of Mines to the Governing Body of the Imperial College dates from January 1, 1908, but the Board of Education, at the request of the Governing Body, undertook to conduct the current work of these institutions up to the end of the financial year (March 31, 1908). In arranging for the continuance and development of the work of the Institution, the Governing Body have had the following matters under its careful consideration: (1) The standard of admission required from students entering their first year courses in the session, 1908–9, together with the tests required by way of entrance examination. (2) The possibility of harmonising the first year courses of the constituent Institutions of the Imperial College, so long as provision continues to be made by these institutions for work of this standard. (3) The provision of fourth year courses of a more advanced character than had hitherto been attempted.

Among the additions to the Imperial College staff are:—Professor of Zoology, Mr. A. Sedgwick, M.A., F.R.S.; Professor of Metallurgy, Mr. W. A. Carlyle, Ma.E., M.Sc., M.I.M.M.; Professor of Physics, The Hon. R. J. Strutt, F.R.S.; Assistant Professor of Botany, Mr. P. Groom, M.A., D.Sc., F.L.S.

Although not falling within the period to which the report relates, it is mentioned that a donation of £4,000 from Mr. C. Hawksley has been promised towards the provision of a Laboratory for the study of hydraulics, in memory of his father, Thomas Hawksley, M.Inst.C.E., the well-known hydraulic engineer. It is with pleasure that the Governing Body are able to report that the Council of the Institution of Electrical Engineers are prepared favourably to consider their co-operation in the equipment of an electrical engineering laboratory at the Imperial College, in memory of the late Lord Kelvin.

Appendixes to the report give further information concerning (1) the membership of Committees; (2) donations and bequests to the Imperial College; (3) members of staff; (4) statement of students enrolled; (5) prize distribution and Rector's addresses; (6) fourth year special advanced courses. The total number of students enrolled in the Imperial College of Science and Technology was 456 in the Session 1908–1909 (to Nov. 11, 1908, only), as compared with 294 in 1907–8, and 303 in 1906–7. The corresponding figures for the City and Guilds College were 459, 438 and 457 respectively.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s. and 5 per cent for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Science Abstracts." Vol. XII. Part 3. March, 1909. Section A, Physics; Section B, Electrical Engineering." (London: E. & F. N. Spon.) 1s. 6d. each.

"Einführung in die Elektrotechnik." By Dr. C. Heinke. (Leipzig: S. Hirzel.) M.13.

"Berechnung und Konstruktion elektrischer Schaltapparate." By Prof. R. Edler. Vol. VII. of "Grundriss der Elektrotechnik." Edited by A. Konigswerther. (Hanover: Dr. Max Jänecke.) M.12.

"Die normalen Eigenschaften elektrischer Maschinen." By Dr. Richard Goldschmidt. (Berlin: Julius Springer.) M.3.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The thirty-fifth issue of the Supplement will be published (Gratis) with the number of "THE ELECTRICIAN" for April 30.

The "INDUSTRIAL SUPPLEMENT" is holed for filing or hanging, and filing covers can be supplied for holding 6 or 12 issues.

SPECIAL NOTICE.

With this week's number of "THE ELECTRICIAN" is issued (Gratis) the Index to Vol. LXII. This includes the Index to the "Industrial Supplement."

Complaints of non-receipt should be promptly made to the Publisher.

COMBINED DESTRUCTOR STATIONS.

Although the combination of a destructor with an electricity generating station has now been attempted for a good many years, the value of the combination is still a subject of some controversy. At one time it may have seemed that the capabilities of the destructor were small. Refuse was, no doubt, destroyed in a more or less efficient manner, and it was thought something of an achievement to attain this result without nuisance, any idea of obtaining useful work beyond that of cremation being given no thought. A great improvement, however, soon took place. The introduction of forced draught, whether by fans or by steam jets, made a great change, and along with more perfect combustion came the desire of attempting to utilise the waste heat. But one most important lesson had to be learned, namely, that the sanitary requirements of a destructor must be paramount—that, in fact, a destructor is essentially a sanitary appliance, and that its functions as such must receive no interference. This point cannot be too much emphasised; but assuming that the destructor accomplishes its work satisfactorily—that the refuse is burnt perfectly, and therefore no nuisance is created—then we may very well inquire whether the resulting waste heat is not sufficient to perform some useful work.

It is well known that the quality of refuse varies according to the locality and with the different times of year. Taking, however, as an average figure, 1 ton of refuse per thousand inhabitants per day—a quantity which must be regarded as somewhat high—and the possibility of producing, say, 70 units per ton, then it follows that a destructor should be able to generate something like 20 units per inhabitant per year. In a general way we might say that

the possibilities lie between 15 and 20 units per inhabitant. At present the number of units of electrical energy used per annum on networks which do not supply tramways, but merely the ordinary lighting and motor load, amounts to something like 20 to 30 units per inhabitant per year. On the face of it, therefore, the outlook of the destructor from the electrical point of view is distinctly promising. When it is remembered, however, that refuse must generally be burnt continuously, and cannot well be handled intermittently to meet the exigencies of a lighting load, and that on Sundays a destructor is not worked to any serious extent because there is no collection of refuse, then it will be realised that a destructor is not a very useful adjunct to electricity stations dependent simply upon a lighting load. Our readers will find this point emphasised elewhere in a Paper read by Mr. J. A. ROBERTSON before the Glasgow Local Section of the Institution of Electrical Engineers.

Where there is a sufficient motor or tramway load to enable a generating station to take up all the steam generated by the destructor throughout the 24 hours the case is distinctly different. Under such conditions the destructor may be certainly beneficial, though there is always a difficulty in arriving at the true value of the steam. A destructor in itself, when coupled up to a generating station, does not improve the steam consumption per unit. The effect of the additional boilers and steam pipes cannot usually be found in an easy manner, but in the case of Greenock the generating station had been run a few months before the destructor was put to work, and it was found that there was an increase of 10 per cent. in the steam consumption per unit generated when the destructor steam was utilised. In this particular case, also, it was comparatively easy to arrive at a valuation of the destructor steam. The amount of coal that was being used previously was well known, and thus any saving in coal could be easily determined.

In passing, we might remark that although the statement of results in terms of units generated per ton of refuse may be very suitable in any particular station, yet from the point of view of comparing one station with another it is desirable that results should be expressed rather in terms of the amount of steam per ton than as the number of units per ton, for the latter depends also upon the class of generating plant as well as on the efficient use of the refuse.

Generally speaking, we think it will be admitted that the refuse destructor as an adjunct to the smaller class of generating station with a tramway load, or a fair motor load, is, if properly designed, a distinct gain. On the other hand, as a station becomes larger such assistance becomes much less pronounced. The destructor can only increase in proportion to the population, whereas the growth of the generating station depends upon the more extended use of electrical energy for various purposes, and the station should increase rapidly in size in any suitable area quite irrespective of increase in the surrounding population. We can well imagine that as a generating station expands the destructor plant may become somewhat of an impediment rather than an advantage. For this reason it appears to us that, generally speaking, the services of a destructor are more desirable as an aid to sewage pumping plant than to electrical generation. Here the load is more or less continuous: as the population increases both the sewage works and the destructor increase simultaneously, and the latter continues to give the same assistance, which is unaffected by other industrial conditions of expansion.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Essays Biographical and Chemical. By Sir WILLIAM RAMSAY, K.C.B. (London: Archibald Constable & Co.) Pp. 247. 7s. 6d. net.

This book consists of a very interesting series of biographical essays of chemists and physicists, which takes up about half of it, and a series of essays upon various chemical subjects, which fills the other half.

Although as chemists we can hardly at the present day consider ourselves the foremost nation, yet as pioneers we were second to none. And it is of interest to notice that some of our London chemists (Boyle, Cavendish, Davy and Graham) were among the very foremost of these pioneers. The author describes the work of these men and their lives in a very sympathetic style. Davy was most extraordinarily ambitious, Graham was retiring, as was Cavendish, who was painfully shy, and Boyle seemed best to hit the medium between the extremes. All these men, however, were of extraordinary genius and ability, and their work was of a most accurate and enduring character.

One of the most interesting personalities which Sir William describes is Joseph Black, of Edinburgh. Black was the first to carry out quantitative measurements, and thus exploded the phlogistic theory. He also determined the latent heat of fusion of ice and the latent heat of steam. The numbers obtained by him show a very great degree of accuracy, considering the very meagre means which he had at his disposal. It is not, however, only his work which is noticed, but in a very sympathetic spirit Ramsay shows us the man. He was a person of simplicity of character, who never said a hard word or made an enemy, and was, consequently, loved by all who knew him.

A short note of Lord Kelvin is also given, but we consider this the least satisfactory biography in the book—it is all too short and the work done by Kelvin was all too great.

The second portion of the book is entitled Chemical Essays, and treats of a number of subjects, such as the Becquerel rays, the aurora borealis, radium and its products, What is an element? and the last essay is on the functions of a university.

Sir William Ramsay considers that the most important function of a university is to attempt to answer the question asked often with painful iteration by the child—"Why?" This, of course, is in essence another way of saying that the function of a university is research. The essence of research is observation. Faraday noticed that if a magnet approaches a coil of wire an electric current is induced in the wire. The results are electric light, electric traction and the employment of electricity for all sorts of motive power.

Perkin noticed an uninviting black product by the oxidation of aniline. Further investigation showed a brilliant dye. To-day there are hundreds such.

A Swiss schoolmaster—Schönbein—noticed the action of nitric acid on paper (cellulose). To-day the chief power for blasting and firing guns and ordnance is nitro-cellulose.

Yet in this country the one thing not understood is research. How many of our universities or polytechnics cultivate research and how many of our manufacturers will recognise its vast importance? We heartily recommend the book as being instructive and also interesting—not always synonymous terms. F. M. PERKIN.

The Proper Distribution of Expense Burden. By A. HAMILTON CHURCH. (London: "The Engineering Magazine.") Pp. 116.

In this work, the contents of which appeared originally as a series of articles in the columns of the "Engineering Magazine,"

a most successful attempt has been made to deal thoroughly with the question of establishment expenditure, and its interconnection with costs in factories, not merely as regards the output as a whole, but of each piece of work carried out, and of each process that takes place, before the finished product issues from the sales department. A volume which deals so thoroughly with details as the one before us is of distinct value at the present time, when the keen competition in the engineering, and particularly in the electrical engineering industry, renders close attention to costs vitally important if the finished product is to show a proper percentage of profit. The main object of all efforts in the direction of ascertaining costs is that they may be filed so as to constitute a record which may be referred to when the article is finished, and which will form, further, a valuable guide for future work. The true method of cost finding appears to be the examining of all the various processes through which the work passes, determining their costs by comparison with the known costs of similar work, and adding that proportion of expense burden which each article should bear. Mr. Church shows how this proportion should be ascertained, and goes to the root ideas of cost finding, laying down broad and thoroughly reliable principles by which safe and accurate figures may be obtained for machine, piece and job costs. The author rightly says that these principles will properly distribute all expenses of manufacture, marketing, and management, so that the truth may be ascertained without trouble as to the profit or loss of any line of product, and changes in manufacturing cost from time to time be instantly detected and the cause discovered. Amongst the subjects dealt with are the interlocking of general charges with piece costs, showing the elements which compose job, prime, shop, and inclusive costs and selling price; the methods of distributing expenses to individual jobs; the scientific machine rate and the supplementary rate; and the apportionment of office and selling expenses. One of the best chapters in the book is that which deals with the classification and dissection of shop charges. The book may be thoroughly recommended, and the author deserves credit for the painstaking way in which he has dealt with this complex and important subject.

G. B. B.

Liquid and Gaseous Fuels. By VIVIAN B. LEWES. (London: A. Constable & Co.) Pp. vi. 237. 6s. net.

In preparing this extremely readable book the author has utilised matter that had already appeared in lectures and Papers given before various institutions, but where such matter has been used it has been brought up to date. We congratulate the auther on the result, and the excellent literary quality which has been attained without detriment to the technical information that such a technical book should contain.

The author has not entirely excluded the discussion of solid fuel, from which in many cases liquid and gaseous fuels are made, but gives a general sketch of the whole subject and its relation to the power problems of the day.

Chapter I. deals with combustion, flame, smoke, the atmosphere, and also the effect of smoke in inducing the formation of fog. Chapter II. discusses the cycle of animal and vegetable life, and the action of the sun in preserving the balance of oxygen in the composition of the atmosphere, formation of peat and coal, and the various theories as to the formation of petroleum. The compositions of the principal natural fuels are given. Chapter III. describes various calorimeters and the methods of using them for the determination of the calorific value of a fuel. Chapters IV. and V., on liquid fuel, describes various burners and furnaces, and discusses the advantages of such fuel for naval use. The manufacture of coal gas, its enrichment for lighting, and its use for heating and power form the subject matter of Chapters VI. and VII. Water gas and producer gas are discussed in Chapters VIII. and IX., with numerous illustrations and descriptions of plant. A brief discussion is given of suction producers and gas engines as compared with steam plant for power purposes.

In Chapter X., on the fuel of the future, the author deals with the future of the fuel problem and the probable lines on which the world development is likely to proceed for securing the energy essential to life and prosperity. The supersession of steam as a motive power by the internal combustion engine is predicted, also the development of the alcohol motor, and the growth of a great agricultural industry for the production of alcohol for fuel when excise restrictions are removed.

A short bibliography is given, which should be useful to engineers who may require fuller information on any special branch of the subject.

A. S.

THE COMPOSITION AND DURABILITY OF CABLE PAPERS.

BY CLAYTON BEADLE AND HENRY P. STEVENS.

(*Continued from page 8.*)

Summary.—Information at present available upon the desirable properties of paper from the insulating point of view is very meagre. The authors attempt to fill this gap by giving the results of their experience in dealing with such papers from the chemical point of view. The composition of manila and other papers is briefly discussed. Tests to which papers should be subjected are considered, and a number of tables of results are given. The effect of moisture is dealt with at some length, and the authors finally express their opinions on changes taking place when papers are in contact with the atmosphere and when they are protected from it.

Mineral matter is to be avoided in cable papers. In determining the ash in a cable paper one almost invariably finds even in the best papers 1 or 2 per cent. of ash. We should always expect to find this quantity of ash in a good manila paper, although paper when very "soft-sized" and made entirely from chemical wood pulp might contain less ash. There is always a certain amount of normal ash in fibrous material, and the 2 or 3 per cent. found in manila is merely the normal ash resulting form the fibre itself, together with the small amount of materials that are used to effect the sizing. The addition of mineral matter, such as china clay, to cable papers to give anywhere from 10 to 20 per cent. or more of ash should not be resorted to; it is quite liable to reduce the strength of the paper as well as its lasting qualities. Such paper should, in our opinion, be rejected by the cable manufacturers.

On examining details of strength tests No. 1 to 12, Table A, it will be noticed that there is considerable variation in strength tests of individual tests A and E, but it is found in practice that five under each set is sufficient, and that if a further five tests be made in confirmation the average of the two sets of figures will come very close together. The greater strength in the Y than in the X direction is universal, and the ratio of Y/X is found to be a useful figure.

It is only in hand made paper that $Y/X = 1{\cdot}0$ and only in a few cases. The greater bulk of hand-made paper $Y/X = 1{\cdot}3$. In papers produced on fast-running machines such as common news Y/X may $= 100$ at times, and perhaps averages 10.

The summary of strength tests in the two directions, together with the mean of the two directions, is given in Table B, and in column 10 is given the ratio Y/X. With the ordinary run of commercial papers of fair strengths we seldom find such high figures for Y as is to be found in many of these papers, about the normal figure may be taken as falling somewhere between 1·7 and 2·0. In this case seven out of 12 samples come above 2·0, the average of these papers being 2·19, one paper being about 3·0. We regard this as being somewhat exceptional. It indicates, of course, a more than usual difference in the strength of the papers in the two directions of the web. It will be noticed also that the percentage of air space ranges on an average considerably over 50 per cent., in fact, more like 55 per cent., and only one falls below 50 per cent. In this respect they resemble the ordinary run of unloaded commercial papers of which one of us has determined the air space volume of some hundreds.* If a paper is sufficiently loaded with mineral matter the air space volume becomes reduced from, say, 60 per cent. to 29 per cent., and consequently its capacity for the absorption of hydro-carbon in a similar ratio.

* "The C. B. S. Units" (E. & F. N. Spon), Cross, Bevan, Beadle and Tindall.

Beadle, "Fibrous Constituents of Paper." *Technics.* (George Newnes

Paper to be impregnated for cables should be regarded not as the insulating medium but rather as the medium which holds the insulator; consequently, it is required to have as great a power of absorption as possible consistent with the necessary strength, durability and other physical qualities.

Table A herewith contains details of the actual breaking stress tests on the individual strips of paper. Direction X is when the pull is applied on a strip cut across the machine direction, and direction Y is when the pull is applied on a strip cut along the machine direction, or direction of the reel. It is usual to take the mean of these directions as representing the strength of the paper, but in this case we are disposed to think that, as the strips are cut in the direction of the reel, the strength in the direction Y is a better criterion from a cable manufacturer's point of view.

TABLE A.—*Details of Strength Tests.*

	Direction X.	Direction Y.
No. 1.		
Test A	16·8	30·0
,, B	16·0	24·6
,, C	13·8	29·0
,, D	12·2	27·7
,, E	14·2	29·2
Mean	13·8	28·1
Mean of both directions in lb. per inch width		20·95
No. 2.		
Test A	20·3	38·5
,, B	18·3	46·0
,, C	18·2	43·0
,, D	17·4	45·3
,, E	13·8	35·8
Mean	17·6	41·7
Mean of both directions in lb. per inch width		29·6
No. 3.		
Test A	30·5	47·2
,, B	30·0	46·6
,, C	30·4	40·1
,, D	30·6	45·0
,, E	27·0	56·0
Mean	29·7	47·0
Mean of both directions in lb. per inch width		38·3
No. 4.		
Test A	19·5	34·8
,, B	19·0	34·8
,, C	16·0	33·0
,, D	15 4	37·0
,, E	15·3	34·8
Mean	17·4	34·9
Mean of both directions in lb. per inch width		26·1
No. 5.		
Test A	17·2	35·0
,, B	18·4	30·5
Mean	17·8	32·7
Mean of both directions in lb. per inch width		25·2
No. 6.		
Test A	31·2	59·9
,, B	38·8	56·4
,, C	35·0	46·6
,, D	28·1	67·1
,, E	35·2	61·0
Mean	33·7	58·2
Mean of both directions in lb. per inch width		46·0
No. 7.		
Test A	12·5	43·3
,, B	18·5	43·0
,, C	10·0	42·0
,, D	16·0	46·5
,, E	16·0	43·0
Mean	16·2	43·5
Mean of both directions in lb. per inch width		29·8
No. 8.		
Test A	14·5	36·2
,, B	13·5	43·3
,, C	16·8	41·3
,, D	13·5	44·8
,, E	17·1	40·8
Mean	15·1	41·3
Mean of both directions in lb. per inch width		28·2
No. 9.		
Test A	23·0	42·6
,, B	23·0	41·0
,, C	21·2	35·2
,, D	23·3	45·8
,, E	22·0	...
Mean	22·5	41·1
Mean of both directions in lb. per inch width		31·8
No. 10.		
Test A	10·4	23·8
,, B	8·0	25·2
,, C	10·4	22·2
,, D	10·2	20·6
,, E	8·9	25·2
Mean	9·5	23·4
Mean of both directions in lb. per inch width		16·5
No. 11.		
Test A	20·0	34·18
,, B	21·8	38·0
,, C	21·9	37·5
,, D	20·0	35·0
,, E	19·0	25·0
Mean	20·5	36·1
Mean of both directions in lb. per inch width		28·3
No. 12.		
Test A	16·0	30·0
,, B	14·8	26·0
,, C	15·8	29·0
,, D	15·6	33·2
,, E	14·3	28·0
Mean	15·3	29·2
Mean of both directions in lb. per inch width		22·2
No. 13.		
Test A	11·5	33·5
,, B	12·4	31·0
,, C	13·1	26·8
,, D	12·2	25·7
,, E	12·5	27·9
Mean	12·3	29·0
Mean of both directions in lb. per inch width		20·6

However, as the mean strength of the two directions is the general figure adopted by nearly all makers and users of paper, we do not care to depart from general custom, and furthermore one has to take into consideration the stresses and strains to which the strips of paper are subjected, at the moment they are lapped round the conductors, as well as any subsequent action to which the paper or cable may be subjected, tending to wear out or break the paper when the cable is reeled, unreeled, &c.

A point might with advantage be here referred to; there is no difficulty in taking any direction for the tests on the paper from the wide reels, but when once the paper is cut into narrow strips, only one direction is available, namely, the "machine," or running direction. As the strips being only, say, two inches wide, we cannot make tests in the cross direction. In order, therefore, to compare paper stripped from cables with the paper in reels one is obliged to compare strips in the machine direction only.

The individual figures of the tests will give some idea of the limits of variation of strength in different parts of the web, &c., the strips having been cut as far as possible equidistant from one another, and across the direction of the web of the large reels as supplied to cable manufacturers.

On page 60, column 5, we have the percentage of air space, from this an opinion can be formed of the relative powers which these papers have of absorbing hydro-carbons, assuming that the air space becomes entirely filled. Column 6, page 60, gives the actual relative thicknesses of the papers in mm. Columns 7, 8 and 9 are merely summaries from page 59. From columns 10 and 11, column 12 is calculated. This gives the actual relative strengths of the paper substance eliminating the question of thickness. A figure useful for comparing the strength of paper with that of other materials.

The volume percentage was determined by the system known as the C.B.S. units, which the authors have found of great service.* The following brief particulars will, perhaps, serve to show how this is carried out. A sharp steel punch is constructed so as to punch discs, of such a diameter, as to give an area of 1,000 sq. mm. This area is such that the thickness readings in mm. of ten discs, measured together by means of a micrometer, expresses the volume of the paper in cubic centimetres without calculation. This is true, no matter what number of discs one takes. The discs so measured are weighed, and the weights in grammes divided by the volume in cubic centi metre gives us the grammes per cubic centimetre, which we call the "apparent specific gravity." As in the case of good cable papers the weight of ash is nominal, it may be neglected in the calculation. The percentage by volume of fibre substance is obtained by dividing the grammes per cubic centimetre by 1·5 (*i.e.*, the specific gravity of the fibre, substance which is not subject to water at variation), and dividing by 100. This figure deducted from 100 gives the percentage of air space as given in column 5, Table B.

We have been asked to issue a printed form of certificate, which we have done, and used for cable papers. The following is a common form as used for the purpose of a general examination:—

Mark or No.	
Weight of five discs	0·520 grammes
Thickness of five discs	0·670 mm.
Grammes per cubic centimetre........................	0 776
Percentage of fibre by volume	50 7 per cent
Percentage of airs pace by volume	48·3 per cent.
Breaking strain in lb. per inch width Y ..	54·0
,, ,, ,, ,, .. X ...	21 0
Mean of X and Y	37 5
Breaking strain in grammes per width of 25 mm.	16,987 grammes
Sectional area in mm. of strip broken	2·68 mm.
Breaking strain in square mm. of section area	6,342 grammes
Ash in paper........................	2·60 per cent.
Colour of ash	reddish white
Sizing	slightly sized

Approximate Composition.—All hempstock, but fibres are very coarse, and paper contains dirty particles which might interfere with insulation.

* "C.B.S. Units" (E. & F. N. Spon), Cross, Bevan, Beadle and S. Tindall.

Table B.—*Summary of Strength Tests and Volume Percentages, &c.*

No.	Weight of five discs.	Thickness of five discs.	Grms. per cubic centimetre.	Percentage by volume. Fibre.	Percentage by volume. Air space.	Thickness of paper. Millimetre.	Breaking strain of strip of paper 1 in. wide, in lb. X.	Breaking strain of strip of paper 1 in. wide, in lb. Y.	Mean of X & Y	Ratio Y/X	Breaking stress in grammes per width of 25 millimetres.	Sectional area of strips, broken. Millimetres.	Breaking stress in grams per sq. millimetre of sectional area.
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0·421	0·66	0·638	42·5	57·5	0·132	13·8	28·1	20·9	2·03	9,468	3·3	2,837
2	0·456	0·70	0·651	43·4	56·6	0·140	17·6	41·7	29·6	2·37	13,409	3·5	3,831
3	0·562	0·72	0·780	52·0	48·0	0·144	29·7	47·0	38·3	1·57	16,550	3·6	4,600
4	0·437	0·58	0·754	50·2	49·8	0·116	17·4	34·9	26·1	2·00	11,823	2·9	4,075
5	0·186	0·27	0·688	45·9	54·1	0·135	17·8	32·7	25·2	1·83	11,415	3·4	3,357
	2 discs.	2 discs.											
6	0·742	1·15	0·645	43·0	57·0	0·230	33·7	58·2	46·0	1·72	20,838	5·6	3,720
7	0 555	0·78	0·712	47·5	52·5	0·156	16·2	43·5	29·8	2·70	13,509	3·9	3,464
8	0·422	0·67	0·630	42·0	58·0	0·134	15·1	38·9	28·2	2·60	12,775	3·35	3,813
9	0·649	0·93	0·698	46·5	53·5	0·186	22·5	41·1	31·8	1·83	14,405	4·65	3,080
10	0·361	0·59	0·612	40·8	59·2	0·118	9·6	23·4	16·5	2·48	7,474	2·95	2,491
11	0·462	0·71	0·651	43·4	56·6	0·142	20·5	36·1	28·3	1·76	12,820	3·55	3,611
12	0·351	0·62	0·705	47·0	53·0	0·124	12·3	29·0	20·6	2·36	10,057	2·8	3,592
Mean of											9,332	3·1	3,010
12 papers	...	...	0·680	45·4	54·6	0·146	18·9	37·9	28·4	2·19	12,606	3·6	3,499

In Germany paper-testing is conducted under the elaborate system of the Konigl. Techn. Versuchsanstalt, Berlin, of which, through the agency and influence of Prof. Sell and C. Hofmann, a department has been organised exclusively for the work of paper-testing.

The mechanical properties of papers are considered to be represented by data of (1) Tenacity, *i.e.*, actual resistance to tensile strain; (2) "Elasticity," or rather elongation up to the point of rupture; (3) Resistance to rubbing.

Tenacity finds a convenient expression in terms of "break in length," *i.e.*, the length of a strip of paper, the weight of which would be equal to its breaking weight. This expression has the advantage that it is independent of the width of the paper, which may, therefore, be left out of consideration. Further, since the expression "breaking length" is calculated on the basis of weight and not of dimensions, and since paper is made and sold by weight, this expression, as a commercial standard, eliminates and discounts the factors of thickness, bulk, loading, &c., and becomes a common measure for the strength-value of all papers, proportional to the number of strength units per lb. of paper. On this basis Germany has adopted the following "normal" standards :—

Table Showing the Various Classes into which Paper is Divided by the Testing House.

Class.	Average breaking length in metres.	Ave. elongation in hundredths of original length (per cent.)	Resistance against crumpling.	No. of double bendings.
1	6,000	4·0	Very great	190
2	5,000	3·5	,,	190
3	4,000	3·0	Great	80
4	3,000	2·5	Rather great	40
5	2,000	2·0	Average	20
6	1,000	1·5	Small	3

The following is the result of high-class manila paper, made in the British Isles as officially tested by the Berlin Testing House, Sept. 14, 1904 :—

Composition Pure Manila Paper.

Test.	Result. Breaking length.	Result. Elongation.
Strength.		
Lengthwise of machine.........	11,450 metres	2·8 per cent.
Crosswise ,, ...	4,450 ,,	7·8 ,,
Average	7,950 ,,	5·3 ,,

Length of samples tested	180 mm.
Width ,, ,, ...	15 mm.
Temperature of room where tests were carried out	17 C.
Humidity of air	65 per cent.
Resistance against crumpling	Extremely great.
Number of double bendings	More than 1,000.
Glue	Impermeable to glue.

Insulating Paper.

Test.	Result Breaking length.	Result Elongation.
Strength.		
Lengthwise of machine.........	7,650 metres	2·3 per cent.
Crosswise ,, ...	2,900 ,,	6·0 ,,
Average	5,275 ,,	4·15 ,,

Length of samples tested	180 mm.
Width ,, ,, ...	15 mm.
Temperature of room where tests were carried out	17°C.
Humidity of air	65 per cent.
Resistance against crumpling	Very great.
Number of double bendings	More than 1,000.
Glue	Permeable to glue.

Under ordinary atmospheric conditions a cable paper made from manila and other suitable fibres, would contain about 10 per cent. of moisture in an English climate; on a dry summer day it might be only 7 or 8 per cent.; in damp and foggy weather as much as 12 or 15 per cent.; before a fire it would undergo contraction and would sink down to perhaps 3 or 4 per cent. Bleached fibre such as cotton and linen contain only about 7 per cent. under ordinary circumstances, as against 10 per cent. in the case of manila, &c.

Cable manufacturers should regard 10 per cent. as the normal moisture content of their paper, as received from manufacturers, and expect to find a reduction of 10 per cent. in weight in desiccating their paper.

Columns 11, 12 and 13, Table B show the data and figures for calculating the breaking stress in grammes per square millimetre sectional area, which really represents the specific strengths of the papers as against the ordinary way of expressing the strengths of papers as pounds per strip of 1 in. wide, which latter method is all very well in its way, but it does not take into consideration the thickness of the paper. In order to determine the "actual" and "specific" strengths of the papers, it has been found by us advisable when reporting to cable manufacturers to report both sets of figures.

It will be noticed that the "actual" strength of the strip is greatest with No. 6 (20,838), and least with No. 10 (7,474), whereas the specific strength is greatest with No. 3 (4,600), and least with No. 10 (2,491). Of course the actual strength of any particular make of paper can be increased by increasing the thickness, but by this means beyond certain limits the specific strength is found to be diminished. Paper of greatest specific strength is generally found to be that of moderate thickness, so that if one wants to impart strength in the way of paper, and at the same time build up considerable thickness, this is best done by working several ply of paper on; rather than by a single ply of *thick* paper, coiled so as to overlap.

In connection with this matter, one has also to consider the question of cost, and in the manufacture of paper a paper of moderate thickness is perhaps the cheapest per pound to pro-

duce; and very thin papers cost considerably more per pound. Furthermore, extra thick papers are somewhat unwieldy to manipulate. The advantage of several ply is also that the layers can be done alternately, right handed and left handed, and when it is a case of impregnated paper the bulking is perhaps greater, and there is greater space for the impregnating material, which in some cables lies not only in the interstices of the paper itself, but also in between the strands of paper, in between the paper and the conductor as well as in between the actual wires of the copper conductor. In other words, impregnating material is now freely used, not only to saturate the paper, but to fill up all the available air space inside the lead sheathing.

(To be continued.)

PATENTS IN 1908.

The twenty-sixth report of the Comptroller-General of Patents, which has just been issued, shows a diminution in the number of applications for patents in the year 1908, 28,598, compared with 28,915 in 1907, which latter figure was also smaller than that recorded in the previous year 1906, when the high-water mark of 30,030 applications was attained. The number of specifications, provisional and complete, shows a small decrease compared with 1907, but the number of patents sealed was 16,284, an increase of 12 over the previous year's total; in fact, the highest figure recorded during the 11 years of which particulars are given in the report. The number of designs registered was also a maximum, viz., 24,389, compared with 21,039 in 1907, whilst the number of trade marks showed a diminution, only 5,965 being registered, against 6,255 in the previous year. We give below an abstract of the report.

The receipts from patents fees were £262,890, compared with £265,012 in 1907, a decrease of £2,122; from designs fees £5,189, compared with £5,473, a decrease of £284; and from trade marks fees £17,358, compared with £18,447, a decrease of £1,089. The receipts from the sale of Patent Office publications were £11,898, compared with £11,457, an increase of £441. The total receipts were £297,335, compared with £300,389, a decrease of £3,054. The total expenditure on behalf of the office was £179,531, compared with £176,230, an increase of £3,301. The principal increase was in the amount paid for salaries, which was £118,520, compared with £106,869. The number of readers who made use of the library in 1908 was 152,221, compared with 148,198 in 1907, an increase of 4,023, or 2·7 per cent., and the largest number recorded in any one year. The number of volumes added to the library was 6,059, of which 1,231 were volumes of patent specifications or journals (English and foreign) and 151 were trade catalogues. The remaining 4,677 volumes were text-books or periodical publications relating to scientific and technical subjects, and of these 3,562 were obtained by purchase and 1,115 by donation. The number of works in the library at the end of the year was 37,647, and the approximate number of volumes (exclusive of duplicates) was 119,000. The new "relative" system of shelf classification of the library has been extended from A A to B J. Its progress has been delayed by work in connection with the printing of the author catalogue. The system of keeping deposit accounts at the sale branch for the purchase of Patent Office publications continues to grow in favour. During the year 11 new accounts were opened, and the total number of depositors is now 308, of whom 33 live in London, 110 in other parts of the United Kingdom, and 165 abroad.

The new provisions in the Patents and Designs Act, 1907, have been largely made use of. In those cases in which the examiner has reported disconformity between the complete and provisional specifications, it is now possible for the Comptroller to cancel the provisional specification and treat the application as having been made on the date on which the complete specification was left. This provision has been made use of in 265 cases. Sec. 16, which allows the filing of a single complete specification and the grant of a single patent in respect of the inventions described in two or more cognate provisionals, encourages applicants to devise and develop slight improvements upon their prior inventions, which perhaps would not have justified the expenditure incurred in filing separate applications. This section has been largely adopted, and in 164 cases complete specifications have been filed respect in of cognate provisional specifications. Under sec. 19, 768 applications for patents of addition were filed; and under sec. 20, which enables patents lapsed in consequence of the unintentional non-payment of renewal fees within the prescribed period to be restored by order of the Comptroller, 61 applications were made during the year, and 33 hearings were held. In 27 cases the patent was restored, 5 applications were withdrawn, and 29 are pending.

Under sec. 27, which provides for the revocation of patents worked exclusively or mainly outside the United Kingdom, 15 applications were made. Two of these were abandoned; in 2 cases the patent was revoked and 11 cases are pending. The copyright of 938 designs, or 4·3 per cent. of the whole number which would otherwise have expired, was extended for a period of five years.

Patents.

The sum received from renewal fees was £154,388, compared with £155,127 in 1907, a decrease of £739; and that from sealing fees was £15,912, compared with £16,071, a decrease of £159.

The number of applications of both provisional and complete specifications fell off in 1908, those accompanied by provisional specifications being 19,495, compared with 19,568 in 1907, a decrease of 73, and those accompanied by complete specifications 9,103, compared with 9,347, a decrease of 244. The complete specifications filed upon previous provisionals were 8,643, compared with 9,482, a decrease of 839, due to the falling off in the number of applications of earlier date. Only once before since the 1883 Act came into force—viz., in 1898—has there been a simultaneous decrease in both kinds of applications and in the complete specifications filed after provisionals. The total number of specifications received was 37,241, compared with 38,397 in 1907, a decrease of 1,156, or 3 per cent. The applications received from women inventors numbered 572, compared with 560 in 1907. There were 1,459 applications made by way of communication from abroad, of which 736 came from the United States of America, 415 from Germany, 52 from France, 33 from Switzerland, 30 from Austria-Hungary, 27 from Canada, and 23 from Italy. The applications made in this country under the provisions of the International Convention of 1883 by inventors living in other States of the Union numbered 2,326, as against 2,286 in 1907. Of these, 877 were received from Germany, 607 from the United States, 536 from France, 87 from Belgium, 62 from Sweden, 42 from Switzerland, 31 from Italy, 27 from Norway, 17 from Australia, 16 from Denmark, 8 from Spain, 7 from New Zealand, 5 from Japan, 2 from Brazil, 1 from Ceylon, and 1 from Cuba. None were received from Mexico, the Netherlands, Portugal, San Domingo, Servia or Tunis.

An appendix shows the number of applications and complete specifications received in 1905, 1906, 1907 and 1908, subject to the provisions of sec. 1 of the Act of 1902 and sec. 7 of the Act of 1907, and the result of their examination. The latter section, which is a re-enactment of sec. 1 of the Act of 1902, has now been in operation for four years, and, during this time, 64,902 complete specifications have been examined in accordance with its requirements. After the lapse of four years, in which a very large number of cases have been considered, it is possible to review the general effect of the working of the section, and to determine how far the anticipations of the Committee appointed in 1900 to inquire into the working of the Patents Acts have been realised. It is satisfactory to record that, despite the drastic changes in procedure introduced by the section, it is working with smoothness, and an established practice, well understood by patents agents and their clients, has been arrived at. It has been recognised that the main object of the official examination of applications is to check the issue of invalid patents, and to ensure as far as possible that all patents issued shall be based upon specifications which are neither misleading nor insufficient. The position of the genuine inventor is thus strengthened, and the patent system is prevented from being misused by adventurers as a means of encroaching on the rights of the public. Applicants and patent agents have been encouraged to confer personally with the examiners at each stage of the progress of their cases, and not less than 10,000 such interviews have taken place every year since the introduction of the 1902 Act. It is noticeable that since the introduction of the present system of examination many more applications than before have been abandoned voluntarily.

It is seen from an appendix that, in spite of the decrease in the total number of applications received in 1908, those from England and Wales were more numerous than in 1907 by 615, and those from other parts of the United Kingdom were almost equal in number. The applications from Australia, New Zealand and Canada show a decided decrease, and there is a general decline in the number received from foreign states, the principal exceptions being France, Holland, Russia, Switzerland, the Argentine Republic, Brazil, Mexico and South America. The applications from Germany decreased by 277, and those from the United States of America by 442. A table given shows the nationalities of the inventors to whom patents were granted during the last five years, the communicator of the invention being regarded for the purpose of this return as the patentee. Out of a total number of 16,284 patentees in 1908, 2,819 were resident in the United States of America, 2,516 in Germany, 822 in France, 334 in Austria-Hungary, 200 in Switzerland, 166 in the Australian Commonwealth, 159 in Belgium, 155 in Canada, 139 in Sweden and 134 in Italy. Another table shows the number of patents issued in 1907 to nationals and foreigners respectively in the United Kingdom, the United States, Germany, Austria-Hungary and Switzerland.

Patents were sealed upon 16,080, or 55·5 per cent., of the applications made in the year 1907, and out of 12,346 patents sealed upon the applications made in the year 1895, 471, or 3·8 per cent., were maintained for the full period of 14 years.

The total number of patents which expired in 1908 was 15,943, and the total number of new patents sealed was 16,284. Thus the number of patents in force was increased during the year by 341.

During the last 10 years the number of hearings upon oppositions to the grant of patents was 1,342, and the number of appeals to the Law Officer in these oppositions 247, of which 43 were withdrawn or abandoned and 20 are still outstanding, while in one case the application for the patent was abandoned. The number of appeals heard by the Law Officer in these cases during the last 10 years was, therefore, 183. In 23 of these appeals the decision of the Comptroller was reversed, in 56

varied, and in 104 supported. During the same period the number of hearings upon oppositions to amendments in specifications was 64, and the number of appeals 23, of which 3 were withdrawn and 3 are outstanding. In the remaining 17 appeals which were heard by the Law Officer the decision of the Comptroller was supported in 13 instances, varied in 2 and reversed in 2.

There were 971 hearings during the same decade under sec. 73 of the Act of 1907 and the corresponding provisions of the earlier patent acts, and 25 appeals, of which 4 were withdrawn and 3 are still outstanding. In 15 of the remaining 18 cases the decision of the Comptroller was supported and in 2 it was reversed. The remaining case was referred back to the Comptroller.

In 1908 5,226 hearings were fixed, but 2,009 of these were rendered unnecessary by reason of the abandonment of the application or amendment of the specification by the applicant. In all of the remaining 3,217 cases formal decisions were given by the Comptroller, with the result that in 2 cases only was there an appeal to the Law Officer.

Four petitions for the extension of terms were lodged during 1908. In 1 case the patent was prolonged for 10 years, and of the other cases 2 were abandoned and 1 was dismissed. There are now 5 patents in force which have been prolonged beyond the normal period of 14 years,—viz., 15,159 of 1888, 8,700 of 1892, 1,272 of 1894, 10,274 of 1894, and 17,112 of 1894.

The names of 10 patent agents were added to the register during the year, the total number on the register on December 31st being 258.

As in former years, the subject of locomotion in general occupies a prominent position in the titles of applications for patents made during the year 1908. This may be regarded as principally due to the continued interest taken in the motor car and in subjects more or less directly connected therewith. The large number of applications made towards the end of the year in connection with valves for internal-combustion engines is probably due to the interest taken by the public in performances of the "Knight" engine. Electrical subjects have in general fallen off in numbers, with the exception of the incandescent lamp and the galvanic battery. The development in railway signals of purely automatic systems and systems for giving signals in the locomotive cab still continues, but a new feature has to be noticed in the form of controlling apparatus for stopping trains in the event of excessive speed. The increasing importance of indiarubber in the industrial world is shown by attention being given to processes for the regeneration of waste rubber and the synthetic production of rubber or rubber-like products. Tungsten and like refractory metals have recently been made available for manufactures by new methods of working them in alloy-like combination with ductile metals, which are afterwards removed by heating the finished article.

DESIGNS.

The number of designs applied for during the year amounted to 23,867, exclusive of 1,040 sets of designs. In the previous year 24,219 single designs and 709 sets were applied for. The number of designs refused registration on account of their similarity to designs already registered was 600. During the year 847 applications for registration of designs (including the above-mentioned 600) were objected to by the Comptroller. The objections, other than those on account of similarity to designs already registered were chiefly on account of want of subject matter or want of substantial novelty.

TRADE MARKS.

The number of applications made in 1908 for the registration of trade marks (including 101 applications made to the Cutlers' Company of Sheffield) was 10,645, as compared with 10,796 in 1907. The receipts from various sources on account of trade marks amounted to £17,358.8s.2d. including the sum of £2,745. 2s. for renewal fees. The notices of opposition to the registration of trade marks lodged during the year numbered 262, and the number of cases heard under sec. 14 of the act was 66.

A number of appendixes are attached to the report, and give in tabular form the particulars referred to in the report.

THE "G.B." SURFACE-CONTACT SYSTEM IN THE MILE END ROAD, LONDON.

We have received the following copies of reports by Mr. W. M. Mordey to the London County Council and other correspondence in reference to the working of the "G.B." system in the Mile End-road:—

82, Victoria-street, S.W., March 6, 1909.

PRELIMINARY REPORT ON TRIAL RUNS.

I have had a car out on the track twice—viz., this morning from 1:30 to 3:30, and yesterday morning (March 5th) from 1:30 to 3:15, and have run in all 16 double journeys, equal to about 16 miles, using both tracks.

On the first occasion the condition of the track was very trying, there being a good deal of ice glazing on the studs and rails, and the ordinary leakage being large, resulting partly from the tracks having been sprinkled with salt, apparently shortly before the run started.

This morning the conditions were less trying, as it was not freezing so hard and the road was cleaner; also the effect of the salting of the previous morning was less noticeable.

Although some adjustments require to be made, I am satisfied with the result of these two trial runs.

The arrangement for stopping the arcs, which are the most common cause of live studs, works well. It has been tried both with the resistance and with the condenser devices described in my report, and was apparently equally successful with either. Further trials will be necessary to determine, amongst other things, the best proportions to use.

A crucial test of this arc stopping device was made this morning. After running several journeys with the device in use, during which the car left no live studs behind it, I disconnected the device and ran three single journeys without it, during which the car was frequently stopped by the detection of live studs. On again connecting the device the running was continued without interruption. This afforded satisfactory proof that the device was acting effectively. A speed estimated at 24 miles an hour was attained.

The new collecting arrangement on the car seems to be much better than the old one. It takes less than half the energy, and gives a perceptibly stronger and more certain action of the studs.

I shall run again on Monday night, and have arranged for Mr. Trotter, of the Board of Trade, to be present informally. W. M. MORDEY.

82, Victoria-street, S.W., March 10, 1909.

FURTHER REPORT ON TRIAL RUNS.

The car has now been run on the altered track four times—viz., on the mornings of the 5th, 6th, 9th and 10th instant, and has run about 39 miles in all.

The state of the track has varied from an icy condition with freshly-scattered salt on it to a fairly clean condition without salt, and at a temperature well above freezing. Under all these conditions the trials have been satisfactory. The arc stopping device recommended in my report of October 1, 1908, is quite effective. On disconnecting the device numerous live studs occur even in the driest state of the track that has so far obtained.

It hardly seems necessary to make further tests under present conditions. I should like, however, to make some further trials with the road in a very wet and muddy condition. I do not, however, expect them to get as much leakage or as many live studs as on the salted road on the 5th inst.

If there is no rain soon it may be possible to make trials by leaving the road uncleaned and watering it, but I would prefer the natural rain-formed mud. Subject to further trials under these conditions, which I do not expect will cause any difficulty, I am satisfied with the result of the trial runs, and confidently recommend the Council to have the whole track overhauled in the same way, and the necessary cars equipped to run the full service.

Mr. Trotter, of the Board of Trade, who accompanied me during the run on the 9th instant, expressed himself satisfied with the result. He was particularly pleased by the effect of disconnecting the arc stopping device, and of finding that live studs then occurred frequently, and that they ceased as soon as the device was again connected. I have no doubt he will have reported favourably to the Board of Trade.

W. M. MORDEY.

82, Victoria-street, S.W., March 23, 1909.

This morning I attended a run of the car from about 12:40 a.m. to 3:40 a.m. The weather was warm and the road was in a rather wet and muddy condition. It was, however, much less muddy than I expected it to be. A very slight drizzling rain was falling.

Seven double journeys were made and various short runs. With two exceptions the running was satisfactory, and the effect of the condenser was proved, as before, by running without interruption when it was on and by the large number of live stud stoppages when it was off.

The two exceptions were as follows:—

In the first place, one stud was always found to be alive and difficult to extinguish, the condenser often failing to put it out. I, therefore, had it taken up, and found the top of the stalk was broken.

The second exception was more serious. A horse received a shock from a stud on the short length of line east of Fairfield-road. The horse fell, and its knees were cut from the fall. The horse did not seem to be otherwise injured.

This short piece of line has not been used at all in these trials, the car never having been taken over it. On testing, it was found the stud was alive, and evidently not an arc, but from a contact. On running the car over it once or twice it cleared itself, and then worked normally. On taking it up it was found to be in good order, and there was no indication of the cause of the fault. The "G.B." Company offered an explanation, which is quite probably the true one. They suggest that a small drop of hardened pitch or other material had got into the fork of the stud and caused sufficient sticking of the armature to prevent it from returning when, by the ordinary vibration of the road, it was lowered a little towards the cable, and so by a succession of small downward movements it was finally caused to make contact. I think this defect, which is one of newness, is very unlikely indeed to recur.*

The collection was very much better than on any of the previous trial runs, the car running almost sparklessly, even at the higher speeds. It was found possible to run well with only one collector in use.

The mud did not interfere with the running, although it was evident that it was the cause of a good many live studs. W. M. MORDEY.

82, Victoria-street, S.W., March 31, 1909.

FURTHER REPORT ON TRIAL RUNNINGS WITH THE "G.B." SYSTEM.

In accordance with the request made to me by telephone to-day, that I should send you a report on the trial runnings, I may say that I have

* It is, perhaps, hardly necessary to explain that this fault would not have occurred if the line had been in use, as then the ordinary working of the stud would have kept it free.

sent reports or letters in the nature of reports on the six short runs which have been carried out. These were dated March 6th, 10th and 23rd respectively. These runs were very short and in some ways incomplete. The reports were made in order to let the Council know at the earliest possible moment the progress of the trials.

Although they left certain points still to be cleared up by further runs, they afforded, in my view, sufficient ground for the opinion that the main or essential difficulties—namely, those which led to the stopping of the service—had been removed, and to enable me to recommend the Council to put the line into a condition to give a public service.

I desire that the reports or letters above referred to should be taken as part of this report, to which I wish to add the following :—

These six short runs have shown that comparatively little preliminary running will be required to get the line into working order. An examination of the records of those runs shows that on the last run, with the exception of the accident to a horse on a section of the line which had not been tested or run over, no defect of any kind was met with, except one stud, which was found to be broken. Two or three such broken studs have been found during the previous runs.

It will be remembered that in my original report of October 1, 1908, I said that I did not consider it necessary for the purposes of this trial that cast steel should be substituted for the cast-iron stud heads, but that a small number of such steel stud heads should be tried. This has not been done, as I have not insisted on it. It was not essential for the purposes of this trial. I think, however, it would be well to use steel heads in order to avoid the occasional breakages which would otherwise occur.

The arc stopping device, as already reported, has proved to be effective. I have been informed by Mr. Trotter, of the Board of Trade, that he considers it a very satisfactory solution of the difficulty caused by arcs, and that, together with the alarm device previously fitted, it affords an adequate provision against danger to the public. This is satisfactory in view of the original reference to me to report in accordance with the terms of the Council's resolution of July 28th-29th, "on the possibility of rendering the system efficient with due regard to the safety of the public."

I may explain that both the arrangements for arc stopping mentioned in my original report were tried. On the first run and part of the second run the resistance was in use. It was quite effective except at crossovers. At those points 11 live studs were found in all, due to short-circuiting by the brush. By adjustment of the resistance and width of brush this could probably be remedied, but it is not necessary to go into that, as the difficulty does not exist with the condenser which was afterwards used.

The trial runs have not been sufficient to enable me to finally determine the amount of capacity of the condenser necessary to deal with the worst possible conditions, but that is a matter that can easily be determined by some further trials. Experiments were made showing the need, for such cases of excessive leakage, of a larger capacity than I at first thought necessary. The excessive leakage was due to very severe climatic conditions, probably accentuated by salting of the tracks. I have already reported that on the occasion of the first run I found the track had been salted shortly before the trial started. The "G.B." Company has reported to me that on the morning of the 17th inst., shortly after the trial attended by members of the Council, the track was being salted, the salting not being continued beyond Burdett-road. They were informed by the man in charge of the work that he had been engaged on this work for some time. If this information is correct, it accounts for the very great amount of leakage which I found during all the runs. I am glad this salting was done, as it ensures that the conditions were abnormally severe, but I am surprised that I was not informed of it.

Some difficulty was experienced with the collector, two stoppages being due to breakages of cast iron links. The "G.B." Company agrees with me that these links should be of steel, and are preparing a design in that material. A further difficulty with the collector was caused by the support of the chain working loose. This is a small and easily remediable mechanical defect. It led to considerable sparking on the surface of the road. When it had been put right, as it was on the occasion of the *last run*, the collection was admirable and sparkless. Successful trials were then made with one of the two collectors out of action, the result being so good that it may prove on further experience possible to dispense with half the collector equipment, and so simplify and lighten the car. This would also slightly lessen the cost of the special work and reduce the cost of equipment of the Bow-road to Cambridge-road from the figure given in my estimate of the 18th ult. of £4,313 to about £3,200. I prefer, however, to leave this matter open for the moment.

I have already reported that a speed of probably fully 24 miles per hour was attained without difficulty. Apart from other questions, this is about twice the speed which, I was informed by the Council's officials, it was possible to run with the original equipment.

The fact that in even six short runs under very trying conditions we had got the line into satisfactory working order (with the exception of one stud which was found to have a mechanical break) shows how comparatively little preliminary running is likely to be necessary to get the whole line into satisfactory order. I was prepared from the first for a considerable longer period of trial before demonstrating this. I think it highly satisfactory, and may remind you of the long period of three months of preliminary trial (in actual service) allowed by the Lincoln Corporation to enable the contractors to remedy small defects of construction and to eliminate the weaknesses incidental to all new work.

With regard to the shock experienced by a horse on the untried and untested part of the road, two things are satisfactory—one that the owners of the horse have reported, as I have already informed you, that it is satisfactorily recovering, and should be at work again in a few days. The other good point is that, although the stud was fully alive and all the conditions very favourable to a severe shock, the horse was not killed. From its appearance and condition immediately afterwards, I should have said that, except for its knees, which were bruised as by an ordinary fall, it was none the worse for the shock. This experience, regrettable as it is, seems to show that the risk of fatal injury to horses is much less than I have supposed. I have already reported that this accident would not have occurred if we had taken the precaution of running over this short length of line.

During the preliminary construction work a large number of the earthenware T-pieces—more than 100—were found to be slightly cracked or broken, but only in one case had any dirt penetrated into the T-piece. I, therefore, did not consider these slight defects were serious, as they had been down a long time without developing faults. In any further overhauling I should not consider it necessary to replace them.

With regard to the special work, a suggestion was made to me by Mr. Fell that this should be dealt with before proceeding with further overhauling. I do not think this necessary, and, therefore, did not advise it at the outset, partly because I wished to limit the expense of the trial, and partly because a sample turnout—namely, that at Burdett-road—had already been equipped with satisfactory results in the manner necessary for the other special work. This Burdett-road junction, I gather from the correspondence, has given satisfactory results in working. I look upon this special work as of a character that presents no problem such as that which has already been disposed of.

Mr. Fell also mentioned the question of the hammer blows due to horses possibly making the studs momentarily alive in the same way that they can be made alive by the blow of a hammer. This matter attracted my attention at the first, and it was only after a long series of careful experiments, made with the help of the Council's officials, that I was able to satisfy myself that no danger would arise from this cause. Until I made those tests I held the view that Mr. Fell has very naturally expressed. Fortunately, also, there is the 3½ years' experience at Lincoln which confirms my experiments. There, although the traffic is thin, there are plenty of fast trotting horses and heavy vehicles, and yet there has never been any case of such effect as I at first feared. I am sure Mr. Fell will agree that these tests and this experience dispose of this difficulty.

In my opinion, after a very short time, the stoppage of a car by the action of the alarm would be very infrequent indeed. This alarm seems to be quite effective, and I may remind you that this occasional effect has always been known in connection with this system, and was within your knowledge before the adoption of the system. So far as I know, no other surface-contact system has so adequately provided for giving warning of these occasional defects. Their existence does not appear to me to constitute a reasonable cause for anxiety or to be inconsistent with "due regard to the safety of the public." W. M. MORDEY.

On the 5th April the following letter was forwarded to the Council by the company :

Hamilton House, Bishopsgate-street Without, London, E.C.

ALDGATE TO BOW TRAMWAYS.

GENTLEMEN,—It would seem from reports in the Press and elsewhere that your Highways committee has been led to advise the Council that the use of the "G.B." system on the above route be abandoned. Some months ago you appointed Mr. W. M. Mordey, the president of the Institution of Electrical Engineers, to advise you, as an expert, on the suitability of the "G.B." system. Later we contracted with the Council to put in order a car and a piece of the above route. The two main provisos of our agreement were :—

1. That the work should be carried out to Mr. Mordey's satisfaction.
2. That the trial runs should be of such a nature and extent as Mr. Mordey should deem necessary or expedient.

It would seem unjust that the Council should come to any decision either to retain or reject our system until Mr. Mordey had reported that the trial runs and his investigations thereof were complete.

On Wednesday last the solicitor to the Council read to us parts of a letter from Mr. Mordey in which he asked for more trial runs. It is, therefore, seen that the second proviso of our contract is unfulfilled. We should, however, remind you that Mr. W. W. Thompson told the Council, on March 9 last, that Mr. Mordey had informed him that the experiments up to that time were "eminently satisfactory."

On the last—or sixth—trial run a horse (now well and at work) received a shock from a stud which had not been tested or at any time run over by the car, and, therefore, was not included in the trial runs. A like accident could not happen in service conditions. We mention these facts that the truth may be known in place of the Press account of the incident.

It seems that the system is about to be condemned on the advice of the Council's officials; but we can hardly think that any practical man would seriously say that it is possible justly to condemn any system after only six preliminary runs, or in all about 12 hours' experience. There were no faults, beyond mere details of adjustment, found during any of the runs, and before the trials ended these adjustments were made and the system worked perfectly. The official view is, therefore, the harder to understand.

Apart from all other things, it was an implicit if not an explicit provision of our contract that if your expert advised the abandonment of the system, then it should be abandoned, but if he advised its retention, then it should be retained. Our belief that the Council will not knowingly set aside the spirit of their bond with us is the foundadation of this letter. THE "G.B." SURFACE CONTACT CO.

We conclude our account of this matter by the insertion of the following very lengthy communication from the Company to Mr. Mordey. By so doing we place our readers in possession of all the information at our command :—

Hamilton House, Bishopsgate-street Without, London, E.C.,
W. M. Mordey, Esq. October 1, 1908.

Dear Sir : We have received a letter from the Clerk to the L.C.C. dated the 18th ult., a copy of which he informs us has been sent to you. We have replied to him as per copy enclosed, and, in accordance with the promise made therein, we now proceed to give you what information we can respecting the surface-contact system laid in the Bow-road and the special equipment on the cars running thereon. We do not know how far you have been informed of the earlier history relating to the Bow-road installation, but it appears to us desirable that you should have some information respecting matters which are largely responsible for the exceedingly unsatisfactory state of affairs to-day.

Early in June last year, after a visit of the Highways committee to Lincoln, our engineer, Mr. Bedell, was asked to call upon the chief engineer of the Council, and was informed by him that the Council would not consent to place a contract direct with us for any line to be equipped on the "G.B." surface-contact system, nor would such contract be placed with the firm who had worked with us in installing the line at Lincoln. Mr. Bedell then submitted the name of another firm who would be willing to do the work and leave £9,000 in the Council's hands as a guarantee of the proper working of the system. This firm was also refused, and Mr. Bedell was referred to Messrs. Dick, Kerr & Co., with whom, however, we could not come to terms on a royalty basis, as they required preferential terms from us, and we had been informed by the chairman of the Highways committee that any arrangements made must be such that the Council could be sure of tenders in open competition.

The final arrangement made by the Council was to enter into a licensing agreement with the patentees for the use of the patents. The price first asked was cut down from £800 per mile to £500 per mile, on our being informed in the committee's presence that no technical assistance would be required from us, remuneration for which was included in the higher figure. We mention this to show that we have been placed by an arrangement made purely to suit the Council in a position where it has been exceedingly difficult for us to obtain a working knowledge of what was going on. This arrangement applied both to permanent way and car equipment. We very soon learnt, however, that our technical assistance would be required, although it was not proposed to pay for it in most instances.

As far as the track was concerned, all we were at first asked to do was, for a fixed sum per mile, to supply the contractors with men who had experience of laying our system, and who should teach their men how it was done ; but the car equipments were dealt with in an entirely different way.

As early as June, 1906, we had been shown some of the Council's cars, with a view to seeing whether our collecting gear could be fitted to them. We considered that it could, but that considerable alterations to the car would have to be made. We stated this opinion in a letter to the chief officer dated June 25, 1906, and again referred to it in ours of July 31, 1906. On July 16, 1907, we again quoted the chief officer for car equipments at £99 each, instead of £75, which was our original quotation when we supposed that we should be given the whole contract for both car and track work. We, however, agreed to reduce this figure when we learnt that, through a mistake, insufficient money had been voted for the car equipments, and we eventually took a contract for them at cost price.

Before this contract was entered into we were asked to prepare drawings of the equipments, and to prepare a wooden model to be fitted up under a car, all of which we did, supplying our technical assistance and labour free of cost. We experienced much difficulty with the design because drawings of trucks, &c., with which we were furnished were difficult to get and unreliable. We also were informed that the alterations we had thought could be easily effected on the cars were not supposed to be possible ; the design was, therefore, cramped unnecessarily and far from what it might easily have been. In these circumstances we were naturally unwilling to take any responsibility for the design, much of which had been imposed upon us by the officials of the Council. We, therefore, had to insist that the terms should be such as apply to agents merely, and that no guarantee as to satisfactory working should be included in the contract. We explained this position clearly before the contract was entered into. On December, 21, 1907, the chief officer wrote instructing us to proceed with the 48 car equipments. On January 1, 1908, we wrote the chief officer asking whether he wanted any alterations made to the contract drawings. He replied that he couldn't and wouldn't take any responsibility in the matter. To this we replied that, as we could know nothing about the special brake gear involved, he must really decide the matter. All this delay and correspondence was due to the fact that the conditions expressed in the contract for car equipments were not frankly accepted by the chief officer and he still tried to make us responsible for the working of the system, altered and crippled as it then was both in track and car equipment.

On February 3, 1908, we were instructed to proceed with only one of the 48 equipments. Early in March the first equipment was delivered, covered in wood and erected on a car in a rough temporary manner, as it was quite understood that it was for experimental purposes only that this first equipment was hurried through. The collection with this magnet was found to be very bad at first. This was due to the short collection chain getting a periodic swing, which caused it to leave the studs after it had come in contact with them. We found that this defect was cured by deadening it with rubber buffers. There remained, however, a more serious defect—the magnet was not strong enough to work the studs properly. The Council's officials tried placing a conduit yoke round the stud to see if it worked more forcibly, but found, of course, that the yoke magnetically short-circuited it and prevented its working at all. They also tried the effect of removing the outer pole of the magnet, as they held the theory that it was worse than useless. This experiment resulted in the magnet failing to work many of the studs altogether. We ourselves found that the gunmetal piece we had been made to insert in the outer pole was chiefly responsible for the weakness, and, as there was no real reason for this piece of gunmetal, it was bridged with iron, and after this the strength of the magnet was about normal. There was, however, a great exception taken to the swinging polar extension, which, although in strict accordance with the contract drawings, was considered objectionable on account of the attention it would require when changing over from conduit to surface-contact lines. As we know nothing of the L.C.C.'s service requirements or the time available for changing over, we can express no opinion of this matter. The swinging pole was removed, and without it the magnet was too short for continuous collection, and during the Easter holidays the officials began the manufacture of double magnet equipments—*i.e.*, two magnets on each car.

On April 22nd we wrote to the chief officer concerning the relative merits of one and two magnet equipments, and on 24th the chief officer wrote us a letter from which it appeared that he was suffering from some misapprehension of technical facts connected with the system, but at the same time considered our engineer's presence to be superfluous when trial runs were being made. On April 27th we again wrote explaining many technical points germane to the system which did not appear to be perfectly understood. On the same day we wrote another letter dealing with the commercial aspect of the case and we would suggest that you refer to these letters, as they deal with many aspects of the matter not easily condensed.

We were not consulted as to the design of the magnets which the officials had made, and when we were permitted to examine them we found that they were badly designed and constructed in almost every way. The section of the cores was not sufficient to carry the flux for the pole bars, with the result than even when many more than the normal number of cells were used to excite them there was still insufficient magnetic force to operate the studs properly. In many places the iron parts of the magnets were much too close to members of the trucks to be at all safe. The wood protection was much less efficient and of an even more temporary character than on the experimental magnet first used, and iron screws passing into the metal of the magnets were used to fix the wood. The bulk of the scrap iron collected by the magnet found its way to the screw heads and caused short-circuits, and though we frequently suggested their replacement by brass screws we could never do more than get them covered with compound—a quite inadequate substitute. Although we had found in the earlier runs that the insulated suspension bolts required shielding, no shields were provided. The collector chains, also, were not buffered. There were many other matters, too numerous to mention, in which these magnets were defective.

The result of running the cars equipped with these magnets was naturally disastrous both to the equipments themselves and the studs, to say nothing of the ridicule which [illegible] to be cast on the trial.

The patentees felt so strongly that something ought to be done to put matters right that they took the extreme step of laying a formal complaint through their solicitor before the Council, when it was proposed to hold a B.O.T. inspection. This step had the effect of delaying the inspection for a short time, but nothing material was done in the meantime to put things right, and a service was started under conditions which, if not speedily remedied, could but end in a fiasco.

We will now revert to the equipment of the track. After receiving the order from the contractors for the line for materials for the "G.B." road equipment, we sent them drawings of the parts that we were going to supply, we also gave them our ideas as to the method they should adopt in draining the conduit at the lowest points into catch pits, which were not included in our order for material. The design of cable access box which we submitted was objected to by the Council's officials, who drew out one of their own. This design was sent to us, and we wrote to the contractors on August 26, 1907, objecting to some points and pointing out the superiority of our design. One of these points was the inadequacy of the grease joint, as it was necessary that the box lids should be tight in order to secure efficient ventilation. It has proved in practice that this objection was well founded. Another objection to the design was made verbally to the chief engineer's assistant in that the depth of the box was such that the metal work of the lid would be flush with the top of the paving, and might possibly come in contact with any scrap iron carried by the magnet and cause partial short-circuits. We were informed that it was L.C.C. practice to arrange their street boxes in this way. It turned out in practice that partial short-circuits occurred on these boxes in nearly every case. This was a very unfortunate thing for the system, as it gave rise to widespread adverse comment. The violence of the arc was such that we thought it impossible that the path of the current was through the concrete to the rails, a circuit of comparatively high resistance, and when the frames of the boxes were lowered and the paving in the lids raised we discovered that in very many cases a tie-bar or the earthing strip from our insulator pins was in close proximity to or actually touching the frame. It is needless to say that warning had been repeatedly given against fixing earthed metal of any kind near the access box frames. With respect to draining the conduit, we informed the Council's officials of the method we adopted in Lincoln—that is, running a pipe from the lowest point into a closed galvanised-iron tank buried in the roadway, and having a vertical pipe coming up to the road level and covered with a stop cock box cover, through which it could be periodically pumped out. The design of drainage sump got out by the L.C.C. officials was quite different ; the sump itself was to be made in concrete and the cover was not airtight.

The patentees wrote to the chief engineer on September 28, 1907, disapproving of the design and recommending the Lincoln system as superior in every way. The sumps, however, were put in to the L.C.C. design, and the result was seen in several dangerous gas explosions. The concrete walls of the sumps were useless for the purpose of excluding the gas in the road, and the badly fitting sump lids and inadequate grease joints of the access boxes made it very difficult to obtain efficient ventilation, so that the blower in the car sheds had to be kept running continuously. At Lincoln half an hour a day is found to be quite enough. Extra cable insulators at access boxes on special work were put in contrary to our recommendation. Some of these have already been the cause of dead earths on the line. It is matter for regret that almost the whole of the track work was completed before the Council had a trial car ready to run. Many, if not all, the mistakes made would probably have been discovered and rectified, and a greater willingness shown to take our advice, had only one car been ready when, say, the first ½ mile of track was completed. As an illustration of this, we may mention the case of the resistance studs at special work. It was assumed that single magnet equipments would be used on the cars, and the resistance studs were arranged accordingly, but double-magnet equipment were finally decided upon, for which quite different special work is required, the large number of resistance studs at each junction rendering it desirable to insert a resistance in a part of the line cable, as we designed the Burdett-road special work to be, instead of a resistance to each pair of studs. The ordinary studs could have been set further apart in order to suit the double-magnet equipments and a saving of expense would have resulted.

When the first car equipment was completed we found it necessary to advise the chief officer that it would be dangerous to run a trial until the conduit was ventilated. We had informed the engineers' department at the beginning of the work that it would be necessary to instal a blower to ventilate the conduit, but this had not been done. The warning we gave to the chief officer was not unnecessary, as was proved by the blowing up of several box lids at some of the later trials.

On June 25th a service of three electric cars was started. At the chief officer's request we supplied, at our own expense, two men who could teach the Council's employés how to extract studs and generally deal with the track. The troubles which were experienced were numerous. Short-circuits and partial shorts between the magnets and the car were of frequent occurrence, and their effect on the studs was of course very damaging. Large numbers of the studs tripped the safety breakers on the cars, and could not afterwards be located, and yet others which sparked on the detector brushes remained undetected, as the action of the safety breakers, which we believe were of L.C.C. design, was very unreliable. Our men noticed that the pitch round the granite stud blocks had sunk away in many instances, and that the passage of a watering cart caused some of the studs to trip the safety breakers. This led us to suppose that considerable leakage must be taking place through the dirt immediately surrounding the studs.

Many studs which remained alive after the cars had passed were extracted, but were quickly removed to an L.C.C. depot, where we could not examine them, so that we were able to gain little reliable knowledge concerning the cause of their failure to act.

On July 8th we ceased to be able to obtain any information whatever, regarding the behaviour of the system except such as the public generally might glean, for our men were on that day ordered to have nothing further to do with the trams. We were greatly astonished at this, as it had been arranged with the chief officer that they should be employed for three months, and no warning was given that their services were to be dispensed with. We wrote to the chief officer on July 11th, saying that now we were excluded from the works we thought it desirable that we should give him our opinions, already verbally stated from time to time, respecting the working of the system as far as we had been able to see it. We had already quoted the Council for double magnet equipments, the designs for which we had got out at our own expense, and a draft contract for the supply of these had been forwarded to us through our solicitors. As these magnets differed in many ways from those already on the cars we think it fair to assume that the Council's officials did not regard their own design as satisfactory.

We wrote to the chief officer on July 15th stating that the methods adopted for testing the safety breakers in the car sheds were inadequate ; also that one of the cars was running with a magnet coil short-circuited or inoperative, and that this had been pointed out two days before and remained unremedied, also that the men were using neat pitch to reset the studs which they extracted. This is an illustration of the way in which the most ordinary precautions for the safety of the public and the requirements of the system were neglected. With unreliable safety breakers live studs were left undetected in the road. With a broken down magnet every stud over which it passed was liable to be damaged and possibly rendered unsafe. With hard pitch used round the studs loose stud heads and broken T pieces follow as a natural sequence.

On July 17th we received a letter from the chief officer saying that, in consequence of accidents to horses and persons, in addition to other defects in the working, it was decided to stop the service and cut current off till further notice. In reply we wrote on July 20th approving the decision to stop the service, and presuming that this step was to give time for our recommendations to be complied with. We then made an offer to the chairman of the Highways committee either to take over and keep up both car and road equipment for a fixed sum per car-mile, payment to commence after both had been put in order by us, or to take exclusive charge of the roadway, it being understood that we had no commercial interest whatever. On the 22nd we received a letter from the chairman of the Highways committee stating that the committee had decided to abandon the scheme. We wrote in reply that the system had not had a fair trial, and at the same time wrote to the Clerk of the Council offering to take over the road and put it right and maintain it for 12 months if the Council would equip cars to our design to run on it, and only if satisfactory a charge not to exceed £2,500 to be made. On the 27th we received a letter from the clerk saying that our offer had been placed before the Highways committee but that they could not recommend the Council to accept it.

We wrote the chief officer on July 20th reminding him of a telephone conversation that took place on the 10th respecting some tests to ascertain the leakage current through the mud which he had promised to have made, as on the previous day a considerable number of the studs opened the safety breakers on the cars. The road was abnormally muddy that day, and we thought it possible that the extra leakage caused by the mud

might be sufficient to maintain an arc for the time necessary to allow the safety brush to get on the stud, if the switch piece of the latter was not working quite freely. We reminded the chief officer in this letter that though he had asked us to be present when he tests took place, and we had been constantly telephoning to the assistant who had the matter in hand, who assured us that we should be given due notice, yet the tests took place without our being informed, and we would like to know the results. We have never received these particulars and they appear to us to be so important that we should be much obliged if you could communicate them to us.

On July 30th we received a letter from the Clerk of the Council informing us of the Council's decision to go on experimenting with the system during the recess and to appoint an expert to inquire into the matter. We wrote in reply, on August 6th, setting out our view of the line the inquiry ought to take and this letter has doubtless been communicated to you, since then we have tried several times by writing to the Clerk to elicit technical information which would have enabled us to give you the full and detailed statement you asked for in your letter to the Clerk, copy of which was forwarded to us on August 26th. As this technical information is still withheld, we can only give you a statement partly based on knowledge and partly on surmise of what took place.

We have thus far dealt with some of the circumstances which culminated in the inquiry upon which we understand you are now engaged, though as yet we do not know the scope or precise nature of that inquiry. Our ignorance on these points must be our excuse for laying before you many things which, were we better instructed, we should have been able to omit and also possibly for omitting other matters upon which you would have wished information. We propose next to deal with the defects as far as we know or can surmise them and the treatment we should recommend for their elimination.

Line Leakage.—We gathered, although we could never obtain any definite information, that the line leakage was very variable and that three or four dead earths occurred. We consider that anything over 0·1 amperes per section after the current has been on for half an hour indicates that water is present in the conduit or access boxes and that sumps should be pumped out or low points not drained should have sumps provided. In the case of dead earth, we believe the cause has always been that one of the insulators near access boxes on special work (which were not put in in accordance with our design) had broken down.

Resistance Studs.—Several cases of these becoming alive were observed. In the first few instances this was due to current leaking from the resistance wires to their lead covering at the end in the resistance pit, an arc being maintained meanwhile between carbon and cable. The cure for this is to employ reliable wiremen when making the connections with the resistances. With regard to the later instances of these studs becoming live, we were excluded from obtaining any information, and we think that for the most part nothing was done to ascertain the cause; but from a few remarks made to us by assistants to the Council we gathered that in one or more instances it had been found that the resistances themselves had gone to body. This defect would follow inevitably if the wire on the head side was the one that became earthed, because then the full current which the resistance could pass would flow through it till something burnt out and so broke the circuit. During the trial runs there were no men present supplied with the tools for removing stud heads, so anything of this sort that might go wrong was left to burn itself up completely.

There is another explanation that would account for the trouble, viz.: the officials told us that 40 amperes would be enough to allow to move their cars; we thought this rather low and got them to agree to 50 amperes as the amount to be passed by the resistances, and on our own responsibility we ordered them with such a resistance that they would pass about 60 amperes. The cars, however, frequently refused to start with this current, and consequently, instead of the resistance remaining in use for a few seconds only, cars used to stand over them taking full current for minutes at a time, while attempts were made to bar them along. Doubtless the resistances overheated and may even have fused. The remedy for this trouble is to construct resistances to pass enough current to move the cars. The whole matter of resistance studs is only of academic interest now that double magnet equipments have been decided upon, since our arrangement of resistance in the line cable used at Burdett-road would become universal throughout the track.

Live Studs.—These can be divided broadly into two classes: (*a*) those which were left alive and remain so till remedial measures were taken, and (*b*) those which tripped the breaker but became dead by themselves. For reasons already explained we can have no detailed information to go upon, but as far as our observations have carried us we think that in class (*a*) the causes of failure have been:—

(1) Dirt, grit, sand, cement or pitch adhering to the working parts of the stud. *Cause.*—Stud not clean when put in or in some few instances the T piece was broken, admitting foreign matter to the stud. *Remedy.*—Greater care and cleanliness during installation.

(2) Clearance between switch pieces and liners of fork not sufficient in all positions of the former, and had escaped the L.C.C. inspector's notice. *Remedy.*—Greater care in inspection and use of a minimum clearance gauge.

(3) The woodite eyes in the switch pieces have broken in a few cases. *Cause.*—The woodite overheated in turning; this defect was not observable on inspection, but such eyes absorbed moisture and became liable to break after studs were set in the road. *Remedy.*—Replace breakages with a material such as box-wood boiled in paraffin, which is not liable to be affected in this way.

(4) Studs were burnt up, the inside working faces roughened, copper clips fused, carbons loosened, flex fused, &c. *Cause.*—Defects in car equipments producing large leakage currents of hundred of amperes, which on a slowly moving or stationary car would burn up any stud which could be so designed. *Remedy.*—Use only properly designed car equipments and substation breakers set only a little above the normal maximum section load.

In class (*b*), which is far the larger division, the conditions were more complex and varied at different times. (1) There is no doubt but that many of these studs were caused by the magnets which were in use for some time on the cars being too weak to induce the carbons to make proper contact with the cable; the resulting heat sometimes produced a light fusion between the iron of the cable and the carbon, which, however, broke down under the current taken by the safety brush, and so made the stud dead as soon as the car had passed. In some few cases this latter action may not have taken place and then the stud would form a (fifth) division in class (*a*). *Remedy.*—Use only properly excited magnets on the cars.

(2) There appeared to be reason to suppose that in certain conditions of the road surface some of the studs in class (*b*) were due to an arc being maintained between the carbon and the cable long enough to cause the stud to trip the safety breaker. We mentioned this possibility to one of the officials and suggested that measurements of insulation resistance between stud heads and rails should be made. This official informed us a few days afterwards that he had found no case in which the resistance was less than 12,000 ohms, even after a watering cart had just passed over the street. This served to indicate that the surface leakage could not possibly be the cause of the trouble. It was found, however, that there was an unmistakable synchronism between the appearance of studs of this class and rain storms. We were very glad to hear, therefore, from the chief officer that he would be willing to carry out tests by which the road leakage under all conditions could be measured, but we were greatly surprised to find that we had been excluded from witnessing the tests, and still more so when it became apparent that we were not to be told even the results of the measurements. We venture to think that this course was hardly calculated to lead to a rapid solution of the difficulty, for years ago, when our system was in the experimental stages, we considered the possibility of an arc being maintained between the carbon and the cable and devised a simple and efficient means of eliminating this trouble. This arrangement we tested on our experimental track at Ilford, and found no single instance of a stud tripping the breaker or remaining alive, although leakages up to 15 amperes stud to rail were artificially produced, and we think we can promise that if you would care to see the experiment we could demonstrate the fact to you, although our plant at Ilford has been standing idle almost continuously for three or four years. We found in all our experience that there existed in practice no fear of sufficient road leakage to prevent the efficient working of the studs, and so our method of obviating it has not been called into requisition.

We have not sufficient information even now to say definitely that it is required, but if, as we think possible, studs of the description of class (*b*) (2) did really exist on the Bow-road, then we unhesitatingly say that our method of dealing with the trouble will prove a perfect solution. A precisely similar phenomenon would be produced if, as we have some reason to believe, the dirt on the switch pieces prevented their free movement, and that consequently many were much less than their standard distance from the cable.

Stud Heads.—We believe that 1 or 2 per cent. of these have been found broken by the traffic during the nine months they have been in the [illegible]. [illegible] it would be better to replace them when they [illegible] experience shows that constant vibration plays a more important part than the mere weight of the traffic.

Ventilation.—It is important that the means used should be such that [illegible] the air in the conduit is changed at least once in two or three days. The badly designed access box covers and sumps installed in the Bow-road render it doubtful if this condition was met. We believe tests were carried out by the Council's officials, but we were not favoured with the results.

Car Equipments.—These were so defective [illegible] recommendation we need make is that they should be entirely scrapped, and new ones fitted of good design, materials and workmanship. It will then be found that the huge amount of energy they consumed for excitaton is reduced to about 5 or 6 per cent. of that used to drive the cars. The weight of accumulators carried is reduced in like proportion, and the damage to studs and equivalent from constant shorting is avoided.

We think the facts already related are in themselves sufficient to explain how it is that while at Lincoln the "G.B." system runs well, efficiently, and to the satisfaction of all concerned, yet when what was supposed to be the same system was tried in Bow-road it failed signally; but lest we should have overlooked some natural physical reason for this it would be well to consider what difference in the general condition, if any, exists between the two routes. The routes are similar, in that they are flat and with few curves. The amount of general traffic over the lines is much greater in London than in Lincoln, but certainly no heavier per vehicle. The car service is much more frequent in Lincoln than it ever was on the Bow-road. The energy required to drive the L.C.C. cars is more than is required for the Lincoln ones. The London streets are, if anything, better kept and freer from mud than in Lincoln. The greater amount of traffic may be and probably is the cause for some of the stud heads breaking, but this has been a small matter and plays no part in the failure; it is, moreover, a thing easily rectified. The greater frequency of the service would have a beneficial effect on the maintenance costs per car-mile run, but would otherwise not affect the working of the system. The reason for this is that the wear on carbons and cable sleeves is a diurnal matter. The first few cars in the morning, after the line has been out of use for a few hours remove the damp and oxide from the carbon and sleeves, and after that there is practically no wear or loss of material till next morning. It will therefore be seen that the cost of maintenance of the line is but little affected by the frequency of the service. The larger amount of energy used by the London car has had no effect on the working of the system whatever, so far as we have been able to discover.

With regard to the cleanliness of the streets we think that, although to all appearances there is little to choose between Lincoln and London, actual experience and measurements of stud leakage currents might show that, although the quantity of mud in the two places differs little, yet the chemical composition and therefore the conductivity may not be at all alike. If, therefore, we postulate, for want of definite knowledge, that the London mud has a much higher conductivity, then all that is needed to meet this, the only conceivably important condition, peculiar to London, is to use our arrangement for preventing class (*b*) (2) studs.

There is, further, the possibility that there is more scrap iron lying about the Bow-road than in the Lincoln High-street, but in view of the number of engineering works in Lincoln this does not seem likely. If, however, this is the case it would have no detrimental effect on magnets efficiently covered.

There is one aspect of the possible leakage through the Bow-road mud which we trust will not escape investigation. It is that during the earlier trial runs there was an almost total absence of studs in class (*b*); and we think certainly none in class (*b*) (2), although during most of these early runs the mud was in about the best condition, as far as dampness is concerned, to produce a large leakage. Yet, during the hot dry summer weather a shower of rain caused great inconvenience. It seems, therefore, necessary to postulate either that the stiffness of action of the dirt-covered switch-pieces was increasing as time went on and that there was therefore less average gap between carbons and cable, or that the mud formed by rain falling on the dust after the road has been dry has a much higher conductivity than the mud that is met with throughout the greater part of the year. We think there are physical reasons why one would expect this result. This matter seems to us to require careful investigation before any reliable figures of road surface leakage can be obtained.

If there are any matters with which we have not dealt already, or upon which you wish further information, we hold ourselves at your disposal either to answer questions which you may address to us or to meet you and discuss the points.

THE "G.B." SURFACE CONTACT CO.
(Signed) B. H. BESELL, Engineer.

A GRAPHICAL METHOD FOR DETERMINING THE FLUX DENSITY IN TEETH.*

BY F. BLANC.

Summary.—After showing the limitations of the ordinary methods for finding the *actual* induction in the teeth, the author proceeds to show how the general equation combining the apparent and real flux densities can be used in connection with the magnetisation curve in question for graphically determining the required ampere-turns.

In the design of dynamo machines it is of great importance to know how to accurately calculate the magnetising current, because on this a number of characteristics such as leakage, overload capacity, armature reaction, &c., depend. The magnetising current, or rather the M.M.F. required to produce the flux, depends on the magnetic reluctance, and this again in the case of iron depends on the induction, which effect becomes very considerable at high densities. In order to utilise the material of a machine to the fullest extent, the designer is compelled on the one hand to work with the maximum possible flux, and on the other to make the ampere-turns per centimetre of the armature circumference as high as is allowable with respect to armature reaction, heating, commutation, &c. One result of this is to reduce the tooth dimensions to such an extent—in order to make room for the winding—that densities of 24,000 lines per square centimetre frequently occur, consequently a considerable percentage of the ampere-turns is required for the teeth alone, and it becomes of great importance to be able to calculate the actual flux density in the same. Since, however, the magnetisation curve cannot be accurately expressed by any simple formula, recourse must be had to graphical methods.

Now parallel to the teeth there is an air section formed by the slots, and assuming the latter of constant width—as usually they are—the section of the teeth increases the further it is taken away from the axis. This, of course, leads to a variation in the flux density in the

* Abstracted from the "Elektrotechnische Zeitschrift."

teeth, and at the same time a varying value of μ, this latter quantity being an unknown function of the field strength.

The usual method for finding the ampere-turns is to calculate a fictitious density in the teeth at any particular section, by assuming that the whole flux at this section passes through the teeth, and none through the air (*i.e.*, slot). This fictitious or "apparent" density, as it is called, is then corrected in accordance with the ratio of the tooth dimensions, in order to obtain the actual flux density in the teeth. Previously this correction was applied by drawing a series of curves with the actual flux density as a function of the apparent, for different ratios of width of tooth crown to width of tooth root. That this is not correct, however, can easily be seen, since the actual density must obviously also depend on the reluctance of the air path, *i.e.*, on the width of the slot.

Both Lumec and Arnold have shown how the correction for the slots can be made. The latter determines a series of curves to represent the apparent and real densities, for various values of k_3 = air section/iron section, whence the necessary ampere-turns can be directly determined. In this method, however, the series of curves only holds for the given magnetisation curve, and must be drawn afresh for any other. In addition to this disadvantage, it is also often necessary to interpolate, which may well lead to inaccuracies in many cases.

In the following a graphical method is described, whereby the actual flux density in the teeth can be found in a convenient manner from any given magnetisation curve. The symbols used are mainly those employed by Arnold. Let

Φ_a = flux per pole entering armature ;
l_1 = total armature length ;
b_i = ideal pole breadth, measured in direction of the circumference.

Then the mean flux density in the gap is

$$\mathsf{H} = \Phi_a / l_1 b_i \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and the apparent density in the teeth

$$B_{z_i} = \mathsf{H} t_1 l_1 / z k_2 l, \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where t_1 = tooth-pitch at armature circumference ;
z = width of tooth at depth x from circumference ;
$1 - k_2$ = coefficient of thickness of paper insulation between armature plates ;
l = core length of armature including paper insulation.

Then from (2)

$$\mathsf{H} t_1 l_1 = B_{z_i} z k_2 l. \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This is the total flux per tooth, and is constant all along the tooth, *i.e.*, from $x = o$ to $x = h$, where h = depth of the tooth. Now if b = slot-width, $t = b + z$ = slot-pitch at x, then the flux in (3) can also be written

$$B_{z_w} z k_2 l + \mathsf{H}_x \{ \underbrace{\underbrace{b l_1}_{\text{slots}} + \underbrace{(l_1 - l) z}_{\text{ducts}} + \underbrace{(1 - k_2) l z}_{\text{paper}}}_{\text{total air section at position } x} \}. \quad . \quad . \quad (4)$$

Section

where H = actual density in air at the section taken through teeth at x, and B_{z_w} = actual density in the teeth at this position.

If then we write

$$B_{z_i} = B_{z_w} + k_3 \mathsf{H}_x \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

we get from (3) and (4), as given by Arnold

$$k_3 = \frac{t l_1}{z l k_2} - 1. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This expression can be transformed as follows : Let

$$t = z + b$$

$$\lambda = \frac{l_1}{k_2 l} = \frac{\text{total core length}}{\text{active core length}} \Big\} \text{ measured along the axis.}$$

$$\gamma = \frac{b}{z} = \frac{\text{slot-width}}{\text{tooth-width}}.$$

Then

$$k_3 = \frac{t}{z} \lambda - 1 = \frac{b + z}{z} \lambda - 1$$

$$= \gamma\lambda + \lambda - 1. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

This γ is the coefficient k, used by Lumec. The difference between this and Arnold's coefficient is then

$$k_3 - \gamma = \gamma\lambda + \lambda - 1 - \gamma = (1 + \gamma)(\lambda - 1).$$

This difference vanishes when $\lambda = 1$. In general this is not the case, however.

Now let equation (5) be written in the form

$$B_{z_w} = B_{z_i} - k_3 \mathsf{H}_x.$$

Then since H_x the flux density in air equals the *field strength*

$$H_x = \frac{4\pi}{10} \text{AW/cm.}$$

We can write

$$B_{z_w} = B_{z_i} - k_3 H_x \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

or

$$= B_{z_i} - 0{\cdot}4\pi k_3 \text{AW/cm.} \quad . \quad . \quad . \quad (8\text{A})$$

Now the assumption that the flux in the teeth, and in the slot, is the same wherever the section x is taken, is not strictly correct. Such an assumption would only hold when the flux entered the teeth from an infinite distance. The proximity of the pole, however, at a distance δ from the tooth, causes more flux to enter the sides of the teeth, especially at the upper portions. Nevertheless the error introduced by the above assumption seldom exceeds ½ per cent. in practice, so that it is unnecessary to introduce any complications into the calculation.

Now equation (8) represents a straight line, which cuts the ordinate axis, representing flux densities, in the point B_{z_i}. The point of intersection with the abscissa axis, representing field strengths, is at the point $H_0 = B_{z_i}/k_3$. Whilst the inclination of the line to the horizontal is given by $\tan \propto = k_3$. Then the actual tooth density B_{z_w} must lie on this line. Further, we have $B_{z_w} = f(H)$, the magnetisation curve on which B_{z_w} must also lie, and the point therefore which satisfies these two conditions will be the intersection of this curve with the straight line.

The graphical determination of B_{z_w} is therefore as shown in Fig. 1. Calculate $B_{z_i} = \frac{H t_1}{Z} \lambda$, and draw through B_{z_i} a horizontal to cut any chosen vertical in the point a. With regard to the scale for k_3, it is convenient to take this ordinate at $H = 1{,}000$, or when the abscissa axis represents A W/*cm*, as in Fig. 1, we draw the ordinate at $\frac{1{,}000}{0{\cdot}4\pi} = 796$ ampere-turns per centimetre. We now set off below a the length $\overline{ab} = k_3$, with 1,000 or 796 as unit, as the case may be. Then the point c, where $B_{z_i} b$ produced cuts the magnetisation curve, gives the actual induction B_{z_w}, whilst the abscissa at c gives the necessary ampere-turns per centimetre.

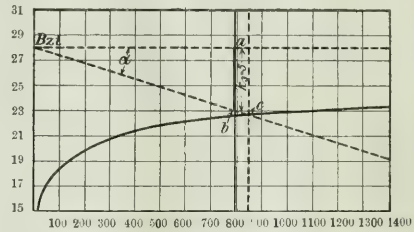

Fig. 1.

In this way the ampere-turns required for the teeth at a given flux density can be found from any given magnetisation curve. Since k varies according to where the section through the teeth is taken, *see* equation (6), it is clear that $H_0 = B_{z_i}/k_3$ must be determined for each position, provided strict accuracy is required, although it will usually be found that the point of intersection of the several straight lines falls only slightly below the axis, as can also be easily demonstrated by extending the above equations further. Also for each particular gap density, these straight lines must be determined, but a little experience with the method will soon enable the designer to shorten his work by adopting convenient constructions, by means of which the ampere-turns under the several conditions can be found.

The total ampere-turns for the teeth can, of course, be then determined by means of any of the well known rules, *e.g.*, when the difference between the maximum and minimum is not too great, it is sufficient to find $aw_{z_{\text{max.}}}$ and $aw_{z_{\text{min.}}}$ them from Simpson's rule

$$\text{AW}_z = \left(\frac{aw_{z_{\text{max.}}} + 4 aw_{z_{\text{mean}}} + aw_{z_{\text{min.}}}}{6} \right) h.$$

THE BUILDING EXHIBITION AT OLYMPIA.

The most casual visitor to the Building Exhibition which was opened at Olympia on Saturday last and which will remain open till May 1, cannot help being struck by two things. One is the wide range covered by the exhibits, and the other is the high degree of artisticness in the arrangement of the stands and in the goods displayed. A wide range of exhibits can, of course, be obtained at any trade exhibition by including apparatus and equipment which do not come strictly within the scope of the trade exhibiting. But this has not been done at the Building Exhibition ; in fact, Mr. H. G.

Montgomery, the promoter, is careful to point out in his preface to the catalogue, that every exhibitor not connected with the building trade has been rigidly excluded. This action, far from proving a deterrent to the success of the Exhibition, has, it is claimed, made it more popular than any similar undertaking.

As regards the position held by electrical work we may first point out that on this, as on former, occasions extended use has been made of the electric light for illuminating the stands and Exhibition generally. In many cases metallic filament lamps are combined with exceedingly artistic fittings and furniture, so that the *tout ensemble* has a very pleasing effect on the jaded eye of the Londoner.

The purely electrical exhibits are few, but altogether they form a very representative show. First among the exhibitors may be mentioned Messrs. R. Waygood & Co., of London, who are showing their well-known lifts. Their exhibits include an electric passenger lift, which is doing yeoman service in conveying visitors to the gallery, working models of an electric "push button" and suspended hydraulic lift, together with a model wharf crane and patent rope grip for use on either electric or hydraulic cranes. The model wharf crane, which is a counterfeit presentiment of a much larger one that is actually worked by hydraulic means, is interesting from the fact that while a derricking motion can be obtained the load moves in a straight line instead of along a parabolic arc, as is usually the case. Further, the jib is fixed solidly to the crane structure instead of by chains, so that any accident through the latter breaking is quite avoided. These two conditions are made possible by the use of a special counterweight arrangement. Another interesting piece of apparatus shown on this stand is the "Waygood" electric grip. This is an electrically-operated device which prevents the working rope being pulled, and the lift started, when any gate is open. It can be adapted to any kind of rope-controlled lift in any building where suitable electric power is available.

Another exhibitor at the Building Exhibition is Messrs. C. J. Thursfield & Co., of Birmingham, who are showing a number of tasteful and artistic fittings for use with the electric light. They make a speciality of designing fittings which will harmonise with the existing decorations, and some examples are shown which are of the type that used to be in vogue in the 17th and 18th centuries. This firm are carrying out their work in an exceedingly British sort of way, and we hope to return to the subject of their fittings in a later issue.

Messrs. Tredegar & Co., of London, are to be commended for their efforts in bringing before the world at large the benefits to be obtained by using electricity in the home. Their exhibit, in fact, exemplifies the employment of electricity in the country house. The complete set includes an engine, dynamo and accumulators, together with the necessary switching arrangements. The engine, which is direct coupled to the dynamo, is of the vertical type, using petrol for fuel. It is fitted with water cooling arrangements, and the ignition is effected by means of a sparking coil. This engine, it is claimed, can be started with a minimum of trouble and needs very little attention. This last remark also applies to the dynamo, accumulators and switchboard, which are all designed on generous lines and seem well fitted for the work they will be called upon to do. This exhibit also includes some examples of Messrs. Tredegar's well-known wooden fittings for electric lighting, and it is interesting to note that these fittings are being used on other stands in the Exhibition.

Messrs. Medway's Safety Lift Co. are showing examples of their standard work, including an electric passenger lift gear, which is self-contained on a strong cast-iron bed-plate. The type of control shown is the hand switch, but hand rope or automatic push button gear can also be provided. A special safety device is fitted with this latter which prevents the lift being moved if a gate is open. They are also showing a safety arrangement which can be fixed to hand-rope worked lifts.

Messrs. Matthews & Yates, of Swinton, near Manchester, have a representative exhibit of their well-known "Cyclone," fans which are specially adapted for use with an electric motor. The exhibit includes a small refuse handling plant, in which a fan sucks away sawdust and chips from the wood working machinery, and conveys it to a dustheap. The "Cyclone" fans shown are very good examples of this firm's work, and are made in any diameter from 1 ft. to 16 ft., all parts being interchangeable. Electric motors for driving these fans are also a speciality. We hope to return to this subject in the special Fan Issue of our Industrial Supplement published next week.

Another well-known electrical firm which is exhibiting at this Exhibition, but which is not showing electrical gear is The India Rubber, Gutta Percha & Telegraph Works Co. Their exhibit consists of a display of indiarubber tiling, stair nosing and rubber goods generally, and includes the flooring of the stand which is made of handsome mosaic work, all carried out in indiarubber.

PARLIAMENTARY INTELLIGENCE.

Electric Lighting Acts (Amendment) Bill.—The Glasgow Corporation have been recommended by their Parliamentary Bills committee to endeavour to have new clauses inserted in this bill for (*a*) saving the local Acts of the Corporation and (*b*) providing that—"Where in any area a local authority, company or person is authorised to supply electricity under Act of Parliament, or under licence or provisional order granted under the Electric Lighting Acts, it shall not, after the passing of this Act, be lawful, without the consent of such local authority, company or person, to supply, distribute or transmit electricity within the same area unless such supply, distribution or transmission is authorised by Act of Parliament or by licence or provisional order granted in terms of the Electric Lighting Acts."

Telephone Plant Renewals.—In the House of Commons on Tuesday, the Postmaster-General stated that he believed there was now no substantial difference between the National Telephone Co. and the Post Office with regard to the terms for the continuance of construction works which did not involve the replacement of existing plant of the company which was not worn out, and he hoped it might shortly be possible to conclude an arrangement with the company for the continuance of such works. An arrangement for the continuance of the more numerous works which involved replacement of existing plant presented greater difficulties, but he (Mr. Buxton) did not think it would be expedient to state the points of difference.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of assistant to the mains engineer in the electric supply department of the Corporation of Birmingham. Applicants must have had thorough experience in e.h.t. alternating-current work, including switchgear, transformers, &c., and be conversant with modern systems of h. and l.t. distribution, laying and testing of cables, &c. Commencing salary £150, rising to £250. Applications to the city electrical engineer and manager (Mr. R. A. Chattock, M.I.E.E.), 14, Dale End, Birmingham, by 4 p.m., May 4. See also an advertisement.

A switchboard attendant is wanted by the Newcastle & District Electric Lighting Co., 38, Grainger-street West, Newcastle-on-Tyne. See an advertisement.

As we go to press we learn that Marylebone (London) Council have appointed Mr. A. Hugh Seabrook to the position of borough electrical engineer. An amendment in favour of Mr. L. L. Robinson, of Hackney, was moved, but the Lighting committee's choice was confirmed by a large majority.

Mr. J. W. Beauchamp, who has been for the past five years deputy manager of Sheffield Corporation electricity department, has been appointed resident electrical engineer at Tunbridge Wells.

Mr. E. J. Taylor has been appointed meter inspector to Belfast Corporation electricity department.

Gloucester City Council received 248 applications for the position of city electrical engineer, but this number was reduced by the Electricity committee to the following five:—Messrs. J. W. Beauchamp (Sheffield), F. H. Corson (Blackburn), C. E. Savage (Wolverhampton), R. N. Torpy (Wimbledon), and H. A. Howie (Dudley). In the meantime Mr. Beauchamp has been appointed borough electrical engineer at Tunbridge Wells.

EDUCATIONAL NOTICES.

Proposed Bristol University.—Bristol City Council decided on Tuesday to contribute in the proportion of 1d. in the pound on the rate, or about £7,000 per annum, towards the support of the proposed University for Bristol and the West of England, for which over £200,000 has been subscribed, mainly by members of the Wills family.

Technological Scholarships.—The West Riding of Yorkshire County Council offer minor technological scholarships (up to £50 each per annum) tenable by persons who have had practical experience of a trade for at least one year, and have concurrently attended day or evening classes, or by pupils who are about to leave secondary schools. The scholarships will be awarded on the results of a written, practical and oral examination. Application forms and full particulars from the Education Department (Technical Branch), County Hall, Wakefield.

Institute of Chemistry.—Of 10 candidates who presented themselves for the recent intermediate examination, the following 6 passed:—

B. M. Brown, A. S. Dodd, T. S. Hames, G. S. W. Marlow, G. A. Smiley, B.Sc., and O. J. Stone. Two candidates presented themselves for the final associateship examination in mineral chemistry and one passed (P. W. Copeland, B.Sc.); in metallurgical chemistry, of two examined, one passed (H. T. Reeve); and of five candidates in organic chemistry

three passed (C. Gilling, B.Sc., G. E. Johnson, B.Sc., and J. Yates, M.Sc.). B.Sc.). In the examination in the chemistry of food and drugs and of water six presented themselves and four passed viz., T. Cockburn, C. E. C. Ferrey, P. A. W. Self, B.Sc., and F. F. Shelley. Three of the candidates (J. Yates, T. Cockburn and F. F. Shelley) were examined for the Fellowship.

Electrical Standardizing, Testing and Training Institution.—As the result of the recent examinations at Faraday House the following scholarship awards have been made :—

To Richard Willan, Widnes (Lancs.) Municipal Secondary School, a Faraday scholarship of 50 guineas per annum, tenable for three years ; to Cyril L. Underwood, Bedford Grammar School, an extra entrance scholarship of 35 guineas per annum, tenable for three years ; to John R. S. Hawker, Goldsmith's College (New Cross, London), an entrance exhibition of 25 guineas per annum, tenable for three years ; and to Roger Brunton, Wellingborough Grammar School, a special entrance prize of 20 guineas.

Aberdeen.—The Electricity committee have considered the report of the city electrical engineer (Mr. J. Alex. Bell) as to the present system of charging for electric current, depreciation, &c., and the town clerk and the city chamberlain will report upon the powers of the Council as to the formation of a depreciation fund. Mr. Bell will bring up a fresh report showing what flat rate of charging would meet the present situation.

Australasia.—Melbourne Chamber of Commerce recently passed a resolution expressing the opinion that, before the Government increase their telephone charges, a statement showing the results of the working and setting out a comparison with the expense of working telephone systems elsewhere should be issued to the subscribers and the public, to enable them to form an opinion as to whether their system is worked economically.

The "Australian Mining Standard" says a trial is being made at the Ballarat West railway station with a 5 ton electric crane, and it is believed that if this is satisfactory electric cranes will also be installed at other Victorian stations.

It is proposed to instal electric pumping plant in the deep levels of the New Chum Railway gold mine, Bendigo, similar to that in the Long Tunnel (Walhalla) mine, which has been found completely satisfactory, both as to costs and efficiency.

Mr. Johns, resident engineer, has recommended Leonora (W. Australia) Council to purchase a 54 H.P. producer gas engine and a 34 kw. dynamo at an estimated cost of £1,500, and to retain the present plant for peak loads and emergencies. An independent expert has endorsed Mr. Johns' recommendations.

Austria-Hungary.—The Hungarian Government have granted concessions for the construction of the following railways :—Vacz to Budapest and Gödöllö (to be an electric line, estimated cost £375,000); Hölak to Trencsentaplitz (electric, 3¾ miles, £27,792) ; Kerepes to Gödöllö (steam and electric, 8 miles, £256,250). The names of the concessionaires and particulars (in Magyar) can be seen at 73, Basinghall-street, London, E.C.

The British Consul-General in VIENNA will receive communications from British firms who can equip a factory for a Vienna firm for the manufacture of incandescent electric lamps, or supply the machines and apparatus required.

Barking.—During the past year the electricity department sold 1,337,344 units of electric energy, an increase of 269,906 over 1907-8. There is an increased demand for power, especially at Creeksmouth, and it is anticipated that the undertaking will be self-supporting this year. The tramcars carried 1,280,420 passengers, against 946,890 ; and the receipts were £3,130, against £2,660. The financial position of this undertaking is, the chairman of the Council reports, still unsatisfactory.

Barnes.—The electrical engineer (Mr. C. S. Davidson) recommends the Council to allow the London General Omnibus Co. to use for power 20 per cent. of the electric current supplied to them, thus reducing the average price to 2·04d. per unit.

Mr. Davidson is to report upon the effect which a reduction of 25 per cent. in the charges for public and private lighting and of 12½ per cent. for power from October next would have on the electricity undertaking.

Belfast.—The city electrical engineer (Mr. T. W. Bloxam) has been asked to report upon the question of the charge to be made for electricity supplied to the tramways department, and to ascertain from other corporations owning combined lighting and tramway power stations the basis of their charges.

Bermondsey (London).—The Electricity and Street Lighting committee recently prepared a report on the working of the refuse destructor department, in which figures of the cost of refuse destruction in other towns were given. The committee recommended that no alteration be made in the system of dust destruction, and this was agreed to by the Council.

Birmingham.—A deputation from the Trades Council has waited upon the Tramways committee to urge that the Corporation should construct their own tramway rolling stock instead of obtaining it by tender. The committee have promised to consider the matter.

Cardiff.—By the casting vote of the Lord Mayor, it has been decided not to engage an expert to report upon the state of the tramway track.

City of London.—The five members of the Streets committee, who recently visited certain continental cities in order to collect information as to street lighting, have returned.

In an interview with a Press representative some of the members are reported to have stated that they had nothing to learn in the matter of street lighting from any of the cities visited except Berlin, where the Council propose to expend £50,000 per annum for a period of seven years in perfecting the lighting arrangements. "In addition to a chief engineer, a gas engineer, and an electrical engineer, the municipality employs six chemists, the chief of whom, a member of one of the universities, has been making experiments with gas and electric lighting for some considerable period." In addition to Berlin, the deputation visited Brussels, Cologne, Dusseldorf, Dresden, Munich, Vienna and Paris.

Devonport.—The Town Clerk has issued summonses against the Devonport & District Tramways Co. for the recovery of penalties for the discontinuance of the service on the leased lines. The summonses are returnable before the borough justices, and will be heard to-day, Friday.

Dunster.—Somerset County Council have given the Minehead Electric Supply Co. permission to use overhead cables for supplying electricity to Dunster.

Edinburgh.—The Electric Lighting committee have approved the provisional estimates for the year ending May 15, 1910.

The estimated expenditure is at £65,560, against £65,900 last year. The revenue is estimated at £130,060, against £131,360. The ordinary expenditure, together with interest and sinking fund contributions will amount to £127,650, and the estimated balance available for appropriation is £2,400.

Electric Traction on the Congo.—It is reported that M. Thys has been sent out to examine the rapids and falls of the Lower Congo in order to decide whether sufficient power is available to generate current for operating the Matadi-Leopoldville railway electrically.

Exhibitions.—We have received further literature relating to the Buenos Ayres International Exhibition of Railways and Land Transport, which is to take place from May to November, 1910, inclusive.

Applications for space must be received by the Executive committee by July 31 next and goods will be admitted from April 1 to May 5, 1910. Applications to exhibit engines or other objects requiring foundations or special buildings must, however, be in by June 15, 1909, and such exhibits must be delivered by Feb. 28, 1910.

The Duke of Argyll will perform the opening ceremony of the Imperial International Exhibition at Shepherd's Bush. The date of the opening (which has not yet been fixed) will probably be about May 18.

Glasgow.—Last week the Corporation adopted the recommendations of the joint sub-committee of the Electricity and Tramways committees in regard to the generation of electrical energy.

Mr. J. Dalrymple, general manager of the tramways department, and Mr. W. W. Lackie, chief engineer of the electricity department, in a report prepared by them, state that—

During the winter of 1906-7, when the question of the production of electricity was raised by ex-Treasurer Stevenson, arrangements were in progress for connecting the Pinkston power station of the tramways department and the Port Dundas power station of the electricity department by means of two interconnector cables. This work was completed about 12 months ago, and now an interchange of energy is given from one station to the other as and when required. This arrangement is working with complete satisfaction. In view of this inter-connection having been made, and also of the fact that considerable extensions to the plant have been and are at present being made in the power stations of both departments, we consider that it is inexpedient to make any change in the existing arrangements. The object aimed at in the proposed change is greater economy and efficiency. We submit, however, that this object is largely, if not altogether, attained by the above-mentioned arrangement of interconnecting cables, which enables the two departments to co-operate in the use of each other's plant whenever this can be done with advantage. We are convinced that no sufficiently substantial benefit could accrue by disturbing the present working arrangements between the Tramways and Electricity committees, unless and until some change of circumstances should arise in the position of the two departments which might require the whole question of the production and distribution of electrical energy to be considered anew. Meantime, the practice of both departments is, as far as possible, being rendered uniform. We are at present looking into the demand at different hours of the day and night and on different days of the week on the generating stations of both departments, and if further economy can be made as the result of this inquiry, we will arrange a regular interchange of energy, so as to ensure that the minimum of plant is run to meet the aggregate demand of the two departments. We therefore recommend that the two departments should be allowed to complete the work in hand along the present lines, and that they should con-

tinue to grant to each other, whenever required, the use of any of their available spare plant.

Under these circumstances the sub-committee unanimously resolved to report that, in their opinion, the existing arrangements for the production of electrical energy should not be disturbed, and this view has been endorsed by the Corporation.

Greenock.—The Secretary for Scotland has sanctioned the proposal of the Corporation to borrow £25,000 for extensions of the electricity works.

In their report on the loan the examiners of accounts state (1) that the capital expenditure has not been in any way excessive, having regard to the economical construction and effective value of the undertaking; (2) that the extensions for which additional powers are applied are necessary in order to meet obligations already entered into, and the natural calls on the undertaking during the next two years; (3) that the general financial administration of the undertaking has been conducted on a sound financial basis.

Grimsby.—The Electric Lighting committee are dissatisfied with the increase in the assessment of the electricity works by £2,374, and the Machinery Users' Association has been instructed to report upon the matter.

Hammersmith (London).—In view of the present position of the copper market, the Electrical committee has been authorised to purchase 10 tons of cable.

Handsworth (Staffs.)—Mr. H. Graham Harris has been appointed Board of Trade arbitrator to fix the amount to be paid by Handsworth Council to the City of Birmingham Tramways Co. for the section of the cable tramway between Hockley and New Inns.

Heston and Isleworth.—The Electrical committee is considering an extension of the storage battery at the electricity works.

Hindhead.—In connection with the application of the Hindhead & District Electric Light Co. for a provisional order for Hambledon, &c., the Board of Trade have decided against the application of the Council to reduce the maximum price from 8d. to 6d. per unit, as 8d. was the universal price, except in large towns. The villages of Witley and Thursley have been excluded from the order, and the area of supply extended in certain portions of Haslemere.

Hounslow Railway.—The new line which has been constructed by the Metropolitan District Railway Co. to Heston-Hounslow and Hounslow Barracks will be opened on May 2.

Inquest.—At West Ham on Monday an inquest was held on Albert Rawlins, who was killed at Stratford on the 16th inst.

Deceased, who was employed by the G.E. Railway Co., was polishing the panels of a saloon carriage at Stratford, and a fellow workman named Nash handed to him a portable electric lamp. Deceased grasped it by two fingers and immediately stumbled "as though he were drunk, and fell dead." Artificial respiration was without avail.

Mr. Maurice Vice, electrician-in-charge of the carriage department of the G.E. Railway, said the pattern lamp in question had only been in use for six weeks, and in consequence of the advice of the Home Office it was intended to discontinue them. Witness had tested the lamp, but could find no leakage; the lamp and lead appeared to be in good condition. He was unable to account for the accident. He did not think deceased could have received a shock unless the "cage" had been alive. Witness did not think a shock of 250 volts serious. On many occasions he had had a shock of 450 volts.

Dr. T. Inglis said deceased was a perfectly healthy man and there was no external sign of injury, but in his opinion death was due to syncope caused by electric shock. Electro-medical experts agreed that a voltage of 250 was never serious to a healthy man.

A verdict of accidental death was returned.

Liverpool.—Owing to the unsatisfactory results of running first-class passenger tramcars, the City Council on Wednesday adopted a recommendation of the Tramways committee to open the upper decks of the first-class cars at ordinary penny fares.

The report of the auditors of the Corporation tramway accounts (Messrs. Lewis & Mounsey) for the past year has been issued.

The traffic revenue was £563,143, and the total receipts (including £7,594 from advertisements) £574,977, a decrease of £8,080 compared with 1907. Expenses were £401,181, an increase of £2,447. The revenue balance stood at £173,795, added to interest on loans, &c., making £190,012. After meeting interest on debt, sinking fund, &c., the available balance is £74,574, which was absorbed by the allocation of £49,716 to reserve, renewal and depreciation, and £24,858 in aid of general rate. The capital expenditure is £2,031,291, which has been reduced by £308,062, leaving the net capital expenditure at £1,930,602 All the non-recurring expenditures are, in the view of the auditors, adequately met by the several sinking funds. The assets are stated to be £2,606,830.

Motor Car Regulations.—The Local Government Board have issued a circular on the decision of the High Court in Burton v. Nicholson, stating that the Board have come to the conclusion that it is desirable to rescind both subdivision (3) and subdivision (4) of Article IV. of the Motor Cars Order of 1904, and to leave the matters at present dealt with by these subdivisions to be governed by the ordinary law applicable to other classes of vehicles. These regulations will be found on pages 200 to 202 of "The Electrician" Electrical Trades Directory and Handbook for 1909.

Manchester. The estimates of the Tramways committee for the present year have been prepared, and the committee propose to grant to the relief of rates £60,000 out of the profits.

The Electricity committee met on Wednesday to consider their estimates and decided to make a contribution of £12,000, as in the year 1908, in aid of the general city rates. The past year's accounts showed a surplus of £33,304 (of which £12,000 had already been paid over in aid of rates), and the balance (£21,304) was placed to renewals account. Compared with the previous year the sales of current showed an increase of 3,500,000 units (mainly on power sales) and a decrease of £17,848 in income. The lighting sales were temporarily affected by the use of metallic filament lamps. The majority of the business premises in the city had already been fitted with the new lamps, and the result showed a considerable reduction in cost, amounting on the average to no less than 40 per cent. Owing to the general depression in trade the growth of the industrial power business was not so marked as in the previous year, but there are signs of considerable development in the current year as the committee have recently concluded contracts with several well-known engineering firms for large bulk supplies.

Mountain Ash.—The Council have now let contracts for the laying of distributing mains, &c., and an agreement has been entered into with the South Wales Electrical Power Distribution Co. for supply of electricity in bulk. Current will be supplied to the Council at a pressure of 11,000 volts, which will be transformed and distributed by the Council.

Oxford.—The City Council have decided to enter into an agreement with the promoters of the Oxford and District Tramways Bill, 1909, whereby a combined conduit and overhead system will be adopted on the tramways instead of a surface-contact system. The conduit system will be installed on three routes, and the rental to be paid to the Corporation in respect of the tramways when electric traction has been adopted is £1,100 per annum for a period of 12 years.

Postal Telegraph Clerks Association.—At the annual conference of this association, which was held at Southampton last week, the following matters were dealt with:—

Press Telegrams.—A resolution was passed in favour of the work of transmitting all messages being performed by an established staff of telegraphists placed upon a uniform scale of wages, and protesting against the departmental authorities encouraging newspaper proprietors to rent telegraph lines for the whole day, and supplying their own operators.

Women's Labour.—Resolutions were adopted in favour of the abolition of Sunday duty by females in the trunk telephone department; and also in favour of equal pay for men and women for equal work.

Postal Telegraph and Telephone Services.—Resolutions calling for the appointment of a committee to inquire into postal, telegraph and telephone services, and the institution of an advisory board of the House of Commons for the assistance of the Postmaster General, and also in favour of a seven hours' day were adopted.

Rochdale.—The total income of the tramways department (including the Heywood lines) for the past year was £57,270, against £56,557 for the previous year. The gross profit was £25,417, and after meeting charges for interest (£11,432), sinking fund (£9,557) and rent of leased lines (£1,862) there was a loss of £189, against £1,352 in 1907-8.

Russia.—The "Journal de St. Petersbourg" states that the Government has sanctioned the formation of the Oranienbaum Electric Railway Co. to construct and work an electric line from St. Petersburg to Oranienbaum and Krasnaiä Gorka.

Saffron Walden.—The Council have declined to give a guarantee to the Board of Trade that they will carry out the provisions of their electric lighting order within 12 months.

Shoreditch (London).—The salary of Mr. W. Weeks, assistant engineer, has been increased by £25 per annum, with a further increase of £25 in 12 months.

South American Cable Rates.—The Western Union Telegraph Co. announce that the following reduced cable rates will come into effect on May 1: Bolivia, Chili and Ecuador, 4s. 2d. per word; Peru, Iquitos, Masisea, Orellana, Requena, 6s. 2d. per word, and other places, 4s. 2d. per word.

State Telephones in Canada.—The Saskatchewan Government has purchased the Bell telephone system of the province as from May 1.

Sunderland.—In moving the minutes of the Electricity committee at last week's Council meeting, which recommended the sealing of an agreement with a firm of millers for the supply of electric power.

Ald. Bruce said the committee found themselves with a considerable amount of Corporation machinery in Laing's yard and in a building for which the Corporation had to pay rent, and for which they got no return. In future they would not put down Corporation plant in other people's premises and pay rent; the manufacturer must bear the loss in transmission.

Mr. Lawson said the proposed agreement was the thin edge of the wedge for an expenditure of £21,362 for electric lighting extensions. They were losing on the lighting consumers and on shipyard cus-

SPECIAL NOTICE.

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tomers, and the only customer out of which they were making any money was the Tramways committee.

Mr. G. NEW said it was proposed to spend £340 and thereby gain valuable experience of supplying electricity in bulk which they had not before had. As to decreased profits of the electricity undertaking the price had been reduced to every consumer of electric light and only the results of shipyard extension made that reduction possible.

The minutes were approved.

Tramways and Railway Assessment.—In consequence of the competition of electric trams and motor omnibuses, the North London Railway Co. have served notice upon Shoreditch Borough Council requiring the reduction of the present assessment of the line from £21,700 gross and £15,500 ratable, to £17,256 gross and £11,056 ratable. The Council have decided to seek to raise the assessment of the tramways in the borough from £7,400 gross and £3,000 ratable to £14,400 gross and £10,200 ratable.

West Ham.—The Education committee is to report on the method of lighting the infants' department of the Abbey school.

Whitehaven.—The Council have decided to supply electric current to local electrical contractors for display purposes at 1¼d. per unit.

Wireless Telephone Notes.—The sucesss of the experiments in wireless telephonic communication between the Eiffel Tower at Paris and Melun, which we noted last week, has decided the French Minister of Marine (M. Picard) to resume the experiments which were some time ago commenced, of endeavouring to establish wireless telephonic communication between the French fleet in the Mediterranean and the station at the Eiffel Tower, and also to establish communication between the French Northern and Mediterranean squadrons. It is stated that already communication has been successfully made between the Rouges Terres and the Mediterranean squadron.

From New York it is announced that another inventor has overcome "all the difficulties attendant upon the establishment of an efficient system of wireless telephony," and that a public wireless telephone service has been established between Portland and Casco Bay Islands, distant about 10 miles.

Wireless Telegraph Notes.—A new factory which has been established at Genoa, as well as the Marconi station at the extreme point of the ancient mole, have been opened. The factory and station adjoin, and at the former plant has been installed both for manufacturing radio-telegraphic apparatus and for repairs. A section of the factory is set apart for the manufacture of telephones for use on board ship, and there is to be a training school and a thorough equipment connected with the undertaking.

It is announced that the Ceylon Government is about to establish wireless telegraphic communication between Colombo and Minicoy, a distance of about 500 miles.

Wolverhampton.—The Electricity committee propose to extend the electricity supply mains at a cost of £700 to Messrs. Chubb & Sons' new works in Wednesfield-road for the supply of current for power and lighting.

Worcester.—An unopposed inquiry was held last week into the Council's application for sanction to a further loan of £5,752 to cover excess expenditure, and to provide for extensions of the electricity undertaking.

Of the sum applied for £852 was for excess expenditure, and of the balance £3,900 was for mains, £600 for services, and £400 for meters.

The city electrical engineer (Mr. SHAW) said that the excess expenditure was due to the very large number of new customers. The output last year showed an increase of 50 per cent.

York.—A town's meeting was held on Friday to consider the question of the municipalisation or leasing of the tramways.

The vice-chairman of the Tramways committee (Ald. MEYER) explained the provisions of the York Light Railways Order, and gave an analysis of the tenders received. There were three proposals—(1), complete municipalisation; (2), the Corporation to construct the lines and then to lease the working; and (3), the construction and working by a company. On being put to the vote, the second proposal failed to find a supporter, and the municipalisation clause was then carried by a large majority. A requisition for a poll was handed in on behalf of those opposed to the municipal scheme.

Football.—Birmingham Tramways Department won the final match for the municipal tramways shield at Aston Villa ground on Tuesday, defeating the Potteries eleven by one goal to nil.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1909 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in handy book form. These are included in the 1909 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

LONDON County Council invite tenders for withdrawing about 18 miles of l.t. lead-covered cables, now laid and jointed in stoneware ducts, and relaying and jointing about 15 miles of l.t. lead-covered cables, &c. Tenders (upon official forms to be obtained from the Clerk of the Council, Mr. G. L. Gomme, County Hall, Spring Gardens, S.W.) by 11 a.m. of Tuesday, May 4. See also an advertisement.

WOODBRIDGE Urban Council, who are desirous that a company should establish electricity works in the district, announced that they would support a company in an application for a provisional order and would enter into a contract for public lighting from April 1, 1912. The population is 4,600 and gas is 4s. 6d. per 1,000 ft. Tenders by June 1.

STOCKPORT Electricity and Tramways committees require tenders for supply until March 31 next, of various stores, including cotton waste, castings, ironmongery, tubing, glass, oils, paints, &c. Forms of tender, &c., from the Borough and Tramways Electrical Engineer.

SALFORD Corporation want tenders by 5 p.m., April 29, for the erection of private telephones at the Town Hall. Specification, &c., from the Borough Engineer.

MANCHESTER Tramways committee want tenders by 10 a.m., May 4, for supply of a 40 to 45 B.H.P. chassis for motor tower wagon. Forms of tender, &c., from Mr. J. M. M'Elroy.

WHITEHAVEN Electricity committee require tenders for castings for feeder pillars and lamp columns. Particulars from the Borough Electrical Engineer.

KENSINGTON (London) Guardians require tenders by 3 p.m., April 29, for electric lighting of workhouse chapel and offices, Marloes-road. Specification, &c., from the Clerk.

CHELSEA (London) Council want tenders by 5:15 p.m., May 12, for supply of electric light fittings, &c., for the Town Hall extension. Specifications, &c., from the Borough Surveyor.

BEXHILL Council want tenders by noon May 1 for 12 months' coal for the electricity department.

Tenders are invited for the supply of about 48,200 metres of lead-covered cable, of various dimensions, and for various voltages, and also for certain fittings and accessories for COPENHAGEN Municipality. Tenders to the Direktoren for Belysningsvaesenet, Raadhuset, Copenhagen, by noon of May 3. Specifications, &c. (in Danish) may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Correction.—In our last issue we stated that Watford Council had placed an order with the Lea Recorder Co. for a CO_2 recorder. We are informed that this is an error, as the instrument ordered was one of the company's ordinary V notch water recorders for measuring steam consumption and boiler feed water.

Hammersmith (London) Council received six tenders (varying from £124. 10s. to £192. 5s.) for supply and fixing of additional panels

for the main switchboard, and the lowest (that of the British Westinghouse Co.) was accepted. The Council have also accepted the tender of H. F. Harrison for supply of 30 lanterns and brackets at 14s. 6d. each in connection with the conversion from gas to electricity of the street lighting in Latimer-road.

J. G. Childs & Co., Hawthorn-road, Willesden-green, N.W., have secured an order for one of their wind-driven electrical generating plants for shipment to the Canary Islands.

Darlington Corporation received the following tenders for supply of 500 kw. electric generator, driven by an exhaust steam turbine :—

Brush Co.	£2,000	B. Thomson-Houston Co.	£3,505
British Westinghouse Co.	2,670	Willans & Robinson	3,800
C. A. Parsons & Co.	2,850	Siemens Bros. Dynamo Works	3,860
Bellis & Morcom	2,880	J. Musgrave & Sons	3,898
J. Howden & Co.	2,950	P. G. Mitchell	3,950
Fraser & Chalmers	3,228	Richardsons, Westgarth	3,980
Elec. Construction Co.,	£3,260, £3,320 and £3,370		

No tender has been accepted but the Electricity committee have authorised the engineer (Mr. J. R. P. Lunn) to present a report on the tenders, after he has visited Weymouth and Weston-super-Mare, where exhaust steam turbine plants are in operation.

For the supply of a 300 kw. motor-generator set Brighton Corporation received the following tenders :—

Phœnix Dynamo Mfg. Co. (*accepted*)	£978	Siemens Bros. Dynamo Works	£1,157
E. Scott & Mountain	1,579	Vickers, Sons & Maxim	1,154
Dick, Kerr & Co.	1,494	Electrical Co.	1,145
Brit. Thomson-Houston Co.	1,276	British Elec. Plant Co.	1,139
Electric Construction Co.	1,256	Crompton & Co.	1,130
Lancashire Dynamo Co.	1,235	British Westinghouse Co.	1,117
Brush Co.	1,223	Bruce Peebles & Co.	1,075
Schorch Electrical Co.	1,200	Electromotors (Ltd.)	1,055
		General Electric Co.	1,027

The following tenders have been accepted by Newport (Mon.) Corporation :—

Edison & Swan Co. and General Electric Co., carbon filament lamps ; Edison & Swan Co., radiator lamps ; Oliver Arc Lamp Co., flame carbons (other flame carbons are under test) ; Chamberlain & Hookham and Gillespie & Beales, d.c. meters ; Ferranti Limited, prepayment meters ; Electrical Co., two-rate meters. The contract for a.c. meters has not yet been let.

Swindon Council have accepted the following tenders :—

Crompton & Co., circulating pump, £109 ; Babcock & Wilcox, superheaters, £175 ; Worthington Pump Co., softener pump, £31 ; H. Pooley & Son, weighbridge, £79 ; Brooke, Hirst & Co., switchgear, £46 ; Evershed & Vignoles, megger, £23.

Mountain Ash Council have entered into contracts with the British Insulated & Helsby Cables for cables, distributing mains, &c. ; with Ferranti Limited for high and low-tension switchboard and transforming plant ; and with Williams Bros. for erection of a substation.

Wolverhampton Guardians have accepted the tender of the District Electric Co. for wiring the nurses' house extensions at £113, and that of the Premier Accumulator Co. for the maintenance of the battery at £37. 10s. per annum.

Hackney Electricity committee report that Cowdenbeath and Edinburgh washed peas are being supplied to the electricity department at 10s. 6d. per ton, and as the most satisfactory results are being obtained from them the committee have accepted the offer of W. Cory & Son to deliver 4,000 further tons at 10s. 3d. per ton.

Heston and Isleworth District Council have accepted the tender of J. M. O'Brien for annual maintenance of electric light fittings in the isolation hospital.

Lowestoft Corporation have accepted the tender of Crompton & Co. for a 200 kw. set at £2,313. There were 20 tenders and the lowest was accepted.

Bermondsey (London) Council have accepted the tender of W. Geipel & Co. for supply of arc lamp carbons for the year ended March, 1910.

The annual contract for motors at Middleton has been placed with Veritys Limited.

Dartford Joint Hospital committee have accepted the tender of G. E. Beaven for wiring and telephone work at the new hospital.

Cleckheaton Council have placed an order with G. W. Birkett for wiring the new Secondary School and Technical Institute.

Newport (Mon.) Council have placed an order with Dick, Kerr & Co., for three tramcars at £2,140.

Clacton Council have accepted the tender of H. Morris & Bastert for a 13-ton travelling crane at £165.

Grays Council have placed an order with the Brush Co. for electric pumps at £379.

Siemens Bros. Dynamo Works have received an order for supply of tantalum lamps for St. Andrew's Cathedral, Singapore.

Lowestoft Corporation have accepted the tender of the Lahmeyer Electrical Co. for the annual supply of cables.

Commonwealth Tenders.—The following tenders have been accepted by Government Departments of the Australian Commonwealth :—

The Postmaster General's Department, Brisbane, Queensland, have accepted the tenders of the International Electric Co. for trembling bells and visual indicators ; Siemens Bros. Dynamo Works for flat brass ; India Rubber Co. for condensers, galvanometers, pivots for Q. and I. detectors, platinum, resistance boxes and sounders ; British Insulated & Helsby Cables for switchboard and receiver cords ; J. A. Newton & Co. for coin attachments ; Lawrence & Hanson for ebonite sheet ; J. Paton & Co. for micro-telephones, with cord and plugs ; Slater & Co. for spring ink-writers and sounders ; Brisbane Electrical Co. for Frier's relays, transmitters, solder, strip indicators, ringing and listening keys, ebonite knobs, plugs, receivers, screws, sleeves, switchboards, aluminium shutter fronts operator's telephone sets and pulley weights for cords.

The General Electric Co.'s tender for switchboards and annunciators has been accepted by the P.M.-G.'s Department, Perth (W. Australia).

BUSINESS NOTICES.

Messrs. Balchin, Schulz & Co. have opened a branch of their business at Prudential-buildings, 97, Above Bar, Southampton, for dealing with the installation of electric light and power in country and town houses, factories, ships, &c., and they will be pleased to receive price lists from electrical and machinery manufacturers.

Metal Filament Lamps.—Messrs. G. M. Boddy & Co. ask us to state that they have succeeded in placing on the market metal filament lamps ("Metalik") of 16 c.p. low voltage (100 to 135 volts.), and 32 c.p. high voltage (200 to 260 volts.).

Sales by Auction.—Mr. Frank G. Bowen will sell by auction at his rooms, 62, Aldersgate-street, and Hare-court, London, E.C., on Tuesday, April 27, at noon, the plant, machinery and stock of a firm of electrical engineers and art metal workers, including lathes, tools, &c., electric pendants and brackets, about 1,000 dozen hammered iron, copper and brass leaves, elbows, mounts, ornaments and hammered iron parts, surplus stock of electrical fittings, motors, fans, lamps, switchboards, &c. The lots may be viewed on day prior to and on morning of sale, on the premises of Messrs. F. A. Andrews (Ltd.), 3A, Hall-place, George-street, Edgware-road, W. Catalogues of the Auctioneer. Further particulars are given in an advertisement.

Messrs. Fuller, Horsey, Sons & Cassell will include in their sale by auction at H.M. Dockyard, Chatham, on May 4 and following days, large quantities of old brass borings, iron and steel scrap, old wire rope, lead and zinc ashes and bottoms, old electric cable, electric gear and various stores, 11 lathes, dynamos, engines, &c. Catalogues (6d. each) may be had at the Dockyard and of the Auctioneers, 11, Billiter-square, London, E.C. See also an advertisement.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane, Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

An advertisement in another column contains particulars of some electrical plant, gas engines, &c., which are for sale.

Two alternator-gas engine sets (250 kw. each), direct coupled, are advertised for sale.

Business for Sale.—An engineer's business in a southern town is offered for sale by Messrs. Langridge & Freeman, 28, Queen-street, London, E.C., and Tunbridge Wells.

Patents Development.—The proprietors of British Patent No. 7,942/1906, for "Improvements relating to Wireless Telegraphic and Telephonic Systems," desire to make arrangements for their development and practical working in this country. Applications to Messrs. Haseltine, Lake and Co., 7 & 8, Southampton-buildings, Chancery lane, London, W.C.

Electrochemical Laboratory Premises Wanted.—An advertisement contains particulars of the requirements of consulting engineers, who wish to lease or purchase premises for an electrochemical laboratory, within reach of cheap electric supply, gas and water.

Business Literature.—From the business service department of Burrup, Mathieson & Sprague we have a copy of their sectional catalogue which claims to illustrate the benefits of educational business literature. Those of our readers who are interested in the subject can obtain copies free.

Boiler Economies. Messrs. Ed. Bennis & Co., Little Hulton, Bolton, and London, send us an artistic pamphlet dealing with the extensions at the Coventry electricity works, where many varieties of the firm's well-known apparatus are installed. The pamphlet contains photographs which show the progress of the works from time to time and a detailed account of the whole installation, including the older work, is given.

CATALOGUES, &c.

Prescot Overhead Material.—The British Insulated & Helsby Cables have issued a new list dealing with overhead material. Illustrations are given of "Prescot" non-fouling trolley wire, which was one of the features at the recent Manchester exhibition. Standard Prescot ears for this type of trolley wire are illustrated, and full details, both mechanical and electrical, are given. Frogs, crossings, trolley wheels, hangers and line insulators are also dealt with.

"Kalkos" Fittings.—The Sun Electrical Co. send us the latest list of "Kalkos" fittings, in which are included illustrations and details of a ceiling hook for heavy suspension and a bell push of the flush type adapted for use with "Kalkos" wire. We note that the price of this tubing has been considerably reduced, so that a large demand for this excellent method of wiring may be confidently expected.

Neotherm Cell.—Messrs. Siemens Bros. & Co. have issued a reprint of their leaflet on this cell, in which, it will be remembered depolarisation is secured by the conversion of copper oxide into red spongy copper. Unlike other cells of this class, it is claimed that the Neotherm cell possesses the important advantage that the depolariser can be used again and again. When the cell has been absolutely discharged the depolariser can be re-oxydised by rapidly heating the iron containing vessel in a stove. Batteries of these cells are said to make an excellent substitute for small accumulators and find a wide application for ignition purposes on internal combustion machines and in wireless telegraphy and X-ray work.

"Installation News."—The current issue of "Installation News" deals in a bright and airy fashion with the problems that are at present testing the ingenuity of the electrical industry. It also includes details of the new Simplex flexible system, which we describe in the present issue of The Electrician, and also details advances which have been made in Simplex fan work and in the company's well-known system of conduits and fittings for electric lighting.

Electric Hooters.—Messrs. Marples, Leach & Co. have ready a pamphlet dealing with their electric hooter and fire alarm system, which is, briefly, worked as follows: The hooters are constantly traversed by a direct current, but are not worked until the fire alarm push is actuated. This causes an Adnil vibratory generator to be started up, which converts the direct current into alternating current of high voltage and frequency; the electric hooter then commences sounding and continues until the fire station indicator is returned to its normal position.

Machine Tools.—Messrs. J. Holroyd & Co., Milnrow, nr. Rochdale, have issued two lists which deal with forming lathes and grinding and sharpening machines respectively. These machines, which appear from the illustrations to embody both strength and good workmanship, are specially adapted to the electric drive, and with the motor direct coupled to them form a neat and compact combination. The machines illustrated range from axle lathes of large sizes to quite small grinding machines. A number of useful tools of various kinds are included.

B.E.P. Motors.—The British Electric Plant Co. have issued a list which gives full details, electrical, mechanical and financial, of three-phase machinery manufactured by the company. Accessories, such as motor starters and resistances, are also described.

Motor Car Accessories.—Messrs. D. H. Bonnella & Son have issued a pamphlet dealing with motor car accessories. This firm make a speciality of motor car fittings, such as roof lights and lamps, speaking tubes and carriage fittings generally. We have already dealt with the general features of these fittings in The Electrician, and would recommend anyone who wishes to fit up his car in an artistic fashion to pay a visit to the showrooms of Messrs. Bonnella & Sons.

Speed Indicators.—Messrs. S. Smith & Son, 9, Strand, London, W.C., have ready a catalogue dealing in a very exhaustive manner with their popular type of speed indicators. The utility and reliability of these indicators is well indicated by a letter from a well-known firm of solicitors to Messrs. Smith & Son, in which it is stated that the magistrate was able to take as evidence the reading of their indicators in a case, brought before him by the police, of a motor car exceeding the speed limit. The catalogue also contains illustrations and details of several fittings suitable for motor car work, including accumulators and magnetos for ignition purposes. Such tools as spanners and pliers, which, unfortunately, only too often have to be employed, are included.

Oppermann's Dynamos.—From Messrs. Oppermann, of 11, Lever-st., Goswell-road, E.C., we have received a picture postcard illustrating their electrotyping dynamo, and giving four excellent reasons why these dynamos should be used. We commend these to the attention of our readers.

BANKRUPTCIES, LIQUIDATIONS, &c.

Mr. Jas. V. Haley, 29, Tyrrel-street, Bradford, and Mr. R. A. Vinter, 65, King's-arcade, Bradford, are joint trustees in the bankruptcy of Arnold Roberts (trading as Roberts Bros.), electrical engineer, 21, North-parade, Bradford.

An application for the discharge of Wm. T. Garnett (trading as W. T. Garnett's Cable Co.), Barkerend Mills, Bradford, will be heard on May 18 at the County Court, Bradford.

A meeting will be held at 7, Hertford-street, London, W., on May 18, to receive an account of the winding up of the Electromobile Hiring Co. (Ltd.)

A meeting to receive an account of the winding up of the Monobloc Accumulator Synd. (in liq.) will be held on May 26 at Messrs. Drake & Gorham's, 66, Victoria-street, London, S.W.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

December 19, 1908.

27,684 Leitner. Contact voltmeters.
27,685 Leitner. Reversing the connections of dynamo electric machines.

December 21, 1908.

27,694 Blackburn. Brakes for tramcars.
27,746 Simpson. Wireless telegraphy.
27,748 Fairweather. (Elmer Ellsworth Granger, U.S.) Electric railway conduit and equipment.

December 22, 1908.

27,832 Holdsworth. Trolley arms.
27,833 Veritys & Pipkin. Slow speed operating gear for electric motor starters.
27,834 Veritys & Pipkin. Operating handle mechanism for slow-speed gear of electric motor starter.
27,836 Wood & Wood. Vapour electric lamps.
27,858 and 27,859 Tanner & Claremont. Distribution of electric energy.
27,860 Cross & Merchants' Trading Co. Metal filament lamps.
27,862 Bingham. Telegraphic recording apparatus.
27,867 Muirhead. Electric telegraphy.
27,882 Montgomery, Young, Hellyer & Baker. Storage batteries.*
27,899 Lewis. Arc lamp electrodes.
27,906 Justice. Electric railway switch mechanism.*

December 23, 1908.

27,923 Cummings & Noreau. Locomotive electric alarm systems.*
27,932 W. J. F. Washington, H. Washington & Scott. Coin-controlled and coin-indicating mechanism.
27,951 Köppen. Cable telegraphy.*
27,960 Siemens Bros. Dynamo Works, Hird & Grimston. Searchlights or projectors.
27,965 Ross. Electric heaters.
27,967 Jacoby. Governing the speed of alternating-current commutator machines. (Addition to 20,495/07.)
27,986 Mair. Transmission gear of the magnetic type.
27,991 Highfield. Lamp supports and casings.
27,999 Thompson. (Ernst Eisemann & Co., G.m.b.H., Germany.) Magneto-electric sparking apparatus.*
28,014 Uslianer. Trolley car switch controller.
28,017 Soule. Electric motor control. (Date applied for, 10/1/08.)*†
28,019 Ferranti. Electrical machinery.

December 24, 1908.

28,040 Ferguson. Dynamo-electric machines.
28,050 Phillips. Trolley heads.
28,075 Bilard. Arrangement for plates and electrodes for batteries and accumulators.
28,092 Veritys & Pipkin. Regulating electric switch.
28,102 Westcott & Gartside. Coupling for electric cables, wires and rods.*
28,120 Grob. Electric lighting and heating of vehicles. (Date applied for, 2/1/08.)*†
28,130 Steckel. Induction clutches.*

28,147 Gibbs. Electrolytic cells. (Date applied for, 17/12/07. Comprised in 27,830/17/12/07.)*
28,156 Davidson. Dynamo-electric machines.
28,177 Marsh. Holders or sockets for incandescent electric lamps.
28,186 Merz & Price. Alternating-current distributing systems.
28,188 B.T.-H. Co. (G.E. Co., U.S.) Controllers for electric motors.
28,189 Alexanderson. Single-phase alternating-current electric motors of the commutator type. (Date applied for, 26/12/07.)*†
28,190 Tirrill. Electric voltage regulators. (Date applied for, 28/4/08.)

December 28, 1908.

28,192 Allgemeine Elektricitats-Ges. Starting devices for electric motors. (Date applied for, 28/12/07.)*†
28,226 Veritys & Pipkin. Regulating electric switches.*
28,267 Conti. Telephone receivers.
28,271 H. Aron Elektricitats-Zahlerfabrik G.m.b.H. Single-phase alternating electric current meters. (Date applied for 9/10/08.)*†
28,276 Voelker. Electric furnaces.*
28,285 Boult. (Tom McNaughton, U.S.) Electric batteries.*
28,286 Boult. (Henry O. Jackson and Tom McNaughton, U.S.) Self-winding clocks.*
28,287 Boult. (Henry O. Jackson and Tom McNaughton, U.S.) Electric secondary clocks.*
28,300 Grob. Pole-pieces or pole-shoes for electric machines with compensation windings. (Date applied for, 2/1/08.)*†

December 29, 1908.

28,319 Bohle. (Hermann Bohle, Cape Colony.) Dynamo-electric machine for continuous currents.
28,324 Electromotors (Ltd.) & Greenhalgh. Dynamo-electric machines.
28,351 Baerlocher. Controllers for electric motors.
28,366 and 28,367 Orling. Detecting and recording the passage of electric impulses.
28,378 Eisenstein. Wireless telegraphy.*

December 30, 1908.

28,397 Mansfield. Boxes for junctions, testing, inspecting, or fuse purposes.
28,435 Laigle. Electric filaments. (Date applied for, 10/1/08.)*†
28,438 Johannet. Obtaining variation and reduction of speed electro-dynamically. (Date applied for, 3/2/08.)*†
28,442 Bosch. Insulation of the layers of windings of electromagnetic apparatus. (Date applied for, 12/12/08.)*†

December 31, 1908.

28,467 Brierley. Method of supporting and adjusting overhead electric current wires.
28,474 Poole. Electric current or voltage regulators.*
28,487 Miller & Adshead. Brush-holder attachment or brush yoke.
28,522 Smith & Phillips. Voltmeters, ammeters, wattmeters, and like electrical indicating and recording instruments.
28,545 Akt.-Ges. Brown, Boveri et Cie. Insulation of electric conductors. (Date applied for, 3/7/08.)*†
28,548 Bosch. Magneto - ignition apparatus. (Date applied for, 25/9/08.)*†
28,554 Shaffer. Manufacturing flat incandescent filaments for metallic filament lamps. (Date applied for, 2/1/08.)*†
28,561 Thorpe. Electrolytic devices.*

SPECIFICATIONS PUBLISHED.

1907 Specifications.

14,285 Cowper-Coles. Electric hydrogen and oxygen generators. (Post-dated, 20/12/07.)
27,453 Ort, Rieger & Ort. Telephone instruments.
27,463 Alexander, McCleland & Lange. Unstable chemically or electrolitically produced solutions.
27,582 Hope. Combined electric switch and fuse holder.
27,735 Boult. (Radiogen Ges.) Radio-active preparations and apparatus.
28,014 and 28,015 Rapid Magnetting Machine Co., Thompson & Davies. Magnetic separating machines.
28,080 Moseley. Electric measuring instruments.
28,081 Moseley. Telephone transmitters.
28,138 Allgemeine Elektricitats Ges. Electric incandescent lamps. (Date applied for, 27/12/06.)
28,664 Hornblower. Electro-galvanising apparatus of the revolving cylinder type.
28,736 Cardwell. Telegraph typewriter.

1908 Specifications.

197 Kingsbury. (Western Electric Co.) Switching apparatus for interconnecting the lines of a telephone exchange system.
345 Boult. (Woodbridge.) Electrical distribution.
1,981 Maley & Cockshott. Brakes for tramcars.
2,085 Johnson. Electrically-operated railway switch points and signals.
2,769 Hookham & Holden. Prepayment electricity meters.
3,026 Crompton & Co., Macfarlane & Burge. Rotary electric transformers and motor-generators.
3,985 B.T.-H. Co. & Hopps. Electric ignition devices for internal combustion engines.
4,956 Planchon. Incandescent bodies for electric lamps.
5,172 Chadburn's (Ship) Telegraph Co. & Grant. Ships' telltale telegraphic apparatus.
7,730 B.T.-H. Co. (G.E. Co., U.S.) Telephone relays.
7,853 Morgan. Connectors for electric conductors.
8,962 Bray & Bray, Markham & Reiss (Ltd.) Insulated electric conductors, contacts, and the like.

COMPANIES' MEETINGS AND REPORTS.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)—At the recent meeting the chairman (Mr. F. E. Gripper) said the lamp connections were still increasing, nearly 6,300 lamps having been added during the past year, and the revenue from electricity supplied had also increased by £520. There were somewhat about 3,000 metallic filament lamps installed in Bromley. A new sub-station had been erected at Elmstead. The profit was £9,360. 3s. 6d., compared with £8,933. 10s. 11d. in 1907, and they proposed to pay the same dividend as last year.

CALCUTTA TRAMWAYS CO. (LTD.).—Mr. E. C. Morgan stated at the meeting on Tuesday that of the three lines now running, the first was opened on June 10, the second on July 30, and the third on Oct. 20. The outlay for permanent way, &c., was mainly for the completion of the track construction and equipment of the Alipore, Behala and Gailiff street lines, the extension of the Kidderpore carshed, the Kalighat loop, and the laying down of new cables. The item for power and sub-station plant, buildings, &c., represented the completed installation of the new a.c. plant, consisting of Belliss engine, a.c. and combined a.c. and d.c. generators, with two additional boilers, new condensing plant and reservoir, also the extension of the Belgatchia and Kidderpore car-sheds, the construction of new offices and quarters at Tollyunge, and tiling the power-house. The projected capital expenditure would amount to about £10,000. All their cars were now built under their own supervision in Calcutta. It had been found necessary to effect considerable repairs to 70 motor and 10 trailer cars, and there still remained 90 cars to be dealt with. The general state of affairs in India had decidedly improved.

CITY (OF BRISBANE) ELECTRIC LIGHT CO. (LTD.)—At the recent meeting it was reported that during the half-year ended Jan. 31 the output was 976,789 units, against 853,920 for the corresponding period of 1906-7; the revenue from sale of current showed an increase of 12½ per cent., and, after making provision for renewals, franchise purchase, sinking fund, &c., there was £4,946. 8s. 1d. to be disposed of. The directors recommended payment of a dividend of 6 per cent per annum, and a bonus of 2½ per cent. per annum on the ordinary shares, leaving £1,935. 6s. 9d. to be carried forward. During the half-year further additions were made to the plant in Ann-street station, good progress has been made with the laying of mains, and electricity is now being supplied to the principal streets of the Valley area.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—The net profit for the year ended March 31 was £6,344. 7s. 11d , which, with £682. 18s. 3d. brought forward, makes £7,027, 6s. 2d. After writing off £1,000 as depreciation of buildings and machinery, the directors recommend payment of the preference dividend, and a dividend on the ordinary shares at the rate of 6 per cent. £500 has been placed to reserve. There has been a considerable increase in the volume of business in the cable department.

DEUTSCH-ATLANTISCHE TELEGRAPHENGESELLSCHAFT, COLOGNE.—The directors' report for the year 1908 (to be presented to the general meeting on May 1) states that the Vigo cable traffic shows a slight reduction. Damage to the Atlantic and Vigo cables by trawlers and otherwise has caused heavy expenditure, and a hope is expressed that an International Conference will be held on this subject. In consequence of the laying of the new cable to South America the Norddeutsche Seekabelwerke (of which this company holds half the shares) has been fully occupied during the second half of the year, and it will apparently be fully engaged until the middle of 1910. Total receipts (including £21,204 brought forward) were £228,670 and net profit £128,923 (against £131,010 in 1907). It is proposed to place to reserve £5,380, special reserve and cable repairs fund £10,000, pension and benevolent fund £2,500, directors and officials' fees £4,767, dividend of 7 per cent. (as in the previous year) £84,000, and to carry forward £22,271.

LONDON GENERAL OMNIBUS CO. (LTD.)—At an extraordinary meeting last week the chairman (Mr. H. Hicks) said that the directors had had prepared approximate figures of the amalgamated company for the half-year to Dec. 31 last. The figures had not been audited, but he could give the shareholders the opinion which those figures had led the directors to form as to the position and outlook. The total loss of the three companies for the corresponding half-year in 1907 was about £150,000, but, according to the figures for the past half year, the loss of the combined companies was certainly not more than £5,000 or £6,000. He would be disappointed if, when the next annual accounts were presented, they were not able to issue a balance-sheet showing no loss. Referring to the new police regulations, he said that with regard to the new vehicles not weighing more than 3½ tons, the company were both able and willing to comply with the order in regard to any new 'buses they might build or get built, provided, however, the police authorities allowed the company, as they fairly ought, to keep their present overweight 'buses until they were worn out. They happened to have ordered 16 new motor 'buses some two years ago which were only delivered last autumn and had never

been on the road because they did not require them in the winter time. Those 'buses were ready to go on the road, but the Chief Commissioner seemed disinclined, as he had issued the order, to licence those 'buses.

MELBOURNE ELECTRIC SUPPLY CO. (LTD.)—The gross profit during 1908 on the Melbourne and Geelong undertakings was £17,677. 5s. Adding the dividend received from the Adelaide Electric Supply Co., &c., the total amounted to £22,030. 3s. 9d., compared with £19,741. 4s. for the previous year. After paying management and general expenses at London (£1,983. 8s. 5d.) and interest (£14,758. 10s. 6d.) the balance is £5,288. 4s. 10d., added to £1,593. 15s. 3d. forward, making £6,882. 0s. 1d. £4,000 is put to reserve, leaving £1,771. 15s. 9d. to be carried forward. At August 31, 1908, the total connections at Melbourne were equivalent to 157,412 8 c.p. lamps (90,088 for lighting and 2,150 H.P. in motors), and the total units sold were 2,326,307: at Geelong the equivalent of 51,864 8 c.p. is connected (26,942 for lighting and 818 H.P. in motors), the units sold being 312,661. Arrangements have been made for an issue of a further £100,000 first mortgage debenture stock and of £100,000 first preference shares.

MERTHYR ELECTRIC TRACTION & LIGHTING CO. (LTD.)—The gross receipts for the past year from the traction department were £11,190, and from the electrical supply department £6,466. Deducting all revenue expenses chargeable and placing £1,000 to renewals account, there remains (with £533 forward) £4,740. The equivalent of 22,350 8 c.p. lamps (18,405 for lighting and 3,945 for power) is connected to the mains. A dividend of 5 per cent. is declared on the ordinary shares.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—Including £1,873. 6s. 5d. forward from 1907, deducting interim dividends and making provision for redemption of debenture stock and other charges, the amount remaining to be dealt with for the year to Dec. 31, 1908, is £18,728. 17s. The directors recommend payment of the final preference dividend (less tax) (£1,500) and a further 5 per cent. (tax free) on the ordinary shares £8,965. 13s. (making 8 per cent. for the year), the transfer to reserve of £2,500 and of £500 to contemplated pension scheme, leaving £5,263. 4s. to carry forward. The Indian local companies have declared the same dividends as for 1907 (the Bengal Co. 5 per cent. and the Bombay Co. 6 per cent.), and both these companies report increased accession of subscribers. The Telephone Co. of Egypt has declared a dividend of 10 per cent. for the year on both preferred and deferred shares. The China & Japan Telephone & Electric Co. continues to make satisfactory progress both at Hongkong and Kowloon, and the company declared a dividend of 5 per cent. for 1907.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—The gross profit for 1908 is £31,343. 5s. 6d., and deducting therefrom expenses of administration, debenture interest, &c., there remains £18,979. 7s. 5d. Adding £9,048. 15s. 6d. from 1907, the available total is £28,028. 2s. 11d. The directors recommend that £13,000 be placed to reserve, £3,429. 17s. 5d. to reserve against capital charges on town lighting installations and £1,550 transferred to debenture redemption fund. The depreciation on free wired installations (£200. 6s. 3d.) and furniture, fixtures, plant and tools (£186. 8s. 4d.) absorbs £386. 14s. 7d., leaving £9,661. 10s. 11d. to be carried forward. In view of the fact that the past year has again been one of great depression in the electrical industry, and that finance of tramway schemes in this country has been practically impossible, the directors recommend that the balance of £9,661. 10s. 11d. be carried forward. The first section of the Rhondda tramways was opened on July 11, and on Nov. 11 the last section was opened. The profit earned from the working of the tramways to Dec. 31 was £9,438. 10s. 10d., out of which a dividend of 3 per cent. was paid to the shareholders of the syndicate, in which this company has an interest of over £50,000. The receipts this year are well maintained. In regard to the Mexborough and Swinton tramways, the surface-contact system having proved a failure, the overhead system was installed in its place, and was working by Aug. 29, with the result that there has since been an increase in the receipts and a decrease in the expenses. The directors believe that this will be a dividend-paying undertaking by the end of the current year. The finance for the extension of the Musselburgh and District tramways to Port Seton has now been arranged, and the work is in hand and should be completed early in August. This extension will increase the total length of the tramways from 3 to about 7 miles. The heavy expense in maintaining the surface-contact system at Torquay is hampering the progress of the undertaking. Agreements with Torquay Corporation and Paignton Council have, however, been arrived at for the extension of the tramway to Paignton on the overhead system. Satisfactory terms have now been arranged with Oxford Corporation whereby a small portion only of the tramways will be constructed on the conduit system and the rest on the overhead system. The City of Oxford Electric Tramways Bill before Parliament embodying these terms will be supported by the Corporation. An application has been made for parliamentary powers to instal the overhead system on a portion of the Folkestone, Sandgate and Hythe tramways. The progress of the Bo'ness electricity undertaking during last year has been most marked. Applications are in hand for 22,139 8 c.p. lamps, of which 19,664 are connected, compared with 12,798 lamps connected last year. The Carnarvon undertaking is also making satisfactory progress, applications for 11,139 8 c.p. lamps having been received, of which 10,509 lamps are connected, compared with 8,549 lamps connected last year.

PEARSON FIRE ALARM (LTD.)—The directors' report states that the gross profit is £889 in excess of last year's figure, and the debit balance is £39, against a debit balance of £527 last year. The directors propose to continue to charge an increased proportion of the annual expenditure to profit and loss account, with a view to closing the development account. The gross increase on the rental account for 1908 amounted to £722.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

POLESWORTH ELECTRICAL APPLIANCES CO. (LTD.) (102,510).—Reg. April 14, capital £5,000 in £1 shares, to take over the business of C. W. Shackleton, at Polesworth, Warwick (carried on as the Electrical Appliances Co.), together with his secret process for making glaze and enamel, &c. Private company. First directors, C. W. Shackleton and T. F. Aikin. Reg. office, The Mill, Market-street, Polesworth, Warwick.

SALSBURY LAMPS (LTD.) (102,539.)—Reg. April 16, capital £10,000 in £1 shares, to acquire the business of Salsbury & Son (Ltd.) and to carry on the business of manufacturers of and dealers in lamps, motor cars and accessories, &c. First directors, H. Salsbury, H. Wyman and A. H. F. Fitzherbert. Reg. office, 124, Long-acre, London, W.C.

STATUTORY RETURN.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—Return to Feb. 19 gives capital as £7,000,000 in £557,460 consolidated ordinary stock, £3,221,270 preferred ordinary stock and £3,221,270 deferred ordinary stock. All taken up and paid for in full. No mortgages or charges.

MORTGAGES AND CHARGES.

KILOWATT PUBLISHING CO. (LTD.)—Particulars of £2,500 debentures, created Feb. 4. 1909, filed pursuant to sec. 93 (3) of the Companies (Consolidation) Act, 1908, the amount of the first issue (on April 1) being £1,450. Property charged, company's undertaking and property, present and future, except uncalled capital. No trustees.

ROBINSON & HANDS ELECTRICAL CO. (LTD.)—Mortgage debenture dated March 27 to secure £400, charged on the company's undertaking and property. Holder, W. H. Lovatt.

W. SITCH & CO. (LTD.)—Particulars of £1,000 debentures created March 25 filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (April 22).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{7}{8}$d. per oz. Consols 85—$85\frac{1}{4}$ for money and account. Consols Pay Day, May 5; Stock and Shares Continuation Days, April 27 and May 11; Ticket Days, April 28 and May 12; Pay Days, April 29 and May 13; Mining Shares Carry Over Day, April 26.

PRICES OF METALS (London).—*Copper*, cash, $57\frac{1}{8}$; three months $58\frac{7}{8}$. *Lead*, English, $13\frac{3}{8}$—$13\frac{3}{4}$; foreign, cash, $13\frac{1}{8}$—$13\frac{3}{16}$; two months, $13\frac{7}{16}$. *Spelter*, cash, $21\frac{5}{8}$; two months, $21\frac{7}{8}$. *Tin*, English, 134—136; foreign, cash, $134\frac{1}{4}$—$134\frac{1}{2}$, three months, 135—$135\frac{3}{8}$. *Iron*, Cleveland, cash, 47/$4\frac{1}{2}$, and three months, 48/-. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BRITISH COLUMBIA ELECTRIC RAILWAY CO. (LTD.)—The directors have declared an interim dividend at the rate of 8 per cent. on the deferred ordinary stock for the half-year ended Dec. 31.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the four weeks ended March 26 were 526,496, compared with 407,925 units in the corresponding four weeks of 1908.

CASCADE (1906) POWER CO. (LTD.)—The balance profit for the past year is £213, and, adding the balance brought forward, the available amount is £1,494, which the directors recommend should be carried forward.

CITY OF SANTOS IMPROVEMENTS CO. (LTD.)—The profits for the past year were £46,541, and the directors propose a final dividend of $4\frac{1}{2}$ per cent. on the ordinary shares, making 7 per cent. for the year, leaving £4,196 to be carried forward.

COMPANIA TELEGRAFICA TELEFONICA DEL PLATA.—At a recent meeting it was reported that the profit was $110,965, and a final dividend of 6 per cent. (making 12 per cent. for 1908) was declared.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The transfer books and register of holders of the second debenture stock are closed from 17th to 30th inst. inclusive, preparatory to payment of interest due May 1.

MONTE VIDEO TELEPHONE CO. (LTD.)—An interim dividend for the half-year ended Jan. 31, at the rate of 6 per cent., has been declared on the ordinary shares.

PRIMITIVA GAS & ELECTRIC LIGHTING CO. OF BUENOS AYRES (LTD.) The directors recommend a final dividend of 4s. 6d. per share (tax free) on the ordinary shares, making 7 per cent. for the year

RIO DE JANEIRO CITY IMPROVEMENTS CO.—The directors' report for 1908 states that the outlay on generating station, plant, &c., during the year was £40,994

TRAMWAYS & GENERAL WORKS CO. (LTD.)—The directors have declared a dividend of 1s. per share.

UNITED ALKALI CO. (LTD.)—At the recent meeting Mr. John Brook stated that the one outstanding feature of the year was the serious shrinkage of their trade, not only in this country, but all over the world. Their profits showed a decrease of £116,664, compared with 907, and they had also to pay £62,000 more for raw materials.

WOLVERHAMPTON DISTRICT ELECTRIC TRAMWAYS (LTD.)—A dividend of 1s. per share has been declared.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	April 11	1,368	+ 154	46	62,119	− 90
*Airdrie	,, 9	203	− 7	14	2,975	− 73
Anglo-Argentine	,, 15	39,764	+ 1,324	15	505,647	+ 36,511
‡Ayr Corporation	,, 17	237	+ 40	48	13,461	− 282
Baker St. & Waterloo Ry.	,, 17	3,210	+ 520	15	50,730	+ 4,995
Barnsley	,, 9	186	+ 9	14	2,260	− 34
Barrow	,, 9	264	+ 45	14	2,817	− 180
Bath Electric Trams, Ltd.	,, 14	1,054	+ 410	15	9,703	+ 601
Birkenhead Corporation	...	...	...	...	...	...
Birmingham Corporation	,, 17	7,003	+ 910	3	16,871	+ 491
Birmingham & Mid.	,, 2	800	− 9	13	10,119	− 46
Blackburn Corporation	,, 14	2,037	+ 1,033	3	3,891	+ 954
Blackpool and Fleetwood	,, 17	813	+ 228	15	4,816	+ 716
Bolton Corporation	,, 18	2,197	− 713	3	6,898	− 5
Bombay	Mar. 18	R10,099	+ R5,509	11	R422,820	+ R32,125
Bournemouth Corporation	April 11	2,501	+ 1,018	2	3,932	+ 719
Bradford Corporation	,, 17	5,710	+ 1,096	3	12,896	+ 1,295
Brighton Corporation	,, 18	1,011	+ 101	3	2,575	+ 404
Bristol Trams & Carriage	,, 16	6,531	+ 1,756	21	103,283	+ 10,307
Burnley Corporation	,, 17	1,184	− 458	3	4,158	+ 235
Burton Corporation	,, 18	231	+ 13	3	709	+ 7
Bury Corporation	,, 18	1,125	− 413	†3	3,414	− 25
Calcutta Tramways Co.	,, 17	R44,923	+ R784	15	R757,666	+ R27,936
Camborne-Redruth	,, 17	148	+ 22	16	1,797	− 102
Cardiff Corporation	...	...	...	...	...	...
Cavehill	,, 9	65	− 9	14	765	− 53
Central London Railway	,, 17	4,729	− 265	15	83,432	− 7,720
Charing C., Euston & H'stead	,, 17	4,070	+ 880	15	57,515	+ 10,315
Chatham & Dist. Lt. Rys.	,, 15	1,188	+ 528	15	10,765	+ 1,500
City & South London Rly.	,, 18	3,125	+ 269	15	50,050	+ 682
City of Birmingham	,, 9	2,505	+ 159	14	36,832	− 720
Colchester Corporation	,, 11	235	+ 75	2	375	+ 52
Cork Electric Trams Co.	,, 15	523	+ 84	15	6,262	+ 274
Croydon Corporation	,, 16	1,774	+ 337	12	3,732	+ 492
Devonport & Dist. Trams	,, 9	413	− 34	14	5,131	− 663
Dover Corporation	,, 17	220	+ 18	3	529	+ 47
Dublin & Lucan Railway	,, 16	173	+ 45	15	1,682	+ 177
Dublin United	,, 16	5,807	+ 1,005	15	73,104	+ 774
Dudley-Stourbridge	,, 9	781	+ 32	14	9,878	− 241
Dundee Corporation	,, 14	1,263	+ 179	‡48	56,661	+ 2,148
East Ham Council	,, 17	1,072	+ 176	§2	2,552	+ 64
Exeter Corporation	,, 16	416	+ 115	3	810	+ 160
Gateshead & Dist. Trams	,, 9	1,045	+ 73	14	13,673	− 101
Glasgow Corporation	,, 17	17,610	+ 105	46	778,116	− 16,907
Glossop Trams	...	...	...	...	...	...
Gravesend—Northfleet	,, 9	205	+ 15	14	2,446	− 158
Great Northern & City Rly.	,, 17	1,415	− 119	15	23,394	− 2,905
Gt. Northern, Piccadilly, &c.	,, 17	5,375	+ 285	15	87,155	+ 6,280
Greenock & Port Glasgow	,, 9	563	+ 59	14	6,250	− 214
Hartlepool Tramways	,, 9	239	+ 41	14	2,747	− 173
Hastings Elec. Trams Co.	,, 15	1,639	+ 801	15	11,664	+ 163
Hong Kong	,, 17	$7,470	− $249	15	$123,516	+ $9,347
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation	,, 17	2,624	+ 144	2	6,203	+ 72
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 14	177	+ 16	2	300	+ 10
Ipswich Corporation	,, 17	425	+ 38	3	1,003	+ 167
Isle of Thanet Co.	,, 17	638	+ 215	§18	8,131	+ 406
Jarrow	,, 9	132	+ 33	14	1,447	+ 120
Keighley Corporation	,, 15	226	+ 79	2	391	+ 80
Kidderminster & District	,, 9	91	+ 8	14	1,109	− 59
Kilmarnock Corporation	,, 17	148	+ 3	48	7,139	− 318
Lanarkshire Trams Co.	,, 15	1,313	+ 64	15	17,726	− 1,037
Lancashire United	,, 14	2,286	+ 1,126	15	18,499	+ 1,192
Leamington	,, 9	163	− 11	14	1,974	+ 147
Leeds Corporation	,, 17	7,272	+ 738	3	17,269	+ 2,206
Leicester Corporation	,, 17	2,502	+ 378	...	...	...
Leith Corporation	,, 17	509	+ 22	‖18	24,885	+ 33
Lincoln Corporation	,, 17	124	...	3	363	+ 37
Liverpool Corporation	,, 10	11,100	+ 581	‖14	147,384	− 648
Liverpool Overhead Rly.	,, 18	1,423	+ 99	16	20,666	− 1,350
*London County Council	,, 10	35,328	+ 4,107	§1	51,182	+ 5,650
London United	,, 17	6,792	+ 302	‖18	78,350	− 3,032
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 17	193	− 2	2	465	− 4
Manchester Corporation	,, 17	14,989	− 532	3	38,544	+ 2,968
Mersey Railway	,, 17	2,015	+ 116	15	29,338	+ 740
Merthyr	,, 9	238	+ 23	11	2,758	+ 29
Metropolitan Dist. Railway	,, 17	9,266	+ 1,209	15	145,413	+ 12,092
Metropolitan Elec. Trams	,, 9	7,055	+ 2,039	14	74,462	+ 8,026
Middleton	,, 9	438	+ 119	14	4,107	− 116
Nelson Corporation	...	...	...	...	...	...
Newcastle-on-Tyne Corp.	,, 17	4,499	+ 582	3	10,324	+ 335
Newport (Mon.)	,, 17	705	+ 64	3	2,051	+ 175
Northampton Corporation	,, 16	694	+ 199	§3	1,147	+ 203
Oldham, Ashton & Hyde	,, 9	706	+ 145	14	7,376	− 426
Oldham Corporation	,, 18	2,026	− 169	3	7,213	− 190
Perth (N.B.) Corporation	,, 11	169	+ 38	48	7,300	− 95
Perth (W.A.) Elec. Trams	,, 16	1,584	+ 139	15	22,462	+ 235
Peterborough	,, 2	114	+ 35	14	1,355	− 90
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 9	1,841	+ 67	14	24,148	− 1,056
Preston Corporation	,, 14	889	+ 237	2	1,562	+ 223
Rotherham Corporation	,, 15	766	+ 181	2	1,414	+ 126
Rothesay	,, 9	104	+ 31	14	677	+ 1
Salford Corporation	,, 17	4,410	− 928	‡3	13,071	+ 851
Sheerness	,, 9	43	− 2	14	591	− 80
Sheffield Corporation	,, 18	5,844	+ 340	§3	19,375	− 63
Singapore Trams	,, 17	$9,140	− $48	15	$145,211	+ $3,193
South Metropolitan	,, 9	930	+ 253	14	9,200	+ 129
South Staffs	,, 9	853	+ 5	14	11,029	− 823
Southend Corporation	,, 14	669	+ 383	2	1,003	+ 385
Southport Tramways	,, 9	289	+ 49	14	3,054	+ 120
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 17	770	− 293	§2	2,295	+ 124
Sunderland Corporation	,, 18	1,197	− 17	3	3,017	− 90
Sunderland District	,, 14	690	+ 203	21	10,600	− 87
Swansea Trams	,, 9	952	+ 2	14	12,031	+ 295
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 9	35	− 3	14	462	− 53
Tynemouth and District	,, 9	206	+ 62	14	1,852	− 90
Tyneside Trams Co.	,, 14	831	+ 496	15	6,003	+ 762
Wallasey District Council	,, 17	1,320	+ 172	§2	2,390	+ 287
Walsall Corpn.	,, 17	625	+ 95	15	7,536	− 495
Warrington Corpn.	,, 8	371	+ 2	1	371	+ 2
West Ham Corporation	,, 8	2,233	+ 183	1	2,233	+ 183
Weston-super-Mare	,, 9	67	+ 33	14	382	+ 28
Wolverhampton Co.	,, 9	402	− 22	14	5,361	− 643
Wolverhampton Corpn.	,, 14	1,032	+ 290	15	11,011	− 408
*Worcester	,, 2	293	+ 37	14	3,223	− 25
Wrexham	,, 9	121	+ 5	14	1,242	− 14
Yorkshire W.R. Trams	,, 18	1,487	+ 257	16	17,754	
Yorkshire Woollen District	,, 9	890	+ 22	14	11,578	− 369

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. ‡ Minus 3 days. † Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share.	Last Dividend	Name.	Price Wed. April 21.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to April 21. Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7 0	Bournemouth & Poole Elec. Sup. Ord.	9⅝ −10⅛	5 19 0	Mar, Sept,	9⅞	9[illegible]
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝ −10⅛	4 9 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼ −10¾	5 11 6	Feb. Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 −105	4 5 6	Jan, July	..	..
5	3/6	†Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	95 −98	4 12 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½ −9	5 11 0	March....	8[illegible]	[illegible]
5	3/6	Do. 7 per Cent. Pref.	8 −8½	4 2 6	Mar, Sept	.	..
St.	4%	Cent l Elec. Sup. Co. 4% Guar. Db. Stock	99 −102	3 18 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾ −4¼	5 19 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼ −4¾	4 15 0	Feb, Aug	4[illegible]	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 −98	4 4 0	Jan, July	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red)	95 −100	4 10 0	..	99½	99
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ −4¼	5 8 6	Jan, July	4	..
5	2/6	Chelsea Electric Supply Ord.	3½ −4	5 12 6	March ..	3[illegible]	3¾
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 −105	4 7 6	June, Dec	..	.
10	7/0	City of London Electric Lighting Ord.	10[illegible] −1[illegible]	5 19 3	Feb, Aug	10[illegible]	10½
10	6/0	Do. 6 per Cent. Cum. Pref.	11[illegible] −1[illegible]	4 13 0	Jan, July	11¾	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 −104	4 6 6	Jan, July	102	..
5	2%	County of Durham Elec. P.D. Ord.	1 −2	6 13 4	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3½ −3¾	6 17 19	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅝ −8⅞	5 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾ −11¼	5 6 6	Mar, Sept	10[illegible]	10¾
St.	4½%	Do. 4½% Deb. Stock (red.)	106 −109	4 2 6	Jan, July	108¾	..
St.	4½%	Do. Second Deb. Stock	101 −104	4 6 6	May, Nov	102½	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ −5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 −5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	96 −99	4 11 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7⅛ −7⅝	5 11 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7¼ −7¾	5 16 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ −6⅜	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93 −96	4 3 6	..	—	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 −100	4 0 0	April, Oct	..	—
St.	4½%	Kent Elec. Power Co.	85 −89	5 1 0	Jan, July	..	—
8	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 8 8	Mar, Sept	..	—
5	3/0	Do. 6 per Cent. Pref.	5 −5½	5 11 6	Mar, Sept	5[illegible]	5[illegible]
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92 −96	4 3 6	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅝ −5⅛	5 17 6	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼ −5¼	4 6 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	103 −109	4 2 6	June, Dec	—	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85 −88	3 19 6	Jan, July	..	—
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 −98	4 12 0	June, Dec	96	..
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	5 −5½	3 13 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	88 −90	5 0 7	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	3⅞ −4⅛	10 0 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 −5⅝	4 13 9	Feb, Aug	—	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	91 −96	4 4 3	Jan, July	—	—
100	50/	†North Metro. Elec. Power Sup. 5 Morts	98 −100	..	..	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91 −93	4 17 10	Jan, July	—	..
10	8/0	Notting Hill Electric Ord.	11 −12	5 16 6	March ..	—	..
5	4/6	Oxford Electric Ord.	6 −6½	5 8 0	March ..	6¼	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 −97	4 2 6	Jan, July	..	—
5	5/0	St. James' & Pall Mall Elec. Ord.	9 −9½	5 5 6	Feb, Aug	9¼	..
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	83 −90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	⅛ −⅞	..	Feb	—	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 −70	5 14 0	Feb, Aug	..	..
5	4/0	South London Electric Supply Ord.	2⅝ −3	6 13 0	April	2[illegible]	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	¼ −½	5 0 0	..	..	—
1	0/8⅗	Do. 7 per Cent. Cum. Pref.	1[illegible] −1[illegible]	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −103	4 7 6	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	⅝ −1	—	April, Oct	..	—
5	2/6	Do. 5 per Cent. Cum. Pref.	1¾ −2¼	11 16 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 −82	5 8 0	April, Oct	82	..
5	5/0	Westminster Elec. Sup. Ord.	9⅜ −9⅞	5 1 0	Mar, Sept	9¾	9[illegible]
5	2/3	Do. 4½ per Cent. Cum. Pref.	5¼ −5⅝	4 0 0	Jan, July	5[illegible]	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	95 −98	4 2 0	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.	⅛ −¼	..	April	..	-
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ −¾	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88 −92	4 18 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 −92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	9½ −9¾	6 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ −9	4 9 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99 −100	4 1 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	½ −¾	..	June, Dec	[illegible]	[illegible]
10	3/0	Do. 6 per Cent. Cum. Pref.	2½ −3	10 0 0	Feb, Aug	2[illegible]	2¼
St.	5%	Do. 5 per Cent. Perpetual Debs.	81 −83	5 14 0	April, Oct	83½	85⅝
St.	4½%	† Do. 4½ per Cent. 2nd Deb. Stock	63 −71	6 6 6	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	65 −67	5 3 0	Feb, Aug	—	..
St.	4%	Do. 4 per Cent. Pref. Stock	83 −85	4 14 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	49 −51	4 18 0	Feb	50⅞	50⅜
100	4%	Do. 4 per Cent. Debs.	102 −104	3 16 6	Jan, July	103¼	102½
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 −94	4 5 0	Jan, July	93½	93½
5	2/6	†City of Birmingham Trams. 5% Cm. Pref.	4⅛ −4⅝	5 8 0	April, Oct	..	—
100	4%	† Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	30½ −31½	4 15 0	Feb, Aug	31[illegible]	31
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 −112	4 9 0	Feb, Aug	—	—
St.	5%	Do. (1896)	103 −109	4 11 0	Feb, Aug	—	..
St.	5%	Do. (1901)	102 −105	4 15 0	Feb, Aug	..	—
St.	5%	Do. (1903)	99 −99	5 4 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 −102	3 18 0	May, Nov	..	—
10	6/0	Dublin United Trams. Ord	11⅓ −12⅓	4 16 [illegible]	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	12½ −13⅓	4 9 0	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¼ −½	..	Feb, Aug	..	—
10	4/0	G. Northern, Piccadilly & Brompton Ord.	..	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 −94	4 5 0	Jan, July	..	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2 −3	..	Mar, Sept	2⅜	..
St.	4½%	Do. 4½ Db. St.	79 −84	5 7 0	April, Oct	..	..
10	6%	Imperial Tramways Ord.	7 −8	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	7 −7½	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	85 −90	5 0 0	Jan, July	..	..
5	1 3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅜	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	54 −59	6 18 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9¼ −10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 −93	5 7 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1 −1[illegible]	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	4¼ −5¼	9 10 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82 −4	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	3 −4	12 10 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	70 −75	5 6 8	Jan, July	72¾	71
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	—	—
St.	..	Do. 3 per Cent. Perp. Pref.	2 −3	—	..	..	..
1	10½	†Metropolitan Elec. Tramways Ord.	[illegible] −1	—	..	[illegible]	—
1	—	Do. Deferred	[illegible]	..	April.. .	[illegible]	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	[illegible]	[illegible]
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 −97	4 13 0	Jan, July	96	..
St.	½%	Metropolitan Railway Consolidated	35½ −36½	1 7 6	Feb, Aug	36¼	3[illegible]
St.	3%	Do. Surplus Lands Stocks	69 −71	4 4 6	Feb, Aug	70	69
St.	3½%	Do. 3½ per Cent. Preference	87 −89	3 18 6	Feb, Aug	89	87⅞
St.	3½%	Do. 3½ per Cent. "A" Preference	78 −80	4 7 6	Feb, Aug	78½	..[illegible]
St.	3½%	Do. 3½ per Cent. Convertible Pref.	75 −77	4 11 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 −94	3 14 6	Jan, July	94	93½

In calculating the yield allowance has been made for accrued interest but *not* for redemption.
* E. Dividend. † The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Business Week to April 21: Highest	Lowest
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 6	Jan, July	92	91½
St.	..	Metropolitan District Railway Ord.	14¼—14½	–	Feb, Aug	14¾	14⅜
St	..	Do. Extension Pref. (5 per Cent.)	31 —34	..	Feb, Aug	32⅞	[illegible]
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	64 —67	5 3 0	Feb, Aug	..	..
St	3%	Do. 3 per Cent. Consol'td. Rent-charge	78 —80	3 15 0	Jan, July	78⅞	78
St	4%	Do. 4 per Cent. Midland Rent-charge	102 —105	3 16 0	Jan, July	104½	..
St.	[illegible]	Do. Guar. Stock 4 per Cent.	84 —87	4 12 0	Mar, Sept	86¼	85
St	6%	Do. 6 per Cent. Perp. Deb. Stock	135 —138	4 7 0	Jan, July	138	136 1/16
St	4%	Do. 4 per Cent. Ditto	89 —92	4 7 0	Jan, July	–	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—¾	–	May	..	–
1	0/9¾	Potteries Electric Traction Ord.	¼—½	8 0 0	April, Oct	..	–
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	88 —91	4 19 0	May, Nov	89½	90
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	80 —84	5 19 0	Jan, July	..	..
...		Undergd E. Rys. Lon. 6% In. bds. with coup. 3	34 —36	..	June, Dec	35	..
..	21/11	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103¼	102¾
..	4½%	Do. 4½% Bonds with coup. 2	84 —86	5 4 6	..	85¼	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	–	March ..	¾	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	–	–	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	84 —88	5 2 6	Jan, July	–	–

ELECTRIC MANUFACTURING, &c.

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Highest	Lowest
1	..	Aron Electricity Meter Ord.	9/32—13/32	..	..	⅜	..
1	0/7½	Do. 6% Cum. Pf.	[illegible]	6 12 0	April, Oct	..	..
1	1/7½	Babcock & Wilcox Ord	4 1/16—4 3/16	4 13 0	April, Oct	4 3/32	4 1/16
1	0/7½	Do. Pref.	1 1/16—1 9/16	3 15 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¾—7¼	7 0 0	July, Feb	7	..
5	3/0	Do. 6 per Cent. Pref.	6⅛—6½	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	5/16—9/16	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	94 —96	6 5 0	..	95½	95
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —43	9 4 0	Jan, July	40	39¾
St.	4½%	Brush E. Eng Co. 4½% Perp. 1st Deb. Stock	40 —50	9 0 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	29½	–
5	5/0	Callender's Cable Con. Ord.	9½—10½	6 13 6	Jan, July	9½	–
5	2/6	Do. 5 per Cent. Cum. Pref.	6¼—6¾	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106 —107	4 4 0	Nov, May	105¼	..
1	1/6	Castner-Kellner Alkali Co.	1 11/16—1 13/16	7 4 6	May, Nov	1¾	1 11/16
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —105	4 4 0	Feb. Aug	103	..
	0/7½	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	7 10 6	March ..	..	–
	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1 1/16	5 13 0	April, Oct	..	..
1	[illegible]	Consolidated Electrical Co.	6/16—7/16	8 5 0	August ...	73	..
1	1/0	†Consolidated Signal Co.	1⅛—1 5/16	7 12 0	April, Oct	1 7/32	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	[illegible]—3⅛	6 4 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	1 —1¼	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	95 —98	5 2 0	Jan, July	..	–
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	¾	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1¼	8 0 0	Sept	1 1/16	–
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 5/32—1 7/32	4 16 9	Sept ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅝—⅞	..	Feb, Aug	–	–
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	–
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	75 - 78	5 2 9	June, Dec	.	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	85½	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	–
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	59 —62	7 5 0	Jan, July	60½	..
2	..	Electric Construction Co.	¼—½	..	Jan, July	⅜	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1 —1½	9 6 9	July	1⅛	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 —64	6 6 0	Jan, July	..	..
10	6/0	General Electric (1900) 5% Cum. Pref.	7¼—7¾	6 9 0	June, Dec	7½	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	83 —87	4 10 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11½—12½	6 0 0	Feb, Aug	11⅞	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 2 0	Feb, Aug	5⅛	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 2 6	Mar, Sept	..	..
10	15/0	India Rubber, Gutta Per., &c., Wrks.	14½—15½	6 9 0	Feb, Aug	15¼	14 11/16
10	..	Do. 5 per Cent. Cum. Pref.	10 —11	..		..	..
100	4%	Do. 4 per Cent. Debs. (red.)	98 —100	4 0 0	April, Oct	–	..
1	..	National Elec. Construction Co.	⅜—⅝	..	April	–	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—⅝	..	Nov	[illegible]	..
1	7½	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	[illegible]	[illegible]
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	–	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	–	–	..	–
12	24/0	Telegraph Construction & Maintenance	32 —34	5 9 0	Mar, July	33½	33¼
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 1/16—2⅛	4 11 0	–	2 3/32	2⅛
1	1/6	Do. 5 per Cent. non-Cum. Preference	1 5/16—1⅜	4 8 0	–	1½	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	107 —110	4 11 0	–	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	104 —106	3 14 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 6	June, Dec	106	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 9	..	107⅞	107
1	6/0	J. G. White & Co. 6% Cum. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	4 0 0	Apr, Oct	¾	..
5	3/0	† Do. 6 per Cent. Cum. Pref.	2¾—3¼	9 4 0	Apr, Oct	3⅛	2 11/16
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	75 —80	5 0 0	May, Nov	80	..

TELEGRAPHS.

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Highest	Lowest
10	..	Amazon Telegraph	2¾—3¼	–	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	92 —95	5 5 0	June, Dec	..	..
St.	[illegible]	†Anglo-American	55 —58	5 13 6	F,My,Ag,N	55½	..
St.	6/0	† Do. Preferred	99½—101½	3 18 6	F,My,Ag,N	101⅛	100⅞
St.	3/0	† Do. Deferred	14⅛—14⅝	2 14 3	F,My,Ag,N	14⅜	14¼
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	85 —90	4 9 0	Jn,Ap,Jy,O	88½	87½
10	10/0	Cuba Submarine Ord.	7½—8½	7 1 0	Feb, Aug	..	..
10	10/0	† Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3 —3½	5 16 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9½	5 8 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. Deb.	100%—102%	4 8 0	April, Oct	..	..
20	14/0	Direct United States Cable	12¼—12¾	6 15 3	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	..	..	..
[illegible]	[illegible]	Eastern Telegraph Ordinary	134 —137	5 2 0	Ja,My,JyO	135½	131½
St	[illegible]	Do. [illegible] Pref. Stock	85 —87	4 0 6	Ja,My,JyO	[illegible]	85¼
[illegible]	[illegible]	Do. 4 per Cent. Mort. Deb. Stk. (red.)	101 —106	3 16 3	May, Nov	..	..
[illegible]	[illegible]	Eastern Extension	12 —12½	5 12 9	Ja,Ap,Jy,O	12⅛	12¼
[illegible]	[illegible]	Do. 4 per Cent. Deb. Stock	100 —102	3 18 0	Feb, Aug	..	..
[illegible]	[illegible]	Eastern & S. Af. [illegible] Mauritius Sub. Debs.	101 —103	3 17 0	May, Nov	101½	..
[illegible]	[illegible]	G. N. [illegible] with Coupon 75	29 —31	6 9 0	Jan, July	..	..
[illegible]	[illegible]	Halifax & Bermudas [illegible] 1st Mt. Dbs red.)	100 —102	4 8 0	June, Dec	..	..
[illegible]	[illegible]	[illegible]	63 —66	5 19 3	May, Nov	64	[illegible]
[illegible]	[illegible]	[illegible]	72 —77	5 4	Ja,Ap,Jy,O	–	..
[illegible]	[illegible]	[illegible]	71 —76	5 5 6	Ja,Ap,Jy,O	–	..
1	..	Marconi's Wireless Teleg. Co.	⅝—¾	..	April	[illegible]	..
1	[illegible]	[illegible] 4½% Guar. Dbs. red.)	100 —102	3 18 0	June, Dec	..	..
[illegible]	[illegible]	West Coast of America	1⅝—1⅞	3 16 6	May	..	..
[illegible]	[illegible]	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
[illegible]	[illegible]	West India & Panama	–		May, Nov	..	..
[illegible]	6/0	Do. [illegible] per Cent. 1st Pref.	7⅞—8⅜	7 2 6	May, Nov	8⅛	..
[illegible]	[illegible]	Do. [illegible] 2nd Pref.	7½—8½		May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
[illegible]	[illegible]	Western Telegraph	13⅛—13⅝	5 2 6	Mr,Ju,O,D	13⅜	13⅛
St	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
...	4%	†Western Union Teleg. $1,000 [illegible] Bonds	87 —92	4 7 0		..	..

TELEPHONES.

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Highest	Lowest
100	$8	Amer. Telephn. & Telegh. Cap. St.	141 —142	5 12 9	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98 —100	4 0 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	98 —100	5 0 0	Mar, Sept	..	–
5	3/0	Chili Telephone	7⅞—8⅜	4 15 6	August ..	..	..
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106 —108	5 11 0	Feb, Aug	107⅞	106¾
St.	6%	Do. Def. Stock	120½—122½	4 18 0	Feb, Aug	122	12 ⅞
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¼—11¼	5 6 6	Feb, Aug	11	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10¼—11¼	5 6 6	Feb, Aug	1 ¼	...
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 9/16—5 13/16	4 6 0	Feb, Aug	5 23/32	5 11/16
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	99⅛	98
St.	4%	Do 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	101	100⅝
1	0/7½	Oriental	1⅜—1½	5 6 9	April, Oct	[illegible]	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	89½	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100 —102	4 8 0	Jan, July	..	..
5	3/0	United River Plate	6 13/16—7 1/16	5 13 0	July	7	6 15/16
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	June, Dec	5 5/16	..
St.	4½%	Do. 4½ Deb. St. Red.	103½—105½	4 5 0	Jan, July	104½	..

FINANCIAL INVESTMENT, &c.

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Highest	Lowest
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜—3⅞	7 14 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10⅞—11⅛	6 6 0	Sp De Mr Ju	10⅞	10 9/16
10	3/0	Do. 6 per Cent. Pref.	12¾—13¼	4 10 6	Sp De Mr Ju	13 3/32	12⅞
10	6%	†Submarine Cables Trust (Cert.)	127 —130	4 12 0	April, Oct	127	..

COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Highest	Lowest
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6 1/16—6 5/16	4 15 3	April, Oct	6¼	6 3/16
5	5/0	Do. 10% Non-cum. 2nd Pref.	9 1/16—9 5/16	5 8 0	Jan, July	9 3/32	9 3/32
St.	4%	Do. 4% Deb. Stock	91 — 93	4 6 0	June, Dec	92⅛	89¾
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 0	Jan, July	..	..
5	2/6	Brisbane Electric Trams. Invest. Ord.	5¼— 6	3 6 6	May	5 31/32	5¼
5	2/6	Do. 5 per Cent. Cum. Pref.	4 15/16—5 3/16	4 16 9	May, Nov	5⅛	5 3/32
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	101 —105	4 5 9	Jan, July	..	..
St.	8%	British Columbia El. Ry. Df. Ord.	142 —146	5 9 6	Mar, Sept	145½	148½
St.	6%	Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	122½	122⅛
St.	5%	Do. 5% Cum. Perp. Pref. Stock	107½—109½	4 11 0	Jan, July	109	108½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 0	April, Oct	...	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 6 8	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	98½—100½	4 4 6	–	..	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	98¾	9[illegible]
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	91 —95	6 6 0	Feb, Aug	91	..
5	2/0	Calcutta Tramways (1 to 137,610)	4 —4½	5 0 0	Mar, Sept	4⅓	4¼
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅜	4 16 6	Jan, July	..	–
1	4½%	Do. 4½% 1st Deb. Stock (red.)	99 —102	4 8 0	Jan, July	..	..
St.	–	Cape Electric Tram Shares	⅛—⅜	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 11/16—5 15/16	4 4 9	F,My,A,N	5 13/16	5¾
St.	4%	Do. 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	90 —93	5 7 0	May, Nov	–	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 —88	5 13 9	June, Dec	84⅞	–
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	89 —91	5 6 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	84 —88	5 14 0	Jan, July	87	8[illegible]½
5	6%	Do. 6 per Cent. "B" Ditto	58 —63	9 10 0	Jan, July	..	–
5	1/0	Lisbon Elec. Trams. Ord.	1 —1⅛	4 9 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Jan, July	–	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	95 —100	6 0 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	90 —93	5 7 6	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	92 —96	5 4 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	139 —141	4 7 6	..	143	37½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	93¼—94¼	5 5 6	..	94½	94
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	102 —104	4 6 6	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	103 —106	..	..	104⅜	..
1	1/0	Perth Elec. Trams Ord.	21/32—25/32	6 12 6	May	[illegible]	..
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	–	–
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅝	5 6 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..	–
100	..	Rio Janeiro Tram, Lt. & P. Co.	101 —102	..	..	101¼	100
..	5%	Do. 30 yr. Gold Bnds.	94½— 95½	5 5 0	..	95	[illegible]
100	5%	Do. 10 yr. Mt. Bnds	84½— 85½	..	..	85	84½
–	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	155½ —157½	6 7 0	..	–	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100 —101	4 19 0	June, Dec	..	–
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..

COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.

Share	Last Dividend	Name	Price Wed., April 21	Rate % Yielded (£ s. d.)	Dividend Due	Highest	Lowest
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	90 —94	4 16 0	Jan, July	..	..
1	3/3	Calcutta Elec. Supply Ord.	6¾—7⅛	5 12 0	April, Oct	7	6 15/16
100	$1¾	Canadian Gen. Elec. Co. Com. St.	115½—117½	5 19 0	..	117½	115
100	$3½	Do. 7% Cm. Pf. Stock	116 —118	..	..	117¼	116½
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —102	4 18 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	85½—88½	5 12 6	..	87	85½
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1¾—2½	..	Feb, Aug	..	–
St.	5%	Do. 5 per Cent. Deb Stock	90 —94	5 6 6	Jan, July	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½—90½	5 10 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	–	..	–	..
10s	0/3	Kalgoorlie Elec. Power & Ltg. Ord.	1/16—5/16	..	..	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	⅝—¾	7 10 0	April, Oct	..	..
St.	5%	†Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	76 —80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	87 —89½	5 14 0	..	88	87½
St.	$1	†Mexican Lt. & Power Co. Com. St.	75½—77½	7 17 6	–	77	76
500	5%	Do. 5% 1st Mort. Gold Bnds.	91 —92	5 8 6	..	93	91
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	116 —118	5 2 0	F,My,A,N	115	..
1	1/7½	†River Plate Electricity Co. Ord.	1½—1⅝	4 4 9	April	1⅝	1 9/16
1	1 2⅝	† Do. 6 per Cent. non-Cum. Pref	1 —1⅛	5 6 6	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	101 —104	4 18 0	Jan, July	..	–
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5¼	5 14 0	April, Oct	..	..
100	$1	†Shawinigan Water & Power Co. Ca	95 —97	4 3 0	–	97½	95
..	5%	Do. 5 per Cent. Bds.	106 —108	4 12 6	Jan, July	106¼	..
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 — 99	..	–	98¼	..
..	6d.	Victoria Falls Power Co. Pref.	11/16— 13/16	5 6 9	Jan, July	23/32	⅞

* In [illegible] has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Surface-Contact Systems.

SURFACE-CONTACT systems combine such marked advantages from the æsthetic point of view with comparatively low cost that the inventor has naturally turned his attention very actively to this subject. Innumerable surface-contact systems are the result, but, unfortunately, they all possess some inherent disadvantages. The loss by leakage under certain conditions is considerable, and there may be serious difficulties in regard to live studs. Nevertheless, a certain number of these systems have come into commercial use, and it is, of course, only under everyday working conditions that their efficiency can be definitely disproved. The Dolter system is a case in point. In this instance it might have been thought that the experimental stage had been fairly passed, yet it has been found necessary to remove this system on the Mexborough and Swinton Tramways, and to replace it by the more usual overhead system. Not only has this course resulted in a decrease in the working expenses, but, curiously enough, there has been an increase in the receipts through the change. At Torquay also there has been trouble in maintaining the Dolter system, and the progress of the undertaking has been correspondingly hampered. At Oxford, again, the original scheme has been changed and, where the overhead system is not permissible, the conduit system is to be used. Lastly, as our readers know, the "G.B." surface-contact system has fallen on rather evil days in London. We do not wish to express any very definite views on this particular case, as there is another side yet to be heard; we think, however, it will be admitted that the documents published by the company do not form very satisfactory reading. It is difficult to understand why the ordinary course, and what appears to us to be the only possible course, was not followed—namely, to give the company a free hand with the work and to make them entirely responsible for its satisfactory operation. As already remarked, however, the other side of the story has yet to be heard, and we shall refrain from further comment until this is told.

The Greenwich Generating Station.

ALTHOUGH three evenings were devoted to the discussion of Mr. J. H. RIDER's Paper on "The Electrical System of the London County Council Tramways," the list of members wishing to express their views was by no means exhausted, and Mr. RIDER's reply to the criticisms and questions raised by the various speakers had to be held over for publication in the "Journal." Under these circumstances, either the discussion or the reply must suffer at the time, and we fear that the postponement of the author's reply will result in it being somewhat overlooked. As far as the discussion is concerned, unusual interest has been aroused by some of the points involved in the Paper. Among these may be mentioned the advantages of a waterside site, the life and economy of steam turbines, the discarding of reverse relays on the generator circuits, the choice of induction motor-generators for transforming the high-tension energy in the sub-stations, the breakdown of the stator coils when these machines were switched on, and the apparently large current consumption by the tramcars. Mr. RIDER's reply dealing with these subjects should prove of no little value.

IN a recent issue we mentioned, in connection with Mr. ROGER SMITH's remarks, that the choice of the Greenwich site would be likely to receive the approval of the majority of engineers. As several speakers were strongly in favour of that site with its abundant supply of condensing water, we think that the "communicated" remarks of Mr. LEONARD ANDREWS, an abstract of which appears elsewhere in this issue, are worthy of attention, particularly

as they are based on information obtained from a number of engineers. It will be seen that Mr. ANDREWS' figures show a small advantage in favour of the Camberwell site. In view, however, of his advocacy of gas engine stations, we are more particularly concerned with his criticism of the capital cost of a steam-driven station. Mr. ANDREWS mentions that the figure of £14 per kilowatt for such a station, given in his recent Paper read before the Institution, was criticised as being too high, although the expenditure at the Greenwich station now works out at over £23 per kilowatt. We would point out, however, that Mr. ANDREWS' figure was given for a modern steam turbine station, whereas the Greenwich station was originally laid out for reciprocating engines, and therefore the expenditure on land, buildings, generating plant, &c., is by no means comparable with that in the hypothetical station considered in the Paper referred to; whilst the condensing arrangements and the river work involved exceptional expenditure which should not appear in any comparative estimates. Mr. ANDREWS' conclusion that gas-driven stations could have been installed at a lower capital outlay, and at the same time show an annual saving of £32,208 in running costs, is probably too optimistic, although it may be said that, in the light of modern developments, the Greenwich station, if started *de novo*, could be laid down with a smaller capital expenditure. There is, however, one important point that must not be forgotten, namely, reliability; if this remained constant with decreasing capital expenditure, the task of the engineer would be simpler.

Accidents to Tramway Passengers.

A JUDGMENT of considerable importance to tramway undertakers was delivered on Saturday last. The case arose from a claim against the West Ham Corporation for damages for injuries to a passenger on one of the Corporation's tramcars. The injuries were caused by a shock received from a trolley standard whilst the passenger was proceeding to a seat on the roof of the car. The facts were admitted, and the jury returned a verdict for the plaintiff for £500, but the Corporation contended that, as placards were exhibited in their cars, and notices were printed on the backs of the tickets, stating that the Corporation's liability for accidents was limited to £25, that sum was the maximum that could be claimed. Similar bye-laws and notices have been introduced by other Corporations, and therefore the judgment of Mr. Justice COLERIDGE will be of general interest to tramway managers. In delivering judgment, his Lordship drew attention to the fact that although a railway company—and apparently a tramway company—may allow passengers to travel at reduced rates, if the latter waive their claims for compensation in case of accident, the option of paying a higher fare, which carried with it full responsibility on the part of the company, always existed. In the case in question, however, no such option was provided, and the plaintiff being entitled, in common with the general public, to use the tramways, he was carried at the defendants' risk, as he had not had the option of paying a higher fare. Although the Corporation are desirous of appealing, we think that the judgment is a reasonable one under the circumstances and is likely to be upheld. Should this be the case an interesting position will result, and it may, in future, become the custom for two fares to be offered, only one of these entailing full responsibility on the tramway undertakers. Apart, however, from the trouble thereby involved, we think it would be reasonable for the various Councils to take full responsibility for accidents to ordinary passengers. We do not suppose there would be any demand for the higher-priced tickets.

The Indo-European Telegraph Service.

THE proceedings at the meeting on Tuesday of the members of the Indo-European Telegraph Co., over which Mr. J. HERBERT TRITTON presided, were of more than passing interest. The chairman was able to announce that, despite the troubles in Persia, the directors had successfully negotiated an extension of the company's concession with that country, and he was able to show that, amid the throes of civil war, respect had been paid to the property of the company. There is no feature more conspicuous in connection with international telegraphy than the success which has attended the delicate negotiations between the directors of British telegraph enterprises and the ever-changing Governments of the nations of the world. The directors and chief officials of the Indo-European Company may claim particular success in this direction, and it was a fitting sequel to the 40 years almost unbroken progress of the company that the shareholders should, on Tuesday, have unanimously voted a considerable sum of money to the directors in recognition of the valuable services which have culminated in the present conspicuous prosperity of the company, whose 40th year of existence has been marked by successful experimental direct working between London and all parts of India, and daily successful direct working between London and Karachi, which proves the company to be as progressive at the present time as in the past. The fact that the resolution voting the grant to the directors was proposed by Mr. GEORGE VON CHAUVIN (a veteran telegraph engineer, one of the oldest members of the Indo-European Company, representing large financial interests, and a gentleman closely identified with both the past and present of the electrical industry), accompanied, as it was, by a very interesting retrospect of the company's past history, must have made the vote additionally agreeable to the directors. Everything points to the future success of the Indo-European Company, and we are sure the telegraphic world especially will join us in congratulating the management.

"Physikalische Zeitschrift."—It is announced that Prof. F. Krüger, of Göttingen, has been appointed editor of this journal. Prof. Bose, who has held the position for the last 4½ years, is retiring to take up new work in the University of La Plata.

Electrical Trades' Benevolent Institution.—From the balance-sheet just issued it is gratifying to note that the income for the year to December 31 last amounted to £1,267. 12s. 6d. Of this amount £1,101. 11s. was invested, money in the bank was £129. 16s. 6d., the balance representing the total expenses, including salaries, of the past three years' existence of the institution. We are glad to note that Sir William Preece is to preside at the annual general meeting which takes place to-day (Friday) at the Hotel Cecil, London, at 4 p.m., and which we hope will be well attended.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Hong Kong—Macao	Apr. 13, 1909	Apr. 23, 1909
Obock—Djibouti	Apr. 15, 1909	—

University College of Dundee.—It is announced that Prof. T. Claxton Fidler, who has occupied the chair of Engineering in this college since 1891, is about to retire.

The "G.B." Surface-Contact System in the Mile End-road.—The "G.B." Surface Contact Co. have asked us to state that the copies of Mr. Mordey's reports, which we published in our last issue, were supplied by the company, and that they were entitled to take this course under their agreement with the London County Council.

Institution of Municipal Engineers.—At a meeting of the members of this Institution resident in the home counties district (northern division), which includes Bedford, Buckingham, Essex, Herts and Middlesex, held at Olympia on April 24th, Mr. Henry C. Adams was elected chairman of the District Committee and a Member of Council of the Institution. Mr. Bernard Partridge was elected honorary secretary, and an executive sub-committee was appointed.

Engineering Standards Committee.—We have received from the Engineering Standards committee a copy of their latest report which deals with "Reciprocating Steam Engines for Electrical Purposes." It is, in general, intended to assist towards a mutual understanding between makers and purchasers, and contains recommendations on governing, cyclic variation, economical questions, maximum load, steam and exhaust pressures and other matters.

"**Engineering Wonders of the World.**"—The complete history of engineering has yet to be written, but a laudable attempt to give some account of recent developments in this branch of the world's work is being made by Messrs. Thos. Nelson & Sons by publishing a volume having the above title. To do this they have enlisted the services of numerous engineers who are experts in their own particular class of work, and it is proposed to give fully illustrated descriptions of many of the best known wonders in engineering throughout the world, the publication being issued in fortnightly parts. Except in the first chapter, attention will be confined to engineering work completed since the year 1800, though it will probably be agreed that this is quite a wide enough field. The first part of this new work, which we have under notice, contains an interesting article on "Ancient Engineering," by Mr. A. Williams, the editor, in which a description is given of such feats of prowess as the Pyramids, the Sphinx, and the great stone of Baalbec. Other articles describe the "White Pass and Yukon Railway," "The Royal Albert Bridge at Saltash," "The Rotherhithe Tunnel" and the "Salving of the Gladiator." We shall be pleased to hear that this work is achieving a great success, for there is no doubt, as stated by the editor in his preface, that the principles involved in most engineering work are very imperfectly understood by the "man in the street"; and any efforts which are made to alter this condition of affairs ought to receive the support of all those interested in the well-being of the profession.

The Institution of Mechanical Engineers.—The annual dinner was held on Thursday, April 22nd, at the Hotel Cecil, Mr. J. A. F. Aspinall, President of the Institution, in the chair. The company, which numbered about 160, included many distinguished guests, among these being the Right Hon. Lord Strathcona, G.C.M.G., the Right Hon. Lord Stalbridge, Sir William H. White, K.C.B., Sir Archibald Geikie, K.C.B. (President of the Royal Society), the Hon. Sir Richard Solomon, K.C.B., Dr. H. T. Bovey, F.R.S. (Rector of the Imperial College of Science and Technology), Dr. R. T. Glazebrook, F.R.S. (Director of the National Physical Laboratory), Mr. J. C. Inglis (President of the Institution of Civil Engineers), Mr. James Swinburne, F.R.S., and Dr. W. C. Unwin, F.R.S. After the loyal toasts had been honoured, Sir William White proposed "The Houses of Parliament," comparing them to a machine, of which the second chamber was the very essential "governor." Lord Strathcona replied for the House of Lords, and Mr. Harmood Banner, M.P., for the House of Commons. The toast of "Our Guests," proposed by Mr. E. B. Ellington, followed, Sir Archibald Geikie responding. The remaining toast of "The Institution of Mechanical Engineers" was entrusted to Mr. J. C. Inglis, who, in an interesting speech, mentioned that it was impossible to over-estimate the services rendered by engineers in assisting the development of the commerce of this country. The President, in his reply, referred to the importance of mechanical training in combination with theoretical education in the early years of a young engineer's work.

Tantalum and its Industrial Applications.—At the Royal Institution last Friday evening, Mr. Alexander Siemens delivered a discourse having the above title. The lecturer first dealt with the physical and chemical properties of the metal and showed that at ordinary temperatures tantalum was unaffected by all acids (except fluoric) alkalis and moisture. He also showed that it was an ideal material for mechanical apparatus and for implements which, if made of steel, would be liable to rust. As regards physical properties it was tough and malleable, so that it could be drawn into fine wire or hammered into thin sheets. Nevertheless, it was quite elastic, and as hard as soft steel, its tensile strength being 27 tons per square inch. The filament used in tantalum lamps was 0·03 mm. in diameter, and should therefore support a weight of about 80 grammes. Tantalum was also being used for making nibs, which were manufactured in the usual way, though at first it was not entirely satisfactory for this purpose, as the loss by abrasion was rather great; but by slightly oxidising the surface the nibs became hardened, so that this loss was considerably reduced, though it was still greater than that of the ordinary steel pen. Another use of tantalum was that it seemed to be a suitable material for making the knives used by surgeons, if slightly oxidised before polishing. If heated to a dull red it absorbed gases, and in so doing lost its strength and became brittle, a property which somewhat detracted from its usefulness. Its melting point *in vacuo* being about 2,300°C., it was suitable for use as electrodes in vacuum tubes, and was, in fact, being extensively employed for this purpose. Turning to its application as filaments for incandescent lamps, the lecturer showed that the original diameter of the wire used for this purpose had been reduced from 0·05 mm. to 0·03 mm. After the lamp had been used for a short time the strength of the filament decreased and it also underwent certain structural changes. After about 1,000 hours it showed signs of capillary contraction, as if the filament were going to break into a series of drops. In conclusion, Mr. Siemens mentioned two interesting properties of the metal—*viz.*, that if heated in a high vacuum any oxygen contained in the metal would be expelled, so that filaments which were "spotted," owing to the fact that a certain amount of oxide was contained in them, would become uniform after burning for a few minutes at the normal voltage. Tantalum would also act as a rectifier when used in an electrolyte if it were made the anode. It then became quickly covered with a film of oxide, which stopped the current.

ARRANGEMENTS FOR THE WEEK.

WEDNESDAY, May 5th.

BIRMINGHAM SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.
7 p.m. Annual General Meeting at the Grand Hotel, Birmingham.

STUDENTS' SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.
7:45 p.m. Meeting in the Library of the Institution, 92, Victoria-street, Westminster, S.W. Paper on "Some Notes on Relays," by Mr. E. W. Moss.

THURSDAY, May 6th.

INSTITUTION OF ELECTRICAL ENGINEERS.
8 p.m. Meeting at the Royal Society of Arts, John-street, Adelphi. Paper on "The Theory and Application of Motor Converters," by Mr. H. S. Hallo.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.
8 p.m. Meeting at Caxton Hall, Westminster, S.W. Paper on "The Past, Present and Future of the Organisation of the Engineering Profession," by Mr. R. O. Wynne Roberts.

Corps of Electrical Engineers (London Division).
Commanding Officer, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 3rd,
"A" Company ...... Infantry drill, 6:30 p.m.
Tuesday, May 4th,
"B" Company ...... Infantry drill, 7 p.m.
Thursday, May 6th, Infantry drill, 6 p.m.
"C" Company ...... Technical drill, 7:15 p.m.
Friday, May 7th, Infantry drill, 6:45 p.m.
"D" Company ...... Technical drill, 8:15 p.m.

EXPERIMENTS ON THE CURRENT AND ENERGY EFFICIENCIES OF THE FINLAY ELECTROLYTIC ALKALI-CHLORINE CELL.*

BY F. G. DONNAN, J. T. BARKER, AND B. P. HILL.

Summary.—The main features of the Finlay electrolytic cell are first described, and particulars are then given of efficiency tests carried out in the Muspratt Laboratory of the Liverpool University. The efficiency is very much higher than in cells where the electrolyte does not flow through the diaphragm.

1. *Description of the Cell.*—The electrolytic cell referred to in this Paper was patented in England by Messrs. Archibald and Robert Finlay, of Belfast, in 1906. It has for its object the production of alkali and chlorine by the electrolysis of alkaline-chloride solutions, and embraces the following main features:—(1) Use of a double diaphragm with middle brine chamber separating the anode and cathode compartments. (2) Electrolytic (brine) percolating under head from the middle chamber towards both anode and cathode compartments, and so continuously flowing through the cell diaphragms. (3) Arrangement of compartments on the plan of a filter press, whereby great compactness of construction is obtained, and resistances are reduced to a minimum by a reduction of the thickness of electrolyte in the compartments of the cell. (4) Suitable arrangements for the escape of the gases and the circulation of the electrolyte. Although entire novelty cannot be claimed for the ideas involved in the middle chamber with double diaphragm, the percolating electrolyte or the filter-press arrangement, the combination as embodied in the Finlay cell represents a form of construction which has not been practically realised and tested before.

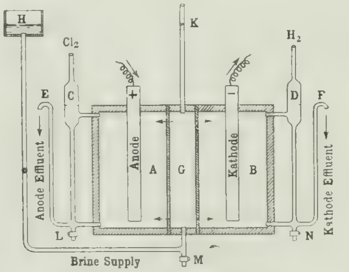


FIG. 1.—DIAGRAM OF FINLAY ELECTROLYTIC CELL.

The general circulation system may be illustrated by the sketch shown in Fig. 1. Brine is fed from the constant-level tank H to the middle chamber G, the pressure-head being measured by the gauge tube K. The salt solution flows as shown by the dotted arrows through the diaphragms to the anode and cathode compartments A and B. The gases escape through the vessels C and D, whilst the chlorinated brine and the mixture of salt and caustic soda flow respectively from the swan-necks E and F. By regulating the height of these swan-necks the rate of flow of salt solution through the anode and cathode diaphragms can be separately adjusted. By this means all mixing of the anode and cathode liquors due to ordinary diffusion or electric endosmose is entirely prevented, whilst the losses due to electrical migration of the OH -ions from the cathode to the anode compartment are very considerably reduced by the counterflow of the electrolyte. The anode A consists of dense carbon, or still better, Acheson graphite, whilst the cathode B is made of wrought iron. The taps L, M, and N are used for emptying the cell when required.

The actual construction of a commercial unit is illustrated in Fig. 2, which explains the filter-press arrangement referred to previously. By this means any number of compartments, anodes, and cathodes can be simply juxtaposed and bolted together in a teak frame, and both surfaces of every anode and cathode made electrolytically active. The carbon anodes are fixed in position in brass or copper troughs (set in the teak frame) by means of lead, the latter being protected from the action of the Cl_2 or electrolyte by a layer of a suitable cement. Electrical connection to the anodes is obtained by the outer edges of these metal troughs, as shown in Fig. 2. At PP are shown the slots and holes connecting the anode compartment to the ducts which convey away the chlorine and anode liquor. QQ and RR are the corresponding holes forming portions of the ducts which convey the brine and cathode liquor to and from the middle and cathode compartments respectively. VV are bolt holes. The dimensions of a 2,000-ampere unit, such as shown in Fig. 2, are as follows: length, 4 ft.; breadth, 2 ft. 6 in.; height, 4 ft. The current-carrying capacity per cubic unit is very considerable.

For the purpose of the tests a small laboratory unit (carrying about 10-20 amperes) was employed. This cell contained a central anode compartment, two middle compartments, and two cathode

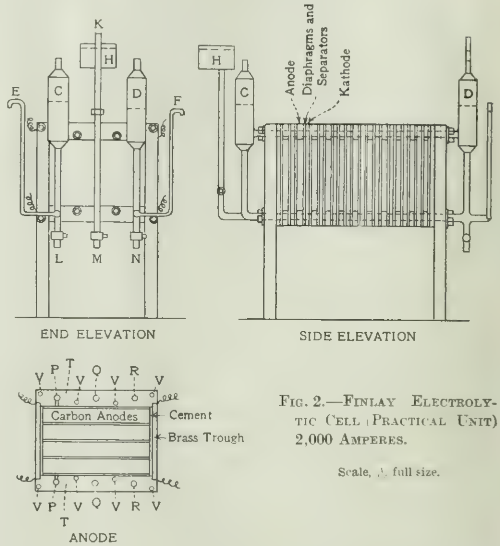
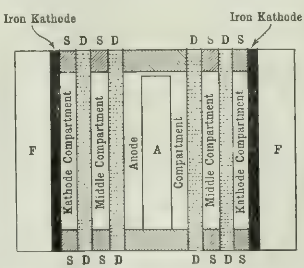


FIG. 2.—FINLAY ELECTROLYTIC CELL (PRACTICAL UNIT) 2,000 AMPERES.

Scale, [illegible] full size.

compartments, as shown in Fig. 3. These were bolted together by two end frames FF. The diaphragms DD (Fig. 3) consist of sheets of specially prepared asbestos 2-3 mm. thick. These are separated from each other and from the iron cathodes by rectangular frames of waxed cardboard SS, which are also about 2-3 mm. thick. It will be seen that the middle and cathode compartments are in reality thin sheets of liquid only a few millimetres thick. By this means the electrical resistance of the electrolyte per unit area of diaphragm or active cathode surface is reduced to a minimum, whilst diffusion and electrical migration are prevented or hindered by the counterflow of the liquid. The cathodes consisted of thin sheet iron. As



S Separator, A Anode, D Diaphragm, F Frame.

FIG. 3.

Acheson graphite rods were not to hand, the anodes employed were rods of dense amorphous carbon. The diaphragm consisted of the asbestos diaphragm sold for electrolytic purposes by Bernfeld of Leipzig. The active sectional area of each diaphragm and cathode was 60 sq. in. (387 sq. cm.). The total cathode area was, therefore, 774 sq. cm., as only one side of each cathode was electrolytically active. The brine was used at a fixed density of 1·18. It was made from ordinary table salt, and was purified from calcium and mag-

* Abstract of a Paper read before the Faraday Society.

nesium salt by treatment with alkali in a small glazed earthenware tank, until a small portion on filtration gave no further precipitate when tested with alkali. After settling, the liquid was siphoned off, filtered, neutralised, and diluted to the required density. In diaphragm cells with flowing electrolyte it is very necessary to avoid any formation of precipitate in the middle compartment, as this would tend to choke the diaphragms.

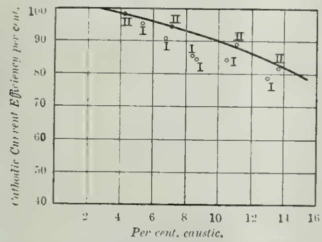
The authors show that, ignoring ionic migration, the steady state for a given current will be reached the more rapidly the greater the value of the ratio V/v, where v is the volume of the cathode compartment and V is the constant flow of liquid into and out of that compartment. Ionic migration, however, complicates this. To determine the cathodic efficiency it is only necessary to wait for the steady state (as shown by a series of titrations of the cathode effluent) then to collect a measured volume of the cathode effluent during a sufficient period (in these experiments usually 1 to 3 hours), determine its alkali contents by titration, and compare with the "theoretical" alkali which the current during this period of time would have produced, had no alkali (OH'-ions) crossed the cathode diaphragm (reckoning 1·494 grammes NaOH to the ampere-hour). It is necessary, of course, that the current and flow of electrolyte remain constant. There was no difficulty in keeping the current constant, but it frequently happened that, even with a constant pressure-head in the brine compartment, uncontrollable variations of the rate of flow of electrolyte occurred. In order to counteract this, the volume of the cathode effluent collected every 5 or 10 minutes was observed, and the pressure-head readjusted, if necessary, in order to keep this flow constant. In the later experiments a further small correction was introduced. Let v = volume of cathode compartment in cubic centimetres, y_1 = alkali concentration of effluent (in grammes or molecules NaOH per cubic centimetre) just before, and y_2 = alkali concentration of cathode effluent just after the test run. Then the amount $(y_2-y_1)v$ of NaOH has to be added to the alkali found in the total cathode effluent during the test run. When this is done very concordant results are obtained.

In several of the experiments the cells were run for about eight hours daily for periods of a month. The cathode diaphragms did not appear to have suffered, but the anode diaphragms appeared to be considerably "pulped" on the surface turned towards the anode. It was also observed that when making the more concentrated caustic solutions (9-14 per cent. NaOH) the cathode liquor appeared to contain a considerable quantity of dissolved alumina, derived evidently from the cathode diaphragm. The diaphragms also appeared to get somewhat choked, as the pressure-head had to be increased in order to obtain the same flow. This choking may have been due to slight precipitation of insoluble matters in the middle compartments, or to imperfect filtration of the brine during the process of purification. These are both points which require the most careful attention when working with diaphragm cells having a percolating electrolyte.

A great advantage which the double diaphragm cell with percolating electrolyte possesses over single diaphragm cells is that when making the higher strengths of caustic it is impossible to avoid a considerable migration of OH'-ions to the anode. This largely helps to disintegrate the carbon anodes with the production, amongst other things, of a suspension of finely divided carbon. In the single diaphragm cell this carbon is carried into the pores of the diaphragm and rapidly chokes it. In the Finlay cell, on the other hand, the carbon particles are swept out with the anode effluent and do not collect at all on the surface or in the pores of the anode diaphragm.

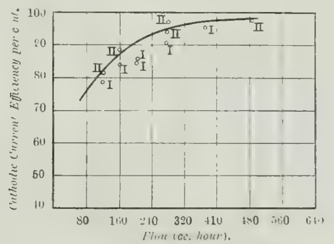
Experimental Results.—The cell was run with currents of 11·6, 16·8, and 22·1 amperes, the current densities covering the range of those employed in practice with diaphragm cells, with the exception, perhaps, of the Townsend cell, in which very heavy current densities are said to be employed. Particulars of all the tests are given in the Paper. The experiments with current density = 0·015 amperes per square centimetre show that when the cathode efflux varied from 954 to 208 cubic cm. per hour the strength of the efflux varied from 1·50 to 6·24 grammes NaOH per 100 grammes cathode liquor, and the current efficiency at cathode from about 99 to 92 per cent. With a current density of 0·0286, the tests show a cathode flow varying from 723 to 109 cubic cm., a per cent. of caustic from 3·61 to 15·0, and an efficiency from 96·0 to 64·0 per cent., the voltage being about 3·3 or 3·4. The results do not appear to show any marked improvement in efficiency with increase of current density, the flow being correspondingly increased, so that the same strength of caustic is made, *i.e.*, the cathodic current efficiency appears to be mainly a function of the alkali concentration in the cathode compartment in the steady régime.

A series of experiments was then carried out at a current density of 0·0286 with 4 mm. asbestos cathode diaphragms. The results were surprising. The average voltage rose to 3·8 (owing to the thicker diaphragm), but the cathodic current efficiencies ranged from 80 to 75 per cent. for caustic strength varying from 5 to 13 per cent. respectively. The results are interesting inasmuch as they show how much depends on the "denseness" of the diaphragm. If we regard a porous asbestos diaphragm as a series of capillary tubes, then clearly for equal total fluxes of liquid across a given sectional area, the actual velocity of flow in the capillary pores may vary very greatly. Experiments were also carried out, employing as cathode diaphragm two 2 mm. diaphragms pressed together. It was found extremely difficult to keep the flow of electrolyte constant during the test run. The pressure-head had to be continually altered, but even this did not suffice to control the flow. It is possible that the doubled diaphragm may have had some part in causing these disturbances. Curves drawn through the mean of the recorded figures seem to indicate that for higher strengths of caustic the current efficiency increases with the current density, whereas for lower strengths the reverse is the case. It is doubtful, however, whether these experiments are accurate enough to justify such a generalisation. The efficiency fell from 98 to 87 per cent. as the percentage of caustic increased from 5·4 to 11·4.



2 mm. Cathode Diaphragm (loaded).
Current Density = 0·0217. Temp., 17°—19°. Sp. Gr. = 1·18.

FIG. 4.



2 mm. Cathode Diaphragm (loaded).
Current Density = 0·0217. Temp., 17°—19°. Sp. Gr. = 1·18.

FIG. 5.

The last series of experiments on cathodic current efficiencies were carried out with 2 mm. cathode diaphragms which had been "loaded" to a certain extent with a precipitate of ferric hydroxide. In these experiments it was found quite easy to keep the flows satisfactorily constant. It is seen that the slight loading with ferric hydroxide which the cathode diaphragm had received did not raise the cell voltage. Also, the average current efficiencies with the 2 mm. loaded diaphragm are about the same as those obtained with the two 2 mm. diaphragms at the same current density, with the great advantage that the cell voltage is sensibly lower (3·38 as compared with 3·65). The results, which are considered to represent the best average performance of the cells, are shown in Figs. 4 and 5. The current density = 0·0217, the temperature was 17 deg. to 19 deg., and the specific gravity 1·18 in the experiments.

The cathodic energy efficiency is next discussed, and finally particulars of experiments to ascertain the composition of the anode gases when the cell was working at high and low cathodic efficiencies respectively. Under favourable conditions the anode gas would be 99 per cent. chlorine, when the cell was making 6-7 per cent. caustic soda.

In order to show what very much higher current efficiencies are obtained in the Finlay cell as compared with diaphragm cells in which the electrolyte does not flow through the diaphragm, two experiments were also made in which both the chloride and alkali concentrations in the cathode effluent (and also in the middle chamber liquor) were determined.

THE ELECTRICAL SYSTEM OF THE LONDON COUNTY COUNCIL TRAMWAYS.

We give below an account of the discussion which took place at a meeting of the Institution of Electrical Engineers, on Thursday last week, in connection with Mr. J. H. Rider's Paper on the above subject. This Paper was read and partly discussed at two previous meetings, abstracts of the Paper and discussion appearing in our issues of March 26th, and April 2nd and 9th.

Mr. W. H. Patchell, referring to the coal contract, expressed surprise that there was no mention of ash. Possibly Mr. Rider only intended his contract to apply to a very restricted coal area, so that his heat values would cover his ash if he was getting coal of a particular kind. He though the contract would have to be altered to be of more general value. Mr. Rider had gone in for washed nuts, and that brought up the question of the chain-grate stoker. He, the speaker, had burned washed nuts years ago, from which he got very high value for a sovereign. Subsequently, owing to very large users taking to washed nuts, these went up to a price which he could not afford, so he turned his attention to other classes of coal. He thought it was a pity to adopt throughout a station a type of plant which so very much restricted the type of fuel that had to be used, unless one was a colliery owner and could produce one's own fuel. On the question of heating surface, Mr. Rider had given them the heating surface of each boiler, but did it include the superheater? The size of the boiler seemed to be very small in proportion to the size of the station. Mr. Rider had given them an interesting test of one of his boilers which had 3,320 sq. ft. heating surface, and which gave an efficiency of 79·49 per cent. Some boilers he (the speaker) had had under his control had 6,209 sq. ft. heating surface. They were Stirling boilers with McPhail superheaters of 800 sq. ft. heating surface, made up as an integral part of the boiler. On test these boilers, with dry fuel, gave an efficiency of 80·29 per cent. That was the boiler and superheater without an economiser, so that the figures were as close as could be expected to Mr. Rider's. He did not claim, therefore, any great thermal efficiency by the use of larger boilers, but he did claim a greater convenience in handling and a very great saving in the cost of buildings and land. In a matter of that kind space was important. For the amount of Mr. Rider's calculated output he certainly seemed to be over-boilered. He had 48 boilers for 34,000 kw. normal, or 42,500 kw. maximum load, and in the test he had four boilers running one engine. Of course, one would not run normally the boilers one would run on test, so he (Mr. Patchell) took for his seven engines 28 or 32 boilers to run the whole of his engines, and he then had some 16 boilers to spare. Perhaps the extra load Mr. Rider would be able to squeeze out of the turbines would occupy some of that plant usefully. The question of water level in London was a very interesting one, and was becoming very important in view of the number of people putting down their own wells. Mr. Rider said the well delivered the water practically up to the ground level, or about 5 ft. below the top of the tube. That level was relatively very much higher than in other parts in the neighbourhood of London; he knew that at Greenwich the water did stand higher, although with a number of wells sunk he thought that the level would now be lower. He would like to ask the author whether the water meters were on the suction or the output side of the pump, as he found that made a great deal of difference. With regard to the steam separator, was this justifiable? With a well-laid-out plant and steam superheaters, why was so large a separator required? As to the generating plant described in the Paper, there was a rather striking difference in the rating of the reciprocating and of the turbo-alternator sets. He asked what was the power factor of the plant as a whole? As to piston rings, he would not have expected that Mr. Rider's would have given out before his Corliss valves did. If Mr. Rider had had any trouble with the latter he had not mentioned it. He (the speaker) was struck when he heard that Mr. Rider was actually reversing the American method. The author claimed for this the advantage of drainage. In the Interborough station in New York they had the heaviest Manhatten engines, and he learned that they had had no trouble with them. It was interesting to know the difference there was in efficiency between the two types of engines. The results of the tests made in the New York station and Mr. Rider's station were very much alike; this fact, he thought, showed the accuracy with which the tests were made. The question of surface condensing for turbo-generating sets was an interesting one. Mr. Rider's figures indicated 6½ lb. per square foot for condensing with his reciprocating sets, but for the turbo sets he had not given the figure. The table of total costs of the plant given in the Paper was interesting. He was glad to see that Mr. Rider adopted normal ways of thinking, and had rated his plant on the normal capacity, and not on the Parliamentary capacity. From the evidence which had been given before the Parliamentary Committees one rather wondered what the rating was going to be. On the question of synchronous machines, Mr. Rider had gone over entirely to induction sets, but had not yet settled how to start those induction motors, and had adopted a compromise. He (the speaker) had put in some induction sets, but only to the extent of one or two machines in large sub-stations, and had arranged so that he could start them from the alternating-current side. He had afterwards experienced trouble with the induction machines—just such trouble as Mr. Rider had described. He, the speaker, would certainly put in synchronous machines in preference to induction. Mr. Rider's experience with the breaking down of the coils brought out an old fact in regard to winding. They had had trouble with induction sets through the breakdown of the coils. He (the speaker) believed that there was most certainly a concentration of pressure on the first few turns of the coils. This trouble might be got over by an external device. He was not at all sure that the defect was not mainly a mechanical one. In tests with resistance boxes for applying up to 100,000 volts pressure he heard that every time insulation broke down they had to suspend the test until the resistance box had been re-wound. They put a choke coil each side of the resistance box and had no further trouble. There was an interesting point in the figure given in the Paper as to the cost of a sub-station. It had to be remembered also that the generating and sub-station plant cost was only about half the total cost of the scheme, as cables and street work had to be provided for. He complimented Mr. Rider on the clean and tidy aspect of the station at Greenwich, in marked contrast to stations in the old days.

Mr. K. Edgcumbe referred to Mr. Rider's remark in the Paper in which he said that his experience with reverse relays had led him to think that it would be better to dispense with them altogether. Three speakers in the previous discussion had agreed with Mr. Rider; but he (the speaker) somehow felt that the question was such an important one that it ought not to be passed over too hastily, and he would very much like to have some further facts from Mr. Rider as to the trouble experienced. He thought, reading between the lines, that reverse relays had been guilty of cutting out generators when there was nothing wrong with them. Did it follow that the only alternative was to do away with all protection on the generators? He did not know what Mr. Rider's settings were at Greenwich, but they were probably rather low—something like 10 per cent. of the output of the generator. Sometimes engineers went as low as one-twentieth of the output. That might be all right on small plants, but he could not help thinking that on large plants, where surges had to be reckoned with, where there were generators of various types running in parallel, some reciprocating engines and some turbines, there were bound to be temporary reversals of energy, and in that case it was necessary to put in a time lag. He had found that a fixed time lag was infinitely preferable to an indefinite time lag depending on the alacrity of the switchboard attendant in cutting out the generator from the switchboard. The other alternative seemed to be to do what Mr. Rider said, and do away with the relays altogether; but that seemed hardly a logical conclusion. Another alternative was to set the relays for a much heavier reverse current. The only objection to that was that the 'bus bar volts were almost certain to fall, and that entailed a corresponding increase of current. But an increase to four or five times the normal output of the machine would not hurt a generator. Personally, before relays were discarded, he would like to see them set to much higher values.

Mr. H. M. Sayers said he had Mr. Rider's permission to mention some facts regarding induction motors which went to show that the troubles experienced were partly mechanical. In some careful tests on the windings a point had been selected in the centre of the winding and a mechanical movement had been detected of, in some cases, as much as ⅜ in. With regard to costs, the figures given in the Paper as to units generated did not enable one to distinguish the works costs for current utilised. From the figures given it appeared that the current delivered to sub-stations was now about 14 per cent. greater per car-mile than the current generated in the year ended March 31, 1907. The transmission losses were a further addition. As to the commercial position of a big station, he took it that at Greenwich there was shown what could be done with a high-tension station, and he thought it was very near the limit. Transmission losses to the farthest sub-stations would amount to about 13·7 per cent. at full load, and assuming the most economical cable section the capital charges would double that loss, making it in value of units generated about 27·4 per cent., so that if instead of requiring about 10 miles of cable the generating station was in a more central district, and 5 miles of cable was saved, there would actually be a net saving, although the cost of coal might be increased by 10 or 12 per cent.

Mr. G. L. Addenbrooke referred to the question of the spploy of water to the boilers and to Mr. Rider's statement that he blew off 5 in. every day, meaning a loss of £500 a year.

In a written communicaion, he further asked for particulars of the amount of water used for the boiler supply and what proportion of the total went through the turbines in the form of steam, and also what was the proportion of the make-up water to the total water pumped into the boilers, and approximately the amount of water lost by blowing off. He believed a good case could be made out for distilling the make-up water, especially in the turbine plant, as the necessity for blowing down the boilers would be greatly reduced, and their efficiency would also be a little higher owing to freedom from scale, and a considerably smaller amount of water would be required. He asked Mr. Rider to explain the large sum which was included in the cost of his generating station for buildings and foundations. There was a certain want of proportion, in considering an undertaking of that kind, in only devoting a few lines to an expenditure which was nearly half the total, and which brought up the capital expenditure per kilowatt to the large amount of £23.

Mr. J. M. G. Trezise asked for information respecting the high-tension switchgear. He noticed that isolating plugs provided with insulating handles were made use of in the generating station and in the sub-stations. Seeing that it would hardly be safe to grip the plugs without the assistance of a further insulating device of some sort, was there any real advantage in providing that special insulation over the ordinary bare copper knife switch operated by a rod with a hook at the end? He

also asked for more information respecting the spark-gaps provided for protecting the feeder cables at Greenwich. Did they act? Did discharges take place from them, and, if so, under what conditions? Were any means provided to indicate if discharge had taken place, and did they give any considerable trouble to keep clean and in order? In regard to the question of straining the water for the condensers, there was an immense advantage in using an automatic strainer to deal with water from a river such as the Thames. But the fact mentioned, that 15 per cent. of the water pumped for condensing at Greenwich went back from the strainer without being used, seemed a very serious matter. The capacity of each strainer was stated to be 1,000,000 gallons per hour, and if the head against which the water was pumped was taken at 30 ft., that meant useless pumping for 3,600,000 gallons of water per day against a head of 30 ft. With constant pump pressure the waste in the strainer would remain practically constant. In regard to the large power required to drive the circulating water at Greenwich, Mr. Bailey attributed it to some defect in the design of the circulating pipes, but Mr. Roberts had not agreed with that idea. He, the speaker, had endeavoured to make some calculations to arrive at the amount of power required to pump the leakage water from the strainer. Taking the pumps as having a capacity of 12,000 gallons per minute, and the motors each at 250 B.H.P., then the amount of water pumped to waste would consume some 52 B.H.P., equaling 377,278 B.O.T. units for the year. If two strainers were used the waste would amount to 104 B.H.P., which equalled 754,555 units per year, so that two strainers in use meant a waste of power equal to more than three-quarters of a million units per annum. The figures showed that a large proportion of the power required to work the circulating system was due to the loss of water from the strainer. The disadvantage of having the pumps outside the strainer had already been referred to. Of course, the great disadvantage of the arrangement was that the strainers did not protect the pumps. It was not possible with the rotary strainer to adopt the economical arrangement of having two or more pumps in parallel, so arranged that one or more was brought into use as the load demanded. The difficulty could be partly overcome by using d.-c. motors instead of a.-c. motors, so as to reduce the speed, but the efficiency fell so rapidly with reduced speed that there appeared to be no advantage in using the former. He had had an opportunity of inspecting the Greenwich station, and the circulating system was certainly interesting, particularly the method of carrying the pipes to the station below the low water level, although there appeared to be some disadvantage in the sharp bend at the river wall.

Mr. J. R. SALTER thought the first thing in the Paper that would strike anyone connected with tramway work was the heavy capital expenditure. What did it represent per car-mile? Another point was the employment of storage batteries, representing only one-hundredth part of the total capacity of the plant. He did not think it was contended that these gave any ordinary advantage. Mr. Rider had told them that the conduit system was liable to many faults to which the overhead system was not subject, but he would like a few more particulars as to the advantages of the conduit system. As to the cost of current, the cost per car-mile in Glasgow was much lower than in London, and if Mr. Rider came anywhere near the Glasgow costs there would be a saving of something like £40,000 a year in generating costs, representing a capital of something like £600,000. There was scarcely any information given as to the low-tension feeder system, which must have cost more than in the ordinary overhead system. One of the most remarkable departures was the use of shunt machines. He suggested that the low efficiency shown was partly accounted for by these shunt machines.

Mr. H. BRAZIL, referring to the switch in the neutral windings, congratulated Mr. Rider and Mr. Shaw on the ingenuity displayed in the device described in the Paper, but when one came to examine the number of switches employed one was inclined to doubt the value of the device. In regard to isolation, when it was necessary to divide the system into two or more parts one only of the parts could be earthed by the device and it would appear to be very dangerous. The aim in such devices should be that the shock to the system was as small as possible, and yet enable the cut-outs to act. He suggested a special arrangement of carbon powder resistances or choking coils connecting the neutrals to a common earthing bar.

Mr. A. B. CLARK thought, from the diagram in the Paper, that there were two water meters in the circulating system. He would like to ask how much water they passed in a given time, and also what vacuum was maintained. As to earth resistances, he asked what the weight of Mr. Rider's was. In the diagram of the switchboard, he noted that two low-tension machines came to the same 'bus bar. That meant that if anything went wrong with that section of 'bus bar the auxiliary motors would be stopped. As to the engines, here they found very good results. He thought there was something wrong with the boiler tests. How was the water for the boilers measured? As to the coal contract, in looking through a large number of analyses for B.Th.U., he found that it was a very poor coal indeed that did not reach the limit in Mr. Rider's contract. Then as to moisture, washed coal usually contained less moisture than unwashed coal, because it was the dusty particles that held the moisture. Altogether, the schedule referring to coal seemed to give too large an allowance to the coal contractor. The amount of small coal allowed was too high.

Mr. G. W. O. HOWE remarked that it had already been pointed out in the discussion that the trouble due to the breaking down of the end coils of the stator windings of the induction motors was by no means new. Makers had for many years put extra insulation on the end coils of transformers and motors. He doubted whether the device adopted by Mr. Rider—viz., putting choking coils in series with the machine—was the best way out of the difficulty. He, the speaker, suggested another method by which all electrical shock to the motor winding would be prevented. In order to demonstrate the cause of the breaking down of the end coils, he showed some diagrams representing the hydraulic analogy. From these the first method which suggested itself to the speaker was to place a non-inductive resistance in parallel with the motor before closing the switch, tappings being taken from the resistance to the connections between the stator coils. This shunt could be made of high resistance, and need only be in use for a fraction of a second. It could be automatically disconnected by pushing the main switch home. Another and probably far preferable method was to put a number of condensers in series across the terminals and to tap off from the wires joining the condensers to the wires joining successive stator coils. These condensers could be fitted once for all and left permanently connected. His colleague, Mr. Irwin, who had independently hit on the same idea, would go into this method in more detail.

Mr. J. FIDDES BROWN (communicated) asked for information as to the weight and seating capacity of the cars, the average speed per hour and the consumption of energy per ton-mile.

Mr. W. H. COLLIS (communicated) referred to the Lister Drive station of the Liverpool Corporation. The output of the turbo-alternators (the neutral points of the stators being earthed on to the water mains) was carried to the switchboard by means of three-phase lead-covered and armoured cables, the armouring being earthed on to the water system. When several of the alternators were running it was found that there was a considerable circulation of low-voltage alternating current in the armouring of the machine cables, and, in fact, one of the cables was once found arcing to the metal hanger, due to the current passing through the hanger to the armouring of other cables. That had now been prevented by insulating all the cables from the metal hangers. The machines were of two types, and experiments showed that practically no interchange of current took place between similar machines. It was therefore decided to group the alternators into two sets, and so arrange the earth connections that either group could be earthed. In future only one group would be earthed at a time.

Mr. FORREST (communicated) was interested to note that, as 75 per cent. of the sub-station plant consisted of induction motor-generators, the author was apparently satisfied with the general superiority of that type of plant over rotary converters for tramway work. He (Mr. Forrest) thought there was nothing so good as rotary converters for rough-and-tumble work, and mentioned, as an example of their reliability, the case of Birmingham, where rotaries were used for both lighting and traction. There had not been a single machine or transformer failure during the 2¼ years they had been running. The best and safest way of overcoming the author's trouble with the end coils was to switch in through choking coils. If the author had used rotaries his sub-station efficiency would have been at least 7 per cent. better.

Mr. R. A. CHATTOCK (communicated) asked for further information as to what had induced Mr. Rider to adopt the opinion that generators should have no tripping relays of any kind. He, the writer, had now obtained a reverse current relay that could be relied upon to act under the condition of a failing field, and also of a reverse or motoring current; also it would be unaffected by any condition of forward current as long as the field current was normal. The arrangement had been installed by the B.T.-H. Co. at the Birmingham Corporation generating station. He was of opinion that with a pressure as low as 6,600 volts, earthing of the neutral point was not necessary. Greater expense was entailed on an earthed system.

Mr. LEONARD ANDREWS (communicated) discussed Mr. Rider's experiment of abandoning the original scheme providing for two generating stations more or less in the centre of the area of supply for one larger station entirely outside that area, but having the advantage of a waterside site. The results, at least so far as generating costs were concerned, were excellent, but possibly these were in a great measure due to the very high load factor. There were many who had closely studied the subject who thought that better results would have been attained if the original scheme had been carried out. After all, the settlement of such a weighty matter should not depend upon mere expressions of opinion, but upon actual facts. The only solid fact contributed to the discussion, having any bearing upon the matter, was Mr. Roger Smith's statement that he was paying a lower price for coal of greater heating value delivered at his works at Park Royal. The question could only be properly considered in its entirety, and for that purpose comparative capital charges, fuel, water and other running charges should be taken into consideration. It might, however, be useful to compare the information Mr. Rider had given with particulars available from various other sources as follows: *Generating Station Capital Charges.* In a recent Paper the writer was severely criticised for assuming a total capital expenditure of £14 per kilowatt installed complete with cooling towers, and was told that if a river-side site had been selected instead of cooling towers the capital outlay would have been considerably less. In view of this it was somewhat surprising that Mr. Rider's actual capital outlay of £23·63 per kilowatt installed for river-side plant was allowed to pass without comment. Cooling towers for dealing with an output equal to that of the Greenwich station could have been erected complete for less than £30,000. Taking interest and sinking fund at 7½ per cent., and adding 2½ per cent. for maintenance and repairs, the fixed charges on the cooling towers would amount to £3,000 per annum. Mr. Rider's expenditure on pier and river work had been over £60,000. The repairs on this would probably be much lower than on the cooling towers, and might be covered by ½ per cent. per annum, making a total annual charge of £4,800; but this did not cover the very heavy capital outlay incurred

in the elaborate strainers found necessary. On the other hand, it might be argued that some of the expenditure under this heading should be charged to coal-handling plant. One of the advantages of the original Camberwell site, however, was that an elevated siding would have been constructed, from which the coal could have been shot directly into the bunkers. It was probable, therefore, that the total cost of coal and ash-handling plant, under the original scheme, would not have amounted to more than Mr. Rider's cost of £18,500, plus the cost of the water strainers. It would be interesting to learn whether the very high capital outlay of £9·82 on land and buildings was attributable to the difficulty, often experienced when plant was erected on river-side sites, of obtaining good foundations. The ground space required for cooling towers of the capacity under consideration would be about 5,000 sq. yds. Assuming a ground rent of 1s. per annum, an additional expenditure of £250 per annum would be incurred under this heading. *Pumping Water.*—A disadvantage of cooling towers was the amount of energy expended in pumping water to the top of the towers. About 2½ million units would be required for dealing with the estimated output Mr. Rider gave of 91 million units per annum, and, taking the cost of the current at 0·34d. per unit, the annual charge under this item would be £3,240. Another serious item was the cost of the extra make-up water evaporated from the cooling towers. At the Camberwell site it was proposed to sink a well, from which the water required could have been obtained at an estimated cost of less than 2d. per 1,000 gallons. Thus, 28,000,000 gallons at 2d. per 1,000=£2,340. *Increased Fuel Consumption.*—The claim of a lower fuel consumption at a river-side station, owing to the lower temperature of the cooling water, did not appear to be borne out in practice. Mr. Rider's fuel consumption of 3·1 lb. of coal per kilowatt-hour, the calorific value of the coal being 12,500 B.Th.U. per pound, corresponded to a thermal efficiency of 9·05 per cent. The fuel consumption at the Pinkston station of the Glasgow tramways undertaking was 3·05 lb. per kilowatt-hour, the calorific value of the coal being 12,000 B.Th.U. per pound. The overall efficiency of the Glasgow plant was, therefore, 9·3 per cent., or higher than Mr. Rider's. The load factor of the Glasgow undertaking was only 37·5 per cent., against Mr. Rider's 47·75, and they obtained their water from a canal, the flow of water in which was very small, the result being that the temperature of the cooling water was often quite as high as it would be at the base of cooling towers. It appeared, therefore, that any advantage in this respect must also be abandoned. The above items showed, on the whole, some advantage in favour of water-side sites as compared with cooling towers. They must, however, consider, on the other side, the extra capital outlay on feeders with the extra transmission losses, and the cost of converting that portion of the total current which would have been generated as direct current if the stations had been placed in central positions. It was practically impossible for an outsider to estimate the high-tension feeder losses and extra capital charges. As, however, under the original scheme it was proposed to instal 6,000 kw., or 20 per cent. of the total plant, as direct current, at least 20 per cent. of the total output would have been generated and distributed as direct current. From a Paper by Mr. Snell, the cost of converting those units would be 0·122d. per unit, or £9,250. A balance-sheet would, therefore, show a debit balance against the water-side site of £5,220, excluding extra costs of transmission. Thus, at the time Mr. Rider started the Greenwich scheme there was little to choose, as far as generating charges were concerned, between the respective systems. Now, however, since the economy and reliability of large gas engines had been proved, the entire aspect of the problem had become changed. At present it would be possible to put down gas-driven generating stations (one south and one north of the Thames) at a lower capital outlay than had been expended on Mr. Rider's scheme, and to guarantee that the total annual running costs would not exceed £60,000 for the output covered by Mr. Rider's running costs of £92,208.

Mr. J. H. Rider said that although he would have preferred to have given his reply face to face with those who had discussed the Paper, he would have to defer it for the "Journal," as the reply to such a discussion as had taken place would occupy as much time as the Paper itself.

Mr. W. M. Mordey said it was a long time since three nights had been devoted to any one Paper, but the Council had given up this time because they thought the Paper was a very important and valuable one, and that they ought to take the opportunity of giving members a full opportunity of discussing it.

THE COMPOSITION AND DURABILITY OF CABLE PAPERS.

BY CLAYTON BEADLE AND HENRY P. STEVENS.

(*Concluded from page 61.*)

Summary.—Information at present available upon the desirable properties of paper from the insulating point of view is very meagre. The authors attempt to fill this gap by giving the results of their experience in dealing with such papers from the chemical point of view. The composition of manila and other papers is briefly discussed. Tests to which papers should be subjected are considered, and a number of tables of results are given. The effect of moisture is dealt with at some length, and the authors finally express their opinions on changes taking place when papers are in contact with the atmosphere and when they are protected from it.

Coming to the subject of the composition of the papers of which we have given the physical tests, and taking first of all the amount of ash, we find that as a rule the amount of ash is least with those containing wood pulp and greatest on those papers consisting of manila or "hemp stock." Thus, No. 9, which consists entirely of wood pulp, contains 0·58 per cent.; those which are mixtures of wood pulp and hemp stock are mostly under 1 per cent., and those which are all hemp stock average about 2½ per cent.; the highest have 4·6 per cent.

The colours of the ashes of those papers which consist either wholly or for the most part of wood are, as a rule, much lighter than those containing a preponderance of hemp stock.

One thing may surprise us in Table C, namely, that they represent papers all of which are supplied to cable manufacturers who tender for a pure manila hemp paper. In this table it will be seen that there are 13 different papers; out of this number seven contain a preponderance of wood, that is 70 per cent. and upwards, six only are free from wood. One, No. 9, consists entirely of wood pulp, and another, No. 8, contains as much as 95 per cent.; the rest contain 70 per cent. and upwards. All those returned as hemp stock contained varying proportions of manila not given in some, the manila would not amount in some cases to more than half the weight of fibres under hemp stock, and a considerable proportion of the fibres in some consisted of jute. This set are not picked, but taken at random and represent the ordinary run of compositions of papers as supplied as manila paper and therefore reveal the importance of making a proper examination of such papers.

A comparison of Tables B and C furthermore assists us in forming some opinion as to the relative strengths of papers made from wood pulp, or mixtures of wood pulp and hemp, and paper containing manila, &c. Taking the first, Nos. 1 to 5, Table B, columns 10 to 12, these are papers containing 70 to 85 per cent. of wood pulp, the "actual" strength (column 10) varies between 9,400 and 16,500, giving an average of 12,500 for a paper of an average composition of 75 per cent. chemical wood and 25 per cent. hemp stock and an average thickness of ·134 mm. This figure is practically the same as the actual strength of the whole lot of papers. The only paper consisting wholly of wood pulp is No. 9; this has an actual strength of 14,000, and has a specific strength of 3,000. Looking at the papers consisting all of hemp, &c., and comparing their strength with that of the papers containing wood pulp, it would appear that the strongest papers of all are those consisting of a mixture of hemp and wood pulp, and these are stronger either than wood pulp alone or hemp alone. But these remarks must not be regarded as conclusive but only true of these commercial papers, for the simple reason that certain kinds of wood pulp produced much stronger results than others, and it would be possible to produce a wood pulp paper stronger than any of those recorded in the above table. Furthermore, if one wanted strength alone, and disregarded other qualities it would be possible to do the same with hemp or manila, so that it is not possible to say which of

Tab e C.

Mark.	Ash. Per cent. 1	Ash. Colour. 2	Sizing. 3	Fibrous constituents. Approx. composition. Wood pulp. p. cent 4	Fibrous constituents. Approx. composition. Hemp stock, manila, &c. per cent. 5
1	0·40	Pure white	Unsized ...	70	30
2	0·80	Greyish white.	Unsized ...	85	15
3	0·68	Greyish, nearly white	Well sized...	75	25
4	0·62	Pure white............	Well sized...	75	25
5	1·00	Reddish white	Well sized...	70	30
6	3·48	Brown, spongy	Sized.........	...	100
7	1·62	Whitish grey	Partly sized	...	100
8	0·70	Warm brown.........	Not sized ...	95	5
9	0·58	Brownish white......	Not sized ...	100	...
10	4·60	Whitish grey	Very slightly sized	...	100
11	2·40	White	Not sized...	...	100
12	2·50	Greyish white	Not sized...	...	100
13	1·70	Reddish white	Not sized...	...	100
Mean	1·62	...	...	44	56

the two would give the greater strength. On the whole, in making large quantities of paper, we should expect a greater uniformity in the case of wood pulp than in the case of hemp stock. This will be better understood by referring to the remarks made at the beginning of the article. We repeat, however, that it has not yet been proved that manila papers can be produced stronger than the strongest chemical wood paper, and we might further point out that the strongest papers we have so far ever come across are made from flax fibre, but they belong to another and a higher class of product.

Seeing that jute is likely to find its way into cable papers either by accident or design we think it as well to here emphasise the differences, both chemical and physical, between jute and manila.

Jute.—The raw material for paper is obtained either from the refuse from jute spinning, or from old packing material (coffee sacks and the like). The elementary fibres of jute are lignified and united in larger or smaller bundles. During the manufacture the bundles may be more or less disintegrated into single fibres, so that both forms may be recognised in a microscopical examination of the paper. The lumen of the jute fibre is characteristic, being in part nearly as wide as the fibre and then contracting to a very narrow channel.

Manila.—Old ship's tow forms the crude material used for paper. As in the case of jute, though less frequently, the fibres in the paper are sometimes united into bundles. The lignin in the elementary fibres is present in so small a proportion as to be readily removed by boiling with alkalis. Jute fibres are generally empty, whilst manila fibres frequently contain protoplasmic masses, which give a yellowish-brown colour with iodine in potassium iodide, and a lemon-yellow colour with iodine zinc chloride. The fibres do not show sudden changes in diameter, and their ends frequently have the form of a lead pencil point, or of a bulb with a fine point.

The table below shows the comparative characteristics of the two fibres.

For the last two years there appears to have been a tendency towards a more uniform composition of a cable paper. At one time they were taken from ordinary stock by the paper maker, now they are more uniform in texture. The composition that we generally meet with is about two-thirds fibres of the manila class mixed with one-third chemical wood fibre; this we have met with in different parts of the British Isles, both with paper submitted to us by cable makers, and paper stripped off cables laid down by public and private undertakings for electric mains. There appears to be a general recognition now that paper need not consist entirely of manila. This the cable makers and users are willing to submit to, and this entirely endorses our views as far as we are able to form an opinion. Thus, if manila is to form the mainstay of cable papers until, say, the purest form of chemical wood fibre has been proved of equal value, during the interregnum, we can see no harm in utilising up to one-third of best chemical wood fibre, provided that the rest is manila or hemp, but we should like to see jute excluded as far as possible. Well treated rags would, of course, be permissible, provided that they are properly treated in the mill so as to produce a pure paper, as rags are as durable as manila itself. Rags are, however, not likely to be used, as strong rags are more expensive than manila. Chemical wood is the fibre that the paper maker would like to see take the place of manila.

The question sometimes arises as to whether a cable is insulated with paper "free from all injurious particles" or whether the impregnating material is free from acids or contains anything that might produce corrosion of the copper conductor or anything that might destroy the lasting qualities of the paper. This may be a question quite apart from the quality of the paper itself, because the best paper might become useless if the impregnating material contained acid substances.

Although the impregnating material may not actually contain such substances as an impurity, it might be of such a nature as to develop rancidity, which in time would act upon and corrode the copper conductor and produce soluble copper salts and impair the insulation. We have already met with such impregnating materials, and, unfortunately, they are used extensively. Under such circumstances, what is the use of durable paper if the impregnating material is not suitably chosen.

Sometimes it is specified that the cable should be free from "chlorine or residual chemicals." This evidently has reference to the paper used. It is quite a fallacy to assume that any paper contains chlorine, which means "free chlorine," but it may, and frequently does, contain chlorides such as sodium magnesium and calcium chlorides in extremely minute quantities; furthermore, it contains minute traces of sulphates, such as aluminium and potassium sulphates. Such substances are present in such minute quantities that there is no fear of their acting upon the copper conductor beyond dissolving a minute quantity of copper. It is the acidity that might be developed by the insulator itself that is to be feared. The action of minute traces of metallic salts would, in our opinion, be entirely arrested by the impregnating material.

In order to determine whether the paper itself contains the impurities or whether they emanate from the impregnating material it is advisable to have some of the paper before impregnation, but, of course, this cannot be done except in a few cases.

In four papers stripped from cables which were recently sent us for examination, after extracting the material used in impregnating the papers in question, we made an examination to determine the nature of the fibrous constituents. The four papers are practically identical as regards the nature of the fibres. The paper consists of a mixture of manila and hemp fibres to the extent of about two-thirds their weight, the remaining one-third consists of chemical wood pulp.

It is impossible to ascertain whether the papers in question are free from all metallic particles, traces of chlorine or residual chemicals, from an impregnated sample. The material used in impregnating the papers renders such an investigation impossible, when the cable only is sent for examination. Small pieces and narrow strips are really insufficient, and it is next to impossible to distinguish between the impurities imparted to the paper by the insulating compound and the impurities contained in the paper itself before the insulating compound is added. To form some idea of the likelihood of impurities in the papers above referred to, we reduced them to ash, which was examined, with the following results:—

	Ash on weight of impregnated paper.
1.	0·77 per cent.
2.	0·90 „
3.	0·82 „
4. Uncoloured	1·10 „
4. Coloured or outside portion (mean)	3·87 „

It should be mentioned that all four samples of paper on examination under the microscope were found to consist

Fibre.	Colouration. Iodine in Kl.	Colouration. Iodine in $ZnCl_2$.	Lumen.	Ends.	Pores.	Subsidiary constituents.
Jute, with lignin	Bright yellow brown or brown	Yellow or yellowish brown	Frequent change in diameter	Usually rounded	Openings parallel to axis	None
Jute without lignin	Grey, sometimes brown	Blue, sometimes reddish violet	Ditto	Ditto	Ditto	Ditto
Manila	Grey, brown, or yellowish.	Blue, reddish violet and yellow, with intermediate shades	In thick walled fibres of varying breadth. In thin walled fibres, regular	Frequently pointed like lead pencil	Openings oblique or parallel to to axis	Groups or single parenchyme cells with fairly thick oblique walls

approximately of two-thirds manila fibre and one-third chemical wood pulp. No. 1 gave a white ash containing traces of iron, alumina, but no copper or lead, &c. No. 2 gave a white ash containing no iron, copper or lead, but traces of alumina. No. 3 gave a light brown ash containing iron and alumina, no copper, but traces of lead. No. 4, uncoloured, gave a white slightly brownish ash containing iron, alumina and copper. No. 4, coloured, gave a greyish brown ash containing iron, alumina, copper and lead.

We were surprised to find lead and copper in two of these samples. Furthermore, we found the ash of the impregnated No. 4 coloured to vary between 3¾ per cent. and nearly 5 per cent. Of course, traces of iron and alumina are the normal constituents of the ashes of a pure manila paper, and therefore would be derived probably from the paper itself, but the presence of iron and copper was at first a mystery to us.

The presence of copper may be due to contact with metallic copper. On later samples we have arrived at the cause of the presence both of soluble copper and lead.

We recently received two papers for examination which had been stripped off some electric cables as representing the material used as the dielectric. They were extracted with solvents to remove the impregnating material, with the following results :—

	No. 1.	No. 2.
Impregnating material (bone dry) ...	49·38 per cent. ...	43·19 per cent.
Paper (bone dry) ...	48·79 ,, ...	56·70 ,,
Volatile matter and moisture (by diff.) ...	1·83 ,, ...	0·11 ,,
	100·00	100·00

It appears evident to us from the above that No. 2 in particular is bone dry in vacuo before impregnation. If it was not so the figure for volatile matter and moisture would have been higher, say, anywhere up to 5 per cent., and, furthermore the low figure proves the absence of moisture in the impregnating material. As these determinations were done on samples of impregnated paper after exposure to air showing a low figure for moisture, &c., a further point is established, namely, that such materials have only a limited capacity for moisture, so that if preserved dry in the first instance they remain dry.

We carefully examined the nature of the extracts constituting the impregnating material, the so-called acidity in terms of resinous acids we found to be in the case of No. 1 44 per cent. and in No. 2 47 per cent. With rosin oil we should expect to find about 40 per cent. The impregnating material has therefore every appearance of being a preparation of rosin oil.

The ashes of the impregnating paper (*i.e.*, paper as received) were determined, with the following results :—

No. 1.		No. 2.
1·03 per cent.	...	2·16 per cent.

The two ashes were found to be similar in composition, consisting for the most part of lime and also containing iron, alumina and lead. All but lead are the ordinary constituents of the ashes of the best cable papers. The paper is enclosed in a lead sheath, and the impregnating material may have dissolved a small amount of the lead. We have noticed traces of both copper and lead in such papers when impregnated with rosin oil, but the amount is too small, in our opinion, to have any effect upon the dielectric qualities.

These papers, after extraction of the impregnating material, were microscopically examined to determine the nature of the fibres, the following is our estimate of the composition of each. The figures, of course, are only approximate :—

	No. 1.	No. 2.
Manila and hemp ...	40 per cent. ..	73 per cent.
Chemical wood ...	37 ,, ...	16 ,,
Jute and straw, &c. ...	23 ,, ...	11 ,,

It will be seen from the above that No. 2 is a much purer manila paper, in fact, in our opinion, it is a very good paper indeed, in spite of the fact that it contains a certain proportion of chemical wood and jute.

Portions of the extracted paper were tested for tensile strength, with the following results (expressed in pounds per inch width) :—

No. 1.		No. 2.
41·5 lb.	...	48·5 lb.

It is evident therefore that paper No. 2 is about 16 per cent. stronger than paper No. 1. Measurements were made of the length of the ultimate fibres, with the results as follows (each figure being the mean of 40 measurements) :—

No. 1.		No. 2.
1·75 mm.	...	2·04 mm.

Therefore No. 2 is about 16 per cent. longer in fibre than No. 1, and may be regarded as a very fair length in comparison with a good class of cable paper. On taking measurements of the thickness of the paper both before and after extraction, we noticed that No. 2 is upwards of 20 per cent. thicker than No. 1.

From all points of view we regard No. 2 as a superior paper to No. 1, and should expect it to be also a very good dielectric, and as far as the paper is concerned, *i.e.*, unimpregnated material, we should regard it as a very permanent nature, and would expect it to be less deteriorated through course of time than with No. 1.

We should have felt inclined to have given a favourable opinion on the lasting qualities of No. 2 paper under ordinary conditions, but these cables were required to stand a considerable temperature, for they pass in ducts not far from steam pipes and are required to stand a temperature of about 160°F. at times. In order, therefore, to make sure on this point it was considered advisable to test some of the paper in question at about this temperature with a view to seeing whether any appreciable deterioration is likely to result.

The two impregnated papers were carefully wrapped in black paper and placed in sealed bottles and exposed for a number of days at temperatures as under :—

Date, 1908.	Degrees Centigrade.	Degrees Fahrenheit.
February 16	54	129
,, 17	54	129
,, 19	69	156
,, 20	64	147
,, 20	70	158
,, 25	76	169
,, 29	70	158
March 2	70	158
,, 3	67	153
,, 5	75	167
,, 6	73	163
,, 6	81	178

Time of exposure to heat 18 days and nights.
Mean temperature during period ... 79°C. = 174°F.
Maximum do. do. ... 81°C. = 178°F.
Minimum do. do. ... 54°C. 129°F.

The variation in temperature was purposely made as far as possible to imitate the conditions in practice.

The above papers No. 1 and No. 2 were extracted and tested for stretch and strength both before and after heating as above. Space will not permit us to give details, but the result showed no deterioration whatever on either sample as the result of the above heating.

A further exposure was made (*see* table on p. 87).

This treatment was purposely more drastic in order to find out whether more elevated temperatures injured the physical qualities of the paper. Each of the papers after this treatment was freed from solvent by treatment with cold coal tar naphtha which completely removed dielectric. They were, after resting for 24 hours, each of them tested for stretch and strength against extracted papers in each case that had not been heated.

Attempts were made to exhaust with ether and other solvents in a soxhlet fat extraction apparatus, but this even in large size apparatus does not yield sufficient quantities of extracted paper for testing, and, moreover, as our tests appear to show, the paper extracted in soxhlet appears to be reduced in strength by the extraction process; whereas, the cold extraction with several treatments with cold redistilled coal

Date, 1908.	Time.	Degrees Centigrade.	Degrees Fahrenheit.
March 3	5·30 p.m.	83	181
,, 10	9·0 a.m.	81	178
,, 11	9·0 a.m.	83	181
,, 11	5·0 p.m.	77	171
,, 12	9·0 a.m.	81	178
,, 12	5·40 p.m.	87	189
,, 13	9·0 a.m.	85	185
,, 13	6·0 p.m.	93	199
,, 14	9·0 a.m.	83	181
,, 16	9·0 a.m.	93	199
,, 17	9·0 a.m.	85	185
,, 17	6·0 p.m.	88	190
,, 18	9·0 a.m.	90	194
,, 18	6·0 p.m.	90	194
,, 19	9·0 a.m.	88	190
,, 19	6·0 p.m.	89	192
,, 20	9·0 a.m.	84	183
,, 20	6·0 p.m.	87	189
,, 21	1·0 p.m.	90	194
,, 23	6·0 p.m.	91	196
,, 24	9·0 a.m.	101	214
,, 24	6·0 p.m.	103	217
,, 25	9·0 a.m.	85	185
,, 25	6·0 p.m.	84	183
,, 26	9·0 a.m.	86	187

Time of exposure to heat, 36 days.
Maximum temperature..........................103°C.–217°F.
Minimum do. .... 81°C. 178°F.
Mean do. ....87·5°C.=189°F.

tar naptha is more effective in every way, and can be done in much less time, especially in cases where rosin oils are among the chief ingredients.

We are anxious to find whether any researches conducted at the National Physical Laboratory would throw any light upon the subject of the durability of papers in this connection. Mr. Albert Campbell, whose researches on the insulation of cable papers we have followed with very much interest,* has not studied the physical and chemical qualities of the paper after impregnation; his tests on paper had reference to telephone cables in which the paper is dry and without any impregnation of any kind. If the insulation goes down, the common remedy is to drive dry air through the whole length of the cable. Paper cables for lighting and power, on the other hand, such as those we have at present under consideration, are always impregnated. On account of the hygroscopic nature of the oils, &c., used, all joints have to be most carefully sealed against the atmosphere otherwise insulation would gradually deteriorate. Mr. Campbell informs us that he has found rosin oil a good insulator, but he expects it and some of the other oils sometimes have a slightly acid reaction, and he says that he doubts whether the action on the lead and copper would really lower the insulation. This is a point which requires careful investigation.

On the subject of rosin oil in impregnated papers as a possible cause of deterioration, we have been in touch with Signor E. Jona, of Messrs. Pirelli & Co., Milan, who is an authority on these matters. We pointed out to him that, as a result of our tests, deterioration of the paper takes place when the heat tests are made under the influence of the atmosphere, but he points out to us that these cables being always lead-sheathed never come in contact with the atmosphere, and suggested that this may be the reason why no deterioration has been noticed in practice. This agrees with our results. Thus we have found that, even at elevated temperatures out of contact with the air and with papers of proper composition even for 36 days' treatment there is no deterioration.

However, we find that with impregnated papers containing oxidizable fibres even out of contact with the atmosphere, there is in this period some deterioration.

With good manila impregnated papers in contact with the air for the above period and temperatures there is some deterioration.

With impregnated papers exposed to air containing oxidizable fibres for the above period and temperature there is very marked deterioration.

We cannot find any publication whatever on the subject.

One of the largest firms of cable makers informs us that it never occurred to them in cables so impregnated that deterioration of the paper might be found; in fact, it was a point that they had not investigated.

Signor E. Jona wrote us on the subject. We give it in his own words:—

"I tested, however, some time ago, paper tapes impregnated with rosin oil, the proportion of rosin being 20 per cent.; these paper tapes were left during 100 consecutive hours in a heated air current, at the temperature of 70 to 75°C.; further, the oil was extracted from the paper by means of cold benzol, and the paper tapes, after such a treatment, when put in comparison with the original paper tapes, did not present any deterioration."

Our physical tests throw further light on this point, as we can record deterioration, if such exists, by actual tests of strength and stretch. It would be interesting, however, to note any alteration for periods of months or years and at less elevated temperatures than those recorded by us. We are now investigating the solvent action of rosin oil in admixture with other oils upon copper conductors.

* "On the Electric Inductive Capacities of Dry Paper and Solid Cellulose." "Proceedings" of the Royal Society, A, Vol. LXXVIII., 1906.

ARTISTIC ELECTRIC FITTINGS.

The present arrangement of our solar system makes the use of some kind of artificial lighting an absolute necessity in this country during a certain proportion of the 24 hours, though the conditions of living in large cities cause these methods of illumination to be used to a greater extent than is perhaps absolutely necessary. Mr. William Willett is endeavouring to change this, at any rate in the summer time, though his efforts at thus alleviating our lot are not welcomed in all quarters. But whatever be the result of his Daylight Saving scheme, artificial lighting will still have to be used very widely and during the greater part of the year.

Fig. 1.
"Benson" Fitting as Table Lamp.

This being the case, the next thing is to seek for the best method of artificial illumination, and this being found we should then try to employ it in the most efficient way. A detail which, there can be no doubt, makes all the difference in the benefits derived from artificial lighting is the proper design of the fittings in which the source of light is to be placed. Our forefathers, with very limited means at their disposal, were, in fact, able so to arrange their artificial lighting that they did not detract from, but rather added to, the decorations of the various rooms. This point requires no elaboration, for many of these old-time fittings are being adapted for use with the electric light, without any loss to their general artisticness.

On the other hand, regrettable though it may be, the present-day lighting fitting is generally not "a thing of beauty and a joy for ever"; more often than not, in fact, it is a distinct eyesore, both from an artistic and illuminating point of view. That there is really no reason why this should be the case is proved by the number of

makers who are now turning out fittings with which no fault can be found under these heads. Whether modern electric light fittings made *d'après* Louis XIV., or *d'après* anybody else, are true art is a matter which need not be discussed here, but at any rate they are more pleasing to look at than certain goods which are sometimes disrespectfully termed "Brummagem" ware, but which usually know little of Birmingham as their source.

We mentioned above that even in this utilitarian age there exist certain firms who are turning out artistic electrical fittings. Among these may certainly be included one of our oldest established electric fittings firms, W. A. S. Benson & Co., whose showrooms are in New Bond-street, London, and whose works are at Hammersmith,

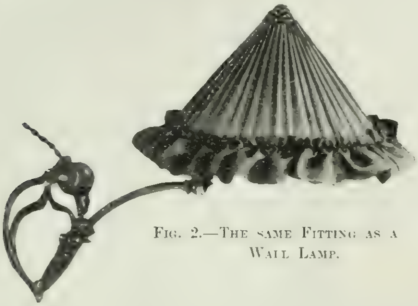


Fig. 2.—The same Fitting as a Wall Lamp.

both districts being "west of Temple Bar." This firm claim that in their fittings sound construction is combined with artisticness, so that they will not only wear but also look well.

In order that our readers may judge of these claims we illustrate a sample of their fittings in Figs. 1 and 2. This fitting can be used as either a table lamp or wall bracket. It is fitted with a double joint, an adjustable shade and a "Benson" switch. Special attention may be called to this last mentioned detail which is supplied with the majority of the portable fittings made by Messrs. Benson. It is designed in a very generous manner, there being plenty of both insulating and current carrying material. The switch itself is fixed in a cylindrical metal case with removable ends, and is actuated by

Fig. 3.—Another "Benson" Table Lamp.

an ivory spindle which moves in the direction of the axis of the cylinder. In the case of the fitting illustrated, this switch also acts as a counterweight. It is therfore possible to place the lamp at the edge of a table or piano and to extend the jointed arms to the fullest extent without there being any fear of it toppling over. Great care is expended on the finish of these lamps, and attention is specially paid to making a strong mechanical job of the joints and other details. Insulating bushes are provided at points where the "flex" comes into the open, as at the joints, and where there is any liability of it rubbing against metal.

As regards the financial details of these lamps we may say that they are very cheap, considering the work that is put into them. Further, the listed price includes the wiring, which is done with standard Cable Makers' Association "flex," lengths of 4 yds. being supplied with table lamps and 7 yds. with floor lamps. Shades and lampholders are also included.

Fig. 4.—Piano Fitting.

A table lamp of rather different design is shown in Fig, 3. It is, as will be seen, carried on a tripod, the Benson switch being in this case fixed to the central stem. One of the feet of the tripod is formed into a hook, so that the lamp can be suspended from a bed rail, while the leg on which this hook is fixed is slotted out, so that the lamp can in its turn be suspended from a wall hook.

The lighting of a piano is a problem to which Messrs. Benson & Co. have paid some attention. In many cases it is difficult so to arrange the light that it illuminates the music efficiently without interfering with the performer should he turn his head. This difficulty is specially noticeable in the brackets usually provided. To

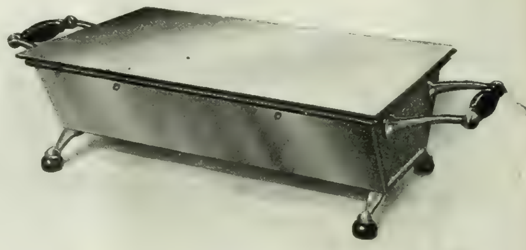


Fig. 5.—"The New Use for Old Lamps" Heater.

get over this trouble the bracket shown in Fig. 4 has been designed. It is arranged to clip on to the music stand, and is fitted with an adjustable reflector and "Benson" switch. A tubular lamp is used with this fitting.

The three examples of Messrs. Benson & Co.'s lighting fittings illustrated herewith by no means exhaust their stock. A glance

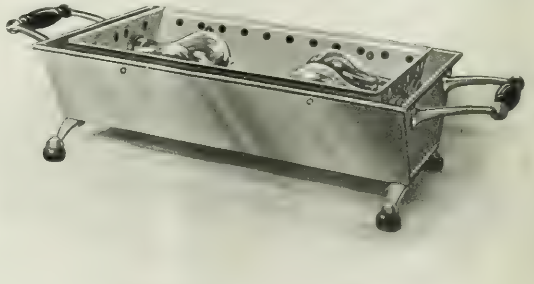


Fig. 6.—The same with Cover Removed.

through their catalogues will show that they are well to the front in originality of design and in maintaining all their goods at a unform high finish. Some artistic table and floor standards may be specially noticed. These are fitted with one or more lamps and form an excellent method of illuminating a room in a satisfactory fashion.

Besides electric light fittings Messrs. Benson are also turning out electric cooking and heating apparatus. One of their patent elec-

tric breakfast heater is shown in Figs. 5 and 6. This heater is of special interest from the fact that it forms a means of using up old lamps whose illuminating properties are not what they might be, but whose heat-giving properties are unimpaired. This heater measures 15 in. by 9 in., and, as will be seen from the illustrations, is fitted with four lamps contained in a special box directly under the top cover of the apparatus. Current is supplied through a flexible wire to a double plug connection whereby either two or four lamps can be used at once. Diagonally opposite lamps are arranged on the same circuit, so that an even heat over the whole radiator surface is obtained, when only two lamps are in use. This heater is supplied with insulated feet and handles, so that it can be stood on the breakfast table, while its high finish in either electro or polished copper or pewter plate makes it quite an adjunct to the table furniture. These heaters are made in both larger and smaller sizes; the smallest of all is round in shape and contains only one lamp. It is specially recommended for warming a single dish or plate or other small work.

Besides these specialities in the way of heaters, Messrs. Benson also supply the ordinary lamp type radiators in a number of new designs, all the features of their apparatus, both as regards wiring and finish generally, being also included in this equipment.

Messrs. Benson, at their showrooms in Bond-street, are exhibiting a great many other designs of electric fittings, all of which it is impossible to describe and illustrate here. We must, however, thank Mr. C. J. Scott, managing director of the company, for spending a great deal of time on the subject with us, and for lending us the necessary photographs and blocks for illustrating the article. We passed a most interesting time going round the showrooms, both from the artistic and technical point of view.

A NEW SYSTEM OF WIRELESS TELEGRAPHY USED BY THE TELEFUNKEN COMPANY.

BY COUNT ARCO.

Summary.—In this article the author describes a new system of wireless telegraphy, which is a compromise between the "spark" and the "arc" systems. Technical details of the equipment used are not given, but its practical and technical advantages are fully discussed. Among these are that the use of small antennæ is possible, a high efficiency is obtained and large powers can be employed, while electrically the arrangement is much more free from disadvantages than are the older systems. There is very great freedom from disturbance, and messages can be made quite "private," while the signals are transmitted as clear musical tones.

After it had been discovered that by means of the Poulsen arc it was possible to generate undamped oscillations of considerable energy, several scientists, especially those of a theoretical turn of mind, were inclined to lay too much stress on the advantages of this system, and the opinion was expressed in several quarters that undamped oscillations obtained from arc lamps would replace the other methods of generation within quite a short time. Practical men spoke against this enthusiasm, and drew attention to the numerous disadvantages present in the new system. To-day, scarcely three years after this period, it cannot be denied that the warning of the practical men was justifiable, and that the disadvantages of the arc lamp are even greater than the greatest sceptics thought. Not only from the practical point of view has the system been found disadvantageous, on account of the heavy upkeep and the many complications, but from a purely electrical point of view as well the position is the same. Of the energy generated at the sending end only a small fraction—at most one-tenth—is converted into electrical oscillations. For this reason both apparatus and machinery must be large and heavy. Moreover, the theoretical advantage—great freedom from disturbance from other stations and from atmospheric effects—is not obtained in practice.

Within the last year the Telefunken Company have designed a new system which is a compromise between the spark system of Marconi and that known as the undamped oscillation system. This new system is known as the "singing spark" (tönende Funken) system.

As regards the technical peculiarities of the new system, it may be said that it depends on spark methods, which in themselves depend on the principle published in December, 1906, by Prof. Max Wien and called by him "Stosserregung." This name has been changed by the Gesellschaft für Drahtlose Telegraphie to "quenched spark" (Löschfunken). This principle has been so perfected by the company that the sparks follow each other equally and regularly; so regularly, in fact, that they give out a clear musical tone, and to this system the name of "singing spark" has therefore been applied.

The first two types of station constructed by the company are: (i.) A ship or land station having a capacity of from 0·5 kw. to 2 kw., and suitable for both large and small ships as well as for portable military stations. It has a radius of action of 62½ to 500 miles both to land stations and ships. (ii.) The largest ship station at present erected, having a capacity of from 8 kw. to 10 kw. With this type it will be possible with standard ship antennæ, under favourable conditions, to transmit 1,875 miles, a distance which has never before been reached from ship to ship. The same station is also suitable for work on land with correspondingly larger antennæ.

The practical and technical advantages of the new system over the older spark methods, as well as over the undamped arc oscillations, are summarised in the following paragraphs:—

1. Singing sparks allow the work to be carried on with considerably smaller antennæ than do the usual wireless systems. The reason for this lies in the speed with which the sparks follow each other in the secondary circuit, thus making it possible to transmit greater power from the antenna at a smaller maximum voltage than formerly. For this reason the new system is specially suitable when it is necessary to transmit over long distances with small antennæ. Theoretically this should also be the case when arc lamps are used, as for a given amount of energy the voltage lost in the antennæ is a minimum. Practice, however, has shown that with arc lamp installations the maximum height of mast must be employed, say, from 300 ft. to 330 ft., while with the new system the same distance can be covered with masts about half this height. The reason for this contradiction between theory and practice is explained by the fact that the nominal oscillation energy from the arc lamp can only be generated when the wave length is very great, which means high antennæ. On the other hand, singing sparks work as well with the smallest as with the greatest wave lengths.

2. Singing sparks allow a high machine efficiency to be obtained, for, according to the size and suitability of the apparatus, from 50 to 75 per cent. of the machine output can be changed into energy at the antennæ. With the old spark systems the maximum figure was 20 per cent., and in the arc lamp arrangement 10 per cent. In places where current for working the station has to be specially generated, this superiority obtained by using singing sparks will lead to a considerable decrease in the working costs. Further, it is specially advantageous where questions of weight and volume have to be considered, since in small ships and portable stations with this system the power and weight for an equal range is only about a quarter that needed for arc lamp stations. On account of this great efficiency another advantage arises. The wear and breakdowns of the apparatus are small, because of the small heat losses present, while regulation of the spark length, or of any other important part, of the new sender is hardly ever necessary. On this point Dr. Kiebitz has remarked that "in the singing spark system we may have a final solution to the problem of high frequency generation."*

3. With the new system it is possible to build senders as large as may be desired without any such limitations (*e.g.*, in the wave length) or difficulties (*e.g.*, in the constancy of the oscillations) as occur when a large amount of energy is transmitted. The new system behaves quite like the spark method, in which power as great as 100 kw. can be transformed into oscillations (though at a very low efficiency). It works better than the arc method of generation, for in this system if a large amount of energy is used, there not only is excessive damping on the long wave lengths, but irregularities of many kinds creep in, because at very high voltages and currents an arc lamp is unsteady, and the great development of heat gives rise to a rapid burning away of the electrodes. As, moreover,

* "Elektrotechnische Zeitschrift," 1909, No. 10, pp. 222, *et seq.* Abstracted on p. 99 of this issue.

these inconstant conditions in the arc have an influence on the frequency the system is put at a still further disadvantage. Such alterations are much more likely to occur at large stations, and it has been up to date impossible to instal this method of working for plants of large size.

4. The sender in the singing spark system is almost as noiseless in its working as is the arc lamp.

5. The sender transmits only one wave, and is thus different from the spark sender, which transmits two coupled waves. This fact marks a great step forward, as the receiver is able to utilise the total sender energy, and, owing to the disappearance of the two coupled waves, multiple telegraphy is made much more easy. Under such conditions numerous stations can work undisturbed close to each other.

6. The wave sent out by the singing spark shows a very small damping, *viz.*, between 0·08 and 0·025, thus enabling a very sharp tuning and great freedom from disturbance in the receiver to be obtained. The freedom from disturbance may, according to circumstances, be much greater than that obtained with undamped oscillations. It varies, under conditions to be hereafter described, from 2 to 5 per cent.

7. These singing oscillations remain absolutely constant and are independent of the arrangement and mechanical properties of the spark gap and very much greater freedom from disturbance can be obtained than with the arc lamp. In the latter the greatest freedom is theoretically from ½ to 1 per cent., because the frequency does not depend upon the electric constants of the circuit alone, but on the arrangement, length and properties of the arc. So long as the principle of generating undamped oscillations has to depend for its frequency on so variable a value as an arc lamp, ideal freedom from disturbance will never be obtained. In spite of the control of the resonance by means of a wave measurer, the frequency of the arc lamp alters, and a choice has to be made at the receiving end between a highly untuned receiver, whose intensity constantly varies so that certain telegraphic working is difficult, and a receiver very slightly free from disturbances, in which the total employment of the resonance is renounced so that the range is reduced. Arc lamp practice requires that the latter method should be chosen. The real freedom from disturbances of undamped waves reaches only 5 to 6 per cent., and even this, from the fact which we mention below, is seldom obtained in practice.

The freedom from disturbances of 2 to 5 per cent. obtained with singing waves may be understood by considering the following example: At the three angles of an equilateral triangle, ABC, three stations of equal power are placed, A and B being fitted with senders and C with a receiver. C can then, as desired, receive from A or from B when these have a difference of wave length of only 5 per cent. This condition depends on the fact that the distance apart of the three stations is as great as possible for the energy available, so that the telegrams will not arrive at C with very great intensity. If the distance apart of the three stations is reduced to one-half that mentioned above the senders at A and B can be made different by 3 per cent. instead of 5 per cent., or by still smaller differences if the distances are still further altered. When speaking of freedom from disturbances, it is understood that the percentual differences which must necessarily be present at the maximum range are included.

8. Singing sparks allow a large scale of oscillations to be obtained, while with the old spark stations only certain fixed waves could be sent out; and, on account of electrical resonance, the scale of waves could only differ from the fundamental of the antennæ by about double the wave length. It is possible with this new system to obtain oscillations of wave lengths four, five and even six times as long as the fundamental, though the range gradually decreases. This new system behaves exactly like the arc lamp system, except that the singing oscillations have the advantage that antennæ with very small fundamentals can be used, while with arc lamps these large scales of oscillations can only be employed with very high masts and long antennæ. The generation of the different oscillations can be obtained on the new system in a very simple way by using the regulating arrangement known as a variometer, and without the use of a wave measurer being generally necessary.

9. As mentioned in § 8, the system allows very short oscillations to be transmitted. Short oscillations are, however, more absorbed on the way, though this apparent disadvantage is often a very great advantage from the military point of view. Suppose a message is sent with very short oscillations to a station 50 km. away, and is received with great intensity. The enemy at a distance of, say, 100 km., would scarcely be able to pick up anything, even with the most delicate instruments, while the behaviour of longer waves is quite different. Over open country, distances of over 200 km. to 300 km. can be covered by these waves, and they possess the advantage that a listener a little further off cannot understand anything. It is, further, possible by using quite short waves to remove the instrument from the operations of large stations which only work with long waves. The use of short waves, also, predicates an extraordinarily high antennæ efficiency, as, on account of the more speedy transmission of energy with short waves, the maximum energy for a given antennæ can be increased.

10. The system of singing sparks allows under all circumstances, unlike the arc lamp, full freedom from disturbance, as the intensity of the oscillations can be regulated in a most simple fashion between wide limits. Even with a station having a range of several thousand kilometres, the intensity can be so reduced that telegrams will only be heard over a distance of 100 km., and, further, "tapping" by unauthorised persons is made very difficult and the freedom from disturbances is greatly increased. Take, as an example, that given in § 7. Suppose the range of a sender, say, at B to be reduced to one-hundredth of the distance from B to C, a 5 per cent. freedom from disturbance will become, perhaps, 30 per cent. if B does not reduce its sending intensity. To do this is quite possible with the new system, while regulating an arc lamp on a small current leads to an unsteadiness of the flame and makes the apparatus work badly. It is, therefore, not very correct to speak of a freedom from disturbance of 5 per cent. with the arc lamp when in many cases a freedom from disturbance of only 20 to 30 per cent. is really obtained.

11. Perhaps the greatest advantage of the new singing spark is the fact that the signals are transmitted as clear musical tones. Musical sparks have already been often proposed and also partly developed, but the tone cannot be made clear, and only by the absolute clearness and regularity of sound were the above results obtained with the new system. With audible working from the old spark stations the signals in the telephone were received as ticks. Each time the spark passed the membrane moved, while with the arc lamp similar noises were also obtained. Similar phenomena are noticed with atmospheric discharges in receivers at these stations, and with this arrangement the working was often disturbed in spark stations; but the conditions were much worse in arc stations, as the noises from atmospheric disturbances are very much like those given by the latter type of working. It is, however, quite different when receiving the sound from the musical spark system. However numerous and strong the discharges may be, an even slightly skilled telegraphist can distinguish them by their singing tone. The sound, if it is truly musical, can be clearly heard even if it is very weak. It may be said that for the first time since the invention of wireless telegraphy a system has been obtained which enables telegraphic work to be carried on through the heaviest atmospheric disturbances, and up to the limit when the detector would break down under the atmospheric discharges.*

The use of a particular tone gives the sender a certain individuality. Turning again to the three stations at the corners of a triangle, it may be supposed that station A gives a sound with a frequency of 500 per second, and B one with a frequency of 1,000, so that C can receive telegrams at the same time to both stations quite separately with only one antenna, a re-

* See "Elektrotechnische Zeitschrift," 1909, No. 10, pp. 222, and p. 99 of this issue.

ceiving apparatus, a detector, and only when the two senders are transmitting oscillations of nearly the same wave length need two operators be present, one of whom writes down the telegram with the higher sound and the other the one with the lower. By this means great simplicity in working and quite considerable freedom from disturbances are obtained. It is no longer necessary to tune the receivers for multiple telegraphy, for it often occurs with this arrangement that the sender for which the receiver is not tuned begins to work. To prevent this danger a suitable working rule has not yet been found. Electrical tuning by using a long wave scale can also be obtained, and by this method not only two but a great number of stations can work without disturbance from each other.

12. The system of singing sparks allows an acoustic tuning of the receiver to be obtained by the use of clear musical tones, while these, as shown under 10, depend on the selective capacity of the human hearing, so that certain parts—for instance, parts of a so-called sound intensifier—can be imposed on the frequency of the sounds received, and prevent senders of other sounds, impulses from ordinary spark stations and especially atmospheric disturbances from interfering.

As to a receiver for this new system, all the well-known acoustic receivers can be used, and no "Ticker" is necessary at the receiving end. In spite of this, a new receiver has been designed for all sizes of stations, which both in construction and in electrical arrangement does not differ considerably from the present type of receiver. A special receiver has also been designed which, as a result of a number of measurements, has been shown to be capable of receiving over a large scale of wave lengths, from 200 to 3,000 metres, with a very small loss from damping in the tuning arrangements. The operation of the rectifying detector, working on the principle of the contact detector, is very sensitive, being about 20 per cent. more sensitive than the electrolytic type. It is also very constant, and is not disturbed either by atmospheric discharges or by "over-intensity" due to neighbouring or strong senders. In connection with this receiver two boosting apparatus have been designed which employ the special advantages of the new form of musical sender. Both these apparatus are of great practical importance. There is then the calling apparatus, which is employed instead of the telephone receiver on the standard receiver, and rings an electric bell whenever a singing sender works for over 10 seconds; but for atmospheric discharges and for discharges from the usual spark sender, as well as for Morse signals, it does not ring, though the calling arrangement operates up to the limit of hearing capacity. The second apparatus is a resonance relay, which makes it possible to intensify the weakest signals while still keeping them as clear musical tones, so that they can be received in the station. Such an increase is only possible by the use of a body oscillating with mechanical resonance, and the sound must be quite clear. By the use of a relay, atmospheric disturbances are practically cut out, as single discharges only slightly influence the resonance system. Several relays of different tones make it possible to differentiate between signals from different senders which are transmitting with equal wave lengths but different notes, and differentiations to be made without the help of the human ear, which becomes tired.

THE ELECTRIFICATION OF RAILWAYS.*

BY J. A. F. ASPINALL.

Summary.—The general question of the desirability of converting existing steam railways to electrical working is first discussed, after which the Liverpool–Southport electrified section of the Lancashire and Yorkshire Railway is described. Valuable information concerning the results achieved on that line is given, particularly in regard to the cost of operation and the maintenance of the various parts of the equipment.

There are so many engineering interests bound up in the question of the electrification of railways which will lead sooner or later to a distribution of work of various kinds amongst engineers that I think it might be useful to review some of the points that have arisen and have had to be considered in connection with a line of railway which has been converted from a steam line into one worked by electricity. No engineering subject requires more thoughtful care than the mechanical and electrical working of railways. There is nothing so coy as capital, and if it is to be won, it must be by convincing arguments, and not by the doubtful pleadings of conflicting interests. It is probably certain that what may be called the "battle of the systems" has had the effect of causing railway companies to defer electrification until they could see that engineers were not at variance as to the system to be adopted. I have no intention of dealing with the controversial point raised in the "battle of the systems." Those who are interested will find in a recent short Paper,* read by Mr. F. W. Carter before the Rugby Engineering Society, a very clear statement of the kind of work to which the different systems can be applied with advantage.

It is too often stated that a general electrification of our railways would be of very great advantage. A careful examination of the subject, however, appears to show that while there are certainly instances in which this work can be undertaken with great commercial success, each individual case has to be considered with the utmost care, not only on account of the costly character of the work, but because the conditions upon which success or failure depends vary in almost every place or district. The length of haul, the density of the traffic, the necessity or otherwise of express trains, the presence of steam trains, the proximity of signal boxes, the density or scarcity of population at different points of the line, and the continuity of the flow of traffic during those hours which are not "rush hours," and a variety of other circumstances will affect the commercial prospects of such an enterprise. In dealing with the question of electrification before the Railway Congress at Washington in 1905 I said that the Lancashire and Yorkshire Railway had not gone into the work to "save money but to make money." I further pointed out that it enabled us to defer for a long time any increase in the capacity of our terminal stations.

To warrant the electric equipment of a main line of railway dealing under present circumstances with long steam-hauled trains at high speeds for long distances without a stop, some great commercial advantage must be shown. It is largely a question as to whether electrical working would induce much larger numbers to travel and to travel more frequently. The existence of a considerable population in two towns some miles apart, without any large number of intermediate towns with a travelling population to feed a railway, would not be sufficient warrant for electrifying an existing steam road designed to carry high-speed trains. It is probable that with two towns 20 miles apart such a railway could not in our present state of knowledge succeed financially compared with a steam-worked road. The cost of widening any railway, the capacity of which has, owing to growing traffic, become too small for dealing with steam trains, should be carefully compared with the cost of electrifying the existing lines with a view of seeing whether the additional capital required for electrifying would or would not exceed the cost of widening. In the case of many suburban lines from our great cities electrification will at once double the train-carrying capacity of the tracks, while in others it will allow for an increase in capacity and yet leave a greater time space between trains which may be utilised for the passage of steam-worked express trains coming in from the more distant parts of the line. To electrify any suburban railway and to arrange the time-table in such a way as to leave trains running at the same speed at which the steam trains formerly ran, would be to throw away most of the advantages of the change, though the working costs could be kept very low. An increase of speed, coupled with greater frequency of trains, will soon begin in a populous district to yield that flow of traffic which may naturally be expected from such facilities, but it must at once be recognised that higher speeds and more trains cost money.

Where a suburban railway has tramways running parallel to its tracks electrification will bring back some of the passengers lost on the installation of the tramways, but it must be remembered that in order to earn a good average fare an electrified railway must be continued for some distance. The main object should be to induce a large number of people who have business in the towns to live further out, leaving the very short-distance traffic to the municipal tramway, which has its right of way in the public streets and has advantages which the railway cannot possibly obtain. Some of the advantages of electrification for local services are:—(*a*) High schedule journey speed; (*b*) much more frequent service when required; (*c*) increased acceleration and deceleration; (*d*) greater possible mileage per train per day.

The Liverpool-Southport section of the Lancashire & Yorkshire Railway, which has been electrified for some time, is next described.† Part

* Abstract of the presidential address to the Institution of Mechanical Engineers, delivered on Friday evening last.

* THE ELECTRICIAN, March 5, 1909, p. 810.

† A description appeared in THE ELECTRICIAN, Vol. LII., pp. 401, 852, 897, 940 and 1,015.

of the section consists of four lines of way and the remainder of two lines. Although the frequency of trains has been more than doubled, the rapid acceleration and the increase in the average speed of travel has enabled the whole of the work, with the exception of one or two through trains, to be done on two lines of way (the eastern lines), thus dispensing with the staff, and enabling the waiting-rooms and other buildings on the western lines to be shut up, and permitting the western lines to be used almost wholly for the steam worked goods traffic, allowing it to flow to and from the various yards without any interruption from passenger trains. This may be looked upon as a distinct gain to the railway in capacity for handling traffic. Here the cost of electrifying is a set off against the necessity for widening and laying additional lines through a most expensive district, which would in time have become necessary if steam working had been continued for passenger trains.

During the first year of electrification, and at an early period when the increased service has shown the public the advantage of greater frequency (with the result that 14 per cent. more people were making use of the trains), it was interesting to note that the total weight of the rolling stock moved in a day, between 5 a.m. and 12 midnight, was 69,160 tons, against 78,393 tons in the days when steam was used. Fig. 1 illustrates this, the dotted lines showing the weight of the steam trains including the locomotives, and the full lines the weight of the electric trains during different periods of the day. A considerable addition to these weights has been the natural result of an increase in traffic since 1904.

The suburban service on the Liverpool and Southport electric line is considered to be the fastest service of such a character in existence. During the conversion stage facilities existed for comparative tests of coal consumption. The six-wheeled coupled-tanked locomotives (of 1904) consumed 80 lb. of coal per train-mile for express trains, and 100 lb. with stopping trains, the high figures being due to the necessary high acceleration. The coal consumption at the power

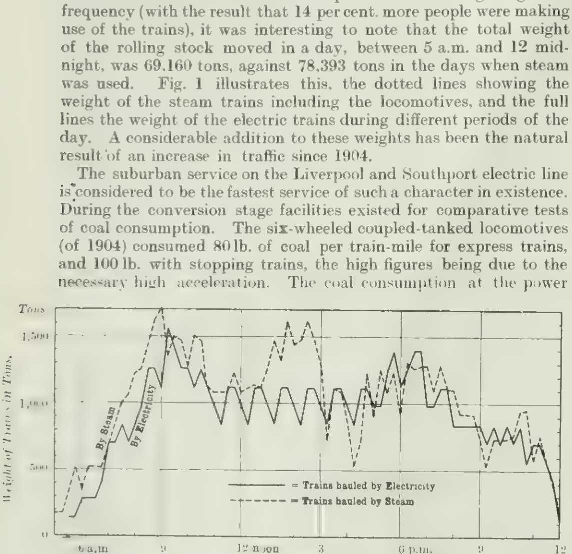


Fig. 1.—Diagram showing Weight of Passenger Stock moved during a Working Day between Liverpool and Southport. 1904. Steam before Conversion, Electric after Conversion.

house in 1908 works out at 49 lb. per train-mile, and the energy consumption of the train is 49 watt-hours per ton-mile for express trains, and 112 watt-hours for express and stopping trains, including all shunting work.

The rapidity with which the conversion work was proceeded with may be gathered from the fact that the order was given on October 22, 1902, and the first experimental train run on December 29, 1903. An aspect of electric lines which must not be forgotten is the question of rating. The curious laws which deal with the rating of railways and the custom which speaks of a hypothetical tenant, result in the steam locomotives of any ordinary railway becoming part of the tenant's capital and therefore lead to a deduction from the rates, but in the case of an electrical road the fixed engines, boilers and dynamos, &c., which supply the power, result in additions to the annual expenditure, as they are rated separately.

Third Rail.—At a meeting held at the Railway Clearing House in March, 1903, it was decided that the most advantageous position for the third rail was that it should stand up 3 in. above the track rail, and that the horizontal distance between the centre of the track and the centre of the third rail should be 3 ft. 11½ in. Fig. 2 illustrates this, giving both the English and American practice. An examination of the loading gauge, the construction gauge and the under gauge shows how very limited is the space within which a proper position can be found for the third rail. In fact, it is impossible in England to use the inverted and covered conductor rail as used on the New York Central, as both rail and covering would be swept away by passing rolling stock, if it were placed in the only available space left between the track and the platforms. If placed further out, as in America, immense alterations in bridge girders and platforms would be required.

Fourth Rail.—On the Liverpool and Southport line a fourth rail is used, but it is below the surface of the track rails, is not insulated, and has no shoes suspended from the cars in contact with it. The current is returned through the car wheels to the running track, and from the track rails by means of copper bonds to the central fourth rail. This has the advantage of enabling the track rails to act as an auxiliary return to the fourth rail. Any single length of fourth rail or of track rail can be taken out for repairs without affecting the trains in the next block section of line. Particulars and diagrams are given of the amount of abrasion and corrosion in the third rail, and of corrosion alone in the fourth rail.

Track Rail.—The wear of track rails has become a serious problem on electric railways. The modern steam locomotive with a high centre of gravity is a very easy riding machine, and it is far less severe on the road, notwithstanding its great weight. The more or less modern motor truck, with its extremely low centre of gravity, has all the defects of the older fashioned steam engines. The result is that the rail wear and tyre wear are present, because the pressure which should be carried by the tread is thrown on to the flange. This is because there is no elasticity, in the form of a spring, interposed between the weight above and the tyre below.

Axle Load.—The centre line of the motor is in the same plane as the centre line of the axle, with the result that while about one-half the weight is supported by the truck frame, and so obtains through the springs a slightly elastic support, the other half is supported directly by the axle and clipped on to it. This greatly increases the weight which is not spring borne. The serious side wear of the rails which has taken place on the curves of railways

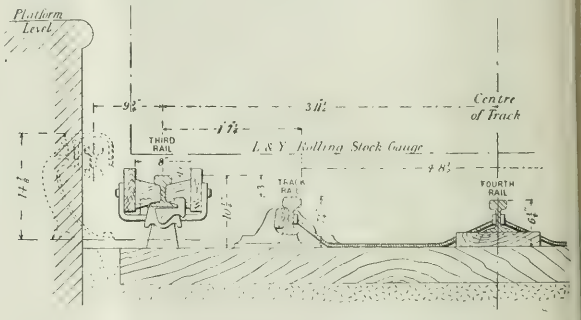


Fig. 2.—Cross Section of Permanent Way, showing Third and Fourth Rails compared with New York Central R.R. Scale 1/20th,

Dotted lines show position of protected third rail as used by the New York Central R.R., and illustrate how this position for the third rail would be in the way of the platforms and certain bridge girders on an English Railway.

which have been electrified is, there is no doubt, due to the centre of gravity of the motor trucks being so very low down. Except for such difficulties as would be created by raising the motor itself, and transmitting its motion by suitable mechanism to the axles, and so blocking up the passages from car to car, there is little doubt that the whole of the weight, except that of the wheels, axles and axle-boxes, could be supported by springs. On the other hand, the great advantages of the direct drive would be lost, and as practice has shown that the gears wear extremely well and show an admirably smooth surface after running many thousand miles, it may be a more commercial method to wear out the cheap rail instead of expensive mechanism. At the same time it must be remembered that it has not been practicable to operate steam trains at the same schedule as is frequently adopted for electric services, and as a consequence, there is no information as to how the tracks would have been affected if they had been so operated. These faster schedules are necessarily brought about by higher acceleration and deceleration than is usual with steam conditions. The division of the weights of the motive power between a larger number of wheels, together with the advantage of the motive power being absolutely in balance, cannot fail to have less damaging effect upon the permanent way, provided that other conditions are equal. Fig. 3 shows the position of the centre of gravity in electric motor cars and locomotives.

Cars.—A multiplicity of side doors means that a larger staff has to be employed on the platforms if they are to be safely closed, or if they are sliding doors worked automatically there is some risk to the public of being caught by them, and there is much greater risk of sliding doors being jammed in case of accident. The system imported from America of having men on each platform between each pair of cars to open the gates and shout out the names of sta-

tions, leads to an excessive train staff being employed. This multiplication of labour is an economic waste, and the effect on the public is that having so many people to look after them they enter and leave the cars in a very leisurely fashion, resulting in too much time being spent at stations. A system of having large side doors at each end of a 60 ft. car, which doors are readily opened or closed by the public themselves, saves the waste of labour, causes the passengers to move quickly in and out of the cars, and has shown in practice in the north of England that the trains may be got away from the stations in less time.

Reference is also made to the platforms, controllers and automatic vacuum brakes.

Cables.—Cables form a very costly part of electrical equipment, and their accessibility when laid along a line of railway is one of the points which requires the most careful consideration. Experience on the Liverpool and Southport line does not point to the practice of laying the cables on the solid system in the 6 ft. way as being satisfactory, and where a railway runs through an open district there seems to be distinct advantages in having bare wires carried overhead on suitable poles. In modern practice large spans are used, the number of poles in some cases not exceeding 10 per mile. In the particular instance of the high-tension line connecting Aintree with Seaforth, the cost per mile of the overhead equipment was £1,300, whilst the cost per mile of the cable line was £2,030, the cost per kilowatt transmitted per mile being—for overhead £1·25, for cable £2·67, based on 500 amperes per square inch of conductor section. This, however, does not represent the full saving which might be obtained by overhead transmission, as the spans were necessarily short, and for a certain distance erection was difficult as the line ran on the top of a high embankment. Lightning arresters, a doubtful requirement for the atmospheric conditions prevailing in this country, are also included in the cost for overhead transmission.

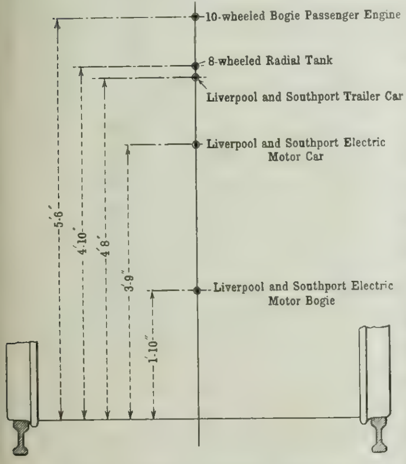


Fig. 3.—Diagram showing Heights of Centre of Gravity.

Battery Plant.—When regular working conditions had been in operation for some considerable time, bearing in mind also the fact that the development of traffic would necessitate sooner or later some increase in power-house and sub-station plant, it was decided in 1905 to instal battery plants. It was felt that these were necessary, not only on account of mechanical requirements, but also with a view to creating an almost absolute assurance that trains could be run during the busiest hours of the day when a large number of business people were using the railway, even if some serious accident happened at the central generating station. The general idea was to put in a battery plant which would keep the whole railway going for one hour. These batteries were of the well-known buffer type, controlled by automatic boosters. To meet the heavy peaks it was originally necessary to run 5,250 kw. of power house plant, though the average load was only 3,500 kw., and the fluctuations of load were so great that at times the engines would entirely cease to take steam, a vacuum being actually produced in the high-pressure cylinders; within a few seconds the load would rise to 4,000 kw. or 5,000 kw., and superheated steam would be admitted to the cooled high-pressure cylinders. This not only led to uneconomical working, but produced severe stresses in the engines.

About the time it was decided to introduce the battery sub-stations, the traffic had considerably increased, and the lighting at certain points was not all that could be desired. Also power was required at Liverpool, and the drop in potential at the train was becoming too great. It was therefore decided to place the battery sub-stations at points intermediate to the rotary sub-stations, instead of combining the two as might be expected. These batteries were installed in September, 1905, and the results have amply justified the policy that was adopted. The momentary peaks in the load were reduced from a maximum of 7,000 kw. to 4,500 kw., and the hourly peak during the rush hours was reduced from 3,800 kw. to 3,100 kw., enabling the load to be carried during the winter with 4,500 kw. of plant, and during the summer with 3,750 kw. of plant. Four battery plants were installed aggregating 5,200 ampere hours, and have a guaranteed efficiency of 85 per cent. in ampere hours and 75 per cent. in watt-hours. Tests made in 1907 showed that 14 per cent. of the total rotary sub-station direct-current output passed through the batteries, the total loss due to the batteries being about 3·5 per cent. of the rotary sub-station output. The coal consumption was reduced by 8·5 per cent., and the consumption for train services became 0·412 lb. per ton-mile.

Typical load diagrams are given in the Address.

Efficiency of Transmission. Investigations made as to overall efficiency of transmission showed that 1·97 per cent of the power house output was lost in cables, 2·95 per cent. in transformers and 5·37 per cent. in rotaries, the overall efficiency of transmission from alternating-current 'bus bars being 89·7 per cent. It is exceedingly difficult to ascertain the exact losses in live rails; calculations made, however, in various ways seem to indicate that these losses amount to about 9 per cent. of the sub-station output. The total efficiency from alternating-current 'bus bars to circuit breakers on the trains is about 81 per cent. In considering the question of coal consumption per unit, the most reliable figure to take for comparison is the coal burned at the power house per unit of direct current delivered to the third rail—that is, with all losses due to conversion. This, for 12 months ended December 15, 1908, was 3·28 lb. These figures for coal consumption must not be confused with those given for the generating stations.

Maintenance.—It is important to have careful periodical examination of the different parts of the electrical equipment, and experience has shown that the examination should be specialised, different groups of apparatus always being dealt with by the same workmen. Charts of these inspections are prepared and afterwards examined daily by the foreman.

Extensions of Electrified Line.—In 1907 all the lines leading to Aintree were electrified, and a very large traffic previously taken away by the municipal tramways, which run parallel with and not many yards from the electric line, has now come back to the railway. A connection has also been made at Seaforth with the Liverpool Overhead Railway.

Operating Costs.—Experience shows that any railway company having the opportunity of putting down its own plant in the country with ample facilities for getting cheap coal and water should be able to produce current at the generating stations at a "works cost" of less than 0·25d. per unit, the coal consumption being under 3 lb. per alternating-current unit. With such figures as these, it is possible to work a high-speed service such as I have indicated at 9·5d. per train-mile, including "works cost" for the power-house, sub-stations, battery stations, "operating costs" for motor and electrical equipment repairs, car repairs, guards' and motormen's wages, lighting and heating of cars, repairs of third and fourth rails, bonds and cables, and all working stores. The cost per car-mile varies between 2·75d. and 3d. according to the number of cars run. The total current producing charges including conversion at sub-station, the cost of battery stations, and depreciation of batteries, absorbs 4·52d. out of the 9·5d. per train mile. With the exception of the depreciation of batteries, no sum is included for depreciation of plant, or for interest on outlay. The above figures are not intended to, and do not include any part of the cost of maintaining the running track, the passenger and goods stations, or costs for the platform staff, or any other items required for the railway, whether worked as a steam line or as an electric line. The great economy to be hoped for in the future for electrical railways, where no water power is available, is in the production of electricity in very large quantities. The other directions in which economies may be sought for in future designs are mainly in such improvements in the motors as will lead to less repairs, and a very careful consideration of the whole design of the motor truck. Brake gear is an expensive item, the continual stopping causing rapid wear of all pins and brake blocks, which, combined with the dust and dirt of the road, all help to increase the cost, and therefore to make one hope for some form of regenerative control which will be of a simple character, and not involve the carrying of extra weights and a complete change of equipment.

Those items, which may be put down as giving no trouble whatever are: controllers, commutators, steel spur-gearing, and the third rail, The latter is easy to lay, cheap to maintain, and has proved by long experience to be the cause of very few accidents.

A number of statistics relating to the operation of the Liverpool and Southport electric line are given in Appendixes, and others give the effect of high schedule speeds, properties of third rail materials, &c.

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MR. ASPINALL'S ADDRESS.

The remarks made by Mr. J. A. F. ASPINALL in his Presidential Address to the Institution of Mechanical Engineers, on the subject of railway electrification, are of more than ordinary interest owing to the fact that the author occupies an important position on the Lancashire and Yorkshire Railway, and is not pledged to one form of traction rather than another. His observations are, therefore, characterised by breadth of view, and by recognition of the fact that both electricity and steam have their spheres of usefulness. Mr. ASPINALL remarks that it has been urged too often that a general electrification of our railways would be of very great advantage. Such statements, however, are made by those who have not gone fully into the matter, and it may be said that no general rule exists. On the other hand, there are certainly cases in which electric traction has been used with commercial success, and among these must be included the electric railway between Liverpool and Southport. Here, as stated by Mr. ASPINALL, electrification was resorted to "not to save money, but to make money." If this course had not been followed it would have been necessary to increase the terminal facilities. By electrification both the platform operations and the signal operations per train are reduced

to one-half the number necessary for steam trains, and thus the capacity of the terminal stations is doubled. In this particular instance not only has there been a great advantage in respect to terminal facilities, but it has been found necessary to use only two tracks for passenger traffic on those parts of the line where four are laid. Consequently a number of waiting rooms and other buildings have been freed, less staff is necessary, and two of the tracks can be used exclusively for goods traffic.

It might be thought that similar advantages would accrue in main line electrification, but, generally speaking, this would not be so. The public would not care to pay for a higher speed, even if desirable, and unless additional tracks were laid down the capacity of the "express" track would be diminished if higher speeds were adopted. The question of high acceleration, so important in suburban traffic, is here comparatively unimportant. In most schemes, whether for short or long distances, it is generally a problem of increasing the capacity of the line, and thus the point must be considered whether electrification or the laying down of additional tracks is the less costly of the two alternatives.

Among the interesting points dealt with by Mr. Aspinall, we may call attention to the fact that before the electrification of the Liverpool-Southport line, the six-wheeled coupled tank locomotives consumed 80 lb. of coal per train-mile with express trains and 100 lb. with stopping trains, these heavy figures being due to the high acceleration required. On the other hand, the consumption of coal at the power station in 1908 was found to be only 49 lb. per train-mile for the electrical trains. Another interesting point is that of rating. Apparently a steam electrified railway stands at an advantage, because the rating law, in dealing with the "hypothetical tenant," considers the steam locomotive as part of the tenant's capital, and therefore allows a deduction from the rate, but in the case of an electrified railway the power station is rated separately, and thus increases the annual expenditure. Yet another point of great interest is that of the wear of track rails. It is well known that early locomotives were built with their centres of gravity comparatively low, but were found unsatisfactory, as they had a tendency to burst the track. The modern locomotive is built with a very much higher centre of gravity and runs much more easily, because the raising of the mass allows the springs to come into play to a larger extent. Thus the wear of rails and tyres is reduced to a minimum. With electric rolling stock, however, the centre of gravity has again been brought low. Not only is this the case, but a greater proportion of the weight is not spring-borne. The result is a greatly increased wear of tyres and rails. This defect could be remedied by raising the motors and transmitting the drive in some other way. The wear would be reduced, but, on the other hand, the drive would be less direct and less efficient, and the construction of motor cars would be more difficult. The case is, therefore, once more a choice between two evils.

It is noticeable that Mr. Aspinall does not go into the question of the relative advantages of single-phase and continuous-current traction. In this connection we think that engineers would do well to take to heart his statement that "there is nothing so coy as capital, and if it is to be won, it must be by convincing arguments and not by the doubtful pleadings of conflicting interests. It is probably certain that what may be called the 'battle of the systems' has had the effect of causing railway companies to defer electrification until they could see that engineers were not at variance as to the system to be adopted." It would be well if engineers would recognise the fact more generally, that engineering problems very seldom class themselves in such a way as to admit of a general solution. What is unsuitable in one case may be eminently suitable in another, and it does not follow that either the single-phase system or the continuous-current system should be adopted to the exclusion of the other, any more than it has been found necessary to adopt alternating current or continuous current exclusively for electric lighting; although not so very many years ago some of our engineers would have had us believe that one or other of these systems must be hopelessly wrong.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electric Power and Traction. By F. H. Davies. London: A Constable & Co.) Pp. vi.—231. 6s. net.

In a book devoted to the applications of electricity to almost all purposes of an engineering nature it is extremely difficult, when such a book is intended for the general reader, to make a proper selection of electrical theory with which to lay a foundation for subsequent descriptions. It is a question whether it is not better to classify the various types of electric motors under their usual names—shunt, compound, synchronous, &c.—with a clear statement of the characteristics of each as far as the purchaser or user is concerned, than to attempt to condense into a few pages the theoretical and technical reasons for such characteristics.

In the volume under review the first six chapters, containing 65 pages, deal with the generation and distribution of power and the electric motor. There is practically no attempt to introduce the reader gradually to the various considerations that he must master, as will be evident from the fact that the fourth page of the first chapter deals with the three-wire system, followed immediately by a general description of the arrangement of electrical apparatus in a three-wire generating station. Chapter V., on the other hand, begins with an explanation of the back E.M.F. in a continuous-current motor.

It seems doubtful whether any practical man who is ignorant of electrical theory will be much enlightened by studying these chapters. He will, however, find a good deal to interest him in the rest of the book, as there are several chapters devoted to such subjects as the applications of electric power in collieries, in workshops, in textile factories, in printing works, at sea, on canals, and in electric traction in general.

The various ways in which electricity may be employed with advantage in collieries, workshops, &c., are dealt with clearly, but almost entirely in a descriptive manner. More precise information might have been given in regard to the outputs of motors required by various machine tools; for example, a certain class of tool is stated to require usually from 2 H.P. to 25 H.P. Electrically-driven cranes are well described, and particular attention is drawn to portable tools.

The second half of the book is devoted to electric traction, and an attempt is made to cover the whole range in 135 pages, with the obvious result that many parts of the subject are insufficiently treated, and others are omitted altogether. Inequalities also are noticeable; for instance, seven or eight

surface-contact systems are mentioned and described without any reference to the Lorain and the "G.B." systems.

On the whole, it must be said that the book is rather too scrappy and superficial to be of any very great value, although it may fulfil a useful function in leading practical men on to study in a more systematic manner the properties of electrical apparatus and the application of electricity to power and traction.

Die Revision elektrischer Starkstromanlagen. By Paul Stern. Vol. XXXVIII. of "Bibliothek der gesamten Technik." (Hanover: Dr. Max Janecke.) Pp. x—227. M. 3.60.

The subject of the inspection and supervision of heavy current electrical installations is very ably worked out in this small work, which forms Vol. XXXVIII. of the "Bibliothek der gesamten Technik." It is naturally based on the rules observed in Germany by fire offices and other societies with reference to the utilisation of electricity for industrial and domestic purposes and the precautionary measures to be adopted. Although in many instances differences from standard English practice are apparent, a perusal of its pages will be found of benefit, not only to those in charge of electrical plant, but to those who make a speciality of inspecting, testing and supervision.

The book is divided into four main parts. Part I. deals with the various classes of electrical inspection, their object, and the method of supervision. A list of German companies who undertake this class of work is added, and remarks are also given as to the selection of an inspecting engineer and his outfit.

Part II. investigates the accidents to human life from the electric current. Some interesting information is contained here in connection with death due to shock, the resistance of the body under different circumstances, the effect of voltage, and the effect of alternating currents of different frequencies.

Part III. is on material damage from electrical causes—damage by fire, damage by acid from accumulators, explosions of the gases liberated on charging accumulators, corrosion of metal pipes by the stray earth currents from electric tramways, disturbances produced in scientific instruments by earth currents or inductive action, derangement of telephone and telegraph systems by heavy currents.

Damage by fire electrically receives a large amount of attention; the other matters are just lightly touched upon. Statistics then follow in considerable detail of the German fire insurance companies. They are instructive and interesting, especially as many cases of fire, as pointed out by the author, are wrongly attributed to electrical causes.

Part IV. is a digest of the most important of the laws and regulations current on the Continent for the installation of electricity. Amongst others, those of the Verband Deutscher Elektrotechniker are dealt with at some length.

Development and Electrical Distribution of Water Power. By Lamar Lyndon. (London: Chapman & Hall.) Pp. vi.—317. 12s 6d. net.

The present work constitutes a general engineering treatise on the salient features of hydro-electric generation, transmission and distribution, with critical practical remarks on the problems encountered in the planning of an up-to-date scheme of generating and transmitting electrical energy from water power. Descriptions of some important typical hydro-electric plants have been selected from prominent American technical periodicals and reprinted. These descriptions form a special characteristic of the book. They not only show in a striking manner the practical application of the principles involved, but enable the reader to contrast readily the different systems used, which otherwise would only be possible after a tedious search through a number of journals.

The book is divided into three main sections, of which Part I., containing five chapters, deals with the hydraulic development of the subject; Part II., composed of seven chapters, discusses the electrical equipment; and Part III. contains the descriptions already alluded to. Chapter I.—General Conditions—contains an account of the factors to be considered in the determination of the probable power available from a water source, and enumerates the data required for deciding the commercial value of an undertaking of this kind, together with figures of cost, which are of value. Chapter II. is on dam construction. Before outlining the various types of dams and stating their relative merits, the forces acting on them are investigated. Canals and flumes are next given in Chapter III., and the design of hydro-electric power houses is explained in Chapter IV. Chapter V., the last of this section, contains a general description of water wheels—pressure, impulse and Pelton wheels, variable gates—and the speed regulation of turbines.

Part II.—The Electrical Equipment—starts with Chapter VI., on the general idea of electrical power, the relative advantages and disadvantages of continuous and alternating currents, the size, type and method of drive of electrical generators. Chapters VII. and VIII. give some very general information on alternating-current dynamos and transformers. The overhead line is next examined in Chapter IX., in which the problems involved are stated and examples worked out of the size of the conductors for direct-current, single-phase, alternating-current and three-phase transmission lines under certain assumptions. The methods of supporting the conductors are given in Chapter X., which includes poles, cross-arms, insulators, insulator pins and methods of leading the high-tension wires out of buildings. The protection of the line against lightning is briefly treated in Chapter XI., which is followed by one on switching and controlling apparatus. An appendix is here added on the computation of pressures set up in long pipes with change in gate opening, being an abstract of a Paper by the author read before the American Institute of Electrical Engineers.

The remaining 154 pages of the book, comprising Part III., contain the detailed descriptions of the nine typical transmission plants already alluded to.

The book is essentially practical, is well printed and illustrated, and will be of benefit to those interested in this branch of engineering.

ELECTRIC TRACTION ON RAILWAYS.*

XIV.—PRACTICAL CONSIDERATION OF OVERHEAD CONDUCTORS.

BY PHILIP DAWSON.

(*Continued from page 14.*)

Summary.—In this article the author first considers the many objections which have been raised against the use of the third rail for main line railway electrification, and then proceeds to discuss the use of overhead conductors, dividing the latter system into those where two overhead conductors per track are necessary and those where only one conductor per track is required. The construction of the overhead work is also considered in detail.

Primarily it may be laid down that for high-tension work non-combustible insulation must be used and, furthermore, that the insulation must be capable of keeping up its insulating qualities for any length of time without the least signs of deterioration. If insulation had to be used only indoors there might be many substances to choose from, but the conditions of being able to stand all weathers are practically only met by materials of a glassy nature; besides the properties of insulation, very high mechanical properties are required in connection with the suspension of overhead conductors for traction purposes. These combined qualities are only met, as far as present experience would indicate, by porcelain or certain kinds of earthenware. It is essential to have insulators which, whilst constructed of sufficient thickness for mechanical reasons shall not possess any blow holes or inequalities inside their mass. Experience has shown, furthermore, that unless the thickness of the insulator in all directions is more or less uniform, owing to unequal shrinkage in baking very large stresses are set up in the interior of the baked mass when completed,

which cause very serious risk of the insulator breaking at the least shock, and frequently quite unexpectedly. Furthermore, experience has also shown that it is impossible to bake insulators possessing considerable thickness in certain parts without the danger of blow holes arising when baked, which are very difficult, if not impossible, to detect. For this reason the best insulators of to-day, if of any size or intricate, are frequently made in separate pieces, some of which get two bakings. Thus, in the case of tubes having heavy corrugations on the exterior, the inside sleeve is made separately, the outside is baked, and then the inside sleeve is cemented in with glazing and the two are baked together, the outer being baked twice and the inner only once. The chemical composition of the insulator and the mechanical methods adopted in manufacturing play a most important part in the securing of reliable insulation. In modern practice the ovens in which insulators are baked are often fitted with recording pyrometers, so as to ensure an even and correct temperature throughout the whole process of baking, and also to ensure an even and sufficiently slow cooling down after baking. Great resistance against electrical stresses is frequently combined with great brittleness, and an exact adjustment of these two qualities is required in all insulators, and can only be reached by a most conscientious, as well as scientific, process of manufacture. It is essential that the insulating properties of the porcelain should be due to the porcelain itself, and not to the glaze of the porcelain, the object of the latter being only to ensure an easy clearing of the insulation by rain. Thus, insulators broken up and

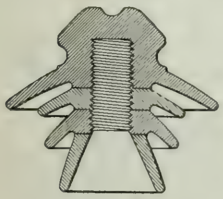


Fig. 12.

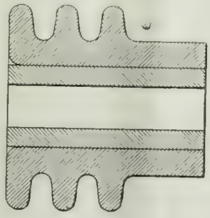


Fig. 13.

High-Tension Composite Porcelain Insulator.

allowed to soak for a considerable period in water should not absorb the slightest amount under any circumstances. It is essential that good insulators when once formed should be fairly treated, and that they should never be submitted to stresses for which they were not intended. Furthermore, it is essential that all stresses should be distributed as evenly as possible; that they should be fixed so as not to come in close proximity with very hot gases, which, by causing uneven expansion, will produce breakages. Care should be taken to fix insulators so as to prevent any possibility of water getting in between them and their supports and, by freezing in cold weather, producing fracture. Indeed, the greatest care must be exercised in the choice of the make of insulator and in seeing that the design is suitable for the working conditions, and that before and during erection it is properly handled, and last, but not least, that proper means are taken to fix the insulator to its support. It is, of course, essential to fix any attachments which branch off from the insulator on to it in a rational manner so as not improperly to stress the material. Thus iron clamps should never be bolted straight on to the insulator without sheet lead or other suitable medium being put between the porcelain and the iron clamps. The make and shape of insulator once chosen, the greatest care should be taken to test electrically each insulator for at least 30 minutes, and, according to circumstances, at from 4 to 10 times its working pressure, with a capacity of at least 20 kw. in the testing transformer. Mechanical tests for resistance to compression and extension should be made, and, finally, weights should be dropped on to the insulator to ascertain its tenacity to violent shock.

It is surprising what severe tests porcelain of the proper composition and make will stand, and how uniformly the results of tests on a batch of insulators come out. Finally, care should be taken to test insulators mechanically, and submit them to electrical stresses at the same time. Too great care cannot be exercised as regards the choice of a proper design and make, or in the tests to which *all* insulators used should be submitted at the maker's works and under most careful supervision. What may prove a very good electrical design may frequently show up very badly as regards mechanical properties and *vice versa*.

Fig. 12 shows a high-tension insulator which, in order to secure absence of blow holes and unequal stresses in the material after baking, is made in four pieces as shown, each piece being baked separately. Then a glaze is put on at the

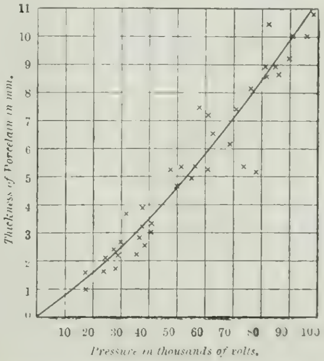


Fig. 14.—Curve showing pressures which will perforate different thicknesses of Porcelain. Made by Porzellanfabrik, Hermsdorf.

joints, and the whole insulator is assembled and baked a second time. In Fig. 13, on the contrary, the outer portion of the insulator is baked, then the interior is inserted and the whole baked a second time; this secures uniform results, and also by this means the inside tube is held most firmly because of the shrinkage which is bound to come even at a second baking in the case of the outside portion of the insulator.

As regards colour, this need not in any way depend on the quality of the insulator, and is produced either by adding a dye to the paste or, preferably, by adding a dye to the glaze, the greatest care being taken to select such a dye as will in no way affect the electrical properties of the insulator when completed.

Porcelain, which has proved admirable for insulating purposes, has stood a maximum compression of anything from 4,250 kg. to 5,410 kg. per square centimetre, or, say, in round figures, 60,000 lb. per square inch, and in tension 1,300 kg. to 2,000 kg. per square centimetre, or, say, 18,500 lb. per square inch. The modulus of elasticity was shown by a large number of experiments to be only slightly smaller than that of cast iron, the ratio in this case being in the proportion of 10 for ordinary cast iron as compared to 5·4 to 7·1 for porcelain. These figures hold good as regards the mechanical properties of good porcelain manufactured

for electrical purposes by the Porzellanfabrik Hermsdorf, Germany. It is their make of insulator which, after the most careful and lengthy researches, the author decided to use in connection with the electrification of the L.B. & S.C. Railway, and Fig. 14 shows the electrical properties of this make, giving nearly a straight line law, to the effect that each 10,000 volts will break through 1 mm. of porcelain.

Having briefly considered the question of porcelain insulators, we will now proceed to deal with the various constructions which have so far been used in connection with overhead conductors for general railway electrification when intense service is to be anticipated. The conditions which govern such an installation may briefly be summarised as follows :—

1. Practical impossibility of mechanical breakdown—*i.e.*, impossibility of the breakage of any one subsidiary part causing actual danger to passing traffic. Thus, for example, the breakage of an insulator, or of a supporting wire, or of the conducting wire, must, as far as possible, under no circumstances allow any part of the construction to sink as low as to interfere mechanically with passing trains.

2. Provision must be made for avoiding as far as feasible electrical breakdowns, and the construction must be such as to enable very prompt repairs to be effected in case of the failure of any part. Hence the number of parts constituting the construction should be as few as possible and as far as can be interchangeable.

3. The system must be sectionalised so that a failure will only affect one section, leaving the rest of the system in proper working order. This, of course, means arrangements for feeding designed so as to provide for these requirements.

The forms of construction so far adopted to fill the above requirements can, for our purposes, be subdivided into two classes as follows :—

1. The double catenary construction, which in its turn can be subdivided into—

(*a*) Rigid construction, originally proposed by the Westinghouse Company of America.

(*b*) Flexible construction.

2. Single catenary construction, which in its turn can be subdivided into—

(*a*) Construction not providing specially for variation in temperature.

(*b*) Construction with provision for maintaining constant tension in the trolley wire.

The former, or double catenary construction, has been so far adopted on a very large scale in America in connection with the electrification of the New York, New Haven & Hartford line in and around New York.

When considering this form of construction it is just as well to remember that special difficulties have to be met in the United States owing to the custom of brakemen walking along the roofs of freight trains to attend to the brakes. Hence, the wire has to be at a normal height of at least 22 ft. and the drop to go under bridges suddenly brings the height down to 14 ft. The collector has, therefore, to be made to run normally and at maximum speed at the height of 22 ft., and yet be capable of operating satisfactorily also at high speeds at a height of 14 ft. These conditions are not met with in Europe to any such degree, although, for reasons which will be explained later, in the case of the L.B. & S.C. Railway, the collector has to work a range of 14 ft. to 21 ft., but not under such difficult conditions as those encountered on the New York, New Haven & Hartford system. In this case the supports on the straight are as far as 300 ft. apart, and consist of latticed girders spanning the tracks on the tops of which the insulators supporting the catenaries are fixed. Special strong bridges, called anchor supports, are located about every 2 miles, and are provided with the necessary section switches dividing the various lines, as explained later.

Experience with this line as described has shown that the wear and tear of the conductor wire is very excessive, and that the sparking at the collector bow, about which more will be said later, is very great. It may here be remarked that the collector is of the scissors type, having easy motion in a vertical plane, but practically none in a horizontal one, and that the contact surface consists of a steel bar some 6 in. wide and fitted with grooves ; the pressure exerted by this against the trolley wire is very considerable, amounting, it is stated, to at least 25 lb. to 30 lb. and probably more. The cause of this result is not far to seek, if one considers the fact that the overhead conductor is composed of copper and is practically rigidly supported without any appreciable elasticity or liberty to move in a vertical plane. The collector bow, on the other hand, is very free to move in this plane, and must, of necessity, due to over-action and pitching of the locomotive, be constantly exercising a series of vertical hammer blows, with a planing action of the copper conductor, which is the softest of the two surfaces in contact. Mr. Murray, the electrical engineer of the New York, New

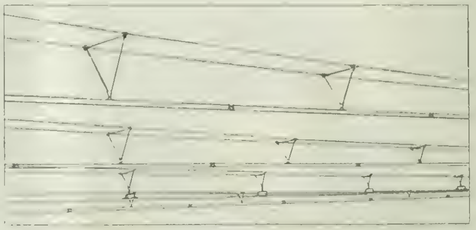


Fig. 15.—Improved Catenary Construction on Main Line, New York, New Haven & Hartford Railroad.

Haven & Hartford Railroad, states that the results of running have been—

1. To reduce the cross-section of the copper conductor by wear.

2. To kink it badly at the point of suspension, with the result that fracturing has been caused.

3. The roughness of the conductor wire produced in consequence of its rigid suspension and of the steel collector bar caused the contact to be constantly broken between the collector and the collector bar, resulting in excessive sparking.

In order to get over this, a fourth wire has been resorted to, which consists of steel wire of 4/0 B. & S. gauge, and attached by means of clips 10 ft. apart and fixed to the original copper conductor wires half-way between the rigid support formed by the apex of the rigid tubular triangle, as shown in Fig. 15. In the original form of construction, when the locomotive shoe made contact with the copper wire, it was found, on account of the high expansion properties of copper, that changes in temperature considerably lengthened the span between the hanger points, and because of the ductility of the copper the passage of the shoe at high speeds, with some considerable upward pressure, gathered up the slack in form of a kink at the hanger point. This attempt at absolute rigidity of conductor has proved a failure, as many, including the author, always thought it would ; but the experience thus gained is of great use to the engineering world in general and the electrical engineer in particular.

Fig. 16 is very interesting and represents the double catenary construction at first adopted in the case of the Swedish State Railways for a short section of their experimental line in the neighbourhood of Stockholm.

It will be observed that in this case no particular care seems to have been taken at the curve to keep the trolley wire free to move in the vertical direction under the pressure of the bow, the push off in this case simply consisting of two tubular struts at either side of the support fixed to the catenary and the trolley wire respectively, in a similar manner to that adopted on the New York, New Haven & Hartford line. The result of this form of construction has simply been what could have been expected—namely, that severe hammer blows were caused at this point when the bows went over it, with resulting sparking and liability to fracture of the wire.

It will also be observed that the other droppers through the flexible wire are firmly fixed to the catenary and the trolley wire without provision having been made for the lateral or up-and-down movement, and that, as a result,

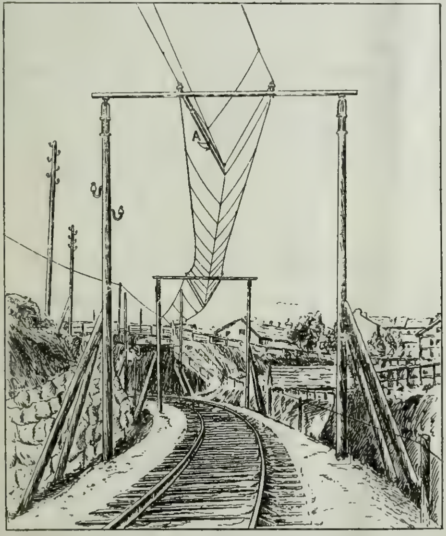


FIG. 16.—DOUBLE CATENARY CONSTRUCTION, SWEDISH STATE RAILWAYS.

A, Tubular struts or push-offs made of steel tube.

these have taken up a permanently bent position. As a matter of fact, the service on the Swedish State Railways is not of such an intense nature as to call for this type of construction, and, as already stated, for the extensions a much simpler and cheaper form has been adopted. The construction adopted on the L.B. & S.C. Railway is of the double catenary form, and is entirely different from anything hitherto erected in any country; but as a detailed description of the whole electrification of the South London line of this railway will appear in a later portion of this work reference will not be made here to it.

(To be continued.)

Electricity in Steel Works.—We are informed that the Prussian Slatoust-Werke have obtained a licence from the Gesellschaft für Elektrostahlanlagen m.b.H., of Berlin, to use induction furnaces in connection with their steel works. The material obtained from these furnaces will also be worked up at the Slatoust Works. The necessary electrical equipment is being provided by Messrs. Siemens & Halske.

FUNDAMENTAL PRINCIPLES IN THE DESIGN OF SPARK-TELEGRAPHY STATIONS.*

BY DR. F. KIEBITZ.

In a lecture delivered before the Elektrotechnischer Verein on December 5th last, the author reviews in an interesting manner the developments which have led to the improved results obtainable in radio-telegraphic work at the present time.

The review is confined to the case of spark telegraphy, and does not deal with the undamped wave method; it is also partly retrospective, in that the author does not deal so much with the more recent devices which have been published from time to time, as with the question how far the spark telegraph stations of the present day represent the theoretical ideal conditions which promise the most favourable results. The performance of the actual equipments as compared with the most favourable possibilities are considered, and by this means it is endeavoured to show clearly which are the features of present-day construction that possess permanent value, and what line should be followed with the greatest hope of success in the further perfection of the method.

Beginning with the transmitter, he follows step by step the energy transformation from the direct-current source onward until the Hertzian waves are radiated into space.

Supposing, first, that a given source of direct or alternating current is available, and that this is used to supply a naval station of the older type, which already employs a coupled system, but does not yet contain a resonance transformer. In this case the wave generation can be regarded as occurring in the following order as regards magnitude: For 1 kw. employed to supply the station, about 200 watts will be used up in the series resistances; 800 watts remain. Of these 800 watts about 750 watts are lost through secondary discharges and heat losses in the spark coil. There remain 50 watts, which are transferred to the condenser circuit in the form of charging energy. Out of these 50 watts about 20 are dissipated in the spark in the form of energy of heat, light and sound; a further 20 watts are converted into heat in the condenser coatings and in the circuit itself (inductance), or else are lost in the form of brush discharges. There remain about 10 watts, which are transferred to the antenna. Of these 10 watts nine are converted into heat in the antenna and the earth connection, or used in ozone formation, and about 1 watt is transformed into the energy of Hertzian radiation—in all an efficiency of one-tenth of 1 per cent.

At the present time this has been considerably improved upon.

The step by step analysis of the energy transformations in a coupled system is then carried out. By utilising the resonance principle in the transformer its efficiency can be raised to about 60 per cent. This energy is used to create a strong electric field between the condenser coatings, and the condenser circuit has to be constructed so as to communicate this energy to the antenna circuit with the least loss. But the damping due to the spark represents loss of energy, as also do the brush discharges. The latter source of loss can be avoided, but the spark damping cannot be entirely. Other causes of damping are the development of Joulean heat in the oscillatory circuit, the generation of eddy currents in neighbouring conductors, and also harmful reflections internal to the system. The first of these cannot be completely avoided, but by suitably choosing the cross-sections it can be reduced to a minimum; further, through using sufficiently large self-inductance. The eddy-current losses used to be considerable in the older type of stations, where the circuit was often made to encircle the Leyden jars, heating up the coatings. This is now avoided with the use of plate condensers; but it is always desirable to place the plane of the turns of the oscillatory circuit at right angles to the plane of the condenser plates. For instance, suitable alterations on these lines will reduce the decrement in the old type stations from 0·34 to 0·16.

It is of chief importance to arrange the system in such a manner that the amplitude decrease due to the coupling is large as compared with all the other causes of decrease of amplitude. This is best secured by the use of Wien's "impact excitation" (Stosserregung) by means of very small sparks.

The important point about this phenomenon is that, although close coupling is employed, no phase swinging occurs, but only a single rapid amplitude decrease; so soon as the whole of the energy for the first time has passed into the secondary system the spark dies out, and the primary is no longer capable of resonance, and can be considered as having disappeared from the system. In this way one is free from all the damping losses of the primary circuit.

The author next considers the fate of the energy which, by any procedure whatever, is communicated to the antenna circuit. Here the same energy-consuming factors are encountered as were found

* Abstract from the "Elektrotechnische Zeitschrift."

in the primary circuit. The brush discharges are, owing to the smaller capacity of the antenna, more harmful than in the closed oscillatory circuit, with its large capacity. In the latter a small charging loss is of little importance, but in a system of small capacity it may mean a quite considerable fraction of the total energy.

The energy losses through Joulean heat are also present in the open oscillator. In addition, there is the amplitude decrease, the damping due to radiation.

An effective aerial conductor must be built in such a way that the radiation decrement preponderates over the decrement due to other losses. In this respect the transmitter does not appear to have been sufficiently investigated. It is, however, certain that, in general, with ordinary antennæ, the radiation decrement is not over one-fifth as great as the resistance decrement.

Owing to the limits imposed by structural considerations, the radiation decrement cannot be made very large and, hence, every thing depends upon the reduction of the resistance decrement to the lowest figure possible.

The author next refers to the advantages and convenience of using the tables and formulæ given by Drude for predetermining the dimensions of the aerial, coupling coil and counterpoise, and deals also with the effect of earthing. This leads then to the discussion of the propagation of the waves in space, in which connection Bellini and Tosi's experiments, and especially those of the author, are dealt with. (For these latter *see* THE ELECTRICIAN, p. 972, April 2, 1909.)

Finally, the author discusses the question of the design of the receiving station.

In order to reduce the effect of atmospheric disturbances, the aerial wire should be of as small dimensions as possible, and this is quite feasible owing to the high sensibility of modern detectors (the electrolytic, galena detector) now available. The detector should be placed in a circuit which is as far as possible aperiodic, and this circuit magnetically coupled to the antenna circuit.

In conclusion, an example is quoted showing the improvement secured by substituting a coupled system for the old arrangement employed in the German naval stations. This, however, seems chiefly to demonstrate how dreadfully inefficient the old stations must have been, since for the 30 watts of primary energy which are required by the coupled system for communicating over a distance of 6 km. between the two stations, it is said that at least 1 kw. had to be employed for communicating with the old equipment.

As a further example, the electrical dimensions of the new station erected at the German Imperial Telegraphs experimental station are worked out in full on Drude's method. As antenna a smooth brass tube 10 metres long is used, with a quadrangular wire umbrella having sides 2·5 metres long as counterweight. With this station the messages from the Norddeich station are readily received.

CORRESPONDENCE.

PARALLEL RUNNING WITH EARTHED NEUTRALS

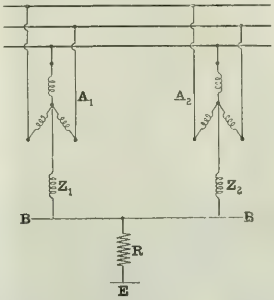
TO THE EDITOR OF THE ELECTRICIAN.

SIR: The automatic earthing switch described by Mr. J. H. Rider in his recent Paper before the Institution of Electrical Engineers is a complicated and costly piece of apparatus. No one will regard its expense as too great if it really safeguards an important generating station, such as that at Greenwich, from a source of danger, while the fact that the switch has been actually designed and used will be accepted as conclusive evidence that such a danger exists. But it appears to me most questionable whether this apparatus is the best one to use for the purpose in view.

The effect of third harmonics in the phase voltages of star connected alternators, with the star points all earthed, has been frequently pointed out. Mr. Brew, of the Dublin Lighting Station, first drew my attention to the matter several years ago, and showed me some oscillograms he had taken of the triple-frequency earth currents occurring under such conditions. But so far as I know no data of the voltages corresponding with these harmonics have been published in reference to any station, and I doubt whether such voltages have been ever actually measured. Oscillograms are very pretty things, but are useless for exact data, and until definite measurements are obtainable I do not know that anyone can estimate the true importance of these harmonics, unless it be from actual experience of their effects.

I write this letter to make a suggestion which I believe is novel, and on which I should be interested to learn the opinions of others. The suggestion is that each alternator should have its star point connected to an earthing bar through a choking coil, and that the earthing bar should be well earthed through a low resistance of the usual kind. The sketch shows two star wound three-phase alternators, $A_1 A_2$, earthed in this way, and parallel connected to the mains; Z_1 Z_2 represent the choking coils and R the earthing resistance.

Under these conditions, if the distributing system is insulated from earth, as will normally be the case, the resistance R will have no current through it and the earthing bar B B will be at zero potential. The point is that each of the impedances Z_1 Z_2 will take a voltage representing the third harmonic voltage in the windings of the corresponding alternator, and will normally choke down any current these voltages tend to cause. Moreover, these choking coils will form essentially the only impedance in the path of the current caused by the third harmonic voltage. The three windings of each alternator are so joined up in parallel that they constitute a non-inductive resistance so far as the current of triple frequency is concerned, and hence when two alternators are parallel connected with star points earthed in the ordinary way it is possible for a third harmonic voltage of small magnitude to cause quite a large current circulating around the machines. It is probably owing to this fact that appreciable currents have been observed due to the third harmonic voltage, for if the windings of the alternator acted as a choking coil, the high impedance of this for currents of triple frequency would reduce any such currents to a negligible magnitude.



In the absence of actual data I can only guess the magnitude of the voltage corresponding with the third harmonic. Let us assume there are three alternators in parallel, the first an ideal alternator with no harmonic in its voltage, the second an ordinary machine with a third harmonic voltage of, say, 2 per cent. of the phase voltage, and finally an abnormal machine with a third harmonic voltage of 10 per cent. of the phase voltage. Assuming the voltage from the star point to line is 5,000 volts, the three third harmonic voltages will then be 0, 100 and 500 volts. The ideal machine will have its star point at exactly earth potential, and can be joined direct to the earthing bar without using any choking coil. The choking coil for the ordinary machine will be subjected to 100 volts, while that for the abnormal machine will have 500 volts upon it. These voltages would cause very large currents through the machine windings were it not for the choking coils. With their aid the currents can easily be reduced to negligible values, while the voltages on these choking coils will indicate important facts about the alternators.

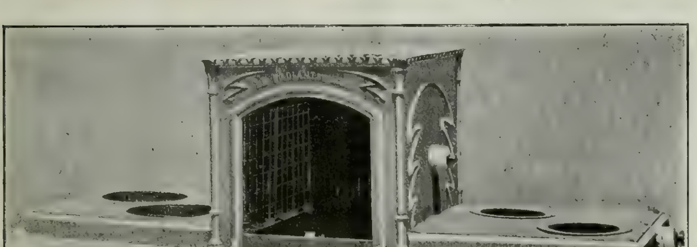
Now, without discussing details of the automatic earthing switch described in Mr. Rider's Paper, let us consider the results it secures. These appear to be three in number. In the first place, any alternator which is shut down has its star point disconnected from earth. No advantage is claimed for this result, and earth potential would appear to be the safest of all potentials for an unused machine. Again, only one acting machine is earth-connected at any given moment. The object of this appears to be two-fold. Heavy earth currents between two machines due to the third harmonic voltage are prevented. The choking coils now suggested seem to secure the same result in a simpler fashion. Another result of the switch

is that if an earth occurs on one of the phases only the alternator actually connected with earth is called upon to supply the short-circuit current, so that the "voltage of the whole station" can be maintained "pending the opening of the time-limit circuit-breaker." But the choking coils here suggested could easily be designed to prevent serious earth currents even in this case. The object of the earth connection is to keep the neutral points of the alternators at earth potential, not to encourage leakage currents to earth. If it is desirable for one of the alternators to be available to force current through a fault, all that is needed is to connect the neutral point of its windings direct to the earthing bar, omitting the choking coil. So far as I can see, the arrangement of choking coils above suggested forms a simple and more certain safeguard than the automatic switch. The cost may possibly be as great, but in this matter safety is the first consideration. The choking coils can be made to give valuable information about the machines. They are approximately at earth potential, and the voltages or currents they take might possibly be utilised to work safety appliances.

Someone may object that according to the above figures the star points of the generators instead of being kept at earth potential differ from it by 100 or 500 volts. But the choking coils are not the cause of this and nothing can possibly alter it, except those heavy earth currents which the automatic switch is designed to prevent, or such changes in the structure of the alternators as will do away with the third harmonic voltages. These voltages exist on the various parts of Mr. Rider's automatic switch, and are only reduced to zero on that switch which is connected to earth by producing a corresponding shift in the values of the line voltages to earth.—I am, &c.,
Technical School, Birmingham, April 26. W. E. SUMPNER.

LE RADIANT COOKING APPARATUS.

The accompanying illustration shows an example of the "Popular" oven, with two side attachments, of the Le Radiant system of electric cooking. This oven is placed on the market in this country by Le Radiant (Ltd.), 76, Newman-street, Oxford-street, London, W., for whom Mr. C. Fonteyn is the representative. The oven is supplied with or without the side pieces, which are completely removable, and are each controlled by two two-way switches. The complete piece of cooking apparatus as shown has a total consumption when at full heat of 4 units per hour. The height of the centre piece of apparatus is 17 in., width 17 in., depth 18½ in., and of the side pieces height 4¾ in., length 17½ in., depth 18½ in. The size of the boiling rings, which are oval-shaped, is 7 in. by 6 in. The available cooking space is 9½ in. by 10 in. by 14½ in., and the diameter of the openings at the top of the oven for boiling purposes 7 in. The total consumption of the centre piece of the apparatus at full heat is 1·8 units per hour. The centre piece is constructed of cast iron, highly enamelled in white or other colour inside and out, and reflectors are nickel plated and removable; the observation holes are of mica, and the heating tubes are protected by removable screens. There are eight heating tubes fitted to the inside of the oven, three on each side and two at the top immediately beneath the opening. These latter tubes are intended to serve the double purpose of browning the joint or poultry and heating the saucepan or kettle above. There are, in addition to these, two heating tubes beneath a sheet of iron forming the bottom of the oven, which are only put into use when required for grilling or baking pastry, cakes, &c. Toasting can be done from the top of the oven effectively. The makers claim that no special utensils are required in using this apparatus and that all the processes of cooking, roasting, baking, boiling, stewing, simmering, or, in fact, anything that can be done in a stove by the regulation of heat, can be performed with these cookers. We have inspected the stoves and have satisfied ourselves of their utility as cooking and heating apparatus and of their neat and taking appearance. The figures as to current consumption have been supplied by the makers.



LE RADIANT "POPULAR" OVEN, WITH TWO REMOVABLE SIDE PARTS.

THE "DENNY" COMBINED NO-VOLT AND OVERLOAD RELEASE.

A new departure in no-volt, and overload release coils, as applied to motor starters, circuit breakers, &c., has been devised and patented by Mr. C. W. Denny, of 67, Cross Brook-street, Waltham Cross. We are able to illustrate in the accompanying diagrams (Figs. 1 and 2) a form of coil arranged for use in conjunction with starting switches of the multiple contact type. By combining the no-volt and overload release features in one coil, the connections are considerably simplified and the manufacture cheapened. A further advantage is claimed in the fact that no shunt connections are brought into the starter (in the case of shunt wound motors), this point being of greater significance when the starter is at some considerable distance from the motor, two wires only being necessary in connecting up, as against three in the usual arrangement. The coil is, however, adaptable to shunt and series motors alike.

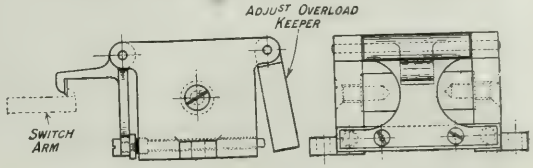


FIG. 1.—"DENNY'S" COMBINED NO-VOLT AND OVERLOAD RELEASE COIL.

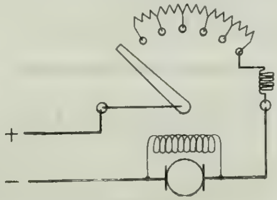


FIG. 2.

The magnet employed, being similar in appearance to an ordinary no-volt coil, is fitted with two armatures, or keepers, the one on the left in Fig. 1 being the no volt keeper, and the other the overload keeper: the coil when in use being mounted in an inclined position the no-volt keeper rests on the magnet face, and the overload keeper rests against an adjustable stop away from the magnet face. Passing through a transverse hole in each magnet pole piece, is a freely sliding rod or plunger, slightly longer than the pole piece, and normally projecting a short distance beyond the overload keeper end of the magnet. The lower ends come opposite to the free end of the overload keeper, and the upper ends opposite to the no-volt keeper.

The action of the magnet is as follows: As soon as the switch arm is brought on to the starter contacts the main current passes round the

coil, and energises the magnet. When the switch arm has arrived at the full " on " position it wipes under the catch which, owing to the no-voltage keeper being attracted and held by the energised magnet, engages with said arm and retains it in its " on " position. Should the current fail or fall below a predetermined value, the magnet will be de-energised; and the spring attached to the switch arm, pulling the latter against the catch, will cause the keeper lever to rock upon the fulcrum, allowing the arm to wipe under and release itself from the catch, and return to its " off " position.

Should an overload occur (assuming the switch to be in its " on " position) the overload keeper will be attracted towards the magnet face, and will strike the projecting lower ends of the loose plungers, which will be forced upwards. This will cause the upper ends to strike the no-voltage keeper (which is against the magnet face) and cause the lever to rock upon the fulcrum and the catch to release the switch. By arranging the no-voltage keeper so that it only has to be lightly attracted (by reason of the system of levers) in order to balance a strong pull on the switch lever, it admits of being easily released by the overload keeper coming into action. The no-voltage keeper is very much smaller in section than the overload keeper, so that many magnetic lines do not flow through it, and it allows a large magnetic leakage from the magnet in the direction of the heavier overload keeper. When the leakage is slightly increased by an excess of current (as above described), the armature is attracted and the magnetic circuit completed.

Should the overload keeper be only attracted very slowly, and with insufficient force to cause the plungers or pins to release the no-volt armature, the latter will be released by reason of the fact that when the overload armature or keeper comes in close proximity to the face of the magnet, the magnetic reluctance across the intervening air gap is very much decreased, and a greater portion of the magnetic field passes through the overload keeper, consequently weakening the pull on the no-voltage keeper, which is then tripped or released by the pull of the switch arm on the catch.

In a modification a no-voltage coil only may be employed, being wound and connected up in the ordinary manner. In this case only the no-voltage keeper (with its lever and catch arm) is employed, the overload armature being dispensed with. Owing to the leverage ratio between the keeper and catch arm, a small pull on said keeper balances a stronger pull of the switch arm on the catch, so that a much smaller coil can be employed than with ordinary no-volt release magnets.

TRACKLESS TRAMWAYS.

The members of the Sheffield deputation who recently returned from a visit to the Continent in order to collect information as to the possibilities of rail-less electric traction have drawn up their report.

They state that the system is applicable to and should be tried in the suburbs of Sheffield. Comparing the rail-less electric traction system with the ordinary motor omnibuses, both in view of the experience in London and other towns in the working of motor omnibuses, and also the experience which the committee had at the trials which took place in Sheffield during 1908, the deputation have no hesitation in stating that they are of the opinion that the rail-less system is very much superior for work of this description. They are of opinion that the Mercedes-Stoll system, which they saw in operation in Vienna, is best suited for Sheffield requirements, both as regards the general equipment, the cars and the flexibility of the system. They believe that this system could be applied and worked at a profit as a feeder to some of the existing tramway routes, and if the present powers contained in the Sheffield Corporation Act, 1907, are insufficient to allow of this being done, they suggest that necessary powers be obtained at an early date. The cost of the overhead line, &c., would be about £3,000 per mile, and the cost of rail-less electric cars should not exceed £600 per car, compared with £9,000 per mile for single track and overhead line (and £15,000 for double track and overhead line) for ordinary tramway construction, and £650 as the average cost of an ordinary tramcar. The upkeep of the rail-less system would also be less, proportionately, than that of the ordinary tramway. The deputation considered that a trial should be made on a route from the present tramway terminus at Woodseats along the Chesterfield-road to Dronfield. If the trial proved successful further routes could be equipped.

The deputation are of opinion that the system is not suitable for operation in the busy streets of Sheffield. The utility of trailers for ordinary tramway traffic was very forcibly brought to the notice of the deputation, especially in Vienna and Budapest, and that method of increasing the ordinary tramcar accommodation was worthy of a more extensive trial than it had received in this country.

The Tramways committee had the report of the deputation before them at their meeting on Tuesday, and they passed a resolution expressing the opinion that rail-less electric traction can with advantage be applied to some of the routes suggested in Sheffield and district.

PARLIAMENTARY INTELLIGENCE.

ELECTRIC LIGHTING ACTS (AMENDMENT) BILL.

The House of Lords considered this bill in Committee on Tuesday.

On clause 1, which provides for the compulsory acquisition of land for generating stations, Lord BALFOUR moved the following new clause:—

" It shall not be lawful for any undertakers after the passing of this Act, except with the consent of the Board of Trade, to construct any generating station on any land acquired by them after March 31, 1909, unless the construction is authorised and the land is specified in a special Act or Provisional Order, and the Board of Trade shall not in any case give such consent until notice has been given, by advertisement or otherwise, as the Board of Trade may direct, to owners and lessees of land situate within 300 yards of the land upon which the generating station is to be constructed, and an opportunity has been given to those owners and lessees of stating any objections they may have thereto."

His LORDSHIP said a generating station was not altogether a thing of beauty, but an evil in almost any district. The object of the new clause was that if anyone proposed in future to put up a generating station the sanction of the Board of Trade must be obtained. The undertakers would have to publish notice and a local inquiry would be held.

Lord HAMILTON of DALZELL said the Board of Trade would accept the clause, which was then agreed to.

After several drafting amendments to clauses 2, 3, 4 and 5 had been agreed to, on clause 12, relating to the audit of companies' accounts, Lord AVEBURY moved to insert a new sub-section to make the section applicable in the case of any auditor or auditors appointed under the provisions of the Public Health Act, 1875, or the Municipal Corporations Act, 1882, or by the Local Government Board, to audit the accounts of any undertakers who are a local authority. He said there was a strong impression out of doors that local authorities did not make proper provision for depreciation and reserve, and the amendment would make it possible for their auditors to report to the Board where the authority declined or neglected to comply with their recommendations. The Government apparently proposed to introduce a drastic amendment which was to apply to companies only. The amendment, however, was just as necessary in the case of local authorities, and certainly the Joint Committee were not at all satisfied with the audit.

After discussion, Lord AVEBURY agreed to withdraw the amendment at this stage.

On clause 21, Lord BALFOUR moved an amendment providing that nothing in any provisional order should in any way limit or affect the powers of any County Council " or railway company " to rebuild, alter, widen or repair the structure of any bridge upon which any work might be authorised.

This amendment was by leave withdrawn.

Lord CLIFFORD of CHUDLEIGH moved an amendment to extend the principle of the clause to diverting, widening, raising, draining or improving any road.

Lord HAMILTON of DALZELL pointed out that if the amendment were accepted there would be one law for county roads and another for non-county roads.

On a division the amendment was carried by a majority of 12, and the bill was then reported.

The Bill as originally presented was set out in full in THE ELECTRICIAN for March 19, 1909.

GAS COMPANIES' ELECTRICITY SUPPLY BILLS.

YORK TOWN, BLACKWATER, CAMBERLEY AND DISTRICT GAS AND ELECTRICITY BILL AND ALDERSHOT GAS AND WATER CO.'S (ELECTRICITY SUPPLY) BILL.

A Select Committee of the House of Commons (presided over by Mr Rose) commenced concurrent consideration of these two Bills, on Thursday last.

Mr. BALFOUR BROWNE, K.C., who, with Mr. Vesey Knox, K.C., appeared for the York Town and Blackwater Gas Co., explained the objects of their Bill, viz.: To extend the gas supply area, to supply electricity in Frimley (Surrey), Hawley-with-Minley and Yately (Hants.) and Sandhurst, Crowthorne, Finchampstead and Wokingham Without (Berks.), to erect on lands now belonging to the company stations, machinery, &c., to supply plant, fittings and materials to Government Departments and authorised distributors, to supply by sale or hire and to fix up, &c., motors, accumulators, cables, lamps and other apparatus, to provide that the consent of a rural council to the placing of electric wires above ground shall not be unreasonably withheld and that the company may appeal on that question to the Board of Trade, to refuse supply to consumers having separate supply unless the consumer agrees to pay a minimum annual sum (to be fixed in case of dispute by an electrical engineer acting as arbitrator), that certain local authorities shall have the right to require the company to sell to them the portions of the undertaking in their districts at the expiration of 21, 28 or 35 years, to raise additional capital not exceeding £50,000, and to repeal the 1906 Camberley Electric Lighting Order. Counsel said Camberley Electric Supply Co. had not done anything. The district might use a certain quantity of electricity which would warrant its supply by a gas company already established, but not the establishment of a separate electricity undertaking. Frimley Council had refused consent to the proposal of the York Town Company to supply electricity in their district and Easthampstead Council thought they should have proceeded by provisional order, but they were compelled to proceed by Bill to acquire electricity supply powers.

The Bill of the Aldershot Gas & Water Co., for whom Mr. Lloyd, K.C., and Mr. Hutchinson, K.C., appeared, seeks powers to generate and supply electricity, to enter into arrangements with and acquire undertakings of companies and persons within the company's area, to supply electrical energy in bulk outside area of supply, to wire consumers' premises, &c.

Mr. E. H. STEVENSON, civil engineer, gave evidence in support of the York Town and Blackwater Co.'s Bill, and in reply to Mr. JEEVES (for Easthampstead Council), said that if they only laid a small quantity of electric cable the Board of Trade could authorise others to compete. The Bill provided for reduction in price when the company had paid 7 per cent. on their capital. Non-duplication of the staff would tend to reduction of prices. Decrease in the price of gas might to a minute extent discourage the consumption of electricity, but on the other hand, the benefits to the consumers would counterbalance that.

Mr. STEPHEN SELLON said the company proposed to transmit current at 6,000 volts and to supply it to consumers at 200 volts. The population of the area was 17,000, but the proportion the company's scheme would supply was taken at 10,000, and the estimated revenue, on the basis of 12½ units per head of that population, was £2,343. The scheme contemplated 13 miles of mains to be laid within a few years. The compulsory area did not extend to Crowthorne, but the scheme as a whole did. If the company chose to limit their mains to the compulsory area a consumer in Crowthorne would have to pay 20 per cent. of the cost of extension of the main from that point.

Mr. A. B. MOUNTAIN, borough electrical engineer of Huddersfield, in his evidence on behalf of the Aldershot Gas & Water Co.'s bill, said it was proposed to transmit alternating current at 2,000 volts (with a periodicity of 50), and to supply consumers at 100 or 50 volts, preferably 50, which was quite high enough to use with metallic filament lamps. He thought one generating station better than several, and theirs would be at Farnborough. He agreed with Mr. Sellon that a company already on the ground would have an advantage compared with a new company, and it was also desirable that there should be only one undertaker. The Aldershot Co. would take in the thinly populated area first on the route of the mains, but the York Town Co., coming from the north, would never reach it. The Aldershot Co. estimated in three or four years' time an output of 450,000 units (at an average price of 4½d.), which would provide an excess of £4,689 over expenditure. He thought town gas for generation of current would be found better than suction gas, which the Aldershot Co. proposed to use.

The Committee passed the preambles of both bills, subject to subsequent settlement of details as to areas, &c.

The York Town Co. brought forward an amendment to the Aldershot Co.'s bill to the effect that the latter company shall not have power to supply electricity for any purpose within any portion of the limits within which the York Town Co. are authorised to supply gas or electricity, and this was adopted by the Committee.

Amendments to the York Town Co.'s bill proposed by Mr. Jeeves (for Easthampstead Council) were rejected.

POST OFFICE TELEPHONE AND RADIO-TELEGRAPHIC SERVICES.

In the House of Commons on Tuesday, on the vote to complete the sum of £18,977,930 for the salaries and expenses of the Post Office, the Postmaster-General (Mr. S. BUXTON) said that he was glad to say the telephone branch showed a very fair increase of revenue. He had been anxious to distinguish definitely between the telegraph and telephone revenue, so that, while the telegraph service was past praying for, the telephone system should be kept on a paying basis. It had been represented to him that the present rates were too high. One answer to that was that they must wait until they had taken over the National Telephone Co., and then see how the matter stood. There had been a very large expansion in the telephone service this year. They had opened 102 new exchanges, 55 call offices in connection with trunk wires and 130 other call offices. He was very anxious that, if possible, the construction work of the National Co. should be continued uninterruptedly until the end of their lease. For some time past they had been preparing the way for the handing over of the company's undertaking to the Post Office. They had done a very large amount of underground work for the company, and a considerable amount of overhead wiring as well of about £1,000,000 in value, and they had also provided, where small exchanges were brought into force, that they should be placed at once on Post Office premises. A Departmental Committee had surveyed the plant of the company in certain sample towns with a view to its more rapid valuation, and to ante-dating, if necessary, the time at which the arbitration might come into operation. In addition, he had come to substantial agreement with the company in regard to that portion of their construction work which did not involve replacement and he hoped he would also be able to come to an agreement with regard to a certain portion of the work which involved replacement. He thought there had been a great deal of exaggeration in the anticipation that there would be a large number of dismissals by the National Co. The company's maintenance and construction staffs were interchangeable, and as there arose vacancies on the maintenance staff they were filled up by the construction staff. In his opinion, the best solution of the question would be an earlier purchase by the Post Office of the National Co.'s undertaking.

Wireless telegraphy was also making considerable progress. When the Berlin Conference was held in 1906 he prophesied that the Convention, far from being harmful to the expansion of wireless telegraphy, and to Marconi's Wireless Telegraph Co., would be to their benefit. Since the Convention came into force Marconi's Co. had loyally co-operated with the Post Office, and he was glad to know that, instead of their operations being diminished, they had very largely increased. It was interesting to note that, while Marconi's Co. had only 18 stations on German ships at the time the Convention came into force, they had now 36 stations. Taking warning by the telegraph and the telephone systems, in which the State allowed a monopoly to grow up which they had subsequently to buy out, they did not intend to allow anything in the nature of a monopoly to grow up as against the State in the case of wireless telegraphy. In 1912 the various licences issued would come to an end, and it would then be for the Government to say whether they would take the whole system over into their hands or whether they would continue to a certain extent the licensing of various companies.

Telephone Equipment for the Artillery.—In the House of Commons last week, Mr. Haldane stated, in reply to a question, that up-to-date telephone equipment had been provided for the Field Artillery brigades of four divisions. Equipment was being obtained for the remaining Field Artillery brigades, howitzer brigades, and heavy batteries of the Field Army. Money had been allocated in this year's estimates for equipment for the Horse Artillery of the Field Army and the 7th Division and for the Field Artillery brigades in South Africa. Pending distribution the ordinary means of communication hitherto in use were employed. None of the batteries which practiced at Salisbury Plain in 1908 had been provided with telephone equipments.

Scottish Provisional Orders.—A commission of inquiry appointed by the Board of Trade considered last week the provisional order of the SKELMORLIE & WEMYSS BAY Gas & Electricity Supply Co. for power to supply electricity within their area.

Mr. M'CLURE, K.C., for the promoters, stated that the area of supply embraced the whole populated district. For 40 years the promoters supplied gas throughout the area which it was proposed to make the compulsory electricity area. They proposed to take power to supply electricity as an alternative to gas if consumers so desired. The promotors case having concluded, evidence for Ayr County Council and Dr. Philp, who opposed the order, was then given, and the inquiry concluded.

In the COLINTON Tramways Order power is sought to incorporate the Colinton Tramways Co. and to confer powers to construct and work a system of tramways in the Colinton district by electric power. Seven tramway routes are specified in the order, and the total mileage is about 2¼ miles. The capital of the company is £50,000 in £1 shares, with the usual borrowing powers. Power is sought to enter into working agreements with existing tramway companies, and also with regard to the supply of mechanical power for working the tramways, which will be constructed to the standard gauge or such other gauge as may be approved by the Board of Trade.

LEGAL INTELLIGENCE.

Clarke v. West Ham Corporation.

Mr. Justice Coleridge on Saturday delivered judgment on the points of law which arose on the jury's verdict in this action. The facts of the case were reported in THE ELECTRICIAN for March 5, p. 813.

In delivering judgment his LORDSHIP said that plaintiff suffered damage as a passenger while proceeding to a seat on the roof of one of defendants' cars through coming in contact with a standard which was electrically charged owing to a defect in the electrical conductor, which constituted an admitted breach of Reg. 12 of the Board of Trade. The jury found that that regulation had not been complied with by defendants, and that plaintiff had not, in fact, taken his ticket or paid his fare at the time the accident happened. Plaintiff, however, knew that a special notice to passengers was put up in a conspicuous position in the tramcars to the effect that passengers were being carried at less than the maximum authorised charges, and every passenger was notified that in consideration of this a passenger was only carried on the terms that the maximum amount recoverable from the Corporation on account of any injury or damages suffered by a passenger, and for which the Corporation was legally liable, was £25. The tickets also contained a statement as to the £25 limit of liability in respect of accidents. The jury returned a verdict for plaintiff for £500 damages, and the question was, could the verdict be sustained? The maximum toll which defendants were entitled to demand could not exceed 1d. per mile. Defendants, in fact, had a toll which they exacted from all passengers alike, of less than 1d. per mile, and those tolls they exhibited inside the cars. They could not in law, and did not, in fact, offer any alternative to the toll which they charged, because tolls at no other rate were exhibited in the cars, the exhibition being a condition precedent to the right to demand them. Plaintiff knew of the conditions accompanying the tolls, but he had no option. He was bound to travel under the conditions sought to be imposed, or not to travel at all. As he knew of the conditions, he thought it immaterial whether he had or had not taken his ticket. His legal position seemed to his Lordship to be the same as if he had. It was settled law that a railway company, and for that purpose a tramway company seemed to him to be in a similar position, might, under certain circumstances, limit their liability. They might, if they pleased, offer a free pass to a passenger, or permit him to travel under conditions which necessarily involved a greater risk to himself on payment of a lower fare or none, and call upon him to absolve them of their liability in whole or in part. But no case had been decided which permitted a railway, canal or tramway company, which had a duty to serve the public at large in the matter of carriage, to limit their liability without giving the passenger the option to travel at their risk. Defendants had to admit

that if they could limit their liability in that case they must logically claim that they were not bound to carry any one, and, if they did, might carry no one except upon the terms that they should be absolved from all liability. But he thought the statutes and regulations which empowered them to lay and work their lines in the public streets forbade such a contention. By 17 & 18 Vict., c. 31, s. 2, which applied to defendants, they were bound to afford all reasonable facilities for receiving and forwarding traffic. By 33 & 34 Vict., c. 78, s. 41, defendants were bound to work the tramway on pain of losing their powers. By sec. 44 of the North Metropolitan Tramways Act, 1884, they were bound to open for public traffic under a penalty, and he thought the legal position of plaintiff was that he was, under the circumstances, entitled as a member of the public to the service of the tramway of defendants, provided there was room. If that was so, he was of opinion that he was entitled to the service of the tramway at defendants' risk. Was his position then altered by his knowledge of the conditions under which defendants claimed to receive him as a passenger? *Prima facie*, where damage had accrued to a person through a breach of a statutory duty of another person the latter was liable. But it had recently been held that you might waive the breach of a statutory duty, and that, for instance, a workman might waive the performance by his employers of a statutory duty towards him by accepting employment under them (David *v.* Britannic Merthyr Coal Co.). The distincion between that case and the present one seemed to him to be that in that case the workman had no right to enter into his master's service; it was a voluntary act on his part. But where the person injured had a right to place himself in a position where the breach of a statutory duty was the cause of injury to himself, the party upon whom the duty devolved could not fetter that right by placing limitations upon the liability which followed from the breach of the duty. On those grounds he gave judgment for plaintiff for £500.

A stay of execution was granted on terms, with the view to an appeal.

Electrical Co. v. O. H. Thomas, Son & Co.

In the Court of Appeal on Saturday, Lords Justices Fletcher Moulton and Farwell heard an appeal by defendants against an order by Mr. Justice Walton, who had sent the action to the Official Referee, reversing an order by Master Macdonnell, who had sent the case for trial before a judge and jury.

Mr. Bailhache, K.C., for appellants, said defendants were owners of a colliery who had wished to substitute electric for steam pumping machinery in their mine, and they entered into a contract with plaintiffs to supply them with pumps, motors and apparatus. The total claim against defendants by plaintiffs was £2,976. 9s. 6d., which included £1,035 for supply of electrical plant to the Llynvi Valley Colliery at Llangonoid, £51. 1s. 4d. for goods sold and delivered, and £1,890. 8s. 2d. for work done and materials supplied and for goods sold and delivered. Defendants counterclaimed for £31,707. 17s. 4d. Plaintiffs' defence to the counterclaim was that any delay in the completion of the work was caused by circumstances over which they had no control, and which were entirely under the control of defendants. In the course of the supply and erection of the electrical plant there was a great deal of delay, and the colliery became flooded, and there was a heavy counterclaim arising out of that. Plaintiffs' claim for £1,890. 8s. 2d. was in relation to services rendered and goods supplied in the necessary operations for the unwatering of the colliery, which became flooded whilst the original contract was being performed. The items of the plaintiffs' claim were denied, but when the matter came before the Master the denials were withdrawn to this extent—that it was not now in issue that the goods were sold and the services rendered, or that the prices charged for the goods sold and services rendered were not fair and reasonable; but the question was whether the charges were recoverable from the defendants, who said that the goods were sold and the services rendered in the process of unwatering the colliery, and that plaintiffs could not recover the £1,890. 8s. 2d. In the counterclaim defendants said that, under the contract, the work was to be completed by Christmas, 1905, or, alternatively, that it was to be completed within a reasonable time, and by reason of plaintiffs' failure to complete by Christmas, 1905, or within a reasonable time, defendants had suffered heavy damage by being deprived of the use and profit of their colliery. They counterclaimed for one large item of £25,000, which was in substance an item for loss of profit owing to delay. In addition, defendants claimed to be repaid their standing charges and expenses of keeping the place open during that delay. In June, 1907, before the electrical plant was completed, the colliery was flooded—or 18 months after the date (Christmas, 1905) when the work was to have been completed. Defendants said that there was then an agreement come to by letters whereby plaintiffs undertook to unwater the colliery, defendants to supply power, engines and unskilled labour, and defendants said that four weeks was a reasonable time in which to do that, and that that period was grievously exceeded. A part of their counterclaim for damages arose under that head. Defendants' third claim was that the unwatering which was agreed to be undertaken in June, 1907, not proceeding satisfactorily, there was a further agreement made in November of that year, by which, in addition to placing steam power, engines and unskilled labour at the disposal of the plaintiffs, defendants placed the whole of their plant and appliances at their service, and agreed to supply them with coal at the rate of 12s. per ton whilst the unwatering was going on. Under that head defendants claimed a balance on account of coal supplied of £151. 4s. 10d. Defendants' fourth claim was that by an agreement, also in letters, plaintiffs arranged to run their plant for three months (from April 28, 1908, to the end of July in the same year). Defendants alleged that plaintiffs failed to do that, and that they (defendants) did so at the expenditure of £395. 9s. 4d. That being the nature of the action, counsel argued that there was no power in the Court to order a case of that class to be tried by the Official Referee.

Lord Justice Moulton suggested that the question as to who was responsible for the flooding of the mine would seem to require scientific investigation, as well as questions of account.

Mr. Bailhoche submitted that there could be no question of account in the case in the ordinary way. The question was one of damages.

Lord Justice Moulton: I have no doubt whatever about the jurisdiction of the learned judge who made the order, and I have not the slightest doubt that that jurisdiction was judiciously and wisely exercised. The appeal must be dismissed.

Lord Justice Farwell concurred, and the appeal was dismissed accordingly.

Re Amalgamated Radio-Telegraph Co. (Ltd.)

In the Winding-up Court last week Mr. Justice Neville heard a summons for the confirmation of a contract of sale of the assets of this company.

Mr. Peterson, K.C., said the two liquidators of the company were Mr. Pixley and Mr. Allen, who proposed to sell the assets for £35,000. There had been a provisional contract for the sale of the assets for £26,500, but a Mr. Hage now claimed to have been the purchaser for £33,000, and Mr. Lees and Mr. Earl claimed as purchasers for £35,000. The liquidators now asked the assent of the Court to their acceptance, subject to the usual guarantees, of the highest offer for the assets. The company was formed in September, 1906, with a capital of £413,000, of which £63,000 was actually paid down in cash, and the assets were mainly patents, apparatus and wireless telegraph stations that had been established. In 1908 winding-up was decided upon, there being a number of unsecured creditors. On March 25, 1909, a conditional contract for the sale of the assets for £26,500 (with Messrs. Lees and Earl) was entered into. Then followed an offer of £33,000 by Mr. Hage, followed by an increase of the offer of Messrs. Lees and Earl to £35,000. The liquidators now, naturally, wished to sell to the highest bidder.

On Tuesday Mr. Justice Neville gave judgment, and said that the only question was whether the sale made before the Registrar for £33,000 was binding. The parties had been called before the Registrar, and invited to bid against each other. £33,000 was offered by Mr. Hage, and that was accepted under certain conditions. In his opinion the order of the Registrar was a final one, subject to the conditions imposed. He could not, therefore, sanction the liquidators accepting a subsequent offer for a higher sum. He would make no order on the summons, the liquidators to pay the costs of all the parties out of the assets.—Leave to appeal was granted.

Devonport & District Tramways Co. v. Devonport Corporation.

On 22nd inst. a Divisional Court (Justices Darling, Bray and A. T. Lawrence) granted a rule nisi prohibiting the Town Clerk and Corporation of Devonport and the magistrates of Devonport from proceeding further with certain information and summonses which had been issued and were pending against the company.

Mr. Macassey, for the company, said the application was made on the ground that the magistrates had no jurisdiction. The company were authorised by an Act passed in 1898 to construct tramways in the borough of Devonport, and by an Act passed in 1902 the Corporation were authorised to construct other tramways in other parts of the borough. By an agreement the Corporation agreed to lease the Corporation tramways to the company. That agreement was scheduled to the Corporation Act of 1902, and ratified by a clause in the Act. The company covenanted to provide such reasonable service of tramcars as the Corporation thought reasonable in the public interest, but if the company did not provide such reasonable service a penalty of £2 a day was provided for. Another covenant was that the company should run workmen's cars to the satisfaction of the Corporation. There was also in the lease a clause providing that if any differences arose between the Corporation and the company they should be referred to an arbitrator, to be appointed by the Board of Trade. The Corporation had now sued the company under the Summary Jurisdiction Act for the recovery of penalties, but he submitted that the penalties were not recoverable under the Summary Jurisdiction Act, but as liquidated damages (if they were recoverable), and not before the magistrates. The Corporation had served a notice upon the company requiring them to run a certain service of cars. The company objected to the notice, and that constituted a difference between the parties which it would be proper to refer to arbitration, as provided for in the schedule of the Act.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s. and 5 per cent for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Modern Electric Practice." Edited by Magnus Maclean. 2nd Edition. Vols. I to VI. (London: Gresham Publishing Co.) 54s.

"Cable Map of the World." Compiled by the Geographical Department of the War Office. (London: Mr. Edward Stanford.) 1s. net.

"Le Réglage des Groupes Electrogènes." By J.-L. Routin. (Paris: La Lumière Electrique.)

"Röntgen Ray Wrinkles." By Leslie Miller. 1s.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An engineering master (mechanical and electrical) is wanted for September next by the Plymouth Education Authority for their science, art, and technical schools. Forms of application from the Education Secretary, Mr. E. Chandler Cook, 18, Princess-square, Plymouth. See an advertisement.

Applications are invited for the position of assistant to the mains engineer in the electric supply department of the Corporation of Birmingham. Applicants must have had thorough experience in e.h.t. alternating-current work, including switchgear, transformers, &c., and be conversant with modern systems of h. and l.t. distribution, laying and testing of cables, &c. Commencing salary £150, rising to £250. Applications to the city electrical engineer and manager (Mr. R. A. Chattock), 14, Dale End, Birmingham, by 4 p.m., May 4.

Mr. F. H. Corson, chief assistant engineer at Blackburn, has been appointed city electrical engineer at Gloucester. There were 248 applicants, but this number was reduced to five, viz., Messrs. F. H. Corson, J. W. Beauchamp (Sheffield), H. A. Howie (Dudley), C. E. Savage (Wolverhampton), and R. N. Torpey (Wimbledon). Owing to Mr. Beauchamp having been appointed electrical engineer at Tunbridge Wells the Council had only four candidates from whom a final selection could be made, and their choice ultimately fell on Mr. Corson. Mr. J. B. Feltham has also been appointed assistant engineer.

Tunbridge Wells Council have appointed Mr. J. W. Beauchamp, of Sheffield, resident electrical engineer; Mr. John Bemrose, of Worcester, as chief assistant, and Mr. V. F. Bush as junior assistant.

Mr. G. Tough, who has been acting manager of the Coventry electricity works for the past six months, has been appointed engineer and manager of the undertaking at £350 per annum.

Mr. Frederick Hy. Edwards, deputy borough electrical engineer at Woolwich, has been appointed deputy electrical engineer at Erith.

Mr. R. V. Weare has been appointed resident engineer to the Chichester Electric Light & Power Co.

Harrogate Council have appointed Mr. W. M. Procter as canvasser of the electricity department at £2 per week, and 6d. per point commission.

Mr. T. W. Davies has been appointed station superintendent at Wrexham.

Correction.—In our last issue (page 67) we stated that Mr. E. J. Taylor had been appointed meter inspector at Belfast. The position to which Mr. Taylor was appointed is installation assistant.

Afghanistan.—A representative of F. & C. Osler has left Bombay for Cabul to make arrangements for the electric lighting of the Ameer's palace.

Australasia.—The "Australian Mining Standard" states that electric power plant is to be installed at the Boulder tin mine, Zeehan, Tasmania.

At the request of the Omah Mines (Ltd.), Zeehan Municipal Council will supply electrical energy to the company's works up to 50 H.P.

Bath.—Mr. E. Schenk has now withdrawn his bill for the purchase of the municipal electricity works, and the Electric Lighting committee recommend the Corporation to return to Mr. Schenk half of the deposit made by him on the purchase money (£2,500).

Battersea (London).—The Lighting committee are preparing a scheme for wiring premises, but in the first place the installation and maintenance of motors and arc lamps are to be dealt with.

Under the provisions of the L.C.C. (General Powers) Act, 1906, charges must be so adjusted as to cover any expenditure involved, and the committee are of opinion that they cannot themselves profitably carry out the installation work involved in all cases until they see the number of applicants and the amount of work likely to occur. They have, therefore, decided that for the present this work should be done by contractors.

Electric light services are to be laid on to 13 premises at an estimated cost of £70.

Bedford.—The Council have offered a supply of electrical energy to Messrs. W. H. Allen, Son & Co., at 1d. per unit, with discounts, the value of the minimum annual consumption not to be less than £1,650.

Additional plant is to be installed at the electricity works at a cost of £3,000.

Bolton.—Duncan-street sub-station is to be enlarged.

Braunton (Devon).—Braunton Lighting committee are to interview Mr. Dennis with regard to his offer to supply electricity for lighting Knowle at the charge at present paid for gas.

Carlisle.—The Electricity committee are considering the question of applying for a provisional order to enable them to supply electricity in districts adjoining the city boundaries.

Chelsea.—The Medical Officer of Health reports that subsequent to June, 1908, the amount of smoke from the Lots-road generating station had materially decreased and little exception could now be taken to the smoke emitted from the chimneys.

The great improvement might be attributed (1) to the new revolving wire-mesh screen, inserted at a cost of £2,500, into the adit conveying the water of the Thames to the condenser pumps, which separated out the leaves and débris, which often occasioned choking of the pumps and a consequent loss of vacuum; (2) to the more thorough regulation of the draught to the furnaces through the fire doors, which had now been carried out on improved principles; and (3) to the use of coal of suitable quality.

Chichester.—Mr. Horace Boot, consulting engineer, has been retained by Chichester Electric Light & Power Co. at a salary, and Mr. R. V. Weare, who has acted as clerk of works, has been appointed resident engineer.

China.—Electricity supply works have been established in the Japanese settlement at Antung. The generating plant is of British manufacture.

Cotton Mill Driving.—The Brush Electrical Engineering Co. has for some time past been engaged in the electrical equipment of some of the mills of the Fine Cotton Spinners Combination in the Manchester and Bolton districts. Up to the present 11 of these mills have been equipped by the Company, and the equipment work at other mills is in progress.

Dock Cranes.—The North Eastern Railway Co. propose to erect three electric cranes at Tyne Dock.

Electricity in Mining.—The report of the directors of Rand Mines (Ltd.) for the past year states that the introduction of electric power in the place of steam plants had engaged the attention of the Boards of most of the subsidiary companies, and a new company was in process of formation, to be called the Rand Mines Power Supply Co., which would generate electricity in bulk for distribution to those companies, as well as to a number of other important mining companies on those fields. Favourable contracts were in course of completion, and it was anticipated that electric power from the new company would be available by October, 1910, and would enable substantial economies in working costs to be effected.

Exhibition.—A Japanese Exhibition will be held at Shepherd's Bush next year, and the Japanese Imperial Diet has sanctioned a grant of 1,800,000 yen for the purposes of the project.

Finchley.—The gross revenue of the electricity undertaking for the past year was £15,390, and the estimated profit was £317.

Fleetwood.—Sanction has been received by the Council to a loan of £20,200 for the purchase of the local electricity undertaking from Broadstone, Ltd.

Hetton (Durham).—The local Electric Supply Co. offer to supply electric current for public lighting at £695 per annum if overhead mains are allowed.

Holland.—The Communal authorities of Arnhem and Renkum-Oosterbeek are considering the question of constructing an electric tramway, eight miles in length, to connect the two districts.

Amerongen Communal Council have granted M. Woolf de Maarsen a concession for the erection and working of electricity supply works.

India.—Messrs. F. and C. Osler are carrying out electric lighting installations in the old and new palaces at Patiala (Punjab).

Institution of Colliery and Mining Electrical Engineers.—At a meeting of persons interested in mining and colliery electrical plants, at Manchester, on Saturday last, it was decided to form an association, to be called the Institution of Colliery and Mining Electrical Engineers. Mr. William Maurice, general manager of the Hucknall Torkard Colliery Co., was elected first president, and Mr. J. Williams, of 3, Moresby-parks, Whitehaven, electrician of the Moresby Coal & Iron Co., is hon. secretary. The following district representatives were appointed: Messrs. J. E. Sayers, M.I.E.E. (Scotland), H. J. Fisher, A.M.I.E.E. (Durham), R. J. Frost (Yorkshire), P. D. Coates (Lancashire), J. Kirkby (Derbyshire), H. Cusworth (Notts.), S. H. Bell (Staffs.), H. J. F. Stewart (Ilfracombe), J. A. Boshes (North Wales) E. Ivor Davies (South Wales). A further meeting of the Institution will be called by the secretary, when the election of Council will take place.

Italy.—The "Bulletin Mensuel" de la Chambre de Commerce Française de Milan, for April (which can be seen at 73, Basinghall-street, London, E.C.), contains a list of 16 electric lighting and power concessions which have been granted by the Prefectures in various parts of Italy.

Lancashire and Cheshire Municipal Tramway Managers.—The quarterly meeting was recently held at Burnley.

Among those present were Messrs. H. Mozley (Burnley) (*chairman*), J. M. McElroy (Manchester), J. H. Cowell (Blackburn), W. Clough (Bury), A. T. Eardley (Stockport), T. J. Kendrew (Southport), H. Holme (Nelson), G. W. Holford (Salford), W. Wyld (Birkenhead), R. R. Greene (Wallasey), J. F. Simpson (Preston), R. W. Smith-Saville (Darwen), J. W. Dugdale (Ashton-under-Lyne), and L. Slattery (Oldham) (*hon. sec.*).

Several matters of local interest were discussed, and afterwards a visit was paid to the car depot and workshops, where the members had an opportunity of inspecting a two-motor bogie car, with body carried wholly on the driving wheels, and the rotating point of the trucks over the centre of the driving axle, a vestibule bogie car with top cover and cabin, the construction of trucks in progress, mechanical run-back preventer, time meters, &c. On the invitation of Mr. W. Wyld, general manager and engineer of the Birkenhead Corporation tramways), it was decided to hold the next quarterly meeting at Birkenhead on July 16.

Leeds.—The surplus on the past year's working of the tramways was £51,556 12s. 4d., of which £4,000 is to be put to reserve fund, and the balance (£47,556) is to go in relief of rates.

The gross profit was £163,677, an increase of £600 on 1908. After paying interest on capital (£41,883) and income tax (£4,429), the net revenue for the year was £120,619. Sinking fund required £41,156, and permanent way renewal £27,906. The surplus in 1907-8 was £64,279. The year's traffic receipts were £338,032, an increase of £1,585, and the average earnings per car-mile 10·36d. The addition of sundry receipts (including £3,553. 17s. 11d. for advertising) brought the total to £342,000. 19s. 6d. Working expenses were £178,323 and included £28,463 for general expenses, £34,045 for general repairs and maintenance, and £20,648 for power expenses. The amount expended on permanent way repairs is £4,799 less than the previous year. Under the head of power expenses there is a large decrease in expenses for repairs and renewals of ducts, feeder cables, &c.

The Tramway committee consider the result of the year's working very satisfactory, and a vote of thanks has been accorded to the general manager (Mr. J. B. Hamilton) and the staff for their efficient services.

Leicester.—In future, power users are to have the option of taking current either at the present flat rate of 2d. per unit or upon the terms of paying 15s. per quarter for every H.P. of motor installed, and ¾d. per unit for current consumed.

Light Railways.—The report of the proceedings of the Board o Trade and of the Light Railway Commissioners up to Dec. 31, 1908, under the Light Railways Act of 1906 has been issued.

On Dec. 31, 1907, 13 orders were before the Board awaiting confirmation, and 11 of these were confirmed during 1908, two being consolidated into one order, and two were held over. During 1908 15 orders were submitted to the Board by the Light Railway Commissioners. Objections were lodged in respect of some of these. The Board considered each order with special reference to the points mentioned in sec. 9 of the Light Railways Act, and made such amendments as were deemed necessary. Eight of the orders submitted during 1908 were confirmed, and in no case did the Board refuse to confirm an order. Of the seven orders under consideration on Dec. 31 last, five have since been confirmed. The 18 orders confirmed in 1908 authorised 80 miles of line, the estimated cost of which will be £601,729.

In the 12th annual report of the Light Railway Commissioners, which covers the year ended Dec. 31, 1908, it is stated that a total of 579 applications for orders to authorise light railways (which included 87 applications for amending orders) had been received since the commencement of the Act. In respect of 366 applications (15 in 1908 and 351 in previous years), orders were submitted to the Board of Trade for confirmation, five other applications in respect of which orders are under settlement have been approved and 197 applications have been rejected or withdrawn. The decisions with respect to four applications have been deferred and seven new applications made in November last remained to be considered. In conclusion, the Commissioners state that though they do not think it necessary to repeat again the reasons set out in their report for 1908, for which amendments of the Light Railways Act appear to be required, they think it desirable again to draw attention to the need for the construction of light railways which has been found to exist in many parts of the country, and to express the opinion that such need is unlikely to be met unless and until some amendments of the Act are effected.

Llandudno.—An additional 300 kw. generating set is to be put down at the electricity works at a cost of £1,750.

L.C.C. Tramways.—In connection with the reconstruction of the tramways in Great College-street, St. Pancras, the engineer to the London County Council claims that where existing tramways have been converted for electric traction the obligation to provide a width of 9 ft. 6 in. between the outer rail and the kerb does not apply. As it may happen that the Borough Council may be called upon to incur the cost of necessary widening the thoroughfare, St. Pancras General Purposes committee have submitted a case to counsel for his opinion as to the powers and liabilities of the Borough Council in the matter.

Lurgan (Ireland).—At the last meeting the chairman of the Council (Mr. H. G. Macgeagh, J.P.) said the question of the public lighting should be considered.

He considered that electricity supply was a scheme that would not only pay but would be a source of income. He knew of no town so admirably adapted to electric lighting as Lurgan, because they had so many small manufacturers who would find electric power much cheaper than that they were at present using.

It was decided to discuss at a special meeting an offer from an electrical engineering firm for lighting the town

Liverpool Engineering Society.—At the annual general meeting on Wednesday Mr. W. Brodie was elected president for the ensuing year and Mr. T. R. Wilson, hon. secretary. A representative council was also elected, and the Derby memorial gold medal for the session 1908-9 was presented to Mr. H. E. O'Brien, and the society's premium to Mr. John H. Parkin,

Macclesfield.—The local Tradesmen's Association have asked the Council to carry out the terms of their provisional electric lighting order, or to transfer their powers to a company.

Manchester.—The Tramways committee have contributed £75,000 to the rates, an increase of £5,000 over last year.

Mexico.—The estimated expenditure on the Department of Telegraphs of the Mexican Government for 1909-10 is £290,441; the revenue for the same period is estimated at £205,000.

Mine Signalling and Telephones.—At a recent meeting of the Cinderella Deep Co., the chairman stated that most efficient signalling apparatus and an underground telephone system, had been installed. That company was, he said, the first to adopt telephones for underground work on the Rand, and their usefulness had already been amply demonstrated in practice. This company was working with one shaft only at a depth below 4,000 ft., in consequence of which extra precautions had to be adopted against accidents.

Nelson.—The annual report of the tramways department was submitted to the Tramways committee on Tuesday. The result of the year's working is a loss of £820, which is ascribed to depression of trade. The number of passengers carried was 1,811,000, a decrease of 248,000.

Neston (Yorks.)—Messrs. Forwood & Williams, who are supplying electricity to the tenants of the Hinderton Hall Estate, are negotiating with the Council for the supply of electricity in the district.

New Brunswick.—The Grand Falls Power Co. will expend about 5,000,000 in erecting a large hydro-electric plant at Grand Falls, New Brunswick. The plant is to be purchased in New York. The main power-house will be equipped with eight units of 10,000 H.P. each. The station will be situated near the Canadian Pacific Railroad, and sub-stations and long-distance transmission lines will be established to distribute current in both New Brunswick and Maine.

Newcastle-on-Tyne.—The profit on the working of the tramways for the year ended March 31 was about £10,000, compared with £19,000 for the previous year, and £8,000 for 1906.

Obituary.—We regret to record the death on 28th inst., at his residence in London, of Mr. Robert Charles Dudley, in his 84th year. Mr. Dudley acted as correspondent of the "Illustrated London News" on the 1865 Atlantic Cable expedition, and is well known as an artist of distinction. His painting representing the "Great Eastern" proceeding homeward, before a rising gale, after her unsuccessful attempts to pick up and repair the interrupted Atlantic cable of the year named, is familiar to many of our readers through its large-scale photographic reproduction, published by "The Electrician" Company.

Presentation.—Mr. Andrews, of Southend, who has been appointed chief engineer of the Malta tramways, has been presented with a diamond ring.

Provisional Order Revocation.—The Board of Trade have revoked the Stroud Electric Lighting Order, 1903, as from April 17.

Rawtenstall.—The formal opening of the electricity works, and the electric tramway undertaking, will take place on May 15.

Southend.—The tramway traffic manager (Mr. Andrews) has resigned.

Southgate (London).—The proposal of the Council to transfer their electric lighting order of 1904 to the North Metropolitan Electric Power Supply Co., is opposed by the Ratepayers' Association.

A communication was recently forwarded to the Board of Trade embodying the Association's objections to the transfer, and at a meeting of ratepayers, Mr. G. W. Spencer Hawes, M.I.E.E. (who is a resident of the district), attended and submitted an electricity supply scheme. He said the Council could reasonably look for a supply of electricity in bulk at between 1¼d. and 1½d. per unit; he estimated the cost of the distribution station and feeder cables and laying mains in 21 of the principal streets at £18,500. Apart from shops, he thought there would be about 475 private consumers who would take current at 5d. per unit. The estimated revenue was £4,000, and after paying all expenses (including interest at 4 per cent., and redemption charges), he calculated on a period of 22 years there would be a surplus of about £500.

After discussion, a resolution was carried, with two dissentients, to ask Southgate Council to consider Mr. Hawe's scheme.

Switzerland.—The Compagnie du Chemin de Fer Electrique de Lugano à Tesserete have secured a concession for the construction and working of a metre-gauge, single track electric railway from Lugano to Tesserete.

Telephone Rates.—At Glasgow on Tuesday at the Annual Conference, of the National Chamber of Trade, a resolution was passed, on the motion of Mr. S. T. Nicholson, of Hull, that a committee should be appointed by Parliament to inquire into the question of telephone rates and charges, and that the interests of small users should be fully represented thereon.

Tyne Tube Scheme.—Representatives of Tynemouth and South Shields Corporations considered on Wednesday the proposals of the promoters of the scheme for constructing an electric railway under the river Tyne between North and South Shields.

The promoters, who desire to find security for the interest upon £100,000 4 per cent. debenture stock, have asked the Corporations to undertake liability. It was stated that the North-Eastern Railway Co. would probably be willing to guarantee one-third of the interest if the Corporations would guarantee the remainder. A resolution recommending the Corporations to favourably consider the scheme, and to ask the railway company to guarantee half the interest, was passed.

West Ham.—In connection with the through running of tramways with those of East Ham over the Plashet Grove section, 4·937d. has been arranged as West Ham running costs and 10d. as the car mile earning beyond what profits are to be divided. In view of the undeveloped state of the district the Board of Trade are to be asked for an extension of two years for constructing the Prince Regent-lane tramway and the unfinished portion of the junction between Barking-road, Prince Regent-lane, and Greengate-street.

Wireless Telegraph Notes.—The enterprising management of an English hotel at Shanghai recently equipped the building with wireless telegraph apparatus. This has led to a protest from the Chinese Government Telegraph Department, and it has been arranged that the installation shall not at present be used.

Interesting experiments are proceeding at the Post Office wireless stations at Hunstanton and Skegness (distant 16 miles) to ascertain the minimum cost of effectively operating stations of this size.

It is stated that the unsettled condition of the French Government postal telegraph and telephone services has led the heads of the French Postal Telegraph Department to resort to wireless telegraph installations as a means of overcoming some of the difficulties of the situation. Stations, specially designed, have been hurriedly erected at Brest, Havre, Lorient, Dunkirk, Cherbourg, Rochfort, Toulon and other centres, communicating with a large number of inland towns. It is feared that a renewal of the strike proceedings will be started to-morrow (May 1).

The Central News is responsible for a message which serves to show the adaptability of wireless telegraphy. It is stated that the captain of the North German Lloyd liner "Kaiser Wilhelm II.," sent a wireless message to New York asking that detectives might be available on the vessel going into dock to arrest some undesirable personages on board.

Walsall.—At a special meeting of the Council on Monday, Mr. Pearman-Smith moved that, having regard to the amount of capital invested in the electricity undertaking, no further steps be taken in reference to the proposed expenditure of £35,000 for new plant and extensions of mains until the General Purposes committee had reported whether the present system was the best adapted for the borough, and if not, the alterations which were necessary and the estimated cost involved.

He disclaimed any wish to pass anything in the nature of a vote of censure on the Electricity committee, but as the outlay was only sanctioned by a majority of one he thought the matter should be reconsidered. £110,000 had been sunk in the undertaking, of which £54,517 represented the cost of machinery. If drastic changes were necessary it was advisable they should be made before any further capital outlay had been incurred, particularly as last year's loss of £600 practically wiped out the small reserve fund which had been accumulated.

Dr. Stead, chairman of the Electricity committee, said if the resolution were adopted it must be understood that it would involve the resignation of the committee, as the scheme submitted was the outcome of careful and prolonged deliberation.

After debate, the motion was adopted by 16 votes to 13.

Woolwich (London).—At the last meeting of the Council the Electricity committee reported that they had been considering the advisability of adopting a scheme of assisted wiring.

The introduction of the metallic filament lamp had, the report stated, considerably modified the old order of things in the electrical industry, and, coupled with a sound assisted wiring scheme, made it possible for the Council to offer a cheap and efficient supply. Many promises of support had been received, and the committee, therefore, thought the proposal should be given a fair trial. The proposal is, briefly, as follows: The Council to put in complete installations of not less than six points in approved revenue-earning positions in houses exceeding £32 rental per annum (exclusive of rates and taxes) without initial cost, on applicants signing the usual application form and a rental agreement. The Council to take a rent of 7d. per lamp installed per quarter for installations in Woolwich and Plumstead, and in Eltham 3s. 6d. per quarter for the necessary transformer in addition, such rents to be perpetual unless the installation is purchased. The consumer to have the option of purchasing the installation at any time, but to pay cash for any special fittings required, and also for any lamp not in a revenue-earning position, such as bathrooms, lavatories, &c. The consumer to maintain the installation in full working order after the expiry of 12 months' guarantee, or the Council would maintain fully, at an additional charge per lamp of 9d. to 1s. per quarter, if the whole installation is to be maintained.

The committee consider the scheme financially sound, and conclude by recommending that the staff and employés of the department (with the exception of the station engineer, distribution engineer and chief clerk) be allowed a commission at the rate of 5 per cent. on the first year's consumption of any new consumers whose signed application under the proposed scheme they may obtain.

The report and recommendation were carried.

Marriages.—Mr. Chas. Garnett, borough electrical engineer at Darwen, was recently married to Miss Belle Aspden, and, among the presents was one from the employés of the Darwen electricity department.

Mr. Thos. Roles, the city electrical engineer of Bradford, was married at Plymouth on Saturday to Miss Bertha Hugo.

On his marriage Mr. H. E. Midgley, M.A., A.M.I.C.E., deputy engineer at Erith electricity works, has been presented by the staff with a brass kerb suite. The presentation was made by Mr. A. Coveney, engineer and manager.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Wigan Corporation invite tenders for the supply and erection of 750 kw. engine and generator, two water-tube boilers, steam and water piping, motor-driven feed pumps, economiser, separators, feed water filter and meter, exhaust steam and water piping, motor-driven pumps and condenser, coal-handling plant and bunkers, h. and l.-t. cables, h. and l.-t. switchboard, removal of plant from Pemberton generating station to Wigan, constructional steelwork for the boiler house extension and switchboard gallery. Copies of specification, &c., from the borough electrical engineer, Mr. Jas. Slevin, Bradford-place, Wigan. Tenders to the town clerk, Mr. Harold Jevons, by May 17. See also an advertisement.

St. Pancras (London) Borough Council invite tenders for supply of arc lamp carbons. Copies of specification, &c., from the Electricity Department offices, 57, Pratt-street, Camden Town, N.W. Tenders by noon, July 10, to the Town Clerk, Mr. C. H. F. Barrett, Town Hall, Pancras-road, London, N.W. See also an advertisement.

London County Council invite tenders for withdrawing about 18 miles of l.t. lead-covered cables, now laid and jointed in stoneware ducts, and relaying and jointing about 15 miles of l.t. lead-covered cables, &c. Tenders (upon official forms to be obtained from the Clerk of the Council, Mr. G. L. Gomme, County Hall, Spring Gardens, S.W.) by 11 a.m. of Tuesday, May 4.

SPECIAL NOTICE.

WOODBRIDGE Urban Council, who are desirous that a company should establish electricity works in the district, announced that they would support a company in an application for a provisional order and would enter into a contract for public lighting from April 1, 1912. The population is 4,600 and gas is 4s. 6d. per 1,000 ft. Tenders by June 1.

HERTFORD Corporation require tenders by May 8 for supply and fixing of a 25 B.H.P. motor and gearing. Forms of tender, &c., from the Borough Engineer.

RAWTENSTALL Corporation want tenders by May 11 for wiring the Tramcar Depot and Municipal Offices. Specification, &c., from the Borough Electrical and Tramways Engineer.

ADELAIDE (S. Australia) Municipal Tramways Trust require tenders by June 15 for supply of 50 tramcar bodies, trucks, wheels, axles, motor equipments and car wiring, and by June 22 for boilers, mechanical stokers, economisers, piping, coal and ash handling plant, steam turbines, generators, exciters, condensers, air and circulating pumps, switchboards, &c. Specifications from the Chief Engineer and General Manager, 8, King William-street, Adelaide.

The Junta de Obras del Puerto de ALMERIA, Spain, require tenders by June 7 for supply of six electric cranes, with accessories, for the Almeria docks. Deposit of about £670 required from all tenderers.

TENDERS RECEIVED AND ACCEPTED.

Brighouse Council have accepted the tenders of the Phœnix Dynamo Co., W. T. Glover & Co., the Edison & Swan Co. and Herbert Morris & Bastert for supplying plant, &c., for a new transforming station.

Woolwich (London) Council have accepted the tender of Strachan & Henshaw, for coal handling plant at £847; that of the Underfeed Stoker Co. for 14 sets of underfeed stokers at £1,300, and four sets at £770.

West Ham Council have placed an order with Bruce Peebles & Co. for converting two 1,200 kw. Ferranti alternators from single to two phase at £825.

Aston-under-Lyne Council have accepted the tender of the Standard Engineering Co. for an induced draught fan, and that of the Stirling Boiler Co. for a water tube boiler and chain grate stoker.

East Ham Council have accepted the tenders for engine room stores for the electricity and tramways departments from Middleton Bros., Pfeil & Co., Wiggins & Rihll, Hy. Freund & Co., and F. How.

Stirling Corporation have placed an order with Callender's Cable and Construction Co. for supplying and laying a new feeder cable to the north end of the town.

Aylesbury Council have accepted the tender of Mackrill & Sons for electrical work during the ensuing 12 months.

Belfast Tramways committee have accepted the tender of Imeson, Finch & Co., for supply of two miles of trolley wire.

The contract for electric bell work at Warwick hospital has been let to Brown & Parsons.

Commonwealth Tenders.—The following tenders have been accepted by the Government Departments of the Australian Commonwealth:

The Postmaster-General's Department, Brisbane, have accepted the tenders of the International Electric Co. for trembling bells, condensers, receiver cords, and carbon diaphragms; British Insulated & Helsby Cables for receiver cords; India Rubber Co., for phonophore carriers, detectors, galvanometers, &c.; J. Paton & Co. for Ericsson telephone armatures, extension bells, dry cells, bell coils, generators and generator handles, jacks, micro-telephones, Ericsson watch receivers, carbon rings, switches, wall sets, table sets and portable telephones, &c.; Brisbane Electrical Co. for binding posts for receiver terminals, carbon shot, carbon diaphragms, microphones and fittings, pole changers, receivers, switches, screws, &c.; Lawrence & Hanson for cells, twin flexible switches, brass terminals, &c., and C. E. Bernays for glass cells for Tudor accumulators and positive plates.

The Postmaster-General's Department, Melbourne, have accepted the tender of J. Bartram & Son for wall sets.

The Postmaster-General's Department, Sydney, have accepted the tender of J. Newland for purchase of old zinc, copper and lead.

BUSINESS NOTICES.

Messrs. Drake & Gorham notify that at the end of April they are relinquishing the sole agency for Jandus arc lamps. They have concluded other selling agencies.

Mr. G. H. J. Hooghwinkel has opened an office at Prudential Assurance-buildings, 20, Park Row, Leeds, and has taken into partnership Mr. Francis Thursfield, M.I.C.E., M.I.E.E., formerly electrical engineer to Burnley and Chester Corporations, and lately of Messrs. Preece & Cardew, Westminster. Mr. Thursfield will take charge of the Leeds office, and the firm will continue Mr. Hooghwinkel's present practice with special reference to the electrification of collieries, steel works and mills, the introduction of exhaust steam turbines and electrical furnaces for the smelting and refining of metals, &c.

Messrs. Pooley & Austin, Victoria-street, S.W., have been appointed sole agents in London and the Home Counties for I. Frankenburg & Sons' cables, &c. Messrs. Pooley & Austin have also made arrangements for supplying a.c. meters, of British manufacture, for either single, two or three-phase circuits.

Mr. Walter Dixon has taken into partnership Mr. Frank Anslow, who has been associated with him for the past nine years in business. Both Mr. Dixon and Mr. Anslow have carried out many important schemes in connection with the generation, transmisison and application of electric, gas and other power to engineering undertakings. In view of the increasing use and possibilities of the economical application of electricity and gas power, the firm will devote special attention to their consulting practice. Messrs. Walter Dixon & Co.'s new address is 38, Bath-street, Glasgow.

Water Turbines.—Messrs. W. H. Allen, Son & Co. (Ltd.), Queen's Engineering Works, Bedford, announce that, in view of the great demand which has arisen for hydraulic turbine machinery, they have come to an arrangement with Messrs. Piccard, Pictet & Co., Geneva, to manufacture water turbines of large size to their designs. This firm is one of the leading manufacturers in Europe of water turbine of the Francis high speed type, and they have placed their great experience at the disposal of Messrs. W. H. Allen, Son & Co., which will enable them to manufacture machines of this character. Some years ago water turbines formed one of the principal specialities of Messrs. Allen, but owing to the rapid increase of other branches of their business they were unable to develop their water turbines to the same extent, and the firm are now again taking up this interesting subject with a view to manufacturing complete installations for hydroel-ectric power stations.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane, Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

Two alternator-gas engine sets (250 kw. each), direct coupled, are advertised for sale.

A second-hand Kc Peache high-speed engine, 340-365 B.H.P., made by Davey, Paxman & Co., is offered for sale in another column.

Business for Sale.—An engineer's business in a southern town is offered for sale by Messrs. Langridge & Freeman, 28, Queen-street, London, E.C., and Tunbridge Wells.

Electrochemical Laboratory Premises Wanted.—An advertisement contains particulars of the requirements of consulting engineers, who wish to lease or purchase premises for an electrochemical laboratory, within reach of cheap electric supply, gas and water.

Oerlikon Three-phase Variable Speed Motors.—With reference to the article on this subject which appeared on p. 53 of our last issue, we desire to state that the London address of this company is Oswaldestre House, Norfolk-street, Strand, W.C., the manager and chief engineer of the British, Irish and Colonial Department being Mr. G. Wuthrich.

CATALOGUES, &c.

ROLLER BEARINGS.—The Empire Roller Bearings Co. have issued a list dealing with their line shafting bearings, which are of a divided pattern, and can therefore, it is claimed, be conveniently fitted in all positions without it being necessary to remove the pulleys or couplings. By their use considerable saving in both power and lubrication are stated to be obtained, while hot bearings are entirely avoided.

PRIMARY BATTERIES.—The Atlas Carbon & Battery Co. have sent us a list dealing with their primary batteries for telegraph, telephone and similar work. The company claim that their present products are the result of 25 years' experience. The pamphlet is illustrated and contains many useful details of the company's cells.

THE "SUN" COLLAPSIBLE SIGN.—It is impossible to make a tour round the streets of any big town in this country without being more or less forcibly struck with the numerous electric signs which are in constant employment. This application of electricity is, of course, extremely good for trade and numerous firms make a speciality of this class of work. Among these may be mentioned the Sun Electrical Co., who have just put on the market a collapsible sign for

general advertising purposes. It is very light and portable and can be fitted up into a very small space.

Siemens Fluid Galvanic Batteries.—We have received from Messrs. Siemens Bros. & Co. a copy of their new catalogue on fluid galvanic batteries. This catalogue is a most comprehensive publication, consisting of some 46 pages of text, profusely illustrated and containing complete descriptions of all the more generally employed types of fluid galvanic cells. The cells described are all manufactured in the battery section of the company's works at Woolwich. The catalogue is divided into three sections. The first deals with the Daniell cell and its many modifications, the second is devoted to the cells of the Leclanché type and describes all the best known varieties of the porous pot, agglomerate and "sack" forms, besides dealing with firing batteries and batteries for field telegraphy and testing. This section concludes with a short and useful dissertation on the best methods of charging Leclanché cells, whilst the third section deals with the Bunsen, Grove, bichromate and the company's recently introduced copper-oxide "Neotherm" cell, the depolariser of which may be regenerated by heating the iron containing vessel. The catalogue concludes with a list of materials for charging primary cells. Copies of the publication will be supplied on application.

BANKRUPTCIES, LIQUIDATIONS, &c.

At Bradford Bankruptcy Court on Wednesday the examination took place of Arnold Roberts, electrical engineer, of Rawdon, lately carrying on business at 21, North-parade, Bradford, as Roberts Bros. Gross liabilities are £3,100, and £2,431 is expected to rank, and deficiency £1,597. 19s. In November, 1902, debtor commenced business in partnership with his brother with about £300 capital, which was borrowed. Subsequently the partnership was dissolved, and the debtor carried on the business alone.

At a meeting of the unsecured creditors of the Aluminium Corpn. (Ltd.) on Tuesday, a scheme of arrangement was adopted. It was proposed that the new board of directors should consist of Messrs. J. E. Davidson, E. Scott, Stennett, Manville and Pentland.

A receiving order has been made against Middleton & Co., electricians, 11a, King-street, Dover.

A meeting of creditors of the Eastern Electrical Synd., Ltd. (in liq.), will be held at 1, Broad-street-place, London, E.C., on May 10.

A meeting will be held on May 24 at 1, Queen Victoria-street, London, E.C., to receive an account of the winding up of the Burmah Tramways Construction Co. (Ltd.)

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

January 1, 1909.

3 Walter. Wireless telegraphy.
16 Taylor. Dynamo electric machines. ...
18 Moakler. Trolley arms.
60 Leitner. Automatic electric switches.
63 Fessenden. Electric transmission of energy without wires. (Date applied for, 31/3/08.)*†
72 Boeckel, Grunberg, Krukovski & Luxembourg. Dynamo-electric machines. (Date applied for, 24/9/08. Comprised in application No. 20,098, dated 24/9/08.)
78 Dey. Controlling electric motors.*

January 2, 1909.

92 Allgemeine Elektricitats Gesellschaft. Electric transformers. (Date applied for, 2/1/08.)*†
103 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Indicating faulty leads in telephone exchanges.*
129 Fricker & Mordey. Alternate current meters.

January 4, 1909.

142 Hirst & Wolfram (Tungsten) Metal Filament Lamps. Electric incandescent metal filament lamps.
172 Shephard. Electro-magnetic contrivances for operating light mechanism.
185 Marconi's Wireless Telegraph Co. & Round. Measuring the decrement of electro-magnetic oscillations.
194 Drysdale. Combined electric adaptor and wall plug.
195 Bell. Electrical ignition for internal combustion engines.
218 Walton. Filaments for incandescent electric lamps.
219 Hookham. Electrical conductors.

January 5, 1909.

259 Ridings. Arc lamps.
272 Sanderson. Make-and-break devices for electrical purposes.*
275 Orling, Oldenbourg & Spiegelberg. Detecting and recording electric impulses. (Date applied for, 6/1/08.)*†
282 Coolidge. Refractory electric conductors. (Date applied for, 23/9/08.)*†
285 Bingham. Electric furnaces.

January 6, 1909.

287 Plumb. Starting and controlling apparatus for electric motors and machines.
299 McClelland. Locking electric lamps in their holders.
318 Marks. (Chicago Coil Co., U.S.) Induction coils for ignition and other purposes.*
319 Rogers, Brecknell & Munro & Rogers. Electric signals for tramways, railways and the like.*
331 Siemens Bros. Dynamo Works & Schupp. Starting switches for alternating-current electric motors.*
334 Bernhard. Coin-freed apparatus.
341 Bowley. Armouring insulated electrical conductors
345 B.T.-H. Co. (G.E. Co., U.S.) Regulating device for systems of electrical distribution.*
355 Rawdon. Telegraph receivers.*

January 7, 1909.

359 Potter. Filaments for incandescent electric lamps and heating purposes.
373 Rawlings. Tumbler switch.
393 Potter. Electric filament lamps.
403 Hardingham. (Hartmann & Braun Act.-Ges., Germany.) Producing alternating-electric currents for exciting resonance apparatus.
404 Kunkel. Dynamo-electric machines. (Date applied for, 10/1/08.)*†
416 Morris & Lister. Regulation of electric alternators.
425 Girard. Electric lamps. (Addition to No. 21,670/08.)
430 Suter. Fittings for electric incandescent lamps.
432 Suter. Holders for electric incandescent lamps.
442 Craven, jun. Regulating or maintaining a constant voltage in the circuits of electric lighting or heating.
466 B.T.-H. Co. (G.E. Co., U.S.) Inductive disturbances due to electric traction systems.

January 8, 1909.

534 Vandervell. Combined magneto and coil sparking mechanism.
550 B.T.-H. Co. (G.E. Co., U.S.) Control of alternating-current electric motors.
551 B.T.-H. Co. (G.E. Co., U.S.) Electric motor controllers.

January 9, 1909.

571 Boxford. Cable clip for insulators and the like.
580 Siemens-Schuckertwerke, G.m.b.H. Electrical resistance coils of covered wire. (Date applied for, 9/1/08.)*†
590 Marchal. Continuous current electrical machines. (Date applied for, 15/2/08. Comprised in No. 3,494/08, dated 15/2/08.)
604 Nicholson. Telephone circuits.

January 11, 1909.

636 Zipplies. Electric current counters or meters. (Date applied for, 18/1/08.)*†
667 Meszaros. Metal filament lamps.
687 Fery. Electricity meters.*
693 Walker. Dynamo-electric machines.
694 B.T.-H. Co. (A.E.G., Germany.) Alternating current dynamo-electric apparatus. (Addition to No. 23,288/02.)*
695 Green & Daimler Motor Co. Electrically-operated clutches.*
700 Dickson. Holders for electric lamps.

SPECIFICATIONS PUBLISHED.

1907 Specification.

22,581 Taylor. Electric battery sub-stations fed from alternating current systems Cognate. (Applications, 26,381/07 and 1,734/08.)
25,744 Felten & Guilleaume Lahmeyerwerke Akt.-Ges. Direct-current machines. (Date applied for, 26/11/06.)
26,762 Schaffer. Transforming machine for operating arc lamps and incandescent lamp circuits of low voltage. (Date applied for, 3/12/06.)
26,829 Awalow. Electrolytical refining of copper.

1908 Specifications.

346 Boult. (Woodbridge.) Electrical distribution.
1,005 Lake. (Clare.) Secondary or storage batteries.
1,240 Guillot. Suspension devices for electric conductors. (Date applied for, 10/10/07.)
1,470 B.T.-H. Co. (G.E. Co., U.S.) Electric furnaces.
1,559 Spence. Electric power transmission systems.
1,848 Schiessler. Alternative wireless telegraphy and telephony.
1,959 Beaumont. Coin-freed or prepayment meters.
2,175 Kennedy-McGregor & Mountford. Electric switches.
2,206 Amalgamated Radio-Telegraph Co. Radio-telegraphy. (Date applied for, 31/1/07.)
2,244 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
2,245 Cleiren. Electrical transmission of power. (Date applied for, 10/10/07.)
2,295 Taylor. Starting devices for electric motors.
2,707 Howard. Incandescent electric lamps.

2,727 VAN RADEN & CO. & METZ. Electric accumulators.
2,728 VAN RADEN & CO., ROBINSON & METZ. Electrodes for secondary batteries and manufacture of the same. (Addition to No. 21,719/06.)
4,683 RIDGWAY, RIDGWAY & BRUNT. Electrical terminal connections.
4,883 BATTY & BATTY. Liquid magnetic compasses.
5,040 PLANCHON. Metallic filaments or rods for electric incandescent lamps. (Date applied for, 9/11/07.)
5,078 GREENWOOD. Electric lamps for motor cycles and the like.
5,611 B.T.-H. Co. (G.E. Co., U.S.) Electric motor controllers.
5,829 JONES. Arc lamps.
6,331 BROWNE & BAYLISS. Metallic conduits.
7,014 ZAHRINGER. Magneto-electric ignition apparatus.
7,434 B.T.-H. Co. (G.E. Co., U.S.) Electric traction and like systems.

COMPANIES' MEETINGS AND REPORTS.

Indo-European Telegraph Co. (Ltd.)

The forty-second ordinary general meeting was held on Tuesday, under the presidency of Mr. J. HERBERT TRITTON.

The SECRETARY (Mr. John I. Bethell) read the notice calling the meeting.

The CHAIRMAN said: The first paragraph in the report informs the shareholders that the Directors have been successful in obtaining an extension of the Company's Persian Concession for a further period of 20 years, that is, up to January, 1945. The condition of affairs in Persia for the last two years has been very unsettled, and the Company, in common with all those having interests in that country, can only deplore the existing state of unrest, which is so prejudicial to the prosperity of that country and to those interested in her welfare. Great, however, as the danger has been to which the Company's business has been exposed, it has always been our fixed policy to avoid any intrusion of any kind into the politics of the country, and only by working in a conciliatory spirit with all parties have we obtained the practical freedom from interruption necessary to enable us to deal with our important international traffic. How successful your Directors have been in securing the goodwill of all parties in Persia is evidenced by the fact that in Tauris, which has been in the hands of the Nationalist party for over nine months, we have enjoyed perfect immunity at the hands of that party, whilst the extension of the Concession referred to is good evidence that we retain the confidence of the Government of His Imperial Majesty the Shah. True, our lines were interrupted near Tauris for a fortnight, but this was due rather to the difficulty of conveying instructions from the Central Government to the local commander concerned. The Directors cannot leave this subject without referring to the services of the staff in Persia. Again and again they have, particularly in Tauris, risked their lives in the protection of the Company's interests and property, and have shown a devotion to duty of which the shareholders may well be proud. The International Telegraph Conference was opened at Lisbon on May 4, 1903. The reductions of tariffs concerning this Company are unimportant, and affect only the Anglo-Russian and Anglo-Turkish tariffs by our route. The Conference got through much useful work in the consolidation of the Service Regulations, and an earnest endeavour was made to grapple with the ever-increasing difficulties of the so-called pronounceable-combination code problem. Repetitions, which are necessitated often by the mistransmission of a single letter, continue in undiminished number, and, by occupying the lines, defeat the endeavour of the Company to meet the ever-present wish both of the Company and of the public for increased speed in transmission. Even the merchants themselves are now beginning to realise that by their very complexity these codes are defeating their own object. However this may be, a general feeling was evinced at the Conference that the limit of concessions in this direction had been reached, and that, in future, the regulations governing the formation of these codes would have to be more strictly enforced. In this connection a Committee of the Governments concerned will sit for the purpose of examining and reporting upon any pronounceable-combination code which may be submitted by merchants for that purpose. The resulting *imprimatur* in the case of a code found to comply with the regulations will be a complete protection to merchants in the event of challenge of any of the words of which it may be composed. The year 1908 will always be a most memorable one in the history of this Company as that in which daily direct Wheatstone working between London and Karachi was perfected, thereby doing away with all retransmissions between England and India, over a line 5,900 miles in length, to the very great gain of our customers both in speed and in accuracy of transmission. The necessity of working through the Persian Gulf cables has hitherto been an obstacle, as a composite line of cables and land-lines does not lend itself readily to through working. This difficulty was, however, recently removed by the completion by the Indo-European Telegraph Department of a land-line from Teheran to Karachi through Central Persia and Baluchistan. The system employed is the result of years of patient work and experiment on the London–Teheran section by our managing Director, Mr. T. W. Stratford-Andrews, to whose able management and technical ability we all owe so much. Our best thanks are also most certainly due to Mr. H. A. Kirk, Director-in-Chief of the Indo-European Telegraph Department, which works the section from Teheran to Karachi. In connection with the inauguration of the direct working London Karachi, we held an interesting little *séance* in the instrument room of our London Central Station, at which the principal organs of the Press were represented. Telegrams were exchanged direct with Bombay, Madras, Calcutta and far-off Rangoon, distant 7,700 miles, with results that showed conclusively that Karachi is by no means the limit of direct working as introduced by Mr. Stratford-Andrews. The experience derived from the duplex experiments conducted during the year is now maturing, and the Directors hope shortly to be able to enlist this important adjunct also to the carrying capacity of the line. In spite of the trying nature of the work imposed upon our instrument clerks by the handling of pronounceable-combination codes in transmission, the Directors are pleased to be able to report that the percentage of error for the year has further decreased from 0·044 for 1907 to 0·040 for 1903—a gratifying figure. Turning to the accounts the revenue from message receipts and other sources, as shown in the revenue account, shows a slight decrease of £3,741 on the last year's figure, which, however, was an unusually high one. The combined commercial and maintenance expenses show an increase of £2,680. The salary scale has often to be adjusted to meet variations in the cost of living in the countries where our clerks are stationed, and the principal increase is under this heading. The balance-sheet shows considerable variation in two items when compared with last year, sundry debtors having increased by about £57,000 and unappropriated investments having decreased by about £35,000. These changes are in connection with an advance which it was at once politic and profitable for the Company to make, and which forms an investment of an unimpeachable character. The Directors consider it advisable, in view of the serious conditions which have been prevalent in Persia for so many months, to set aside £5,000 to meet the exceptionally heavy repairs to the Company's lines which will doubtless be found necessary, and which would unduly swell the maintenance account for the coming year. They also propose to hand over to the trustees of the retirement fund a further sum of £5,000. The Directors propose the usual final dividend, which absorbs £14,875, and bonus of 20s. per share, which accounts for a further £17,000, and have again decided to recommend a special distribution from interest upon investments, of 15s. per share, free of tax in each case. I now move the adoption of the report and accounts, and the declaration of the dividend, bonus and special distributions therein set out.

Sir WILLIAM R. BROOKE, K.C.I.E., seconded the motion.

Mr. G. VON CHAUVIN moved that to the resolution put by the Chairman an addendum be made, and said: The first and foremost necessity of every undertaking which has to deal with technical matters, be it a telegraph, a railroad or a steamship line, is that the material should be excellent. It is not always that, in the early stages of an undertaking, those who are responsible for its management, and have to answer to the shareholders, are ready to spend considerable sums of money upon what, after all, is the real investment of the Company's property —that is, a telegraph line in excellent condition; but we have been fortunate in having had at the head of affairs in this Company gentlemen who understand that first postulate of successful technical management —namely, that your material in the first case and that your maintenance afterwards must be excellent. The proof of what can be done by a well-managed line from the technical point of view is what the Chairman has just told us—namely, what has been done in telegraphing from London to Karachi. That is a performance which perhaps 10 or 12 years ago would have been looked upon as an impossibility. It is a performance which does honour to the Company, and is of benefit to its clients and customers. The excellent technical management of this Company has been accompanied by a wise financial management, and you have had the satisfaction, not only of knowing that you were serving your patrons in an excellent manner, but also of feeling that there was something out of that service which rested in your own pockets. There is a third point, of equal importance, which we must not overlook. In the nature of things your line passes through a number of different countries—and big, important countries. Political conditions between neighbouring countries are not always of a nature to foster the progress of a line which travels through all of them. There must from time to time be difficulties, frictions and jealousies, and it speaks volumes for the tact, judgment and sagacity of the Directors that not only has this line managed, through the various phases of the political evolutions in Europe, to hold its own, but it must evidently have been able to ingratiate itself sufficiently with all those Governments the territories of which are traversed by the line for them to extend their concessions, and extend to the Company, therefore, the invitation to remain there for a long time to come (hear, hear). The Chairman has referred in a generous spirit, which I am quite sure we all share, to the excellent services of the staff, and I have no doubt the thanks of the shareholders are fully due to the devotion to duty and to the pertinacity and pluck of the men who over this long stretch of line have been upholding the banner of the Indo-European Telegraph Co. The best augury for the future of this Company is that there is no slackness in its management. We have had proof of this. I am proposing that you should vote to your Directors, as a proof of your appreciation, a substantial sum of money. If that sum were compared with the totality of the profits which have been paid away by this Company during the prosperous portion of its career, which set in about three or four years after the beginning, the percentage of it would be ludicrously small. I now move that a special sum of £3,000 be voted to the Directors in recognition of their past services to the Company, to be divided among them in such manner as they may determine.

Mr. STEVENS: I rise with singular pleasure to second the resolution.

The CHAIRMAN invited discussion, but no shareholder rising to address the meeting, he put the resolution, and also as a rider the resolution proposed by Mr. von Chauvin and seconded by Mr. Stevens. This

was carried unanimously. Continuing, he said: The Directors have a double, or, I might say, a multiple, pleasure in expressing their thanks to the shareholders for the vote which has now been accorded to them. If anything were necessary—and nothing is necessary, I verily believe—to increase the devotion with which they endeavour to manage your affairs, this would have given the requisite fillip.

The retiring Directors, the Right Hon. Sir Francis Mowatt, G.C.B., and Sir W. R. Brooke, K.C.I.E., were then re-elected, as were the retiring auditors, and a vote of thanks to the Chairman, Directors and staff terminated the proceedings.

AUCKLAND ELECTRIC TRAMWAYS CO. (LTD.)—The total revenue for 1908 was £165,655, and the traffic receipts (£163,848) show an increase of £26,129. After deducting expenses, including £15,718 for debenture and other interest, the rental and percentage of profits payable to Auckland City Council (£3,771) and setting aside £12,500 as depreciation, the surplus is £32,754, making, with £2,165 brought forward, £34,920. The directors have placed £10,000 to reserve, and after payment of the year's dividend on the preference shares (£3,000) they recommend a dividend of 6 per cent. per annum on the ordinary shares, £3,920 being carried forward.

BABCOCK & WILCOX (LTD.)—At the meeting on Friday last the chairman (Mr. John Dewrance) said the year under review had been an anxious one and business had shown signs of deteriorating. The immediate future also did not seem particularly bright. The net profit was £301,614, which, with £38,664 forward, made £340,278. It was proposed to pay a dividend of 8 per cent. and a bonus of 4 per cent. on the ordinary shares, to place £100,000 to reserve, £25,000 to the dividend equalisation fund, and to carry forward £43,278. Answering a question as to the reserve, Mr. Dewrance said it was wise for an industrial company to look forward to a possible rainy day and provide against it. An enormous advantage accrued to the company from having a large reserve fund.

BRISBANE ELECTRIC TRAMWAYS & INVESTMENT CO. (LTD.)—Mr. Henry R. Beeton stated at the meeting on Wednesday that the Brisbane Tramways Co., of which they held all the shares, after placing £18,000 to its renewals fund, had paid in dividend £65,000, against £57,000 for 1907. The growth of the traffic was remarkable. During the past year the passengers carried amounted to more than two hundred times the whole population of Brisbane and suburbs, representing an increase of 12 per cent. compared with 1907, and as the car-mileage ran only increased 1 per cent., the gross receipts per car-mile increased from 11·40d. to 12·66d.

CHISWICK ELECTRICITY SUPPLY CORPN. (LTD.)—The directors' report states that the undertakings at Chiswick and Aberystwith continue to make progress, the number of consumers at the end of the year having reached 1,705, compared with 1,574 at the end of 1907. During the year £3,318 was expended for machinery, mains, free wiring, &c. The total number of lamps, motors, &c., connected to the mains at Chiswick and Aberystwyth was equivalent to 70,285 32 watt lamps. The profit was £6,834. 8s. 9d. Interest required £2,760. 14s. 6d., leaving £4,073. 14s. 3d. The results of the year's working will enable a dividend to be paid on the ordinary shares of 6 per cent. (the same as for 1907).

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—After providing £12,000 for interest on debentures and £12,083. 6s. 8d. for the dividend on the preference shares and deducting £2,104. 14s., being interim dividend at rate of 5 per cent. per annum paid on the ordinary shares for the half-year ended June 30, 1908, there remains £34,873. 2s. 3d. The directors recommend payment of a dividend on the ordinary shares at the rate of 5 per cent. per annum for the six months ended Dec. 31 last, together with a bonus of 5 per cent. (making 10 per cent. for 1908), and to transfer £28,559. 0s. 3d. to reserve. The traffic receipts show a reduction of £2,213 compared with 1907, while the receipts from advertising and interest on investments show an increase of £1,158. The decrease in traffic receipts is mainly due to the competition of the Birmingham Corporation tramways. A reduction of £5,871 has been effected in the operating expenses and in cost of maintenance of tramways and payments to local authorities. The Board of Trade have appointed an arbitrator to settle the price to be paid for the track, rolling stock and depot of that portion of the cable tramway in Handsworth. An agreement with Aston Corporation has been arrived at to settle certain outstanding matters, and an agreement was entered into during the year with Yardley Council to sell to the Council the plant at Yardley power station, but completion of the purchase has not taken place. In view of the excessive cost of maintenance of the Bristol-road permanent way charged by Birmingham Corporation, an agreement has been entered into with the Corporation to reconstruct a portion of the Bristol-road tramway on the basis of the company paying a fixed percentage per annum on the cost of the work until the expiration of the lease in June, 1911. Considerable difficulty was found in disposing of the motor omnibuses of the Birmingham & Midland Omnibus Co. after they had been withdrawn from service, and the prices realised were very unsatisfactory.

COVENTRY ELECTRIC TRAMWAYS (LTD.)—At the meeting yesterday the directors reported that the gross earnings were £28,332 and the cost of operation £19,201. The net profit (after providing £2,637 for interest) was £6,494, £6,607 was available and the directors recommended that £2,000 be placed to reserve for depreciation, and that 3½ per cent. dividend be declared.

DUDLEY, STOURBRIDGE & DISTRICT ELECTRIC TRACTION CO. (LTD.) At the meeting yesterday it was reported that the gross receipts for 1908 were £43,871. 5s. 7d. Deducting expenses (including repairs and maintenance) and placing £1,000 to renewals, there remained £10,188. 2s. 11d. Deducting preference dividend and adding £946. 16s. 6d. brought forward, £6,136. 19s. 5d. remained for allocation. The directors recommended that £1,000 be placed to sinking fund, £1,000 to depreciation and reserve, and a dividend of 4 per cent. on the ordinary shares (£4,000), leaving £137 to be carried forward. The number of passengers carried was 7,649,693, compared with 8,333,032, and the average receipts per passenger worked out 1·35d., against 1·32d. The proportion of expenses to receipts was 65 per cent., against 61 per cent., and the number of cars in stock 59, same as in 1907.

MELBOURNE ELECTRIC SUPPLY CO. (LTD.)—At the meeting on Monday Mr. J. B. Braithwaite said that the energies of the directors had, in the main, been expended during the past year in endeavouring to arrange a scheme to provide the necessary capital for paying off the floating debt and placing the company in a sound financial position. They had succeeded in raising the necessary funds and in providing additional capital for the development of the Melbourne and Geelong undertakings. With regard to the new generating plant at Melbourne, the turbine machinery was working extremely well, and their engineer said that the economy in water alone was sufficient to provide 5 per cent. on the capital invested in the turbine, apart from other economies effected in generating, &c. During the first six months of the current year there was an increase in profits on the Melbourne undertaking of £3,000. At meetings of the debenture stock holders and the preference and ordinary shareholders resolutions were carried agreeing to the company issuing a further £100,000 5 per cent. first mortgage debenture stock.

MERTHYR ELECTRIC TRACTION & LIGHTING CO. (LTD.)—In moving the adoption of the report (given in our last issue) Mr. W. L. Madgen stated, on Tuesday, that the directors were negotiating with Merthyr Council to extend the mains to Troedyrhiw Merthyr Valley and Treharris. The actual expenditure on the combined undertakings was £1,513. They had been compelled to make another application to the Board of Trade for an extension of time to construct the Cefn line, but it was understood the bridge across the river would be proceeded with this summer.

NORTH OF SCOTLAND ELECTRIC LIGHT & POWER CO. (LTD.)—The report for 1908 states that the equivalent of 20,296 8 c.p. lamps is connected at Montrose (against 19,308 in 1907), 17,071 8 c.p. at Brechin (against 16,399) and 18,106 8 c.p. at Inverness (against 14,655), total 55,473 8 c.p. The gross profit (after deducting debit balance) is £3,168, and after paying interest, &c. (£1,601) and writing off £640 for loss on free wiring and motors dismantled and depreciation of wiring stocks, &c., the net profit was £925.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—Mr. Ackers stated at the meeting on Wednesday that they were able to pay the same dividend as last year (8 per cent.), which, even in prosperous times, was a handsome one. They were carrying forward over £5,000. As trade was gradually improving in all those countries with which they had business relations, they looked forward to still better results in the present year. Egypt led the increases, but next to it came Calcutta, which had shown an unwonted activity, the additions to the number of subscribers continuing uninterruptedly. One of the drawbacks to more extensive development of telephone enterprise in India was that the Government provided their own telephone service, which was on a large scale. In several instances they had obtained authority to introduce a telephone service in other centres in India and Burmah—such as Bangalore, Madura, Mandalay, &c.—but without the support of Government lines and their subscriptions they found the number of subscribers among the public was not sufficient to justify them in installing and maintaining telephone exchanges. The Bengal Co. was in negotiation with both the Government and the commercial communities of the newly-created Eastern Bengal Province, the chief seat of which was Dacca, and a new field for telephone enterprise would probably be open there shortly. There was every indication of a revival in their other telephone exchanges at Madras, Rangoon, Singapore and Bombay. The China & Japan Telephone Co. had full employment for all the capital they could spare, both in Hong Kong and Kowloon, and when the Kowloon-Canton Railway was finished they might expect that company to extend their sphere of activity considerably in the direction of, and probably to, Canton itself. In Mauritius they were now negotiating with the Government for a concession to provide the whole island with a service, instead of Port Louis alone, as heretofore.

PEARSON FIRE ALARM (LTD.)—At the meeting on Wednesday, Mr. A. D. Fairbairn stated that the turnover was nearly double what it was last year, and the profit also showed an increase of £889. During the year arrangements were made for further concentrating the business, and when those were completed a further reduction of expenses would be effected. Rentals on installations showed a satisfactory increase, and now amounted to over £3,200 per annum. The branch for the sale of fire appliances (started last year) resulted in sales to the extent of £1,021. The tariff and several of the non-tariff fire offices had recognised the merits of their system by granting rebates to insurers.

SOUTH STAFFORDSHIRE TRAMWAYS (LESSEE) CO. (LTD.)—It was reported at the meeting yesterday that the total revenue for 1908 was £48,087. 10s. against £49,786. 19s. 1d. in 1907. The expenses amounted to £48,048. 0s. 11d. The profit was £39. 9s. 1d., added to £467. 1s. 4d. brought forward, which was carried forward. The capital expenditure during the year in respect of the reconstruction of the tramways in Tipton, Darlaston and Wednesbury was £4,577. 13s. 8d. The repayment by Dudley Corporation to the company of £6,217. 8s. 2d., expended in

constructing the tramways leased by the company in Dudley, is expected to be made on July 1. The terms of the lease have been agreed, and a bill for obtaining the necessary Parliamentary powers has been deposited. In order to effect economies in power supply, the Jamesbridge power station has been closed and the plant disposed of, an agreement having been made with Walsall Corporation for the supply of electricity required for working the tramways previously supplied with current from that station. In order to obviate further capital expenditure on the purchase of new rolling stock, an arrangement has been made to hire, through the Joint Committee, the necessary cars required for working the reconstructed lines in Tipton, Darlaston and Wednesbury. The arrangement with the other companies operating tramways in the district for joint working has proved satisfactory. The number of passengers carried was 8,859,415, against 9,320,602; the average receipts per passenger were 1·24d., against 1·21d., and the average expenditure per passenger (apart from line rentals) was 0·85d., against 0·79d. The proportion of expenses to receipts was 68 per cent. against 65 per cent.

WEMYSS & DISTRICT TRAMWAYS CO.—The directors' report states that the traffic receipts for the past year were £13,987. The balance at credit of profit and loss account, after paying interest and making provision for depreciation, is £3,176. No interest was paid on the preference shares for the half-year the line was in course of construction, and three half-years' interest on the preference shares at the rate of 6 per cent. are now paid, and a dividend of 6 per cent. declared on the ordinary shares.

WOLVERHAMPTON DISTRICT ELECTRIC TRAMWAYS (LTD.)—During 1908 the total revenue was £23,882. 2s. 6d., and after deducting expenses (including interest, repairs and maintenance) and providing £500 for renewals fund, the profit was £1,776. 16s. 5d., added to £268. 19s. 7d. brought forward. The directors recommended that £500 be placed to depreciation and reserve, that a dividend of 1 per cent. be paid on the ordinary shares. The capital outlay during the year was £328. 5s. 2d. The number of passengers carried was 4,282,882, against 4,381,837; the average receipts per passenger were 1·32d. against 1·36d., and the average working expenditure per passenger 0·95d. against 0·93d. The proportion of expenses to receipts was 70 per cent., against 68 per cent.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

AGRICULTURAL ELECTRIC DISCHARGE CO. (LTD.) (102,565.)—Reg. April 19, capital £3,000 in £1 shares (1,000 preference), to carry on the business of vendors of and dealers in certain appliances and apparatus used in connection with inventions for the production of continuous high-potential electrical discharges applicable for the deposition of dust, fume, smoke, fog and mist for the production of rain, and for other purposes in connection with the application of such invention to agriculture and horticulture, and to adopt an agreement with Sir Oliver J. Lodge, F.R.S., L. Lodge, F. B. Lodge, A. M. Lodge, G. Newman, J. E. Newman, W. F. Newman and R. Bomford. Private company. First directors, Sir Oliver Lodge, L. Lodge, F. B. Lodge, A. M. Lodge, G. Newman, J. E. Newman, W. F. Newman and R. Bomford. Reg. Office, 3, Howard-street, Gloucester.

ARCHIBALD WATSON & CO. (LTD.) (7,094.)—Reg. in Edinburgh on April 23, capital £10,000 in £1 shares, to purchase the business of Archibald Watson & Co., electrical engineers, brassfounders, &c., of Glasgow. Private company. First directors, A. Watson, W. W. Watson, D. Dundas and G. B. Young.

PALMER & CO. (ELECTRICIANS) (LTD.) (102,597.)—Reg. April 20, capital £1,000 in £1 shares, to acquire the business of Palmer & Co., and to carry on the business of electricians, engineers, &c. Private company. W. H. Palmer is first secretary.

STATUTORY RETURNS.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.) According to return to March 4, capital is £2,100,000 in 130,000 preference, 130,000 ordinary, 80,000 City undertaking preference and 80,000 City undertaking ordinary shares of £5 each, of which 80,000 preference, 80,000 ordinary, 80,000 City undertaking preference and 70,000 City undertaking ordinary have been taken up. £5 per share has been called up on the preference, ordinary and City undertaking preference, and £1,200,000 has been received. £350,000 is considered as paid on the City undertaking ordinary. Mortgages and charges, £931,846.

DIRECT UNITED STATES CABLE CO. (LTD.)—Return to Feb. 9 capital is £1,300,000 in 65,000 shares of £20 each, of which 60,710 have been taken up. £1,214,200 has been received. Mortgages and charges nil.

W. T. HENLEY'S TELEGRAPH WORKS (LTD.)—The capital in return to March 15 is £400,000 in 40,000 preference and 40,000 ordinary shares of £5 each, all of which have been taken up. £5 per share has been called up on 39,880 preference and 32,616 ordinary, and £362,480 has been received. £37,520 is considered as paid on 120 preference and 7,384 ordinary. Mortgages and charges, £150,000.

OXFORD ELECTRIC CO. (LTD.)—In return to March 19 capital is £150,000 in 20,000 ordinary and 10,000 preference shares of £5 each, of which 20,000 ordinary and 5,500 preference have been taken up. £93,500 has been paid on 13,200 ordinary and 5,500 preference shares, in addition to £1,550 paid on 310 ordinary shares forfeited. £34,000 is considered as paid on 6,800 ordinary. Mortgages and charges, £50,000.

SCARBOROUGH ELECTRIC SUPPLY CO. (LTD.)—In return to March 18 capital is £100,000 in £10 shares, all of which have been taken up and paid for in full. Mortgages and charges nil.

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—Return to March 16 gives capital as £448,200 in 37,350 shares of £12 each, all of which have been taken up. £448,200 has been paid. Mortgages and charges nil.

TURNERS & MANVILLE (LTD.)—According to return to March 2 capital is £50,000 in £1 shares, of which 20,012 has been taken up. £10,621 has been received and £9,391 is considered as paid. Mortgages and charges, nil.

UNIVERSAL TELEPHONE & ELECTRICAL CO. (LTD.)—Return to March 10 gives capital as £10,400 in 2,000 ordinary shares of £5 each and 400 founders' shares of £1 each, of which 400 ordinary and 400 founders' have been taken up. £2. 10s. per share has been called up on 400 ordinary shares, and £1,000 has been received. £400 is considered as paid on 400 founders'. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

NEW IGNITION SYND. (LTD.)—Issue on April 20 of £500 debentures, part of series created Nov. 12, 1908, to secure £5,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees.

NORTHALLERTON ELECTRIC LIGHT & POWER CO. (LTD.)—Issue on April 7 of £260 5 per cent. debentures, part of series created Dec. 11, 1900, to secure £260, charged on the company's property, present and future, including uncalled capital. No trustees.

RICHARD PAPE (LTD.)—Issue on April 5 of £100 debentures, part of series created Sept. 16, 1908, to secure £1,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series £500.

RECEIVERSHIP.

AUTO-CLAW CO. (LTD.)—A notice of the appointment of J. Todd, 135, Wool Exchange, London, E.C., as interim receiver, by order of court dated April 14, 1909, has been filed.

CITY NOTES.

MEMORANDA (April 29).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $24\frac{1}{8}$d. per oz. Consols $84\frac{3}{4}$—85 for money and account. Consols Pay Day, May 5; Stock and Shares Continuation Days, May 11 and 25; Ticket Days, May 12 and 26; Pay Days, May 13 and 27; Mining Shares Carry Over Days, May 10 and 24.

PRICES OF METALS (London).—*Copper*, cash, $57\frac{5}{16}$; three months $58\frac{1}{16}$. *Lead*, English, $13\frac{5}{8}$—14; foreign, cash, $13\frac{3}{8}$—$13\frac{1}{2}$; three months, $13\frac{11}{16}$. *Spelter*, cash, $21\frac{5}{8}$; two months, $21\frac{7}{8}$. *Tin*, English, 132—134; foreign, cash, $132\frac{3}{8}$—$132\frac{5}{8}$, three months, $132\frac{7}{8}$. *Iron*, Cleveland, cash, 47/6, and three months, $48/1\frac{1}{2}$: *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)—The directors have declared a dividend of 1s. 3d. per share (less tax) for the quarter ended March 31.

COLOMBO ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—A dividend of 5 per cent. (tax free) for 1908 has been declared.

EASTERN TELEGRAPH CO. (LTD.)—This company announce that subject to final audit, the accounts for the year ended Dec. 31, 1908, show that after making a contribution to general reserve fund, payment of interest on the 4 per cent. mortgage debenture stock, dividend on the $3\frac{1}{2}$ per cent. preference stock, and three interim dividends of £1. 5s. per cent. each on the ordinary stock to Sept. 30 last, there is a balance available out of which the directors recommend payment of a final dividend of £1. 5s. per cent., and a bonus of £2 per cent., both tax free, and payable on May 12, making with previous payments on account a total distribution of 7 per cent. on the ordinary stock for the year 1908. The transfer books of the ordinary stock will be closed from May 5 to 12 inclusive.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) Subject to confirmation by the shareholders, the directors have declared a dividend for the quarter ended Dec. 31 last of 2s. 6d. per share, together with a bonus of 4s. per share (or 2 per cent.), making a total distribution of 7 per cent. for the year 1908. The dividend and bonus will be paid on 12th prox. The share register will be closed from 4th to 11th prox. inclusive.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The amount of electricity sold for the quarter ended Ladyday, 1909, is returned at 2,934,021 units, estimated to produce £38,238, against 2,879,802 units, which produced £38,709 for the corresponding period of last year.

STEWARTS & LLOYDS (LTD.)—At an extraordinary meeting on Friday resolutions were confirmed for the increase of the capital to £2,250,000 by the creation of 850,000 deferred shares of £1 each, the existing ordinary shares to be known in future as preferred ordinary shares.

URBAN ELECTRIC SUPPLY CO.—There was a profit on the past year's working of £22,735, or £9,764 less than the amount required to meet the 5 per cent. guaranteed dividend on the issued capital, which has been provided by Edmundson's Electricity Corpn.

WEST AFRICAN TELEGRAPH CO. (LTD.)—The directors recommend a final dividend of 4s. per share (tax free) for the year ended Dec. 31, 1908, making, with the interim dividend of 4s. per share already paid, a total distribution of 4 per cent. for the year.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	April 21	1,299	+ 47	47	63,418	- 43
Airdrie	,, 16	228	+ 10	15	3 203	- 63
Anglo-Argentine	,, 22	41,591	+ 5,983	16	637,238	+ 42,1?9
Ayr Corporation	,, 24	253	- 65	49	13,718	- 318
Baker St. & Waterloo Ry.	,, 21	3,310	- 176	16	54,010	+ 4,820
Barnsley	,, 16	220	+ 30	15	2,481	- 4
Barrow	,, 16	218	- 36	15	3,065	- 215
Bath Electric Trams, Ltd.	,, 21	739	- 262	16	10,017	+ 313
Birmingham Corporation	,, 21	6,3?0	- 427	4	23,263	+ 66
Birmingham & Mid.	,, 9	838	+ 43	14	10,957	- 3
Blackburn Corporation	,, 21	925	- 105	4	4,885	+ 114
Blackpool and Fleetwood	,, 24	394	- 489	16	1,342	- 251
Bolton Corporation	,, 25	2,109	- 90	4	9,106	- 95
Bombay	Mar. 25	R38,539	+ R3,1?6	12	R461,351	+ R35,?61
Bournemouth Corporation.	April 21	1,755	- 778	3	5,687	- 59
Bradford Corporation	,, 24	4,629	- 958	4	17,525	+ 337
Brighton Corporation	,, 25	833	- 16	4	3,458	+ 388
Bristol Trams & Carriage	,, 23	5,121	- 775	22	103,407	+ 9,532
Burnley Corporation	,, 21	1,222	+ 27	4	5,380	+ 232
Burton Corporation	,, 25	263	+ 1	4	972	+ 10
Bury Corporation	,, 25	1,121	+ 5	†4	4,565	- 20
Calcutta Tramways Co.	,, 24	R45,540	+ R1,076	16	R803,206	+ R23,012
Camborne-Redruth	,, 21	118	+ 1	17	1,915	+ 101
Cardiff Corporation	,, 24	2,039	- 220	4	7,677	+ 34
Cavehill	,, 16	132	+ 103	15	957	+ 50
Central London Railway	,, 24	5,327	- 205	16	87,759	- 7,925
Charing C., Euston & H'stead	,, 24	3,845	+ 180	16	61,390	+ 10,195
Chatham & Dist. Lt. Rys.	,, 22	801	- 277	16	11,559	+ 1,233
City & South London Rly.	,, 25	3,150	- 280	16	53,200	+ 402
City of Birmingham	,, 16	3,237	+ 527	15	30,063	- 193
Colchester Corporation	...	...	...	...	...	...
Cork Electric Trams Co.	,, 22	469	+ 2	16	6,732	+ 275
Croydon Corporation	,, 23	1,441	- 19	13	5,176	+ 473
Devonport & Dist. Trams	,, 16	398	- 121	15	6,630	- 785
Dover Corporation	,, 24	177	- 35	4	707	+ 13
Dublin & Lucan Railway	,, 23	123	- 48	16	1,910	+ 129
Dublin United	,, 23	5,672	+ 63	16	78,776	+ 893
Dudley-Stourbridge	,, 16	1,0?2	+ 200	15	10,950	+ 69
Dundee Corporation	,, 21	1,167	- 20	‡19	57,828	+ 2,125
East Ham Council	,, 21	978	+ 108	§3	3,500	+ 598
Exeter Corporation	,, 23	305	- 72	4	1,115	+ 88
Gateshead & Dist. Trams	,, 16	1,101	+ 55	15	14,674	- 51
Glasgow Corporation	,, 24	17,358	- 303	47	795,473	- 17,445
Glossop Trams	,, 24	120	- 10	17	1,974	- 59
Gravesend—Northfleet	,, 16	272	+ 67	15	2,718	- 93
Great Northern & City Rly.	,, 24	1,464	- 151	16	24,858	- 3,056
Gt. Northern, Piccadilly, &c.	,, 24	5,665	+ 5	16	92,820	+ 6,285
Greenock & Port Glasgow	,, 16	609	+ 73	15	6,860	- 141
Hartlepool Tramways	,, 16	263	+ 49	15	3,013	- 125
Hastings Elec. Trams Co.	,, 21	1,018	- 628	16	12,712	- 465
Hong Kong	,, 24	$7,636	- $1,026	16	$131,052	+ $9,321
Huddersfield Corpn.	,, 24	1,574	- 430	3	6,103	+ 329
Hull Corporation	,, 24	3,435	- 57	3	8,949	+ 21
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	...	...	...	...	...	...
Ipswich Corporation	,, 24	358	- 7	4	1,361	+ 142
Isle of Thanet Co.	,, 21	421	- 107	§21	8,552	+ 299
Jarrow	,, 16	137	+ 23	15	1,?84	+ 143
Keighley Corporation	,, 22	150	- 62	3	545	+ 17
Kidderminster & District	,, 16	119	+ 58	15	1,258	- 2
Kilmarnock Corporation	,, 25	142	- 7	49	7,281	- 356
Lanarkshire Trams Co.	,, 22	1,318	- 214	16	19,074	- 1,251
Lancashire United	,, 21	1,204	- 989	16	19,703	+ 232
Leamington	,, 16	234	+ 87	15	2,198	+ 234
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	,, 24	2,140	- 226	...	...	...
Leith Corporation	...	...	...	...	...	...
Lincoln Corporation	...	...	...	...	...	...
Liverpool Corporation	,, 17	11,063	+ 311	‖15	153,447	- 334
Liverpool Overhead Rly.	,, 25	1,313	- 134	17	22,009	- 1,184
*London County Council	...	...	...	...	...	...
London United	,, 24	5,807	- 1,145	‖19	84,156	- 4,177
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 21	163	- 21	3	633	- 24
Manchester Corporation	,, 24	14,513	- 931	3	53,057	+ 1,418
Mersey Railway	,, 24	1,933	- 105	16	31,271	+ 635
Merthyr	,, 16	307	+ 83	15	3,065	+ 112
Metropolitan Dist. Railway	,, 21	9,732	+ 1,060	16	155,175	+ 13,162
Metropolitan Elec. Trams	,, 16	7,555	+ 1,652	15	82,016	+ 9,577
Middleton	,, 16	480	+ 51	15	4,587	- 66
Nelson Corporation	,, 21	125	- 1	†3	525	- 13
Newcastle-on-Tyne Corp.	,, 21	3,648	- 652	4	13,972	- 317
Newport (Mon.)	,, 21	615	- 109	4	2,667	+ 66
Northampton Corporation.	,, 23	439	- 83	§4	1,586	+ 121
Oldham, Ashton & Hyde	,, 16	735	+ 11	15	8,111	- 415
Oldham Corporation	,, 21	1,839	- 19?	4	9,052	- 352
Perth (N.B.) Corporation	,, 21	155	- 1	49	7,456	- 97
Perth (W.A.) Elec. Trams	,, 23	1,001	- 125	16	23,8?2	+ 167
Peterborough	,, 16	132	+ 3?	15	1,517	- 60
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 16	1,963	+ 151	15	26,111	- 904
Preston Corporation	,, 21	707	- 182	3	2,259	+ 12
Rotherham Corporation	,, 22	555	- 225	3	1,969	- 100
Rothesay	,, 16	307	+ 159	15	984	+ 100
Salford Corporation	,, 26	4,292	- 171	[illegible]	17,369	+ 256
Sheerness	,, 16	56	+ 7	15	617	- 72
Sheffield Corporation	,, 25	5,437	- 205	§4	24,812	- 269
Singapore Trams	,, 24	$9,399	+ $135	16	$154,610	+ $3,628
South Metropolitan	,, 16	1,058	+ 237	15	10,257	+ 365
South Staffs	,, 13	1,165	+ 323	15	12,213	- 499
Southend Corporation	,, 21	128	- 61	3	1,435	+ 322
Southport Tramways	,, 24	420	+ 151	15	3,484	+ 271
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 24	688	- 131	§3	2,933	- 7
Sunderland Corporation	,, 25	1,0?2	- 49	4	4,060	- 138
Sunderland District	,, 21	410	- 229	25	11,011	- 316
Swansea Trams	,, 15	1,032	+ 147	15	13,113	+ 412
Swindon Corporation	,, 21	131	- 47	...	...	...
Taunton	,, 16	51	+ 8	15	513	- 41
Tynemouth and District	,, 16	232	+ 31	15	2,031	- 59
Tyneside Trams Co.	,, 21	330	- 20?	16	6,388	+ 392
Wallasey District Council	,, 21	925	- 14	§3	3,315	+ 272
Walsall Corpn.	,, 21	478	- 17?	16	8,0?3	- 635
Warrington Corpn.	,, 23	365	- 5?	3	1,197	- 6
West Ham Corporation	,, 15	2,929	+ 861	2	5,163	+ 752
Weston-super-Mare	,, 16	193	+ 157	15	571	+ 185
Wolverhampton Co.	,, 16	575	+ 163	15	5,936	- 480
Wolverhampton Corpn.	,, 21	715	- 300	16	11,756	- 708
Worcester	,, 15	317	+ 77	15	3,570	+ 53
Wrexham	,, 16	136	- 20	15	1,378	- 31
Yorkshire W.R. Trams	,, 25	1,342	- 6	17	19,096	-
Yorkshire Woollen District	,, 16	1,105	+ 120	15	12,681	- 179

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	Name.	Price Wed. April 28.	Rate % Yield.	Dividend Due.	Business Week to April 2?: Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½ -10½	5 17 3	Mar, Sept	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾ -10¼	4 9 0	Feb, Aug	9¾	—
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10½ -10¾	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 -105	4 5 6	Jan, July	..	..
5	3/6	†Bromley (Kent) El. Lt. & Power Shares	4½-4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	95 -98	4 12 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½ -9	5 11 0	March....	8½	8¾
5	3/6	Do. 7 per Cent. Pref.	8 -8½	4 2 6	Mar, Sept	..	..
St.	4%	Centl Elec. Sup. Co. 4% Guar. Db. Stock	99 -102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3½ -4½	5 1? 0	Feb, Aug	4	3¾
5	2/3	Do. 4½ per Cent. Pref.	4½ -4¾	4 15 0	Feb, Aug	4½	4½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 -9?	4 1 0	Jan, July	97½	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99½ -100½	4 1? 6	..	99½	99½
5	2/8	Do. City Undertaking 4½% Cm. Pref.	3½ -4½	5 8 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3¾ -4¼	5 9 3	March ..	4	3¾
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 -105	4 7 6	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10½ -10¾	5 19 3	Feb, Aug	10½	10½
10	6/0	Do. 6 per Cent. Cum. Pref.	11½ -12½	4 13 0	Jan, July	12½	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 -123	4 1 0	June, Dec	122½	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 -104	4 6 6	Jan, July	..	..
5	2%	County of Durham Elec. P.D. Ord.	1 -2	6 13 4	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3½ -3¾	6 17 19	April, Oct	—	..
10	6/0	County of London Elec. Supply Ord.	8¾ -8¾	5 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾ -11¼	5 6 6	Mar, Sept	10¾	10¾
St.	4½%	Do. 4½% Deb. Stock (red.)	106 -109	4 2 6	Jan, July	107½	..
St.	4½%	Do. Second Deb. Stock	101 -104	4 6 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ -5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 -5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	96 -99	4 11 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7½ -7¾	5 11 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7½ -7¾	5 16 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6¾ -6¾	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93 -96	4 3 6	..	—	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 -100	4 0 0	April, Oct	..	—
St.	4½%	Kent Elec. Power Co.	85 -89	5 1 0	Jan, July	..	—
3	1/9⅜	London Electric Supply Ord.	1¾ -2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 -5½	5 11 6	Mar, Sept	5½	5½
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92 -96	4 3 6	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	4¾ -5¼	5 17 6	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾ -5¼	4 6 0	Jan, July	5¼	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 -109	4 2 6	June, Dec	—	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85 -88	3 19 6	Jan, July	—	—
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 -98	4 12 0	June, Dec	96½	—
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	5 -5½	3 18 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	88 -90	5 0 7	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	3¾ -4½	10 0 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 -5½	4 18 9	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1937.	94 -96	4 4 3	Jan, July	—	..
100	50/	†North Metro. Elec. Power Sup. 5 Morts	99 -101	4 19 0	..	101	
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	91 -93	4 17 10	Jan, July	—	..
10	8/0	Notting Hill Electric Ord.	11 -12	5 16 6	March ..	—	..
5	4/6	Oxford Electric Ord.	6 -6½	5 8 0	March ..	—	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 -97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	9 -9½	5 5 6	Feb, Aug	9⅜	9$\frac{3}{16}$
5	3/6	Do. 7 per Cent. Pref.	7 -7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	86 -90	3 18 0	Jan, July	87½	—
5	..	Smithfield Markets Electric Sup. Ord.	¾ -1⅛	..	Feb	—	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 -70	5 11 0	Feb, Aug	..	..
5	4/0	South London Electric Supply Ord.	2¼ -3⅛	6 8 0	April	2$\frac{13}{16}$	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	¼ -½	5 0 0	..	..	—
1	0/8⅖	Do. 7 per Cent. Cum. Pref.	1$\frac{3}{32}$ -1$\frac{5}{32}$	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 -103	4 7 6	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	¾ -1¼	—	April, Oct	..	—
5	2/6	Do. 5 per Cent. Cum. Pref.	2 -2½	10 0 0	April, Oct	2$\frac{1}{16}$	2$\frac{3}{16}$
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 -84	5 7 3	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9⅝ -9⅞	5 1 0	Mar, Sept	9$\frac{11}{16}$	9⅝
5	2/3	Do. 4½ per Cent. Cum. Pref.	5¼ -5⅝	4 0 0	Jan, July	—	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	97 -99	4 1 0	Jan, July	93	..
1	..	Bath Elec. Trams Pref. Ord.	⅛ -¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝ -¾	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88 -92	4 18 0	April, Oct	89	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 -92	4 13 6	Jan, July	89	..
10	6%	Bristol Tramways & Carriage Ord.	9 -9½	6 6 0	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ -9	4 9 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99 -100	4 1 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	¼ -⅜	..	June, Dec	..	..
10	8/0	Do. 6 per Cent. Cum. Pref.	2½ -3¼	9 4 9	Feb, Aug	2..	2⅞
St.	5%	Do. 5 per Cent. Perpetual Debs.	81 -83	5 11 0	April, Oct	81	..
St.	4½%	† Do. 4½ per Cent. 2nd Deb. Stock	68 -71	6 6 6	May, Nov	69	68½
St.	3½%	Central London Ordinary Stock	66 -68	5 2 0	Feb, Aug	67½	65½
St.	4%	Do. 4 per Cent. Pref. Stock	83 -85	4 14 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	50 -53	4 12 6	Feb	52	50½
100	4%	Do. 4 per Cent. Debs.	102 -104	3 16 6	Jan, July	102½	102½
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 -94	4 5 0	Jan, July	93	92
5	2/6	†City of Birmingham Trams. 5% Cm. Pref.	4¾ -4⅞	5 2 6	April, Oct	4..	—
100	4%	† Do. 4 per Cent. 1st Mort. Debs	97 -101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	30½ -31½	4 15 0	Feb, Aug	3.½	31
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 -112	4 9 0	Feb, Aug	—	..
St.	5%	Do. (1896)	105 -109	4 11 0	Feb, Aug	.	..
St.	5%	Do. (1901)	102 -105	4 1? 0	Feb, Aug	102½	—
St.	5%	Do. (1903)	93 -9?	5 4 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 -102	3 18 0	Mar, Nov	..	—
10	6/0	Dublin United Trams. Ord	11½ -12½	4 15 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	12½ -1?½	4 9 0	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	. -⅜	..	Feb, Aug	..	—
10	4/0	G. Northern, Piccadilly & Brompton Ord.	..	..	Feb, Aug	..	.
St.	4%	Do. 4 per Cent. Deb. Stock	92 -95	4 4 0	Jan, July	93½	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2 -3	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	8. -83	5 4 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	6½ -7½	8 0 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	7 -7½	8 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	85 -90	5 0 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ -1⅜	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	54 -59	6 13 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9?-10?	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 -93	5 7 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1 -1$\frac{1}{16}$	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	4¼ -5¼	9 10 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82 -4	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	3 -4	12 10 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	70 -75	5 6 8	Jan, July	72½	72
St.	—	Mersey Con. Ord. Stock	1 -2	—	Feb, Aug.	—	—
St.	..	Do. 3 per Cent. Perp. Pref.	2 -3	—	..	..	..
1	10½	†Metropolitan Elec. Tramways Ord.	⅝ -¾	—	..	..	—
1	—	Do. Deferred	? -?	..	April.. .	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	? -?	5 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 -97	4 13 0	Jan, July	9?½	95
St.	⅜%	Metropolitan Railway Consolidated	35½ -36½	1 7 6	Feb, Aug	36	35½
St.	3%	Do. Surplus Lands Stocks	69 -71	4 4 6	Feb, Aug	69½	69½
St.	3½%	Do. 3½ per Cent. Preference	87 -89	3 18 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. "A" Preference	78 -80	4 7 6	Feb, Aug	78½	78
St.	3½%	Do. 3½ per Cent. Convertible Pref.	75 -77	4 11 0	Feb, Aug	75	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	93 -95	3 13 3	Jan, July	94	93

In calculating the yield allowance has been made for accrued interest but not for redemption.

* Ex Dividend. ‡ The London Stock Exchange [illegible]

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., April 28.	Rate % Yield-ed.	Dividend Due.	Business Week to April 28 High-est.	Low est.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*		£ s. d.			
St.	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	92½	91½
St.	..	Metropolitan District Railway Ord.	14½—15	—	Feb, Aug	14¾	14½
St	..	Do. Extension Pref. (5 per Cent.)	31 —34	..	Feb, Aug	31½	..
St.	3½	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	66 —69	5 1 0	Feb, Aug	68	..
	3%	Do. 3 per Cent. Consoltd. Rent-charge	78 —80	3 15 0	Jan, July	..	..
St	4%	Do. 4 per Cent. Midland Rent-charge	102 —105	3 16 0	Jan, July	..	..
St.	13°	Do. Guar. Stock 4 per Cent.	85 —88	4 11 0	Mar, Sept	87	86½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	136 —139	4 6 3	Jan, July	138½	136¾
St	4%	Do. 4 per Cent. Ditto	90 —93	4 6 0	Jan, July	91½	..
St.	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
5	0/9¾	Potteries Electric Traction Ord.	⅞—1⅛	8 0 0	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅞—⅞	6 0 0	Feb, Aug	..	—
1	4½%	Do. 4½ per Cent. Deb. Stock	83 —91	4 19 0	May, Nov	..	..
St.	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅝	9 12 0	Feb, Aug	..	..
1	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
St.	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db.	80 —84	5 19 0	Jan, July	..	..
100	...	UndergdE.Rys.Lon.6% In.bds with coup.3	34 —36	..	June, Dec	35½	34
..	21/11	Do. 5% Prior Lien Bonds	103 —104	4 16 0	..	103¾	103½
..	4½%	Do. 4½% Bonds with coup. 2	85 —87	5 3 6	..	86½	86⅛
—	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	—	..	..	..
5	4½	Do. 4½ per Cent. 1st Debs.	84 —88	5 2 0	Jan, July	—	—
St.		**ELECTRIC MANUFACTURING, &c.**					
1	..	Aron Electricity Meter Ord.	⅝—1⅛	..	..	..	..
1	0 7½	Do. 6% Cum. Pf.	⅞—1⅛	6 12 0	April, Oct	..	..
1	1/7½	Babcock & Wilcox Ord.	4½—4⅝	4 11 6	April, Oct	4⅝	4½
1	0/7½	Do. Pref.	1⅛—1⅜	3 16 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅞—7⅛	7 0 0	July, Feb	6⅞	..
5	3/0	Do. 6 per Cent. Pref.	6⅜—6⅝	4 12 0	Jan, July	6⅝	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅞—1⅛	—	Feb, Aug	—	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	94 —96	6 5 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock‡	38 —43	9 4 0	Jan, July	42	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	40 —50	9 0 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	30	29½
5	5/0	Callender's Cable Con. Ord.	9¾—10¼	6 13 6	Jan, July	..	—
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5¾	4 7 0	Jan, July	5⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	105½	..
1	1/6	Castner-Kellner Alkali Co.	1⅞—1⅞	7 4 6	May, Nov	1⅞	1⅞
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —106	4 4 0	Feb. Aug	103½	103
	0 7½	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	7 10 6	March ..	..	..
	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 13 0	April, Oct	..	..
1	0/8¾	Consolidated Electrical Co.	⅞—1⅛	8 5 0	August ...	..	..
1	1/0	†Consolidated Signal Co.	1⅛—1⅜	7 12 0	April, Oct	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	⅞—1⅛	6 4 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	1 —1½	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	95 —98	5 2 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	1⅛	..
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1½	8 0 0	Sept	..	—
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	4 16 9	Sept	1⅝	1½
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	103	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅝—⅞	..	Feb, Aug	—	..
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	—	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	75 —78	5 2 9	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅜—⅝	..	Jan, July	½	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	59 —62	7 5 0	Jan, July	..	..
2	..	Electric Construction Co.	½—¾	..	Jan, July	..	..
2	2/9¾	Do. 7 per Cent. Cum. Pref.	1 —1½	9 6 9	July	..	..
..	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 —64	6 5 0	Jan, July	..	..
10	6/0	General Electric (1900) 5% Cum. Pref.	7¼—7¾	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	84 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11½—12½	6 0 0	Feb, Aug	11⅞	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 2 0	Feb, Aug	..	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 2 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c.,Wrks.	15½—15½	6 9 0	Feb, Aug	15	14⅞
10	..	Do. 5 per Cent. Cum. Pref.	10⅝—11	..	..	10½	10⅝
100	4%	Do. 4 per Cent. Debs. (red.)	98 —100	4 0 0	April, Oct	—	..
1	..	National Elec. Construction Co.	⅜—⅝	..	April	—	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—⅝	..	Nov	—	..
1	7½	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	82½	..
1	..	Simplex Conduits Ord.	1½	—	..	—	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	—	—
12	24/0	Telegraph Construction & Maintenance	32 —34	5 9 0	Mar, July	33	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1 0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 11 9	—	2⅜	2¼
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1⅜	4 8 0	—	1⅛	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	110	..
St.	4%	Do. 4 per Cent. 1st Mort. Db.Sk. (red)	104 —106	3 14 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 6	June, Dec	105½	—
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 9	..	107⅛	107⅛
10	6/0	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	1⅛—1⅜	3 15 0	Apr, Oct	..	..
5	3/0	† Do. 6 per Cent. Cum. Pref.	2⅞—3⅜	8 18 0	Apr, Oct	3⅜	3⅛
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	80	79½
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅝—3⅛	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red)	92 —95	5 5 0	June, Dec	..	..
St.	15 0	†Anglo-American	57 —60	5 11 3	F,My,Ag,N	58	..
St.	30/0	† Do. Preferred	101 —103	5 17 6	F,My,Ag,N	101½	99½
St.	3 0	Do. Deferred	17 —17½	2 6 6	F,My,Ag,N	17⅝	14½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 6	Jn,Ap,Jy,O	91½	88½
10	6 0	†Cuba Submarine Ord.	7⅛—8⅜	6 17 0	Feb, Aug	..	—
10	10/0	† Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	—
5	2/0	Direct Spanish Ord.	3 —3½	5 15 0	April, Oct	—	—
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9½	5 5 0	April, Oct	—	—
St.	4½%	Do. 4½ per Cent. Deb.	100% 102%	4 8 0	Jan, July	—	—
20	4/0	Direct United States Cable	12 —13½	6 8 0	Ja,Ap,Jy,O	12½	12½
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	—	..
St.	15/0	Eastern Ordinary	134 —137	5 2 0	Ja,My,JyO	136¾	134½
St.	17/6	Do. 3½ per Cent. Pref. Stock	85 —87	4 0 6	Ja,My,JyO	85½	..
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	101½—106½	3 15 0	May, Nov	106	..
10	2/6	Eastern Extension	12¾—12¾	5 9 9	Ja,Ap,Jy,O	12½	12½
St.	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	102½	100½
25	4%	Eastern & S. Af. 4% Mauritius Sub. Debs.	101 —108	3 17 0	May, Nov	..	..
10	6/0	G.N. (of Copenhagen), Ex. Coupon 75	27 —29	6 4 3	Jan, July	28½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
St.	12,6	Indo-European	63 —66	5 16 3	May, Nov	85	84⅞
10	8/1	Marconi Companies Common	78 —82	4 17 6	Ja,Ap,Jy,O	—	..
10	8/1	Do. Preference	73 —76	5 5 6	Ja,Ap,Jy,O	—	..
1	..	Marconi's Wireless Teleg. Co.	2—¾	..	April	—	—
1	4%	Pacific & European Tel.4%Guar.Dbs.(red.)	100 —102	3 18 0	June, Dec	—	—
2½	1/3	West Coast of America	1½ —1¾	4 3 6	May	..	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅞—1⅛	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref	8⅞—9⅛	6 17 0	May, Nov	8⅞	8
10	12 0	Do. 6% 2nd Pref	8⅞—9⅜	4 9 6	May, Nov	8⅞	—
100	5%	Do. 5 per Cent. Debs.	101 —108	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	13½—13⅞	5 2 0	Mr,Jn,O,D	13½	12⅞
St	4%	Do. 4 per Cent. Deb Stock (red.)	101 —103	3 17 8	June, Dec	102½	102
...	4%	†Western Union Telegh. $1 000 4% Bonds	87 —92	4 7 0	..	..	..

Share	Last Dividend	Name	Price Wed., April 28.	Rate % Yield-ed.	Dividend Due.	Business Week to April 28 High-est.	Low-est.
		TELEPHONES.		£ s. d.			
100	2$	Amer. Teleph. & Telegh. Cap. St.	141 —145	5 13 8	..	145	144½
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98 —100	4 0 0	Jan, July	98½	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	98 —100	5 0 0	Mar, Sept	..	—
5	3/0	Chili Telephone	8 —8½	4 14 0	August ..	8⅛	..
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞—1⅛	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106 —108	5 11 0	Feb, Aug	107½	106½
St.	6%	Do. Def. Stock	121 —123	4 17 6	Feb, Aug	121¾	121½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11½	5 6 6	Feb, Aug	11⅛	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11½	5 6 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5⅝	4 6 0	Feb, Aug	5⅝	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	99½	98½
St.	4%	Do 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	100	..
1	0/7½	Oriental	1⅛—1½	5 6 9	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1½	4 16 0	April, Oct	1⅛	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	88⅞	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	..
5	3/0	United River Plate	6½—7½	5 13 0	July	7	6⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	June, Dec	5⅛	5⅛
St.	4½%	Do. 4½ Deb. St. Red.	103½—105½	4 5 0	Jan, July	—	..
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜—3⅞	7 14 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10⅞—11⅜	5 6 0	SpDeMrJu	11	10⅞
10	3/0	Do. 6 per Cent. Pref.	12¾—13¼	4 10 6	SpDeMrJu	13⅛	12¾
10	6%	†Submarine Cables Trust (Cert.)	127 —130	4 12 0	April, Oct	128½	127½
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅛—6⅜	4 15 3	April, Oct	6⅛	..
5	5/0	Do. 10% Non-cum. 2nd Pref.	9⅛—9⅜	5 8 0	Jan, July	9⅜	9
St.	4%	Do. 4% Deb. Stock	91 — 93	4 6 0	June, Dec	91⅛	91
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 0	Jan, July	..	..
6	2/6	Brisbane Electric Trams. Invest. Ord.	5⅞ — 6	8 6 6	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	5⅛	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	101 —105	4 5 9	Jan, July	101⅛	101
St.	8%	British Columbia El.Ry.Df. Ord.	143 —147	5 9 0	Mar, Sept	146	142½
St.	6%	Do. Pref. Ord. Stock	123 —126	4 15 0	May, Nov	125	123
St.	5%	Do. 5% Cum. Perp. Pref. Stock	107 —110	4 10 6	Jan, July	109¾	108
100	4½%	†Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 0	April, Oct	...	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 6 8	Jan, July	..	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	99½ - 100½	4 4 6	..	—	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db	97 —99	5 1 0	Mar, Sept	98½	..
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	93 —97	6 2 6	Feb, Aug	95	95½
5	2/0	Calcutta Tramways (1 to 137,610)	4 —4½	5 0 0	Mar, Sept	4⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅜	4 16 6	Jan, July	..	—
1	4½%	Do. 4½% 1st Deb. Stock (red.)	90 —102	4 8 0	Jan, July	..	—
St.	..	Cape Electric Tram Shares	⅛—⅜	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904)Sh.	5⅛—5⅜	4 4 9	F,My,A,N	5⅜	..
St.	4%	Do. 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	91 —94	5 6 0	May, Nov	—	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 —88	5 13 9	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	89 —94	5 6 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	⅝—⅞	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	84 —88	5 14 0	Jan, July	87	8⅞
5	6%	Do. 6 per Cent. "B" Ditto	58 —68	9 10 0	Jan, July	..	—
5	1/0	Lisbon Elec. Trams. Ord.	1 —1½	4 9 0	July	..	—
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1½	4 16 0	Jan, July	..	—
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	94 —97	5 1 0	Jan, July	91½	—
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	90 —93	5 7 6	Jan, July	..	—
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	92 —98	5 4 0	Feb, Aug	..	..
100	8⅓	Mexico Trams Co. Com. St.	142½—144½	4 5 0	..	144	32½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	95 —96	5 4 0	..	95½	95½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	104 —1 6	4 6 6	..	105	..
1	1/0	Perth Elec. Trams Ord	⅝—⅞	6 12 6	May	..	—
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	—	—
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 6 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	100½	100½
100	..	Rio Janeiro Tram, Lt. & P. Co.	103½—104½	..	..	104	103½
..	5%	Do. 30 yr. Gold Bnds.	95½— 96½	5 3 6	..	96½	95½
100	5%	Do. 10 yr. Mt. Bnds	85½— 86½	..	..	86½	85⅞
—	8⅓%	Sao Paulo Tramway, Light & Power Co. $100 Stock	155 —157	6 10 9	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100 —101	4 19 0	June, Dec	101	100½
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	9⅞	9⅞
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	89 —93	4 17 0	Jan, July	90	..
5	3/3	Calcutta Elec. Supply Ord.	6⅞—7⅛	5 12 0	April, Oct	..	..
100	8⅓	Canadian Gen. Elec. Co. Com. St.	123 —127	5 10 0	..	126⅞	116½
100	8¾	Do. 7% Cm. Pf. Stock	119 —121	..	..	121	117½
100	6%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —102	4 13 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	88 — 90	5 11 0	..	89	87½
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1½—2½	..	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Deb Stock	90 —94	5 6 6	Jan, July	..	—
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½—89½	5 10 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	..	..
10s	0/3	Kalgoorlie Elec. Power & Ltg. Ord.	⅜—⅝	..	..	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	⅞ - 1	7 10 0	April, Oct	1⅛	..
St.	5%	†Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	88 —89½	5 12 0	..	88½	87½
St.	$1	†Mexican Lt. & Power Co. Com. St.	77 —79	5 17 0	—	77½	77
500	5%	Do. 5% 1st Mort. Gold Bnds.	92 —93	5 7 6	—	92⅝	91½
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	118 —122	4 18 3	F,My,A,N	119	..
1	1/7½	†River Plate Electricity Co. Ord.	1½—1¾	4 4 9	April	1⅝	1⅝
1	1 2⅜	† Do. 6 per Cent. non-Cum. Pref	1 —1⅛	5 6 6	May	1⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock	112 —106	4 14 3	Jan, July	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 11 0	April, Oct	5⅜	..
100	$1	†Shawinigan Water & Power Co. Ca	94 —96	4 5 9	—	95½	94½
100	5%	Do. 5 per Cent. Bds.	106 —108	4 12 6	Jan, July	..	..
St.	4½%	Do. 4½ Per. Con. Mt. Db St.	97 — 99	..	—	99	97
..	6/0	Victoria Falls Power Co. Pref.	⅝ — 1⅛	5 6 9	Jan, July	3⅜	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE
ELECTRICIAN
INDUSTRIAL SUPPLEMENT.

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APRIL 30, 1909.

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The Electric Drive on Shipboard.

AT a time when the general public, among whom may be included those belonging to the electrical engineering profession, are more or less agitated by questions of efficiency in our Navy, and are, therefore, more than usually interested in seafaring matters, it may not be out of place to draw attention to the many uses to which electricity for power purposes is being put on board ship. In this issue we give some account of the wide employment of fans combined with electric motors for ventilating work on ships, where it is not so easy as on land to obtain fresh air, and, therefore, the artificial removal of the used-up "products of combustion" becomes a necessity.

This one application, however, by no means exhausts the possibilities of the electric drive. On passenger and cargo ships electricity is at the present time being largely used for working such auxiliaries as hoists, winches, capstans and lifts of all kinds. While on the newer battleships, though also employed for these purposes, it is now being used as well in connection with the gun machinery. The reason for this adoption is not far to seek, and the only wonder is that electricity, with its many advantages, has not been employed to a greater extent. One has only to recall the work required on a steam-driven donkey engine for warming through and draining the pipes, compared with the instant readiness of the motor, to realise the true facts of the case. Further, the energy losses, caused by condensation and leakage with the older methods of working, are reduced to a small fraction of their former value by employing the motor to do the work of a small and generally inefficient steam engine. Compared with a steam engine, too, the motor is a much more suitable piece of machinery to be entrusted to the mercies of the ordinary "tar." With the first method of drive it is practically essential for a skilled man to be in charge, while in the latter the motor is protected both by its own safety appliances and by the wholesome awe which it generates in the minds of the unitiated. There is also the question of the space occupied, a matter which is of paramount importance on board ship, and here again the electric motor more than holds its own. It can be tucked away in any odd corner, and it is not necessary to connect it by more or less cumbersome pipes either to the source of energy supply or to the outer atmosphere.

The suggestion of driving the ship itself by the aid of the electric drive has been mooted, and, indeed, the idea has much to commend it. A propeller is most efficient when running at slow speeds, while with a turbine the reverse condition is the case. By interposing an electric generator and motor between the turbine and propeller many advantages would be at once obtained, both as regards efficiency and regulation, and from the naval architecture point of view. The use of a three-phase generator coupled to an induction motor has been suggested for the purpose; an idea which possesses an advantage from another point of view, as induction motors are very suitable for ship work, both on account of their sturdiness and lack of vital parts, and also because alternating currents have but little effect on the compass and no special precautions as regards wiring need, therefore, be taken in this case. In the case of an electrically-driven ship, induction motors would therefore be employed for driving the auxiliary machinery. These problems are now coming up for solution, being bound up with the question of the preservation of our natural resources, and it does not show undue optimism on our part when we express the hope that the electric drive will soon "rule the waves" to the same extent as it is pre-eminent on land.

Concerning Electric Fans.

THE summer weather which we have enjoyed and are still enjoying at the time these notes are penned gives rise to the hope that winter is over at last, and that some hot days are in store for us. Although in the abstract, and especially in the winter, hot days are delightful, there does come a time when we wish it were not quite so warm, and when we sigh for cooling breezes and less sunshine. It is then our thoughts turn, or ought to turn, towards the most effective means ever devised for meeting this condition of things climatic—the electric fan—and to sigh for the comfort produced by its use.

With a foresight which we fondly believe distinguishes editors as a class, we have determined in the present issue of the INDUSTRIAL SUPPLEMENT to give some account of recent developments in electric fans, and thereby to show our readers not only how they may themselves best get cool, and keep cool, when the expected hot summer days at last arrive, but how and where they may obtain, for the purposes of their business, supplies of the best makes and most efficient articles of this class.

The fan question, like all others of real interest at the present time, has its industrial side. This has not been neglected in our present issue, and besides describing fans which are intended for more or less domestic purposes, we have also given some account of recent progress in fans and blowers employed for more serious concerns than just keeping us frail humans cool in the dog days.

On the commercial side, selling electric fans is generally looked upon as essentially a summer business. The fan is primarily intended for keeping things cool, and it is for this reason, perhaps, that it has not had quite the vogue in this country which it seems to have in some other countries—to wit, the United States. The fleeting and uncertain character of an English summer is, perhaps, not quite the thing to induce the greater employment of fans, and since this is the case the question occurs to our business instincts whether this apparatus is altogether useless in the winter in this country. It will, on consideration, we believe, be immediately evident that it is not. Ventilation of the proper kind is just as essential in the winter as in the summer; and the aid of the electric fan can very well be enlisted to this end. In large buildings where a hot-air system of heating is used this is an easy matter. The fan can then be employed for drawing in a continuous supply of fresh air over the heating pipes, so that a healthful change of atmosphere is obtained in the room while the temperature is not lowered thereby.

As regards the summer uses of electric fans, there is really little to say. Their value is obvious; and we should like to see their employment become more general, for they make for health and comfort wherever installed. In this direction we feel sure the maker, the contractor and the supply station engineer might well pull together, and how this may be done is the problem for solution. To take first the question of tariffs, though, perhaps, this is scarcely a matter which greatly affects the use of fans; some form of restricted hour system might be employed in which specially low rates are charged for energy consumed in driving fans during the day time and up to, say, 5 or 6 p.m. in the evening. This arrangement would, of course, have to be modified during the winter months. But it would encourage the use of larger fan units. It is assumed, in this case, that the fans would be supplied from the lighting circuit, and except in the case of houses possessing specially dark basements, this arrangement appears to give rise to no great difficulties, for consumers are scarcely likely to burn their lamps all day during the summer time as well as run their fans simply for the sake of getting their energy at, say, 1d. a unit. A two-rate meter would be the only extra piece of apparatus necessary, while if the consumer ran his fans during the evening he would have to pay at the lighting rate. In the case of consumers who have separate circuits for light and power the above arrangement would not be necessary, as they could be supplied from either of these circuits at standard rates. Unless the fan is run for long periods, it is not much good to the supply engineer, so that some arrangement which makes this possible without overburdening the consumer financially would be an advantage. On the other hand, a fan, and an electrically driven one at that, is a good thing to have about the house, and if the consumer can get his "juice" at a low rate, it is extremely probable that he will entertain the idea of employing one for ventilating as well as cooling purposes.

In dealing with fan matters effective publicity is what is really wanted. As an example of what may be done by its aid we may cite some remarks of Mr. W. H. Stuart in a recent number of the "Electrical World" regarding the fan business in New Jersey. In this State energy is supplied to fans on a metered service, while the fans themselves are obtained either from contractors or from the supply undertaking itself. Special care is, moreover, taken to acquaint consumers with the benefits derivable from the use of electric fans, and displays of the various types of fans are arranged in the showroom windows. In New Jersey the supply authorities and contractors work hand in hand to their mutual benefit, with the result that it is estimated that there is at the present time one fan to every two consumers, and in the near future it is thought that every consumer will have his fan. A similar state of affairs is found in New York, where about 250,000 fans were supplied from the Edison company's mains during last summer. Even taking into account the difference in

climatic conditions, it is to be feared that the fan conditions in this country are nothing like so good—or are likely to be for some time to come. But much might be done by well-directed effort.

Some of the more go-ahead of our electricity supply undertakings have recently adopted the method of sending out electric flat irons on a month's trial, on "sale or return" terms at the end of that period. The same methods might be applied to fans with equal, if not greater, success, for the utility of this apparatus is more likely to appeal to the male side of the family. The first cost of these two kinds of electrical equipment is not so widely different, and as the flat-iron venture has in many cases proved of financial advantage to the supply undertaking there seems no reason why the same benefits should not attend a similar fan experiment.

Hiring fans is another direction in which something more might be done. Supply undertakings already hire meters, and often motors as well, so that fans should not prove a great tax on their resources. This system would possess the advantage of allowing the fans to be given a thorough overall during the winter months, when any defects may be remedied and the equipment made ready for the all too short hot days of the following season.

In connection with the actual installation of fans too little attention is, we fear, paid to the arrangement of the equipment in the room. Often the fan is placed in such a position that it only uselessly churns up the air without really aiding ventilation. This is specially the case in kitchens, lavatories, and such-like places, whence it is desirable to withdraw fumes and unpleasant smells. The fan should then be placed on a bracket close to an opening, which should preferably be of the same size as the fan. By arranging the fan in such a position a very effective exhaust of foul air is obtained.

At the present time the electrical industry is looking for new worlds to conquer, but there is certainly no harm in its tightening its grasp on those fields it already occupies. Hygiene is all the rage, and no better method of obtaining hygenic conditions in buildings situated in large towns can be devised than by using effective ventilating processes—and here is where the electric fan should find a prominent place. Hygiene is necessary all the year round, so that the load from this source will be available both winter and summer.

Keith Fans.

AMONG those electrically-driven fans which hold a high position may be mentioned the Keith fan, which is the result of many years' experience. It is made in two distinct types, for low and high pressures respectively, and with either double or single inlet. The low-pressure fans, which are made in sizes from 5 in. diameter inlet upwards, are, in the cases of fans up to $17\frac{1}{2}$ in. in diameter, formed of light sheet steel, and are electric rivet-welded. The fan cases can, however, when desired be made of cast iron. In every size the wheel is exceptionally light in construction, though rigidness also forms a feature, and no internal stays are required. In the single-inlet fan the wheel takes the form of a combination of two truncated cones of different angles, and is built up of blades which are conoidal in formation, and which have their deeper or inner ends set obliquely to the wheel axis. The diameter of the wheel, both inside and outside, is greatest where the blades are narrowest, and the longitudinal edges of the blades lie on conical surfaces inclined at different angles to the axis of the fan spindle.

A single-inlet Keith fan possessing all the above features is shown in Fig. 1. This fan has a $12\frac{1}{2}$ in. air inlet, and is designed for use with a motor running at 760 revs. per min. It delivers 3,400 cubic ft. of air per minute, or could deliver 4,400 cubic ft. if the motor were speeded up to 1,000 revs. per min. Considering the small size of the fan, it will be granted that this is a by no means bad performance. The same diameter fan, but fitted with a wider case and double wheel and air inlet, when running at the two speeds mentioned above, moves 6,800 and 8,800 cubic ft. of air a minute respectively.

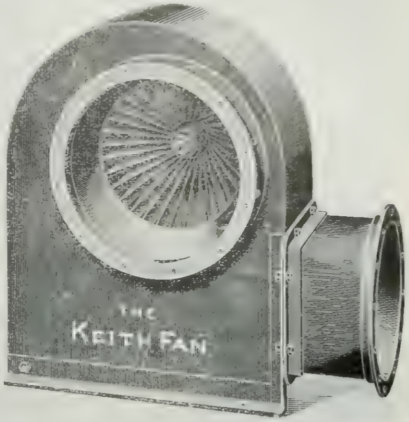


Fig. 1.—Keith Single-Inlet Fan.

As regards the double-inlet Keith fan, we show two examples of wheels used in this equipment. Fig. 2 is a double Keith wheel with deep blades, which are proportioned for handling volumes of air at high pressures. Fig. 3 shows a similar wheel with shallower blades for use in moderate-pressure work.

In both single and double air-inlet fans the wheel is enclosed in a volute case, and blades of the wheel, generally 32 or 48 in number, are of conoidal form and follow a parabolic curve. The blades have an axial length of a little

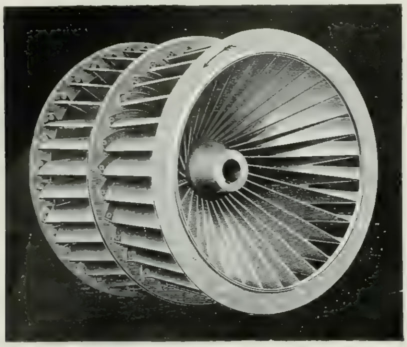


Fig. 2.—Double Keith Wheel for High-pressure Work.

over $1\frac{1}{2}$ times their average radial depth, the mean diameter in each case of the inlet centre of the drum being fully twice the average radial depth of the blades, while the longitudinal edge of the blades are further apart at the other end, and are also at different angles to each other. The blades are, therefore, much shallower towards the inlet ends than they are at the disc or base end (Figs. 2 and 3), while, owing to the outside diameter of the fan wheel being greater at the air-inlet end than at the disc

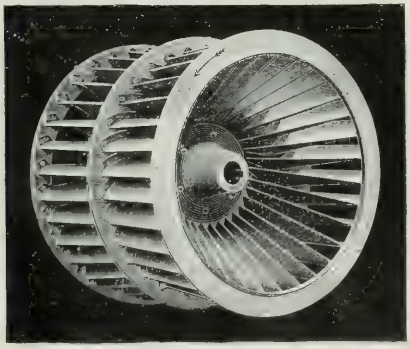


Fig. 3.—Double Keith Wheel for Moderate-pressure Work.

it follows that the blades are located further apart at the air-inlet end than at their base, so that more air is drawn in at the outer than at the inner ends of the blades.

Although the blades themselves are neither screwed nor twisted, their peculiar form and special and natural curve with different edge angles, and their setting on the disc (bringing their deeper ends obliquely across the axis) give (in addition to the usual scooping, inducing and forcing action) a screwing action on the air, all tending, it is claimed, towards increased efficiency. In all other forms of multiblade volume-pressure cased fans, the strongest air current is invariably at the base or back or disc ends of the blades, causing much thrust, and having a tendency to cause recirculation of the air through between the blades at the inlet end or ends and thus back into the wheel centre or centres, which means waste of energy and loss in efficiency.

Unlike all forms of fan wheels having relatively long narrow blades, the Keith fan wheel, by reason of the varying proportions, different angles and conoidal formation of the obliquely set blades—in conjunction with the increased induction towards the air inlet or inlets caused by its double-truncated conical form, and its freedom from thrust—ensures, it is urged, that the air delivery is absolutely equalised along the whole length of its outer blade edges, and there is consequently an entire absence of any kind of air blow-off at any point of the air inlet or inlets, as there invariably is at one point or other on the air-inlet edges of all other such forms of fans.

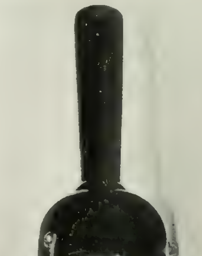
To come from practice to performance, we are able to give some interesting details of how these claims are borne out in practice. In the following table are set out some comparative tests on a "35 in. exhaust fan" made in America, and a standard Keith fan:—

Cubic feet of air per minute.	Pressure in ounces per sq. in.	"35 in. exhaust fan" with 24 in. dia. wheel. 14 in. air inlet.		Keith fan with wheel 14 in. diameter. $12\frac{1}{2}$ in. air inlet.	
		R.P.M.	H.P.	H.P.	R.P.M.
2,600	2·1	1,200	3·0	2·7	1,540
3,200	1·9	1,200	3·5	2·9	1,460
4,100	1·3	1,200	4·0	2·6	1,420
4,600	1·0	1,200	4·2	2·5	1,140

The exhaust fan used had five wide and deep square flat blades, while the Keith fan was fitted with 32 blades of standard form. The height of the exhaust fan was 37 in., as against 29 in. in the case of the Keith fan, and the outside diameter of the latter was only about one-third that of the former.

A Useful Hand Lamp.

AMONG the firms who have recently designed hand lamps in accordance with the new Home Office regulations may be mentioned Messrs. Veritys, Ltd. Their lamp, which we illustrate in the accompanying photograph, seems well fitted for the work it will have to do. The handle and bell-shaped cover are made of hard wood, treated with a black compound, while adequate protection is afforded to the lamp by a substantial wire cage. The entry for the flexible lead is bell-mouthed and sufficient room is left so that the leads can be drawn in without injury. We have not actually tried throwing the sample sent us along the floor, a method of treatment to which lamps are sometimes subjected, but we have no doubt it would come through the ordeal satisfactorily.



Veritys Hand Lamp.

B.T.-H. Fan Motors and Exhaust Fans.

THE tendency of electrical engineering is all for advance, and for this reason alone it is not surprising to learn that the range of apparatus employed for cooling and ventilating purposes which is manufactured by the British Thomson Houston Co., of Rugby, has been kept well up to date. B.T.-H. fan motors for 1909 retain all the advantageous features which have made them popular in the past, and at the same time several improvements have been incorporated in their continuous-current fan mo'ors. These are so designed that they may, with the minimum of labour, be arranged to operate either as desk or bracket fans by means of a universal screw joint, which, by simply unscrewing a bolt and adjusting the fan to the desired angle, enables one fan motor to be used in a number of positions. This universal joint is quite simple, and cannot get out of order, while the bolt used for adjusting purposes can be easily manipulated with the fingers. These continuous-current fan motors are made in two sizes for use with 12 in. and 16 in. fans, and embody the experience obtained in building thousands of similar motors. The speeds at which they operate have been standardised down to two only, as this has been found to meet all requirements in practice, and they are wound for circuits of 95 to 115, 190 to 230, and 210 to 250 volts respectively.

The entire equipment is made of best quality material and thoroughly finished, the frame and base in black enamel and the guards and fan in dipped and lacquered brass. The frame is so arranged that the shield enclosing the armature is removable, and the whole is efficiently ventilated. The bearings, which are an important item on apparatus of this kind, are made self-oiling and self-aligning, and being of brass composition metal will last for practically an indefinite time.

Besides continuous-current fans, the British Thomson-Houston Co. also supply fan motors in similar sizes to the above for operating on alternating-current circuits at voltages of 95 to 110 and 190 to 220. These are finished in the same manner as the continuous-current fans. They are supplied in swivel and trunnion frames and may be adjusted to be used as bracket fan motors by means of a simple and inexpensive adapter.

The British Thomson-Houston Co.'s exhaust fans for alternating and continuous-current circuits are similar in construction to their 12 in. and 16 in. desk and bracket types. These exhaust fans operate at the same voltages as the desk fans, and embody the same details and quality of finish. A particularly noticeable feature is their silent operation. The exhaust fans operate at

B.T.-H. Standard Table or Wall Fan.

standard speeds, and it is not usual to supply them with speed regulating switches, but, should different speeds be required, separate speed regulators can be supplied. The standard finish of the exhaust fans is black enamel.

In designing their fan motors simplicity and reliability have been the chief considerations, but appearance has not been neglected, as the accompanying illustrations will testify. Quality has always been a dominating feature of this firm's manufactures generally, and inexpensiveness has also received due consideration.

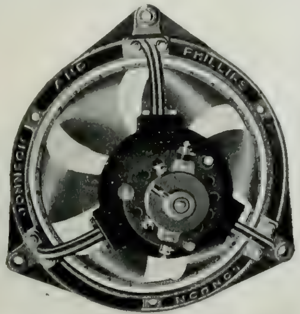
The great point about B.T.-H. fans seems to be their adaptability to various conditions. For instance, one and the same fan may be used, as mentioned above, on the table, or fixed to the wall, as required, an arrangement which possesses the advantage that one fan can practically do the work of two. Again, it is not desirable that fans of this description should take up too much space, and in this direction also B.T.-H. fans seem to fill the bill. They should, therefore, find a wide application.

Johnson & Phillips' Fans.

THE box-blade fans supplied by Messrs. Johnson & Phillips, of Old Charlton, are thoroughly representative of the high standard of their goods. The sizes made range from small fans 12 in. in diameter up to 60 in., the intermediate sizes being 15 in., 18 in., 24 in., 30 in., 36 in., 42 in., 48 in. and 54 in. The speeds range in approximately inverse proportion from 1,200 to 250 revs. per min.

The motors are designed on generous lines, with ample margin for any accidental requirements, and the rise in temperature even on a long run is very small indeed, not exceeding 30°F. for the ordinary standard protected type. If totally enclosed, a type that is always recommended for cases where either dampness prevails or steam has to be exhausted, the temperature rise is somewhat greater, but even then it does not exceed 60 deg. If the fan is for use in hot climates, sufficient margin is provided so that the temperature rise does not exceed 45 deg. under any circumstances.

The thrust of the blade is usually taken up by a washer of hard fibre, for at the comparatively slow speeds at which these fans run hard fibre is found to answer the purpose excellently, and shows no wear even after prolonged running. It is, moreover, more silent than a ball-thrust bearing, though in special cases, such as when the axis is in a vertical position, a ball-thrust bearing may be fitted with advantage. The blade itself is constructed of sheet steel cold rolled and close annealed, securely attached to a hub of gunmetal or malleable iron, according to size, and riveted at the outer edge to a steel rim, special attention being paid to the securing of a thorough balance and trueness of running, whilst the design of the blades themselves is the outcome of years of experience.



Standard A.C. Fan (Johnson & Phillips).

In the case of the alternating-current motors, the short-circuited type of rotor is used, the stator being wound with such a number of poles as will most nearly approximate to the desired speed. In the smaller sizes these motors are arranged to be self-starting—that is to say, they can be operated merely by a tumbler switch even on single-phase circuits. The larger sizes are started by throwing into circuit an additional winding for the few moments of starting, which is cut out as soon as the motor has gathered sufficient speed to enable it to run up into step. On two or three-phase circuits, of course, no starting device is necessary. Speed regulation can be to some extent effected by means of a regulating choking coil or resistance, although, of course, nothing like the range obtainable on direct current can be attained, owing to the motor losing power as soon as it gets seriously out of step. A standard A.C. fan is shown in the accompanying illustration.

Stellite Fans.

AMONG the firms who have devoted considerable thought and labour to the question of the proper design of fans we shall certainly be right in including the Electric & Ordnance Accessories Co., which is well known for its "Universal" direct-current fans. These have now been on the market for some considerable time. In these fans (known as the "A.P." type) the motor, which carries the blades on an extension of its spindle, is supported on two arms, being held in position by a couple of fly nuts. This construction renders it a matter of only a moment or two to convert a table fan into either a wall, ceiling, or trunnion fan, or *vice versa*, simply by slackening the fly nuts. Maximum adaptability is thus attained. The blades are designed to give a solid breeze, unlike many fans, which only propel the air from the tips of the blades. The motor runs noiselessly, the only sound when running being a slight humming due to the rapid displacement of the air. The insulation resistance of the windings is high, and the coils being of ample section the risk of failure due to breakdown of the insulation or overheating in the armature coils is practically nil. The brushes

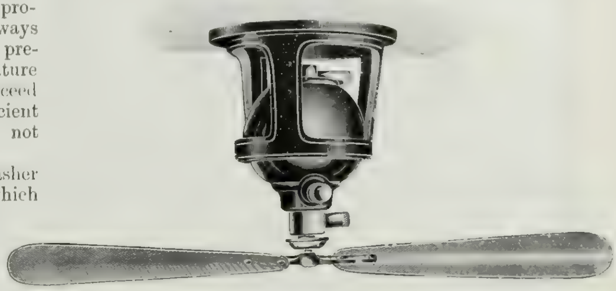


Fig. 1.—"Stellite" Ceiling Fan.

are of carbon and self-adjusting, and the bearings, which are of phosphor bronze, are fitted with wick-feed lubricators. All "A.P." fans are supplied with a starting switch, and a three-speed regulator is fitted to the base of the motor. The fans are made in two sizes—namely, 12 in. and 16 in.—and for all direct-current pressures from 60 to 250 volts.

For the ventilation of small rooms, the E. & O. Company manufacture a port-hole fan, the general design of which is similar to that of the "A.P." fans. These port-hole fans are supplied in three sizes—namely, 8 in., 12in. and 16 in.—for pressures of from 110 to 220 volts.

All first-class steamships are now fitted with electrically-driven ventilating fans, and a fan has been specially designed and constructed for this purpose by the Electric & Ordnance Co. It is of the ceiling type. The space available in a cabin is necessarily limited, and in this company's fan the size has been kept as small as possible, the 26 in. fan being only 9 in. deep. This type of fan is also made in 36 in. size.

The same company also manufacture "Ordnance" centrifugal fans, which are designed for forced and induced draught work in connection with boilers and for ventilating schemes where a fairly high pressure is essential. In these fans the runners consist of a number of corrugated blades firmly secured to the hubs. This corrugation of the blades, it is claimed, renders these fans by far the most efficient of their type. The reason for this is to be found in the entire absence of any slip back of air between the blades—the cause of much loss in efficiency in many fans. The company make the claim that, for a given power and size, the "Ordnance" fan gives a greater discharge than any other like fan made, and we learn that large numbers of these fans have recently been supplied to the British Admiralty. We illustrate each of the above types of fan.

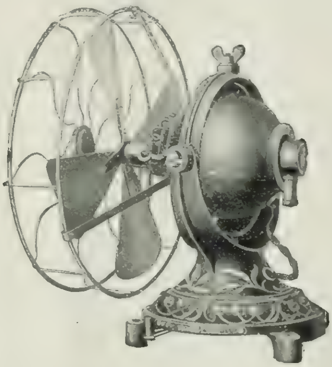


Fig. 2.—"Stellite" Table Fan.

For the removal of foul air, smoke, acid fumes, dust-laden air, &c., from workshops, drying rooms and other similar places this company have yet another type of fan, known as the "Ordnance" propeller Fan, which can be either direct or belt driven according to requirements. These fans are the outcome of lengthy experiments and experience in fan design, with a result that they give an extremely large displacement of air for a very nominal expenditure of power. They are made in four sizes, ranging from 12 in. to 60 in., and have an output varying from 1,100 to 28,000 cubic ft. of air per minute for slow speeds, and from 1,450 to 42,000 cubic ft. of air per minute for high speeds.

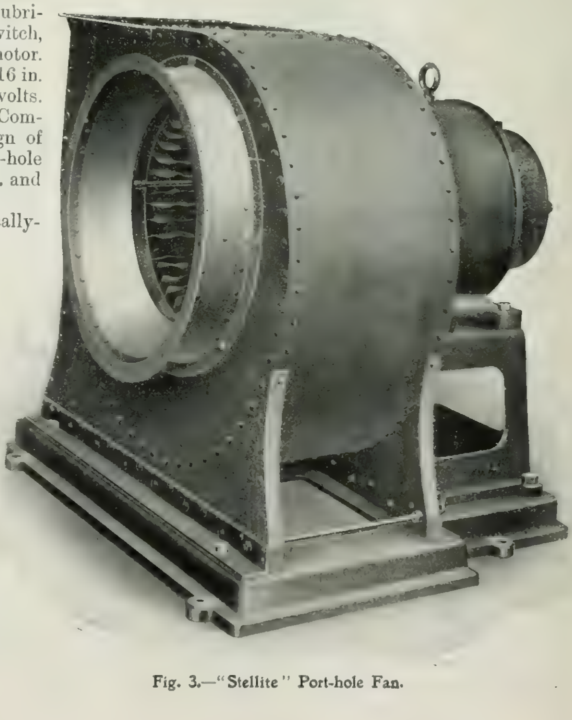


Fig. 3.—"Stellite" Port-hole Fan.

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Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Design of Fan Blades. In this issue of the INDUSTRIAL SUPPLEMENT we have endeavoured, with the assistance of numerous makers, to give some idea of the progress that has recently been made in electric fan matters. From an historical point of view, the fan, as a fan, is a very ancient piece of apparatus. Not to go too far back, one of its first forms seems to have been a flat surface of irregular shape and made of various materials, which was waved to and fro more or less efficiently by human agency. Whether this arrangement was a good one is hard to say, but the air in the neighbourhood of the fan must have been churned up rather than fresh air brought in. The same idea is, of course, applied in the punkah used in India, and this equipment, combined with the electric drive, forms, it is said, a very good method of obtaining fresh air, as the higher speed of operation sets the air in motion over a larger area than could be effected by a hand-worked fan. In such a case as that of the punkah, the flat blade may well be used, but this form has certain disadvantages when the working of modern rotary fans is considered. In using this apparatus, what is required is to draw air into the fan and discharge it at the other side. One is immediately struck by the analogy to the steam turbine. It is the motor and dynamo over again. In the turbine, steam is forced over a number of bucket-shaped blades fixed on a suitable rotor. The energy contained in the steam, together with the proper arrangement of the blades, causes this rotor to revolve. In the fan the rotor is revolved by external means, and the air, if the fan blades are of proper design, is drawn in at one side of the fan and discharged at the other at a velocity which depends on the speed of rotation of the fan and on the design of the blades. The question is not, of course, quite so simple in practice, but taking the above as an indication of the general lines on which to work, the blades may be modified or adapted in accordance with the special purpose for which the fan is designed

Ventilation of Coal Mines. It is not with the idea of stating the obvious that we make the remark that the proper ventilation of coal mines is a subject of very great importance. This fact has, moreover, been recognised since the very earliest days, when various ingenious, though crude, methods, were devised for ensuring a proper circulation of air through the mine. When mines are small natural ventilation is often sufficient, but this method becomes quite impossible as the depth and extent of the workings increase. It has, in fact, been stated that about 75 per cent. of the air currents necessary for efficient ventilation must be furnished by mechanical means. To produce the necessary current of air the use of a high-speed fan possesses certain advantages, among them the property that the speed of this type of fan may be varied more easily and with less danger, while the parts are lighter and more easily handled—a factor of some importance when upkeep and maintenance costs are considered. On the other hand, any increase in the output of a large slow-speed fan is obtained at the expense of safety, for such an increase may be detrimental to a heavy wheel, and at the same time this type of fan is expensive to run when only small volumes of air have to be dealt with. It will, therefore, be seen that the use of the electric motor direct coupled to a high-speed fan is almost a necessity in mining work.

An American View of the Daylight Saving Bill. There is a widespread notion in those countries that are unfortunate enough to be outside the British Empire that the English, as a nation, are hopelessly mad. This idea is well brought out by a leader in our contemporary, the "Electrical World," on the question of the Daylight Saving Bill. It looks upon the whole affair as a good joke (and we are not sure on further consideration that this is not the proper point of view). It is hard put to it to discover both the origin and reason for the bill, and is finally of the opinion that a thrifty Scot possessed of a grudge against the gas and electric light companies is at the bottom of it. A truly delicious idea! Our contemporary suggests many ways of improving the bill, and it is regrettable that the exigencies of space prevent us from quoting from this article at great length. We cannot refrain, however, from reprinting the concluding paragraph, in which the real opinion of America on the bill as exemplified by the "Electrical World" is neatly summed up. The paragraph reads:—

> Frankly, we trust that the present bill will pass, as the greatest advertisement (barring the suffragette movement) of the new century, and as fresh evidence of the far-sighted astuteness of the body that annually turns down the Metric bill. The Lords can be trusted to suppress it or to amend it into some form yet more facetious. Meanwhile, people will keep up the same old game of getting up about when they please, working as long as they please, and then turning night into day, to the profit of the dispensers of liquids and lights.

Comment is needless, but we are sure that the promoters of the bill will welcome the encouragement given to their project by our cousins across the herring pond.

The Fan in the Boiler House. For the first few weeks, or years, after an idea which has been germinating in the inventor's mind has at last taken tangible shape, the improvements he is able to introduce into its working are many, and follow the conditions dictated by the experience of its practical working that have been obtained. After this initial period, however, the number and importance of the improvements is reduced and the progress made is not seldom quite invisible to the casual observer. The above lines are not inapplicable to parts of the electrical industry, and particularly to that portion of it which is engaged in generating electric power. To take but one example, the improvements made in dynamo design during the first 10 years of its existence were greater and more far-reaching than those made, say, in the last 10 years. In fact, the design and operation of the plant employed in central stations has now been so standardised that engineers are hard put to it to discover methods for effecting the economies in working demanded from them. In fact, practically the only part of the station which offers them any scope is the boiler house, and here there is plenty. One of the most prolific sources of waste is doubtless due to the low efficiency of the ordinary chimney as a means of producing the necessary draught, the figure being placed by competent authorities at less than 0·0005 of 1 per cent. The use of an economiser, it is true, raises this figure somewhat, but on the other hand, it decreases the intensity of the draught and thus leads to still further losses. Some means of artificially producing draught would, therefore, appear to be absolutely necessary, and one of the best methods of thus inducing a draught is by using an electrically-driven fan. Such an arrangement, especially if an induced draught method (as distinct from forced draught) is employed, makes for a more uniform passage of the air through the fuel bed, while a steadier flow of the hot gases is at the same time obtained. The use of mechanical draught immediately introduces another advantage, for by its use a control over the combustion is at once obtained and the fires can be forced or retarded, in a manner not possible when a chimney alone is used, by simply altering the speed of the motor driving the fan. Such methods lead to an increased rate of combustion, while the flue gases contain a high percentage of carbon dioxide, a factor which indicates efficient working. The greater draught obtained under these conditions makes the use of an economiser both possible and efficient, while the size of the boiler plant necessary for a given electrical output is greatly reduced. There is at the same time a much more complete absence of the smoke nuisance and the efficient working of the station is less dependent on atmospheric conditions. From these data it will be seen how much the application of mechanical draught to boiler-house working can aid in obtaining a higher plant efficiency. It is interesting to note that the production of induced draught in the boiler house by means of the electric drive forms another example of the way in which this form of energy takes a hand in assisting in its own generation.

Electric Fans on Sea and Land.

THE benefits derived from the use of electricity for the operation of auxiliary machinery on board ship, are amply borne out by the great improvements that can be effected in the ventilation of the vessel by the employment of electrically-driven fans. The ease with which the purity of the atmosphere can be maintained is chiefly due to the provision of small plenum or exhaust fan sets, each consisting of a high speed fan direct-coupled to an electric motor, a combination of sufficiently small dimensions to be placed on deck without occupying too much of its valuable space. The accompanying view (Fig. 1) of the deck of a first-class Atlantic liner shows four electrically-driven "Sirocco" fans, supplied by Messrs. Davidson & Co. of Belfast, which are used for the ventilation of the passengers' quarters. Electrically-driven fans are also used extensively on ship board for supplying forced draught to the boilers for ventilating stokeholds, as well as for circulating the cold air in the cold storage chambers of the meat and fruit carrying steamers. Part of an order of 30 "Sirocco" fans for refrigeration purposes on board fruit boats is showu in Fig. 2. On land one of the most important applications of fans is in connection with boiler draught. Steam users have frequently found an induced draught fan to be one of the most profitable investments they had made, for by its use the steaming capacity of their boiler plant could be increased without the addition of new boilers. Further, their coal bill could be reduced by permitting the burning of a cheaper grade of fuel than would be possible with natural draught, and, finally, by their use the emission of black smoke was reduced, thus bringing the plant well within the nuisance limit. Such a fan direct coupled to an alternating current motor is shown in Fig. 3.

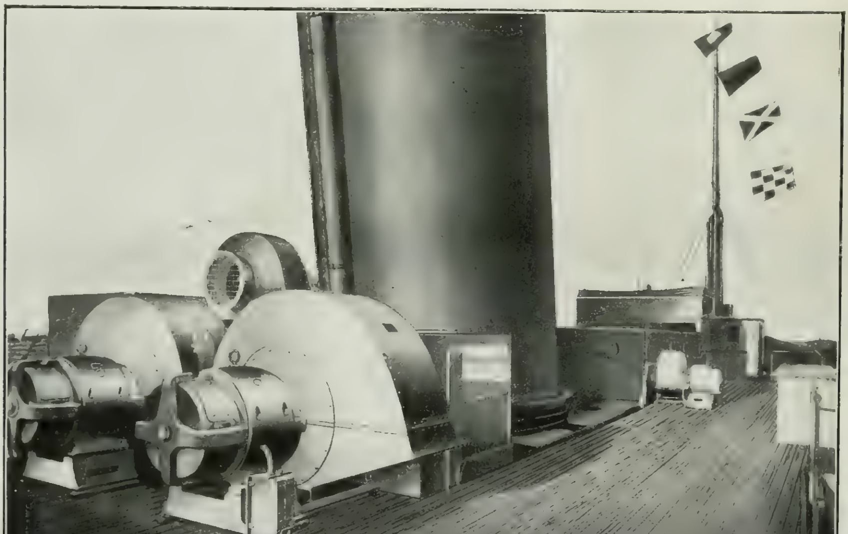


Fig. 1. "Sirocco" Fans on Atlantic Liner.

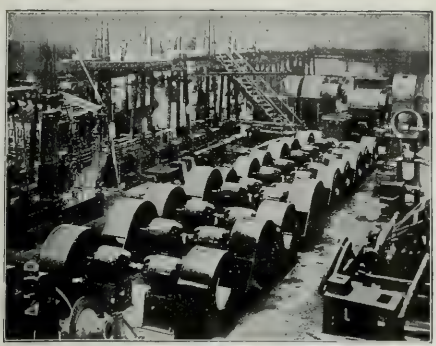


Fig. 2.—"Sirocco" Fans for Refrigerating Purposes.

With the increasing facilities offered now-a-days by the power distribution companies, electrically-driven mine fans are rapidly increasing in number. A large fan of this description has just been installed by the Glamorgan Coal Co. It is a double inlet "Sirocco," 140 in. in diameter,

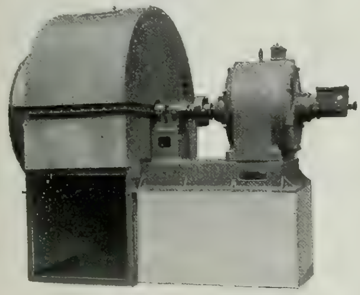


Fig. 3.—"Sirocco" Fan coupled to A.C. Motor.

direct coupled to a 450 H.P. B.T.-H. motor, and ventilates roadways aggregating 60 miles. On test the fan gave an efficiency of 82 per cent., a figure most satisfactory to the colliery manager and fan maker alike.

Pickard Electric Screw Fans.

It may be truly said that the most important part of any fan, however it may be driven (though, of course, we hope it will be by electrical means), is the blade. This portion has to perform the work for which every fan is installed—*viz.*, to move the air—and it is, therefore, surprising that not more attention is paid to its design. It is strange, but nevertheless true, that in almost all electrical fans the design of the blades receives but a secondary consideration, which results in the crude shapes often met with. Such shapes are of little use for extracting air from rooms, especially when air ducts have to be employed.

A firm who have given a great deal of consideration to this question of blade design is Messrs. F. Hattersley Pickard & Co., of Leeds. The blades of all their fans are, in fact, carefully designed and constructed on correct scientific principles for moving large volumes of air in an economical and efficient manner. They will also, it is claimed, move air against a good deal of resistance, and are, therefore, particularly suitable for the ventilation of public buildings, restaurants, smoke rooms and offices. A geometrical development of one of the blades is shown in Fig. 1.

A view of one of the standard fans is given in Fig. 2. The Hattersley Pickard fans are supplied with either continuous or alternating-current motors. A special feature

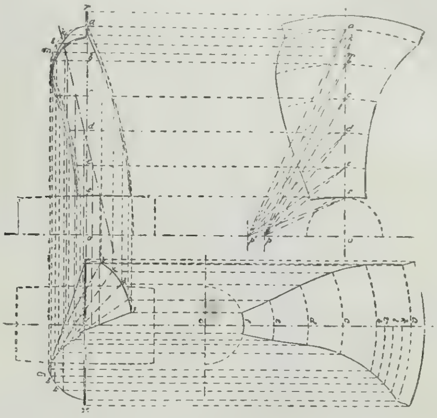


Fig. 1.—Geometrical Development of a Hattersley Pickard Fan Blade.

is made of the single-phase induction motor for fan work. These motors do not, it is claimed, require any special starting switch, but can be started by an ordinary tumbler switch. This arrangement, which is obviously very convenient from all points of view, applies with equal force to both large and small sizes of fans. Fans and fan apparatus are too often given over to the tender mercies of some one who has only the remotest idea how to treat them, so that the simpler the apparatus the better for both fan and motor.

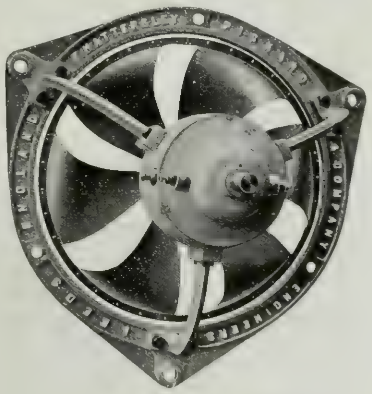


Fig. 2.—Hattersley Pickard Standard Fan.

The Hattersley Pickard fans are finding a wide application not only for ventilating work, but also for such purposes as drying, dust removal and induced draught, and on consideration it will be granted that it is only right that this should be so, seeing the scientific principles on which they are designed. The theory of the design of fan blades is an interesting subject and we shall wait expectantly for some further development along these lines.

"Fortiter" Fans.

In writing of fans the journalist is much put to it to avoid referring to that kindred but rather wore-worn subject of the weather. Though at the present time it is not quite so warm as it might be, yet there are signs of something better to come, and it is really not so very unreasonable to bring the fan subject to the front.

He who at the present time is thinking of purchasing a fan might do worse than consider the claims of the "Fortiter" fan, made by the Union Electric Co. It is put on the market in a number of shapes and sizes, each designed to do its best in its own sphere of usefulness.

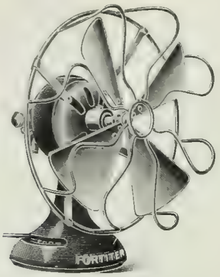


Fig. 1.—"Fortiter" Table Fan.

The common, or usual table fan is shown in Fig. 1. This can be obtained in a number of sizes, the blade diameters varying from 10 in. to 14 in. The air displaced per minute varies from 350 cubic ft. per minute in the case of the smaller fan to 1,200 cubic ft. per minute when the larger is employed. Standard types made for working on pressures of 110 or 220 volts are supplied, while by means of a regulator placed in the base of the fan speeds of 800, 1,000 and 1,200 revs. per min. can be obtained from both types. Though rated at 110 and 220 volts, these fans can be used on any voltage between 100 and 120 volts or 200 and 240 volts, the standard frequency in the case of alternating current supply being 50.

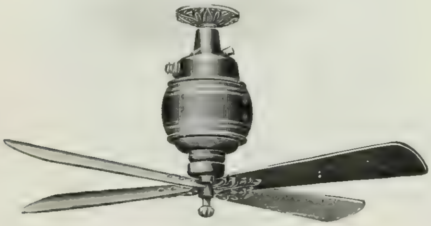


Fig. 2.—"Fortiter" Ceiling Fan.

Those who prefer ceiling fans are also catered for by the Union Electric Co., one of the "Fortiter" ceiling fans for use on direct-current circuits being shown in Fig. 2. These fans are fitted with either two or four blades, and with or without suspension rod as desired. To those who rejoice in dimensions we may say that the overall vertical length of these fans is 53 in. when a suspension rod is fitted and 16 in. when it is not employed. The diameter across the blades is 53 in. in the case of the two-bladed fan and 39 in. for the four-bladed pattern. Suspension rods can also be supplied in longer and shorter lengths up to a maximum of 5 ft. All these fans must necesarily be fitted with starters, and a speed regulation down to 110 and 140 revolutions in the case of the two-bladed and four-bladed fans respectively can be obtained. The weight of these fans varies between 35 lb. and 44 lb., so that the strain on the ceiling fitments generally is not great.

The "Fortiter" porthole fan is shown in Fig. 3, with its Iris diaphragm closed. Similar fans with open rings are also supplied. The sizes of these fans vary from one with a diameter of 9½ in. to one with the quite respectable dimensions of 59 in. The Iris diaphragm fans are made in sizes up to 16 in. in diameter. The air displaced per minute varies from 500 cubic ft. in the case of the 9½ in. open ring fan to 35,000 cubic ft. in the case of the 59½ in. size. The limiting figures for the Iris diaphragm fans are 500 cubic ft. and 2,100 cubic ft. respectively.

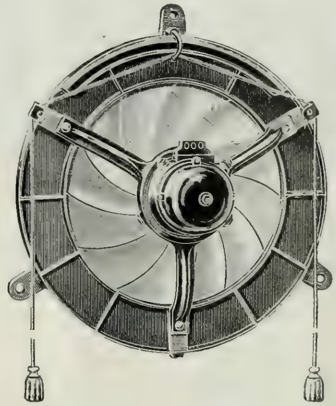


Fig. 3.—"Fortiter" Porthole Fan, with Iris Diaphragm.

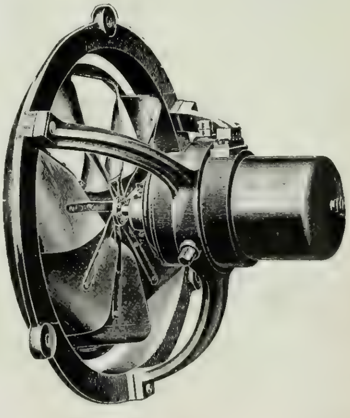


Fig. 4.—"Fortiter" Porthole Fan, with Bucket Blades.

A porthole exhaust fan fitted with bucket blades is shown in Fig. 4, and as regards output and dimensions is similar to those set out above. All these porthole fans are very similar in operation, and can be driven by direct current, three-phase or single-phase motors. The number of blades varies from four in the case of the small sizes to eight in the largest types. These fans can also be fitted with automatic louvre shutters which open or close as the fan is started up or shut down.

"Acme" Blowers.

THE question of blowers is becoming more and more interesting to electrical engineers from the fact that within recent years blast-furnace gas has been to a great extent used for driving engines to generate electric power. The connection between the blower and the current may seem rather remote, but in installations where gas engines supplied with blast-furnace gas are used it is not unnatural that the blowers themselves should be driven by electric motors.

Blowers are, however, used for a variety of other purposes, and like the majority of apparatus employed in engineering work, their present design is due to large development from very small beginnings. A firm which has to a considerable extent assisted in this development is Messrs. Samuelson & Co., of Banbury, who for nearly twenty-five years have been manufacturing positive blowers of various kinds. The experience obtained over this period has given them a knowledge of the wants of the user of these machines, and these wants are, it is claimed, met in the newest designs of their improved "Acme" positive blowers. This blower is designed upon new principles, and is said to embody a radical change from the old style of construction, while at the same time it combines all the advantages of the earlier forms and

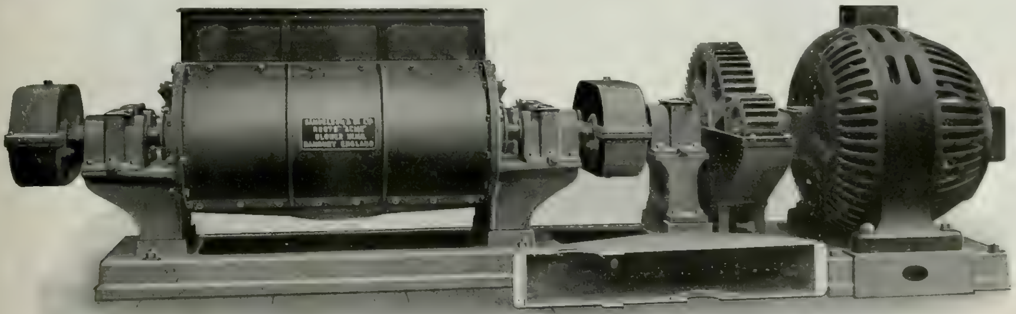


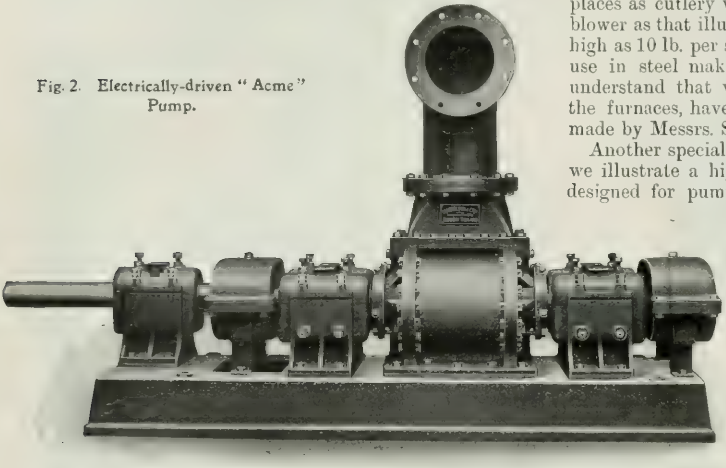
Fig. 1.—Standard Electrically-driven "Acme" Blower.

eliminates every detail which experience has shown to be objectionable.

In the accompanying illustration we show an electrically-driven "Acme" high-pressure motor blower coupled through gearing to an electric motor. This blower is composed entirely of metal. The revolvers, of which there are two, are cast in one piece and contain no screws, bolts, nuts, or other similar parts which might become loose during working. This detail of the machine is obviously not without importance to the user. The wings of the revolvers, which are cut back to afford a clearance, do not touch the bottom of the recess, and therefore pass through this latter without obstruction, while the contact between the two revolvers and the case is, it is claimed, maintained during the entire revolution, so that any backward escape of air is reduced to a minimum. Such blowers as these not unfrequently find a place in foundries and other places where dirt is more abundant than welcome, so that the arrangement described above, which prevents any collection of dirt or grease in the bottom of the recess, is a distinct advantage. It is also claimed that liability to thumping, and any chance of the spindles being strained from this cause, is thereby avoided.

Each revolver is perfectly balanced on its axis, and is not one-sided, as in the case of some positive blowers; it therefore runs with a steady even motion and does not jerk the belt when the drive is effected by this means. The line illustration herewith shows the construction of the revolvers, which are arranged so that all air taken in is, it is claimed, forced forward while a minimum is carried backward.

Fig. 2. Electrically-driven "Acme" Pump.



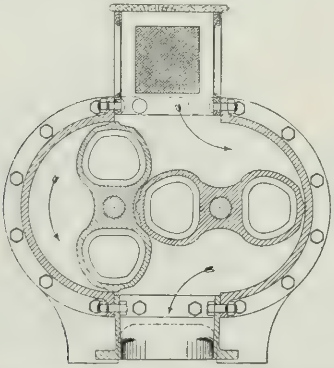


Fig. 3.—Section of "Acme" Blower, showing Revolvers.

There are a number of ways in which "Acme" blowers can be used, but we need only mention here that Messrs. Samuelson recommend the use of blowers with iron revolvers for blowing and exhausting hot air or steam for any purpose, and for extracting dust in such widely different places as cutlery works and soda manufactories. Such a blower as that illustrated would work against a pressure as high as 10 lb. per square inch, and is specially designed for use in steel making with the "Tropenas" process. We understand that very good results, as regards yield from the furnaces, have been obtained by using Root's blowers made by Messrs. Samuelson.

Another speciality of this firm is pumps, and in Fig. 2 we illustrate a high lift pump which has been specially designed for pumping 42,000 gallons of water per hour against a head of 140 ft. It is electrically driven, and is being used in coal mining work.

The "Acme" rotary pumps consist of two revolvers, which are accurately machined to roll together without actual contact. There are no valves, and there is, it is claimed, a minimum of wear in the pump of parts liable to get out of order. The revolvers are mounted on steel spindles of large diameter, which are forced in under hydraulic pressure keys then being fitted. The casings are of substantial construction, and are accurately bored to receive the revolvers. The end plates are fitted with long stuffing boxes and are machined on the face.

Telephone Exchanges in Works and Warehouses.

THE British Insulated & Helsby Cables (Ltd.) have recently erected at their Helsby Works a typical exchange, such as would be suitable for all large works, stores, warehouses and the like. The system employed is the central battery with automatic calling and clearing on Helsby drum indicators with double supervision in the cord circuits. Current, both for signalling and speaking, is obtained from a central battery.

A 50-line switchboard (Fig. 1) is installed, having five strips of 10 spring-jacks and a corresponding number of indicators, room being provided for extensions. The indicators are of the gravity type, and the drum normally closes the opening in the plate so that dust cannot enter. The surface usually exposed is black, though when the indicator is revolved to indicate a call a white surface is shown. The night bell contact is in the rear, so that there are no parts projecting in the front to interfere with efficient cleaning of the front of the board, an arrangement which possesses certain obvious advantages. The line circuit is as shown in Fig. 2. There are 15 pairs of connecting plugs, each pair fitted with a speaking and ringing key of the vertical type, and with tandem supervisory signals. These signals are also of the gravity type, and are similar to the line indicators except that they are adjusted to work on a horizontal shelf, while the electromagnets are sheathed

to prevent "overhearing" between adjacent cords. The rear signal is associated with the answering plug and the front one with the calling plug, so that the operator can at any moment tell the operating position of the instrument by the position of the indicators.

The cord circuit is shown in Fig. 3. It will be noticed that the tip conductor is divided by a condenser, and that a supervisory signal is connected from each side of this condenser to earth. The B conductor has no condenser, and one retardation coil is connected through the battery to earth. A generator key is provided so that either the hand generator or a power-driven generator may be switched on as required.

The operator's instrument is a breastplate transmitter with headgear receiver, as shown in Fig. 4. The breastplate transmitter with attachments weighs only $6\frac{1}{2}$ oz. The transmitter is, we believe, the smallest of its kind manufactured, whilst it is at the same time claimed to be equal, as regards its operation, to the best "solid back." It will be noticed that it is mounted at the end of a bracket so that the operator talks directly against the diaphragm. The instrument is detachable, as the cord ends in a suitable plug so that a hand set may be introduced for use at quiet times. A test board is provided at the rear of the switchboard and is illustrated in Fig. 5. This board includes twin test jacks, so that when a plug is inserted the two line wires and the two switchboard wires are connected by the plugs to suitable testing instruments.

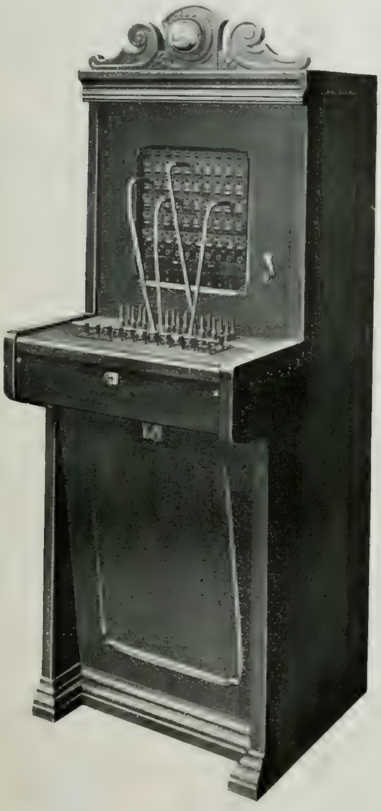


Fig. 1.
50-line Telephone Switchboard at the Helsby Works.

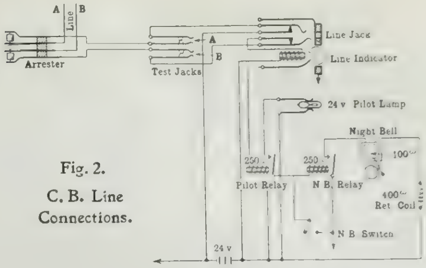


Fig. 2.
C. B. Line Connections.

In addition, the installation is protected by carbon arresters, heat coils and fuses, one of each of the latter being fitted in series in each wire. The former, when a current exceeding one-third of an ampere passes through, is heated, and low temperature solder melted so that a pin is withdrawn by a spring which opens the circuit. The fuse causes the circuit to open when a current of over 3 amperes passes. In the arrester a line spring, which is a "tap"

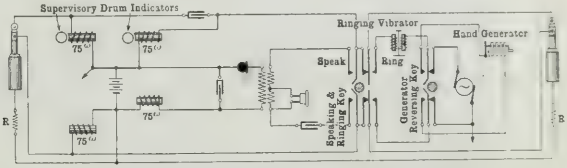


Fig. 3 —C.B. Subscriber's Cord Circuit

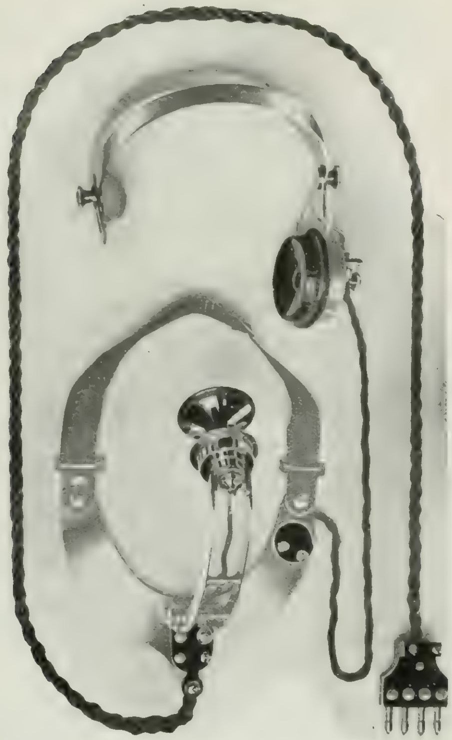


Fig. 4.—Operator's Instruments, including Breastplate Transmitter, with Headgear Receiver.

from the line, rests on a carbon block which is separated from another block by a thin slip of mica, the under block being connected to earth. When lightning, or currents of a voltage of 500, or thereabouts, reaches the line, the latter sparks to earth through this arrester, and so protects the switchboard apparatus. Insulated rings are provided at the rear of this board so that it may be used as a distributing board when required.

The instruments fitted are of various types, and illustrate in practical fashion the range of the company's manufactures. The majority are of the radial-arm type (Fig. 6), in which the transmitter has a rise and fall of 6 in. to make it suitable for use by different height users. Bracket-arm instruments are also used, as well as the table sets similar to those shown in Fig. 7. In the latter the transmitter is carried by a knuckle joint at the top of the pillar; the pillar con-

Fig. 6.—Radial Arm Instrument.

taining the switch carries the receiver, but the bell, condenser and induction coil are fitted in a separate case to avoid having a bulky instrument on the desk.

These instruments are all efficiently protected by a compact arrangement of carbon arrester, heat coil and fuse (Fig. 8). This apparatus is similar to that described for the test board, and is enclosed by a dustproof cover.

The necessary power for working this system of telephones is obtained from the existing installation, connection being made from a battery of accumulators provided for other purposes, so that the voltage is 24 volts above earth. If this source of power were not available, it would, of course, be necessary to fit a small power plant or to work from primary cells. The switchboard is placed in a room near the entrance gate, and the wires are carried to the various departments partly by means of bare and partly by means of covered wire.

This system of telephones has been found a great convenience and has given very little trouble since its installation. We are informed that the company will be pleased to give any further information regarding it or would be pleased to show it to anyone interested. The central battery system is not often used on what may be called a purely private installation, and for this reason the equipment at the Helsby Works should be of special interest to telephone engineers.

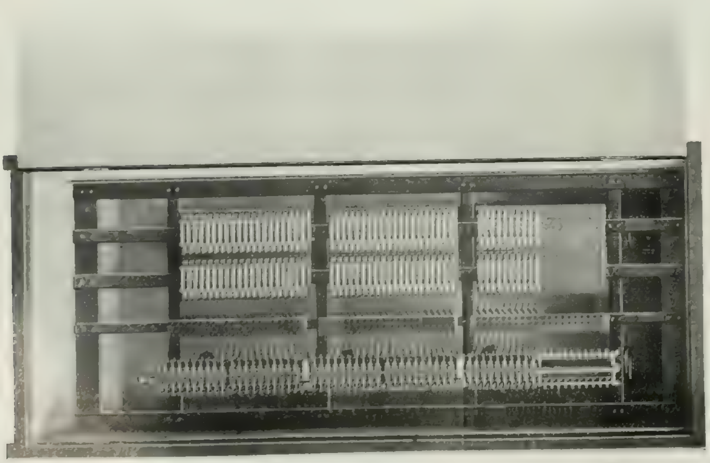


Fig. 5.—Test Board.

Helsby articles are so well known throughout the engineering world for good workmanship and general suitability for the conditions under which they are to be employed that the results of this departure by the firm in installing a C.B. system in their own works will be watched with interest. Telephone engineers are agreed that this system possesses many advantages over the older methods of working, and its adoption in works, large offices, and other similar places will bring the internal telephone system more into line with the "National," with consequent advantages to all concerned. We shall hope to see its wider adoption in the near future.

Fig 7.—Table Telephone Set.

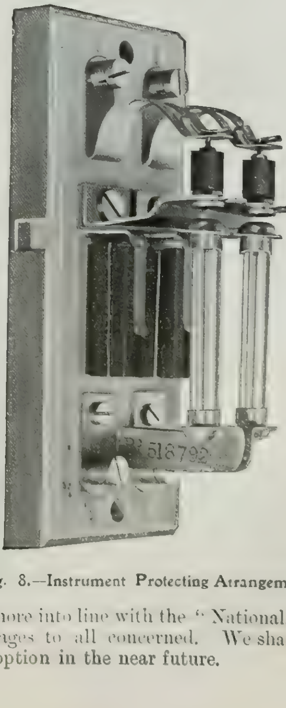


Fig. 8.—Instrument Protecting Arrangement.

Stothert & Pitt Electric Cranes.

NO better example of the economies which can be effected by using the electric drive need be taken than that of the electric crane. To the most unbiassed observer it will quickly be evident that the losses present in the system are much lower when power is supplied from one efficient central station by electrical means than when each crane is fitted with a small, and therefore inefficient, steam plant. It is, therefore, scarcely surprising that many already existing cranes are being fitted with motors, while practically all new installations are similarly equipped.

quay-side by means of a flexible cable which is rolled up on the truck by means of a cable-drum. The main feature of the crane is the lifting gear, which is arranged on the Stothert & Pitt patented system of working with a free barrel and special interlocks. The hoisting speed is 4 tons at 38 metres per minute, or 2 tons at 76 metres; the slewing speed is 108 metres per minute.

Fig 2 shows a portion of the crane installation recently set to work by Messrs. Stothert & Pitt at Rio de Janeiro. This consisted of 13 30 cwt. cranes and four 5 ton cranes. Both these sets of cranes lifted their loads at 14 metres radius. They are fitted with lifting, slewing and jib-derricking motions operated by separate motors. These cranes, like those previously described, are each fitted with the patented system of working with a free barrel with its

Fig. 1.—Stothert & Pitt Cranes at Buenos Ayres.

After generalisation follows example; and in this connection we cannot do better than illustrate and describe same recent crane installations which have been erected in South America by Messrs. Stothert & Pitt, of Bath.

Fig. 1 shows some of the cranes which have lately been put into use at Buenos Ayres, the total number supplied being 24. These cranes are capable of lifting 4 tons at $10\frac{1}{2}$ metres radius on the single part of rope. As will be seen from the photographs, they are placed on high gantries so as to permit of the passage of rolling stock beneath, and to have the superstructure in such a position that it would clear the high sides of vessels lying alongside. The cranes are fitted with separate motors for lifting and slewing, while hand-power travelling is also provided so as to bring the crane hook "plumb" into a vessel's hold. Three-phase current is collected from crane junction boxes on the

special interlocks, and they lift their loads on the single part of rope. The lifting speed for the 5 ton cranes is 60 ft. per minute, and they are fitted with a change of gear to lift loads of $2\frac{1}{2}$ tons at 120 ft. per minute. The slewing speed is 300 ft. per minute. The 30 cwt. cranes lift at 200 ft. per minute and slew at 400 ft. per minute.

Another interesting set of cranes built by Messrs. Stothert & Pitt is that working at the new dock at Avonmouth. The installation consists of two 3 ton, two 10 ton and one 30 cwt. crane, the radius of all the cranes being 46 ft. $2\frac{1}{2}$ in. They are fitted with lifting, slewing and jib-derricking motions operated by separate motors, and the 3 ton and 30 cwt. cranes are fitted with the system of working with a free barrel. The gauge of the under-structure is 15 ft. centre to centre, and current is collected by means of flexible cable from junction boxes on the quay.

Fig. 2.—Stothert & Pitt Cranes at Rio de Janeiro.

The accompanying illustrations indicate that Messrs. Stothert & Pitt's cranes contain true engineering features, as they appear well suited for the work they are called upon to do. The many ingenious details of the equipment generally help to that end.

Electrically-driven Propeller Fans.

THE selection of the particular type of fan which shall be most efficient for any given conditions is a problem best left to the expert to solve. Our readers will doubtless grant this title to Electromotors Limited, of Openshaw, who have had a wide experience of fan motor requirements. It is interesting to note that this firm recommend that where silent running is specially desirable their slow-speed fans should be used. They have, therefore, made this type their standard, and supply them with either ventilated or totally enclosed motors. For special cases, where higher speeds are required—for instance, where the aperture is limited—high-speed fans are necessary. In this case the motor is provided with a small amount of ventilation, and high speeds should therefore be used for moderately clear air or inactive gases. Other things being equal, the use of a slow-speed fan is thought preferable, not only on account of its silent running, but as an investment. For its extra first cost is soon repaid by the lower power necessary when running.

The type of propeller fan made by Electromotors Limited, is, it is claimed, designed on the simplest possible lines to ensure continuous running with a minimum of attention. Fig. 1 illustrates a standard wall type of high or low-speed propeller fan connected to a totally-enclosed two-pole continuous-current motor, which is provided with a slotted drum armature and former windings. These fans can be supplied for either horizontal or vertical discharge, the horizontal fans being supplied with ring oil bearings and the vertical fans with grease lubricators. Carbon brushes are fitted to all types of fan and can be very easily renewed. The blades are of stamped sheet steel, and are

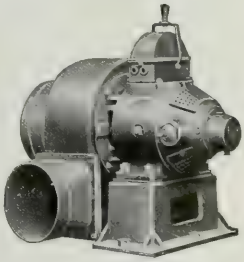


Fig. 2.—Small Blower Combination.

Fig. 1.—Electromotors Standard Wall Fan.

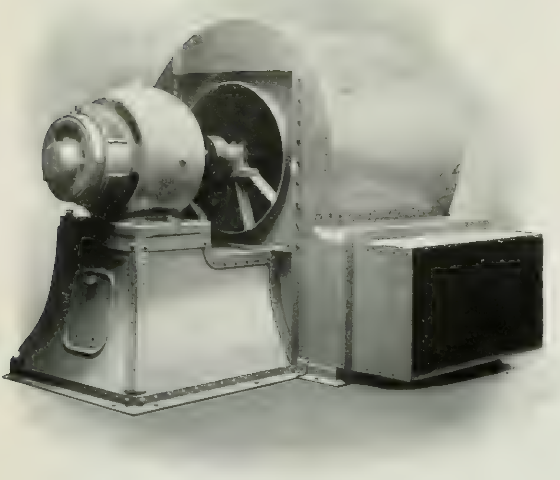


Fig. 3.—Large Capacity Forced draught Apparatus.

carefully designed to minimise air friction and slip. Galvanised iron or other blades can be supplied if required. A tumbler switch instead of a starting switch is quite suitable for sizes up to 20 in. diameter and for moderate voltages. In the selection of a fan it is advised that careful comparison should be made of the efficiencies of various types—that is, the volume of air moved compared with the current consumption of the motor.

In addition to the propeller fans referred to, Electromotors Limited are supplying large numbers of motor-driven cased fans from the small sizes used for suction gas plants, smithy fires, &c., to the larger combinations used for heating and cooling plants, forced draught, &c. Fig. 3 illustrates a large-capacity forced-draught fan and Fig. 2 a small blower combination of Electromotors make.

Crompton Fans.

MESSRS. Crompton & Co.'s long experience of electrical work in hot countries, especially in India, has given them quite a premier place in the industry as regards fan design. In their fans they have embodied all the special features which their experience in tropical climates has shown to be necessary to ensure satisfactory and efficient operation. Crompton fans run absolutely without noise, at the same time giving a powerful breeze with the consumption of only 90 watts. One of these fans can, therefore, be run for about 12 hours off one Board of Trade unit. All these fans are made at Chelmsford, and their parts are freely interchangeable, being turned out by automatic machinery, so that a minimum of trouble with "spares" has to be provided for.

These fans are driven by series-wound motors, and run at a speed of 140 revs. per min. Two windings are standardised, one suitable for 100 to 130 volts and the other for 200 to 250 volts. The fans, however, can be supplied for any other voltage up to 250. The armature is of the slotted drum-wound type, with former-wound coils, the core and windings being very carefully insulated and arranged to withstand the severe conditions to which electrical apparatus is subjected in tropical climates. The field-magnets are of circular pattern, and to secure lightness are made of cast steel of high permeability. They are fitted with cast-iron end covers, arranged to protect the commutator and armature from dust and mechanical injury, while allowing free ventilation through the windings. The bearings are fitted with dust-proof, self-oiling and self-adjusting renewable ball bearings, which will run without noise and for long periods without attention. The motor is fitted with substantial brush gear, the brush holders being of the lever type.

The suspension consists of a ½ in. steel rod, covered by a brass tube, polished or nickel-plated. This arrangement has been adopted after much experience and testing, and it has been found that such a suspension is many times stronger, and therefore safer and more reliable than the tubular suspension usually supplied with fans. With this method of suspension it is, it is claimed, impossible for the fan to detach itself, and consequently serious accidents, such as have occurred with gas tube suspensions, need not be feared. The standard fan (Fig. 1) has a suspension 4 ft. long, making the total length of the fan from the ceiling to the bottom of the blades about 5 ft. 6 in., this having been found the most suitable over-all length for a room 12 ft. high. A porcelain insulator is provided at the upper end of the suspension, and ornamental spinnings are placed at the top and bottom, giving the whole a neat and handsome appearance.

The motor can be fitted with either two, three or four aluminium or wood blades, each 8 in. wide at the tip, and of such a length as to give a total sweep of about 5 ft. The aluminium blades can be either flat or curved, and particular attention may be called to the special form of curved aluminium blade, the shape of which has been chosen after prolonged experiment as being the most suitable for delivering the largest possible quantity of air for a given current consumption, and at the same time spreading the air to the best advantage, thus increasing the effective area of the breeze.

Fig. 1.—Standard Crompton Fan.

The blades are fastened to the carrier by means of screws working in slots, so that it is impossible for them to accidentally fly out; at the same time the blade angle is easily adjusted. The setting of the fan blades is a matter of great importance, and this is done in the following way in Crompton's fans. A mark is made on the blade shank, and a corresponding mark on each barrel of the blade carrier. The blade is then pushed home into the barrel and turned round until these marks are opposite to one another. The blade screw can then be screwed home through the slot so as to hold the blade in the desired position, care being taken to see that the screw is properly tightened.

In some cases it may be necessary to alter the amount of breeze produced by the fan; for this purpose the barrels of the blade carrier are provided with slots so that the blades can be turned in their sockets. If this is to be done, the greatest care must be taken to see that all the blades are turned by exactly the same amount, as should one blade be set at a higher angle than the remainder the fan will certainly give trouble.

The standard suspension used with Crompton fans is of interest. By its means the motor and fan are so suspended as to be perfectly safe from falling, while the leads to the motors are well insulated and, being wrapt round the suspending rod, are quite out of the way.

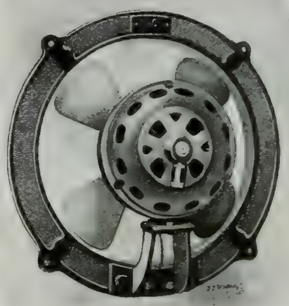


Fig. 2.

"Sun" Fans.

IN the following illustrations we show some examples of "Sun" fans which may be taken as representative of the class of work turned out by the Sun Electrical Co. in this respect.

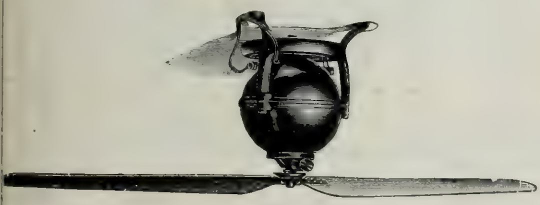


Fig. 1.

Fig. 1 shows a "Sun" ceiling fan designed for use on continuous-current circuits and in such places as ships' cabins trains and where the ceilings are low pitched. The sweep of the blades is either 26 in. or 36 in. and the motors are designed for voltages between 65 and 110 or 200 and 220 respectively.

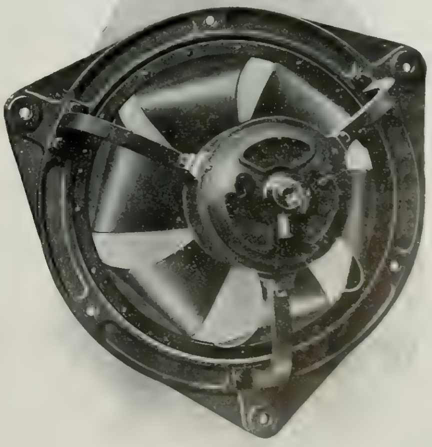


Fig. 3.

Fig. 2 shows an alternating ring fan. These fans are made in two standard designs, suitable for running on pressures between 100 and 110 and 200 and 220 volts respectively, and in two sizes having fan diameters of 12 in. and 16 in.

Fig. 3 shows a "Sun" box blade fan designed for exhausting large volumes of air. These are made in 11 sizes from 12 in. to 60 in. inclusive, and run at speeds varying from 1,000 to 1,500 revs. per min. At these speeds, it is claimed, the fans run quite noiselessly. Fans can be built for higher speeds if required, but any speed above these will be much less economical in power. The motors coupled to these fans are arranged to work either vertically or horizontally without alteration.

The Sun Electrical Co. also supply centrifugal fans suitable for the electric drive in which a special type of construction is employed. This, it is claimed, makes them exceedingly strong and rigid and reduces vibration to a minimum. These fans are fitted with oil well journals which are both self-aligning and self-lubricating. This arrangement, it is claimed, reduces both friction and cost of driving.

Siemens Fans.

In saying that Messrs. Siemens Bros. Dynamo Works are as much to the fore in fan work as in other branches of the electrical industry we mean to convey the idea that their fans are well designed, and are admirably adapted for the work they have to do. Siemens fans include all the usual types—viz., table and bracket, ceiling

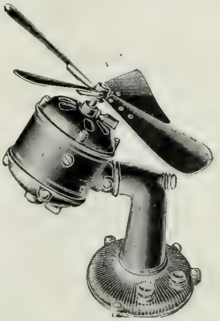


Fig. 1.—Siemens Table and Bracket Fan.

and pendant, as well as porthole fans, and those more properly classed under the head of blowers. All these are, of course, electrically driven, a suitable Siemens motor being provided in each case.

Table and bracket fans can be supplied with or without knuckle joint, and for pressures of 6, 12, 110 and 220 volts. The diameter across the blades of these fans varies from 6 in. to 14 in., and from 3 to 30 cubic metres of air are circulated per minute. An example of a Siemens fan of this description is illustrated in Fig. 1.

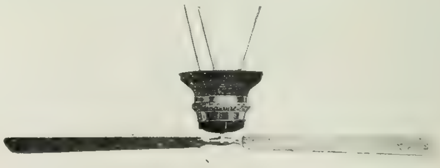


Fig. 2.—Siemens Ceiling Fan. Short Type.

A short type of Siemens ceiling fan is show in Fig. 2. The motors of these fans are standardised for pressures of 100 and 220 volts, while the fans themselves are made with either two or four blades. Besides the type illustrated ceiling fans can also be supplied with an extension rod of any desired length.

As regards porthole fans, these are normally arranged for counter-clockwise rotation (viewed from the motor end), while the movement of the air is away from the observer looking from the motor end. These fans can, however, be

supplied for running in the opposite direction or for reversing, if desired, and fans can also be fixed with the spindle vertical. In this case the blades must be above the motor and the bearings must be provided with grease lubricators. When a fan is required for use in a damp situation Messrs. Siemens recommend that their apparatus should be provided with their special damp-proof insulation. A centrifugal fan can, however, be used for this purpose, if required, as the air drawn through the fan does not then come in contact with the motor. Figs. 3 and 4 show two fan and motor combinations which have recently been supplied by Messrs. Siemens for ship work. Fig. 3 shows a $7\frac{1}{2}$ in. "Sirocco" fan, and Fig. 4 a $12\frac{1}{2}$ in. fan of the same type. The compact nature of these sets makes them specially suitable for use on ships, where as is well known, efficient ventilation is an absolute necessity. The starters are fitted on the top of the motors, while the motors are fixed on a special stand to keep them well out of the way.

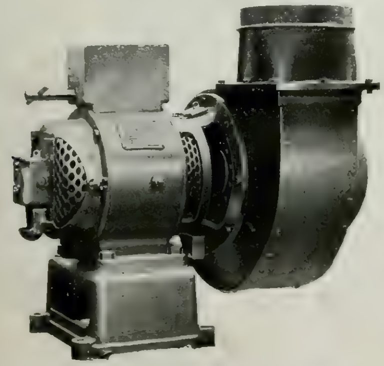


Fig. 3.—Siemens Motor and $7\frac{1}{2}$ in. "Sirocco" Fan for use on Ships.

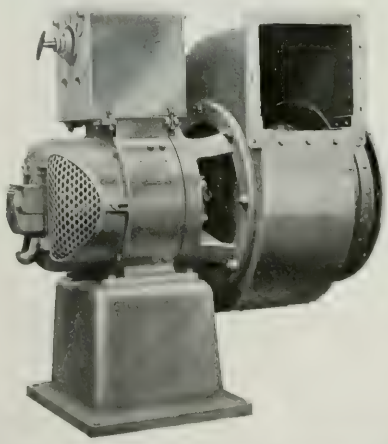


Fig. 4.—$12\frac{1}{2}$ in. "Sirocco" Fan driven by Siemens Motors for Ship Work.

Simplex Fans and Motors.

AMONG those makers who include electric fans within the scope of their specialities the name of the Simplex Conduits Limited will not be overlooked by our readers. The small electric motors used by this firm for the purpose are made in two sizes suitable for employment on circuits whose pressure varies between 100 and 120 and 200 and 230 volts respectively. Standard alternating-current motors are also designed for frequencies between 40 and 60. Between these limits, therefore, the outputs are approximately proportional to the pressures and inversely proportional to the frequencies. These motors can, of course, also be wound for any special voltage or speed.

Fig. 1.

The Simplex direct-current motors are specially distinguished by their neat design combined with high efficiency and light weight. There is, however, no lack of stability, while small dimensions are the rule. The Simplex motor coupled to a table fan is shown in Fig. 1. These motors have field frame of special shape built up from laminations. By the use of this arrangement, it is claimed, the losses are reduced to a minimum and the commutation is considerably improved. The insulation of all current-carrying parts forms a special feature of these motors. As regards lubricating arrangements, automatic grease lubrication is always supplied with the small motors, and in the case of larger motors either this form of "greasing" or ring lubrication can be used as desired. Totally enclosed motors can be supplied with 75 per cent. the output of the open type motors.

Simplex alternating-current motors are of the series type, fitted with a special winding and a highly insulated commutator. By the introduction of a special field frame the losses and heating are, it is claimed, considerably reduced and high efficiency obtained. Single-phase commutator motors, used in conjunction with the fans can, if desired, be connected to one-phase of an ordinary three-phase motor. The regulation of these motors is effected in the same way as in the direct-current types. Alternating-current motors, of an output exceeding $\frac{1}{8}$ H.P., are of the asynchronous type, and consist of a laminated stator, which carries the winding, and a short-circuited rotor. In the case of single-phase motors they are started by means of an automatic arrangement. The Simplex alternating-current motors are practically the same in general design as those of the continuous-current type.

One of the most important uses for small motors is for driving domestic sewing machines, as shown in Fig. 2. Simplex standard machines are, it is claimed, particularly suitable for this purpose, as they have been specially designed with a view to the special requirements of this class

Fig. 2.

of work. These motors are supplied suitable for both direct and alternating current, single and three-phase, and they can be attached to drive the machine by being fixed upside down underneath the sewing machine table. Speed regulation is best effected by means of a device fixed to the treadle of the machine, by which the tightness of the belt is varied and a certain amount of slip obtained. This device consists of a roller fixed to an adjustable lever, so that the pressure of the roller against the belt can be altered by pressure on the foot treadle; by moving the treadle in the opposite direction a brake is automatically applied to the hand wheel of the sewing machine, thus stopping it immediately. The standard form of machine does not require to be altered in any way if this method of driving is adopted, and at the same time the machine can be used as an ordinary hand machine after this device has been attached.

For switching off direct-current motors it is usual to adopt a Simplex regulating rheostat, which can be attached in a convenient position underneath the table, or worked from the treadle in a similar manner to the brake described above.

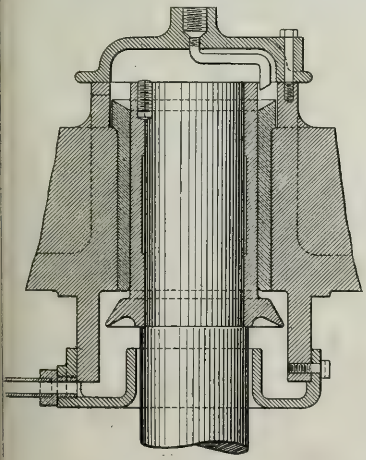
Simpson Coil Tester.

In these days of large tramway undertakings it behoves those responsible for the efficient working of the various systems to keep a sharp eye on the effect of wear and tear on the rolling stock, and also to have a ready means of testing those parts of the car which are liable to derangement. Perhaps one of the chief causes of the rise in "units per car-mile" is the gradual and continuous deterioration of the insulation of the field coils on the tramway motors. In order to facilitate the rapid and accurate testing of coils of this description, Mr. A. G. Brown, of 23, King-street West, Manchester, has placed the Simpson Coil Tester on the market. This instrument is made on the principle of the Hughes magnetic balance, the balancing coils, condenser, &c., being contained in a compact teak case.

The only preparation necessary for use is to connect the terminals on the outside of the case to any direct-current lighting circuit, with a lamp in series; or, with alternating current, to connect up without the lamp. When the current is switched on a faint buzz indicates that the instrument is ready for use. The coil to be tested is then placed on the base board with the projecting coil of the instrument approximately in the centre. A "short" in the coil is immediately detected by a loud musical note being heard in the telephone receiver, the intensity of the sound varying with the number of turns on the coil short-circuited. It will be seen that, as no connections need be made to the coil under test, great rapidity and, it is claimed, absolute accuracy in testing for faulty insulation can be obtained by using this ingenious piece of apparatus.

Vertical Balancer.

It will be remembered that in the last issue of the Industrial Supplement we gave an account of the interesting vertical balancer made by the Westminster Engineering Co. In the accompanying drawing we show a section of the upper bearing of this machine.



Bearing of Vertical Balancer, Westminster Engineering Co.

An iron sleeve, with an umbrella at the lower end cast in one piece, is fitted on the upper end of the armature shaft. This cast-iron sleeve runs in a gunmetal bearing bush, while the umbrella runs inside a deep-lipped ring.

As regards the table contained in the former article we should mention that in the second column "amperes down along wire" should read "amperes down middle wire."

It is interesting to note that the Westminster Engineering Co. are also making vertical type motors very similar in construction to this vertical balancer. Some of these motors have been constructed for coupling to vertical spindle cement mills, and have a normal output of 25 H.P. at 200 revs. per min. These machines have been at work some two or three years, and have given every satisfaction.

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NOTES.

Maximum Demand Indicators and Tariffs.

ALTHOUGH most engineers admit the soundness of the basis on which the maximum demand system of charging is based, the practical impossibility of explaining the system to the great majority of consumers and the necessity of installing additional apparatus, involving extra capital outlay by the supply authorities, have resulted in the method diminishing in popularity. The second objection just mentioned—namely, the additional instrument required—becomes very important in the case of small consumers, the cost of whose services and attendant apparatus should be reduced to a minimum. This desire for a reduction in the heavy capital outlay associated with the connection of consumers' installations has resulted in some cases in the abolition of a meter, the charge for current supplied being then based only on the number of lamps installed. This system, so excellent in simplicity, may lead to abuses; but although it is difficult to avoid the use of meters completely, a good case can be stated in favour of abolishing maximum demand indicators for small installations, even if retained for the larger consumers.

IN this connection it is interesting to note, as mentioned in the "Electrical World," that the Commonwealth Edison Company, of Chicago, one of the largest electric supply authorities in the world, has decided to discontinue the use of maximum demand indicators in the case of installations of less than the equivalent of twenty 50-watt lamps, and the consumers thereby affected have been informed that in future their maximum demands will be determined according to a fixed schedule. The company has made a careful study of the records of some 25,000 consumers, and has ascertained the average relation between the lamps installed and the maximum demand for the various classes of consumers. From these figures a table has been drawn up, showing that, in the case of consumers having the equivalent of five 50-watt lamps, or less, the connected lamps are to be taken as giving the maximum demand. In regard to larger consumers we may mention, as giving some idea of the relation adopted, that with seven lamps connected the maximum load is taken as six lamps for private houses and 6⅔ lamps for commercial consumers, whilst for 18 lamps the maximum demand of residential consumers is estimated as 10 lamps and of commercial consumers as 14 lamps.

THE most important feature in connection with this new policy is that lamps only are reckoned in estimating the connections; thus, current used by all heating appliances will, in general, be obtained at the lower price per unit, and in this way the use of such apparatus, particularly flat-irons, is likely to be encouraged. The elimination of the demand indicator should prove of considerable benefit to the company, and the consumers will, doubtless, in many cases welcome a reduction in the amount of apparatus installed, whilst the additional convenience of less attention being necessary to keep the lighting bill down to a small amount should be much appreciated and should lead to increased sales of current. In fact, the system has many possibilities, particularly as all reference to a maximum demand is rendered unnecessary, the charge being based on a fixed price per unit up to a certain consumption,

depending on the number of lamps, and a reduced price per unit for all current used after this consumption has been exceeded. No doubt there will be critics who will urge the inconvenience of inspections which such a tariff involves, but its adoption by so large a concern should prove that such difficulties are not so very serious. We have frequently advocated a tariff of this kind, and now that it is being adopted in Chicago perhaps engineers in this country will look into the question more seriously.

English Technical Education.

There is a very prevalent idea that technical education in this country suffers from want of money, and in support of such a view it is customary to point to the magnificent equipment of certain institutions abroad. This form of complaint is natural to those who look merely on the surface, and appeals to the somewhat rare individual who is seeking an object on which to dispose his superfluous wealth. But a closer examination of the subject leads to other opinions. Elsewhere we give an abstract of a Paper in which Dr. R. Pohl shows that Prussia spends about £600,000 per annum on her technical institutions, whereas England spends the larger sum of about £1,000,000. Since the population of Prussia is greater than that of England, the expenditure per head in the latter is about twice that in the former, and yet the results are very much inferior. This unfortunate difference is accounted for by the simple fact that technical education is organised in Prussia; the institutions are fewer, but they are more efficient. In this country we are imbued with municipal aspirations, and every locality must therefore have its technical school. Our schools are numerous and correspondingly mediocre. When the education is necessarily elementary this may not much matter, but in the higher branches there is much to be said for Dr. Pohl's view that a national scheme should be adopted, thus avoiding waste and increasing efficiency. By so doing, it becomes possible for the teaching staff of an important college to consist of specialists instead of the professor having to embrace a very wide field. At Charlottenburg, for example, there are seventeen professors and lecturers in electrical engineering subjects; but such a staff would be impossible on the smaller expenditure to which we have referred, if our methods were adopted.

Accumulators v. Steam Plant.

Mr. A. M. Taylor is to be congratulated on the outcome of the crusade which he has carried on so vigorously for the last two or three years in favour of using batteries to level up the load in generating stations, and thus to dispense with a certain proportion of the steam plant. The first result is not at Birmingham, but at Manchester, where, as will be seen in another column, a 12,000 ampere-hour Tudor battery is to be installed with boosters to correspond. By so doing the traction generators will be worked at full load and the battery will help to meet the peak load at the close of the day. This departure in the engineering practice of this country will be watched with much interest, and we hope it will give all the advantages claimed by Mr. Taylor.

Wireless Telegraphy in the Territorial Force.—In our issue of April 23 we published an article dealing with the work of the Territorial Force in the domain of wireless telegraphy, the article being illustrated by two photographs showing the men at work. These photographs should have been accredited to the Topical Press.

Royal Field Artillery—Territorial Force.—The "London Gazette" of April 30th contains the following announcement: "Royal Field Artillery—Territorial Force. 1st Monmouthshire, 4th Welsh Brigade. Capt. R. J. Wallis-Jones, to be major."

Dublin Section of the Institution of Electrical Engineers.—On Friday last the members of this section held a most successful smoking concert, which was presided over by Mr. G. F. Pilditch, chairman of the section. A first-class vocal and instrumental programme was arranged and duly executed, the performers including Messrs. R. Woodhouse, V. Sanderson, R. E. Young, G. Nesbitt, C. Burton, P. Hoey and C. A. Haigh.

Royal Society.—Among the Papers read at the meeting last week were the following: "A Phenomenon connected with the Discharge of Electricity from Pointed Conductors," by Prof. H. T. Barnes and Mr. A. N. Shaw; "On the Effect of Temperature on Ionisation," by Mr. J. A. Crowther, and "The Ionisation in Various Gases by Secondary γ-Rays," by Mr. R. D. Kleeman.

Institution of Municipal Engineers.—At recent meetings of this Institution it was decided to form district committees to control the affairs of members residing in the southern, south-western, and south-eastern districts. For the southern district committee Mr. H. Boot, of Tunbridge Wells, was elected temporary chairman, and Mr. E. W. Veale temporary honorary secretary. The head quarters of this district will be in London. Mr. F. Latham, of Penzance, was elected chairman of the south-western district committee and Mr. C. O. Baines, of Paignton, honorary secretary. At a meeting of the members resident in the south-eastern district Mr. H. C. Adams and Mr. B. Partridge, both of London, were elected chairman and honorary secretary respectively of the district committee.

Duplex System of Wireless Telegraphy.—A patent has recently been granted to F. van der Wonde, of Berlin, in which a system of duplex wireless telegraphy is described. The apparatus used consists of a shaft which carries a series of conducting arms. These are arranged to engage intermittently with a number of stationary contacts. When this shaft is rotated the following cycle of operations takes place: (*a*) the transmitter is connected; (*b*) the aerial is earthed; (*c*) the transmitter is disconnected; (*d*) the receiver is connected; (*e*) the earth connection is interrupted; and (*f*) the receiver is disconnected. If the shaft is rotated so rapidly that during the time of a "dot" one or more revolutions take place, two stations provided with this apparatus can transmit and receive simultaneously.

Faraday Society.—At the meeting on April 27th, in addition to the Paper on the Finlay Electrolytic Cell, an abstract of which appeared in our last issue, the following were also read: "On the Coefficients of Absorption of Nitrogen and Oxygen in Distilled Water and Sea Water, and of Atmospheric Carbonic Acid in Sea Water," by Dr. C. J. J. Fox; and "On the E.M.F. of Certain Platinum Compounds, with Special Reference to the Oxygen-Hydrogen Gas Cell," by Dr. P. E. Spielmann. The conclusions reached by the author of the last-mentioned Paper were as follows: It is in the highest degree likely that the E.M.F. of the oxygen-hydrogen cell, as usually constructed, is due to a definite hydrated oxide formed by the direct oxidation of the Pt electrode by oxygen in presence of the electrolyte: this substance, however, has not yet been chemically prepared. The theoretical value of 1·23 volts can only be reached at temperatures high enough to prevent hydrated oxides from forming—*i.e.*, when a true reversible cell exists. Also further evidence is supplied in support of Werner's valency theories, since the N_2O molecules must be closely connected with the structure of the molecule, on account of its effect on the E.M.F. of the substance. Grave doubt is thrown on explanations of the decomposition potentials of H_2SO_4 between platinum electrodes.

Cable Interruptions.	Date of Interruption.
Obock—Djibouti	Apr. 15, 1909

The Chartered Institute of Patent Agents.—The annual conversazione of this Institute was held on Thursday, April 29th, at the Royal United Service Institution, Whitehall. A large number of members and guests attended, and were received by the president (Mr. W. Trested Clark) and Mrs. W. Trested Clark. At affairs of this description it is often an act of kindness to allow those present to forget themselves, and for this reason the decision of the Chartered Institute to hold its conversazione in the Royal United Service Institution, where the exhibits in the museum always prove of great interest, is highly to be commended.

Royal Institution.—The annual meeting of the members of this Institution was held on Saturday last, Sir James Crichton-Browne, treasurer and vice-president in the chair. The annual report of the committee of visitors for the year 1908, testifying to the continued prosperity and efficient management of the Institution, was read and adopted, and the report on the Davy Faraday Research Laboratory of the Royal Institution, which accompanied it, was also read. Forty-eight new members were elected in 1908, while 63 lectures and 19 evening discourses were delivered. The following officers were elected for the ensuing year: *President*, the Duke of Northumberland. *Treasurer*, Sir James Crichton-Browne. *Secretary*, Sir William Crookes. *Managers*, Sir T. Barlow, Mr. W. P. Beale, Mr. H. T. Brown, Sir H. B. Buckley, Mr. C. Hawksley, Dr. D. W. C. Hood, Mr. A. B. Kempe, Lord Kinnaird, Sir F. Laking, Mr. H. F. Makins, Mr. G. Matthey, Mr. R. Messel, Sir J. Fletcher Moulton, Sir. Andrew Noble and Hon. L. W. Rothschild. *Visitors*, Dr. W. A. Brailey. Mr. A. N. Butt, Mr. J. M. Davidson, Dr. R. T. Glazebrook, Mr. J. W. Gordon, Dr. J. D. Grant, Major-General Sir C. Grove, Mr. C. E. Groves, Mr. J. List, Sir Philip Magnus, Mr. R. Mond, Col. Sir F. Nathan, Hon. C. A. Parsons, Mr. J. Swinburne and Mr. A. J. Walter.

At a general monthly meeting of the Institution, held on Monday, May 3rd, the chairman announced that he had appointed the following vice-presidents for the ensuing year: Dr. D. W. C. Hood, Mr. A. B. Kempe, Sir F. Laking, Mr. G. Matthey, Sir J. Fletcher Moulton, Sir A. Noble, Sir J. Crichton-Browne (treasurer and Sir Wm. Crookes (hon. secretary).

Junior Institution of Engineers.—The twenty-fifth anniversary dinner was held on Saturday evening last at the Hotel Cecil, the president of the Institution, Mr. James Swinburne, F.R.S., being in the chair. Among the many distinguished guests were the Right Hon. R. B. Haldane, M.P., Sir William H. White, K.C.B., Engineer Vice-Admiral H. J. Oram, C.B. (president-elect), Lieut. A. Trevor Dawson, R.N., Mr. W. M. Mordey (President of the Institution of Electrical Engineers), Mr. W. Trested Clark (President of the Chartered Institution of Patent Agents) and Mr. A. J. Walter, K.C. After the loyal toasts had been duly honoured,

Lieut. Dawson proposed the toast of "The Territorial Force," remarking that it was a happy inspiration on the part of the Council to include the territorial forces in the toast list, because engineers were keenly interested and involved in the success of the great scheme of Mr. Haldane.

Mr. Haldane, in responding, said that the foundation of our defences was our naval power, and it was vital that mind should be put into it as well as organisation. In these days science was more important than brute force, and the highest science and the most careful construction were necessary if we were to keep our position. His study of the question of defence showed that the problem was: How to bring the navy and the army into the closest co-operation? Officers were coming in well for the territorial force, which at present had reached about 87 per cent. of its war strength, although it had been in existence little more than a year. The most successful element had been the technical one. No other nation had got technical men who would come forward and offer their services as they had done in this country. The two professions which had done this were the engineers and the physicians and surgeons. He only wished that they could find room in the force for all the engineers who wanted to join. Was the territorial army a sufficient force for home defence? He thought they had done much in making a start for the solution of the problem, and time alone would show. If we were to have compulsory military training the navy would suffer, and he preferred an efficient navy to a large highly-trained regular army. He also believed in aggressive tactics, and seeking out the enemy. It was best to concentrate our attention on a navy which would completely command the seas, and on an expeditionary force for fighting across the seas. At present we had a better expeditionary force than Germany and France combined. Those were his notions of strategy. To-day organisation was everything, and we were doing the best thing at present in concentrating our attention on organisation.

The President (Mr. Swinburne) then proposed the toast of "Invention" in a speech full of the humour for which he is noted, describing the experiences of a patentee. He hoped that some day we should have patent laws which would encourage invention.

Mr. W. Trested Clark and Mr. A. J. Walter responded, the latter drawing attention to the way in which every other country looked after and took care of the inventor. Something more, he said, must be done to encourage science in this country, and before long we must have another act of Parliament to restore the rights of the patentee. He considered that the good of the community was best served by specialisation. Electrical inventions were likely to be much in evidence in the future, and at present if the word "electricity" was introduced into a patent specification there was no difficulty in getting the assistance of capitalists. His advice to inventors was to invent electrically.

Mr. Mordey, in proposing the toast of "The Junior Institution of Engineers," congratulated the members on belonging to an institution which had the reputation of being one of the most alive of the engineering institutions. He asked them to avoid pessimism, whether national, personal or professional. They belonged, as engineers, to the country that leads the world—and that had always in modern times led the world—in engineering. The engineering of the world was at present largely being carried on by British engineers—they were to be found everywhere. It was not true, as was so often stated, that we were backward in technical training, and were being ousted by other countries. As president of the Institution of Electrical Engineers, he had endeavoured—in season and out of season—to show that there was no truth whatsoever in the statement that we were backward in the electrical branch of the profession; and if, as he contended, we were not behind in the applications of science, then we could not be backward in scientific training. The object of training was engineering results, and the only safe guide to the efficiency of technical education must be those results. There was no sign of falling off in invention in this country. The most profound change in steam engineering since the days of those great Englishmen, Watt and Stephenson, was due to another Englishman—the Hon. C. A. Parsons. They had listened with great interest to the words that had fallen from Mr. Haldane, and he knew Mr. Haldane would agree that there was nowadays a fight between nations that was going on all the time—that the real battle was now commercial and technical. Each engineering institution, such as this one, was a regiment of highly-trained soliders equipped for, and engaged in, this constant battle. It was of the greatest public moment that the standard of these regiments should be kept up and their strength increased. For that reason he had great pleasure in Mr. Haldane's presence in proposing the toast that had been entrusted to him.

Mr. G. T. Bullock, vice-chairman of the Institution, responded; and the toast of "The President" was then proposed by Mr. B. E. D. Kilburn, Mr. Swinburne suitably replying and adding to the official toast list the toast of "The Secretary." The speeches were interspersed by several vocal and instrumental selections, the violin solos of Mr. T. E. Gatehouse being much appreciated.

ARRANGEMENTS FOR THE WEEK.

MONDAY, May 10th.

Graduates' Association of the Institution of Mechanical Engineers.

8 p.m. Meeting at the Institution of Mechanical Engineers, Storey's-gate, Westminster. Paper on "Railway Permanent Way," by Mr. H. H. Bird.

TUESDAY, May 11th.

Glasgow Section of the Institution of Electrical Engineers.

8 p.m. Annual General Meeting at 207, Bath-street, Glasgow, followed by a Paper on "Interpole Designs," by Mr. W. B. Hird

WEDNESDAY, May 12th.

Junior Institution of Engineers.

7:30 p.m. Meeting at the Royal United Service Institution, Whitehall. Paper on "The Construction of Controlled Mechanism as applied to Gas Meters," by Mr. T. S. F. Gibson.

THURSDAY, May 13th.

Institution of Electrical Engineers.

8 p.m. Meeting at the Royal Society of Arts, John-street, Adelphi. W.C. Paper on "Economics of Medium-sized Power Stations," by Mr. A. J. J. Pfeiffer.

FRIDAY, May 14th.

Physical Society of London.

8 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda (1) "On a Bifilar Vibration Galvanometer," by Mr. W. Duddell, F.R.S.; 2) "Effect of Temperature on the Hysteresis Loss in Iron in a Rotating Field," by Messrs. W. P. Fuller and H. Grace.

Royal Institution.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Solar Vortices and Magnetic Fields," by Prof. G. H. Hale.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 10th,
"A" Company ...... Infantry drill, 6:30 p.m. Adjutant's Parade.

Tuesday, May 11th,
"B" Company ...... Infantry drill, 6:30 p.m. Adjutant's Parade.

Thursday, May 13th,
"C" Company ...... Infantry drill, 6:45 p.m. Adjutant's Parade.

Friday, May 14th,
"D" Company ...... Infantry drill, 6:45 p.m. Adjutant's Parade.

THE THEORY AND APPLICATION OF MOTOR CONVERTERS.*

BY H. S. HALLO.

Summary.—A description is here given of the principle, operation, design and characteristics of motor converters. Reference is also made to the arrangements necessary when converters are used on three-wire and traction systems.

Up to the year 1904 the motor-generator held, in this country, the field for machines for the conversion of alternating to continuous current. The only other class of machine—the rotary converter—with the advantages of higher efficiency and lower first cost, made little headway, due to most plants being designed for 50 ∾, at which frequency the rotary converter is unsuitable. As regards regulation, the synchronous motor-generator is the better machine. A rotary is reversible in theory, but as soon as wattless currents are taken from the alternating-current side the rotary shows a tendency to race. Also, from the point of view of hunting, the induction motor-generator is the safer machine, and the synchronous motor-generator is far superior to the rotary; this has been amply borne out by experience gained on both sides of the Atlantic.

Since the year 1904, however, a new machine has been put upon the British market under the name of "motor converter."† It is claimed that this machine combines the good points of both the other systems, whilst it avoids their defects. It is self-starting, yet runs synchronously when up to speed. The characteristics of the continuous-current side may be adapted to any ordinary requirements; its voltage may be regulated by adjusting the shunt resistance, and it can further be arranged as a three-wire generator, when it will automatically deal with very large out-of-balance currents. There is no possibility of reversal of polarity as with the rotary converter. The efficiency is substantially higher than that of a motor-generator of the same output, and is nearly equal to that of a rotary with its transformers. It is reversible, and even when supplying current to modern induction motors its regulation is excellent. The first cost is less than that of a motor-generator, and when a large voltage variation is required the motor converter works out considerably cheaper even than the rotary, alternating-current boosters being necessary with the latter machines in such circumstances. Furthermore, the motor converter takes up considerably less floor space than either of the former types of converting plant. Under these conditions the motor converter has made such rapid headway that by this time almost 200 converters, with an aggregate capacity of over 80,000 kw., have been installed.

Principle.—The motor converter consists of an ordinary induction motor with wound rotor and a continuous-current machine, rigidly coupled and arranged with either two or three bearings. Fig. 1 shows the diagram of connections of a motor converter in its simplest form. The stator winding is shown as a star-connected three-phase winding, but it is evident that the winding may also be mesh connected, or wound for any desired number of phases. To make connections clearer the rotor winding in Fig. 1 is shown with nine phases, although the majority of converters have been built with 12 phases. Three of the phases are connected to a suitable three-phase starter through slip-rings.

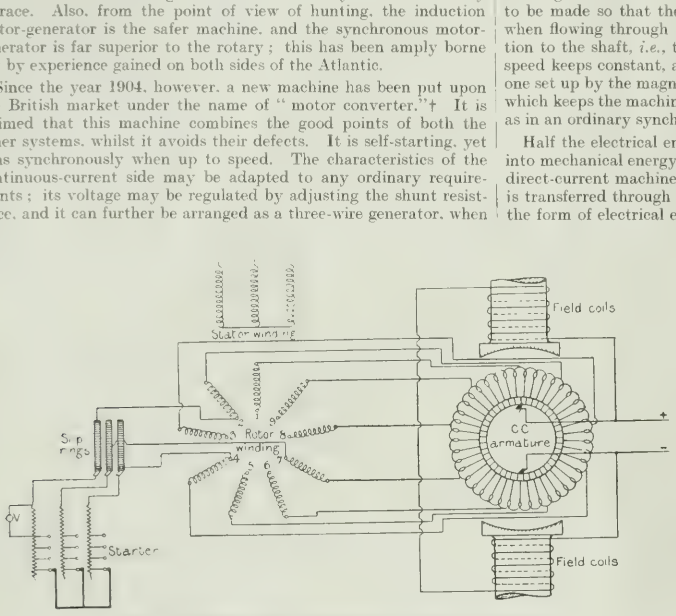


FIG. 1.—DIAGRAM OF CONNECTIONS OF MOTOR CONVERTER.

For the sake of simplicity it may be assumed that the induction motor and the direct-current machine have the same number of poles (in Fig. 1, two poles) and let us assume that rotor and armature are running at a speed corresponding to half the frequency of the primary circuit. The rotating field set up by the primary currents induces in the rotor windings a series of E.M.F.s, which have half the frequency of the primary circuit. Also it is obvious that the E.M.F.s induced in the continuous-current armature windings have half the frequency of the primary circuit, therefore it is possible to connect the rotor and armature windings together—provided they are wound with a suitable number of turns—when their E.M.F.s are equal and in phase, and when this is done the speed remains constant and the two machines connected in tandem behave as a single synchronous machine. In order that the E.M.F.s induced in rotor and armature winding shall balance each other, the connections between them have to be made so that the rotating field set up by the rotor currents, when flowing through the armature, revolves in the opposite direction to the shaft, *i.e.*, this rotating field is motionless as long as the speed keeps constant, and it is the action between this field and the one set up by the magnet winding of the continuous-current machine which keeps the machine in synchronism, in exactly the same manner as in an ordinary synchronous motor.

Half the electrical energy supplied to the stator will be converted into mechanical energy and transmitted by means of the shaft to the direct-current machine, whilst the other half of the energy supplied is transferred through the rotor winding to the armature winding in the form of electrical energy. As the rating of the induction motor depends on the speed of the rotating field and not on that of the rotor, the motor is theoretically half as large as though with the given number of revolutions it had to convert the whole of the energy into mechanical energy. The converter runs at a speed corresponding to half the primary frequency, which is more advantageous with regard to commutation; consequently it is made of smaller proportions than an ordinary continuous-current generator or converter for the same output and primary frequency.

When the induction motor and converter have different numbers of poles the set will not run at a speed corresponding to half the frequency of the supply circuit, but the speed will be inversely proportional to the sum of the number of poles of both machines. Thus $n = 60c/(p_a + p_c)$, where n = revs. per min., c = periods per second, p_a = number of pairs of poles of induction motor, p_c = number of pairs of poles of continuous-current machine. The direct-current side deals with $p_c/(p_a + p_c)$ of the energy supplied as a rotary converter and with $p_a/(p_a + p_c)$ as an ordinary dynamo. It will be seen that a further reduction of size of the induction motor is possible by taking $p_c > p_a$. Of course, p_a should not be too small, otherwise the stator winding end connections would become unduly long; moreover, it is well known that for any direct-current machine of a given output there is a definite number of poles which will secure maximum economy in construction.

Starting.—This from the alternating-current side is a very simple matter. Current is supplied direct to the stator winding, and at first only three (Fig. 1) of the nine or twelve phase-windings on the rotor are utilised. These are connected through slip-rings and an external resistance to a neutral point. The other ends of these three phase-windings are permanently connected to the armature winding. The machine starts up as an ordinary induction motor, and the continuous-current end builds up its field. When the machine approaches synchronous speed, the E.M.F.s induced in rotor and armature will alternately be in opposition and conjunction, and consequently the current flowing in the starter will alternately be small and large, causing the needle of the voltmeter, which is connected across the starter resistance, to swing slowly over the scale. When the needle comes to rest near the zero-point the starter is short-circuited, and then the machine short circuiter is pushed home, bringing all windings of the rotor into use.

* Abstract of a Paper read before the Institution of Electrical Engineers.

† The machine was patented by Messrs. J. L. la Cour and O. S. Bragstad in the year 1902.

In practice it is found necessary to insert resistance in the shunt circuit in order to bring the machine up to speed without taking excessive currents from the supply mains. Also a fixed proportion of the resistance of the shunt regulator is kept in circuit during the operation of synchronising. It is found advisable to adjust the starter and shunt resistance so that the machine first runs slightly over synchronous speed, to come down later automatically owing to the stronger excitation at the higher speed. The single voltmeter, shown in Fig. 1, constitutes all the synchronising apparatus required, thus conducing to the greatest simplicity in the lay-out of the sub-station. The starting current is usually about 30 per cent. of the full-load current. In the case of a single-phase converter it is, of course, necessary to put an auxiliary winding on the stator to produce a starting torque.

The motor converter can also be started up from the direct-current side, in which case an ordinary direct-current starter and standard synchronising gear for the high-tension side is required. In order to reduce the starting current to a minimum it is well to keep the short-circuiter open until the machine has made a few revolutions. It is possible, however, to do without the short-circuiter, or to use a mesh-connected rotor, but it is better practice to arrange the rotor windings in star, so that slip-rings and short-circuiter may easily be added, should it become desirable to start the machine from the alternating-current side. Moreover, the star-point can be connected to one slip-ring to supply out-of-balance current for three-wire systems in the manner explained later.

Theory.—The author then considers the relation which the E.M.F.s and currents in the various parts bear to one another. The designer is most interested in the ratio k between the output the

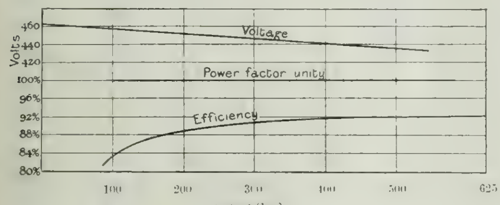


Fig. 2.—Characteristics of 500 kw. Lighting Converter.

machine is capable of giving as converter and as ordinary direct-current machine. In this connection the following comparative list for rotaries and motor converters may not be without interest :—

Table I.—*k for Rotary Converters.*
[I_{2w}=watt current, and I_{2wl}=wattless current.]

Number of phases.	1	3	6	12
$I_{2wl}=0$	0·850	1·33	1·93	2·20
$I_{2wl}=0{\cdot}3\ I_{2w}$	0·775	1·18	1·67	1·87
I_{2wl} 0·5 I_{2w}	0·705	0·98	1·40	1·52

Table II.—*k for Motor Converters with 12 Rotor Phases.*

$\frac{p_c}{p_a-p_c}$	0·4	0·5	0·6	0·67	0·75	—
$I_{2wl}=0$	1·44	1·58	1·74	1·86	2·00	Three-phase
$I_{2wl}=\frac{1}{3}\ I_{2w}$	1·42	1·54	1·66	1·74	1·82	converters
$I_{2wl}=0$	1·28	1·29	1·27	1·23	1·18	Single-phase
$I_{2wl}=\frac{1}{4}\ I_{2w}$	1·26	1·27	1·23	1·19	1·15	converters

A glance at the above list is sufficient to show why modern rotaries are provided with six slip-rings. Whereas for the three-phase rotary the factor k is only 1·33, it is for the six-phase rotary 1·93. With a 12-phase rotary the complication of 12 slip-rings renders the gain impracticable. With a motor converter, however, there is no objection to this large number of phases ; in fact, with two bearing machines there would be no difficulty in using more than 12 phases ; the gain obtained by a still further increase of the number of phases is, however, small.

The extra advantages gained by the motor converter are also evident. When we compare, for instance, the six-phase rotary converter with 30 per cent. wattless current and the 12-phase motor converter under the same conditions, and with $p_c=0{\cdot}06\ (p_a+p_c)$, we find that the factor k is the same for both : that is, all the advantages gained by the application of the motor-converter principle in the way of increased regulation, greater stability in running, &c., do not mean any additional copper losses in the armature winding, in spite of the fact that the direct-current side only works partly as a rotary.

Design.—Little need be said in this connection. The number of poles for each side are determined as mentioned above ; as a rule they will be equal or only differ by two. The design of the alternating-current side does not offer any difficulties. The air-gap need not be very small, since the magnetising current can be supplied from the rotor. The only item requiring special attention is the reactance, which must be sufficient to ensure that the required voltage regulation on the direct-current side can be obtained without affecting the power factor beyond the guaranteed limits.

The design of the direct-current end closely resembles the design of an ordinary dynamo, the only difference being that the demagnetising (or magnetising) effect of the lagging (or leading) rotor currents upon the direct-current field must be taken into consideration. It

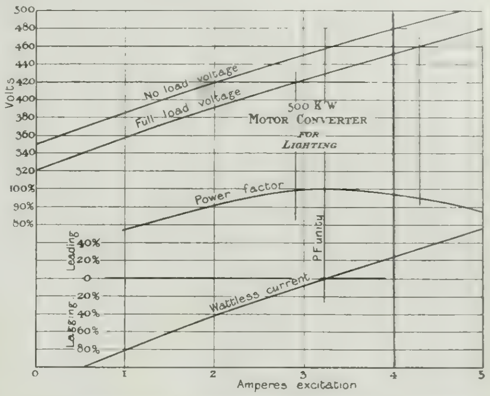


Fig. 3.—Regulation Characteristics of 500 kw. Lighting Converter.

was shown that the wattless current I_{wl} in the armature winding due to the wattless rotor current I_{2wl} is $=\frac{I_{2wl}}{2\sin\pi/m_2}$, where m_2=number of rotor phases. The demagnetising ampere turns per pole are thus $k_0\frac{I_{wl}N}{4ap_c}$, where N=number of conductors in direct-current armature, a=half the number of armature paths, k_0=so-called magnetomotive force factor of a synchronous machine, and which may be taken as 0·75. The introduction of commutating poles gives the designer a still freer hand, and renders the commutation sparkless with fixed brush position up to heavy overloads and independent of the direction of the current.

Application.—Fig. 2 represents the characteristics of a 500 kw. set. The efficiency, especially at low loads, is remarkably high. Fig. 3 indicates the possibility of an excellent regulation by the shunt rheostat. Sometimes a large drop in voltage from no load to full load is desirable, as, for instance, when a battery is floating on the 'bus-bars. It is possible to design a motor converter for a large inherent voltage drop, but there are also other means of accomplishing the desired effect. The most obvious one is to provide the machine with a reversed compound winding, but in the case of commutating pole machines the same effect can be obtained without this complication. In this case the commutating poles are not placed midway between the main poles, but slightly forward (in the direction of rotation of the machine), thus artificially creating armature reaction, without interfering in the least with the excellent commutating qualities.

Sometimes it is required that a motor converter shall be capable of supplying either a traction system at 500 to 550 volts, or a lighting system at, say, 420 to 460 volts. Owing to the great flexibility of the direct-current voltage, it is possible to build converters for the above extreme range of voltage, and, as a matter of fact, several such machines with a voltage regulation of as much as 30 per cent. are in successful operation. In order, however, to improve the power factor in such a case it is advisable to use a synchronous booster in series with the rotor winding.

Motor converters can also be used inverted and also for three-wire supply. The outer mains in the latter case are connected as usual to the positive and negative terminals of the dynamo, whilst the middle wire is connected to the star-point of the rotor windings, and may be earthed. When large out-of-balance currents are to be dealt with, it is necessary, in order not to overload the brushgear of the slip-rings, to use a three-pole change-over switch, arranged so that when the switch is down the three slip-rings are short-circuited and connected to the middle wire, so that all brushes on the three slip-rings are called upon to carry the out-of-balance current. When the switch is in the other position the slip-rings are no longer short-circuited, but connected to the alternating-current starter; the switch must be in this position during the starting up of the converter.

A motor converter, thus connected up, automatically balances the current, and the voltage difference between the two halves usually does not exceed 1 per cent. of the voltage between the outers, with an out-of-balance current of as much as 50 per cent. of the full-load current. With 20 per cent. out-of-balance current the voltage difference would be well under ½ per cent., and it is thus clear that the balance is excellent and more than sufficient for all ordinary requirements. If, however, it should be necessary to raise the voltage of the heavier loaded half, a series booster must be put in circuit, and driven by the extended converter-shaft.

With a motor converter,* not arranged as three-wire balancer, all commutating pole windings are generally fixed on either the positive or negative side of the network. It is, however, obvious that this arrangement cannot be satisfactory, as soon as out-of-balance currents are taken from the machine, since the excitation of the commutating poles would not then correspond to the total load on the machine. The proper excitation will be obtained when the current through the commutating-pole windings is an average between the currents in the two outers. Now, such excitation can easily be obtained by dividing up the commutating-pole circuit and by fixing the windings alternately in the positive and negative mains. It is, however, well known that, with all direct-current generators and motors, there is an advantage in fixing only half as many commutating poles as main poles. Not only does this amount to a certain saving both in material and labour, but it is an effective means of reducing the leakage flux, which plays such an important part in the design of commutating poles. This principle is, of course, also applicable to the motor converter; but it would appear, at first sight, that the use of the machine on a three-wire system necessitates the use of the full number of commutating poles, in order to be able to divide the circuit up in the aforementioned manner. It is, however, possible in this case to use only half the number of commutating poles by fixing additional windings on the poles. These additional windings must have half as many turns as the main windings, and the current of the middle wire must pass through them.

The Paper contains illustrations of several converters running in in sub-stations in this country; the largest is a 1,500 kw. machine of the three-bearing type of the Manchester Corporation electricity department.

ELECTRIC WELDING.†

BY V. D. GREEN.

Probably there are few branches of electrical work about which less is generally known than that of electric welding; and this is due to several reasons: (1) Although the master patents have run out, a great number of the controlling patents are still in force, so the number of manufacturers is small. (2) The purchasers of welding outfits are by no means anxious to advertise the fact that they are using them, and usually prefer to ascribe the cheapening of certain processes to "better organisation," or anything but the real cause, lest their rivals should also go in for a plant. (3) The subject does not appeal to the popular imagination. (4) As the results attained are frequently the outcome of much experimenting, those who are in a position to give information generally prefer not to.

The systems of electric welding in use at the present time may be divided roughly into: (1) Arc welding processes; (2) methods of welding by means of the heat generated by the passage of current through a semi-conducting liquid; and (3) welding by alternating current stepped down by a special transformer to the low pressure required, and the heat generated between the abutting surfaces of the work itself.

(1) Although the first attempts at electric welding developed along this line, it was not until Bernardos introduced his system that a really practical solution of the problem was arrived at. His method was to make the work itself the positive pole of the arc, the negative being a stick of hard carbon. The principal field of the process is repair work and operations on work in position. It has, however, serious disadvantages, and beyond the fact that the heat given out is much in excess of that obtained by the oxy-hydrogen and oxy-acetylene processes, it has no particular advantage over these latter, while its initial cost is considerably in excess of either. Very little heat regulation is possible, and there is a tendency for carbon to be deposited upon and become mixed with the material of the work.

A modification of the Bernardos system, and one which largely overcomes the carbon deposit trouble, is that known as the "Voltex." Here the work is not connected to the circuit at all, and the arc is formed between two carbons, an electromagnet with a suitable regulator deflecting the arc on to the weld. The heat regulation is thus greatly improved, and for jobbing work, such as foundry repairs, it appears to give excellent results.

(2) It is doubtful whether the "acidulated water process" should be included among welding systems. The original patent was taken out in 1892 by Mr. Paul Hohe. The apparatus employed consists of a bath or vat large enough to contain the articles to be heated, a pair of tongs with insulated handles for gripping the work and suitable regulating and generating machinery. The vat is filled with acidulated water or any liquid having a low resistance, and is made the anode, the tongs holding the work being connected to the negative pole. On completing the circuit by plunging the work into the liquid a thin film of hydrogen, formed by electrolytic action, surrounds it and not only by its resistance causes an intense and highly localised heat to be developed, but keeps the surrounding liquid from contact with the metal. The special advantages claimed are: (*a*) As there is no arc to maintain, the efficiency may be considerably increased. (*b*) More heat regulation is possible, and tempering may therefore be successfully carried out, the "quenching" being accomplished by switching off the current and so allowing the water to pierce the hydrogen film. (*c*) As the heating is carried on in an envelope of hydrogen no oxides, scales or blisters are formed in the finished weld. The process has, however, made little if any progress since its introduction, the reasons appearing to be almost entirely of a practical nature.

(3) Perhaps the most interesting of welding systems, and certainly the one which admits of the most delicate adjustment and the highest speed and efficiency in working, is that invented by Prof. Elihu Thomson, in 1885. The principle involved is that of causing a heavy current to pass through the abutting ends of the metal to be welded, thereby generating heat at the point of contact, which also becomes the point of highest resistance. At the same time mechanical pressure is applied to force the parts together. As the current heats up the metal at the junction to the welding temperature the pressure "follows up" the softening surface until a complete weld is obtained, and as the heat is first developed in the interior of the parts to be welded, this interior is as efficiently welded as the visible surface. Other advantages are: (*a*) There are no fumes given off. (*b*) The heat is produced where it is wanted, and practically confined there. (*c*) The weld is perfectly homogeneous. (*d*) The process may be made automatic, and thus uniformity of results obtained. (*e*) The welding may be continually watched. (*f*) Clean metal only comes into contact. (*g*) Flaws in the material are easily discovered and prevented. (*h*) It is extremely rapid. (*i*) In consequence of the perfect regulation of the heat cut-off, &c., it can be applied to many metals which could previously only be united by brazing or riveting. (*j*) Work, especially repair work, may be done which could not be done at all by any other means. About the only objection which can be urged against it is the initial expense, which is unquestionably heavier than in other systems. It will be seen that the principal field of the Thomson process lies in the rapid reproduction of standard work, though a welding apparatus for jobbing repairs is also made.

Although in principle all Thomson welders are alike, yet they undergo many modifications to render them applicable to the several manufacturing processes in which they are used, and may also be hand-controlled, semi-automatic or entirely automatic. To the first class belongs the "Universal" or jobbing welder. In this machine, and indeed in most others, all electrical parts are enclosed within the cast-iron base with the exception of the two ends of the secondary coil, consisting as usual of a single turn of heavy cast copper. These terminate in broad flat surfaces with "V" shaped grooves in the centre to increase the area of contact. Both these and the under surface of the clamps which slide upon them are carefully scraped true, otherwise the loss of power would be serious. The clamps are provided with hand wheels for tightening, and the "follow up" motion is actuated by another hand wheel, about 3 ft. in diameter, working on a rack on the movable jaw holder. Both

* In fact, with all machines producing or absorbing direct current.

† Abstract of a Paper read before the Birmingham and District Electric Club.

jaws are water cooled. A particularly interesting class of repair which may be done with the "Universal" machine is the welding of a broken armature shaft without the necessity of re-winding the core.

Of the semi-automatic class there are numerous examples. Most wire-welding machines, such as are used in cable factories, are of this description. Pipe-welders are not unlike wire-welders, except that heavier currents are required and specially powerful holders and hydraulic "follow up" motion rams are used. In the United States large quantities of the steel conduit used in installation work are welded along the seam by the Thomson process. In this apparatus the two adjustable ends of the secondary are not provided with jaws, but with rollers. In the completely automatic type of welders, such as those used for wire fence making or chain welding, the mechanical power is supplied by a belt. Chain-welders are extensively used in America, but for some reason they have not found favour in the eyes of British manufacturers. Other types of welders are also referred to in the Paper.

Electric welders present numerous points of interest in the matter of design. The requirements differ radically from the ordinary conditions of alternating-current design in many ways. First and foremost a welder must be dust-proof and fool-proof. The secondary voltage and current must be decided upon by experience. An ample overload margin should be allowed for, and air or water cooling should be provided where welders have to work continuously. With regard to the horse-power necessary for various kinds of work, the following figures may prove interesting :—

		Round Iron and Steel.		B.O.T.
Diam., in.	Area, sq. in.	H.P.	Seconds.	Units.
$\frac{1}{4}$	0·05	2·0	10	0·004
$\frac{1}{2}$	0·22	6·5	20	0·026
$\frac{5}{8}$	0·3	9·0	25	0·046
$\frac{3}{4}$	0·45	13·3	30	0·082
(Inside diam.)		*Extra Heavy Iron Piping.*		
$\frac{1}{2}$	0·3	8·9	33	0·060
1	0·6	16·4	47	0·159
$1\frac{1}{2}$	1·1	32·3	70	0·478
2	1·65	42·0	84	0·724
3	3·0	96·2	106	1·5

The figures are from actual tests, and probably the times might have been shortened. Generally speaking, iron and steel require less energy than copper (ratio is about 12 : 17), brass coming between them in this respect. The time required for the former is, however, greater than for the latter.

It is always advantageous to be able to regulate the secondary voltage, and this may be done in the usual way by a rheostat in the exciter circuit of the alternator, by a choking coil in series with the primary of the transformer, or by taking tappings out of the primary coils and connecting them to a suitable regulating switch. In designing for a ring-welding machine, it should be remembered that a fair percentage of current will not go through the weld at all, but will be shunted round the other side of the ring. Where a reactive coil is used, its effect is to cause a more even distribution of the heat, and therefore for metals where rapid heating is inadvisable this form of regulation is used. Shunt regulation, on the other hand, accelerates the welding, and in this case the joint will become weldable before the heat has had time to spread for more than a fraction of an inch on either side of it. Regulation by varying the number of effective primary turns has a result midway between the two previous methods, since its effect is greater on the secondary voltage than on the power factor.

The conditions upon which a good weld depends are clean metal, correct pressure and correct temperature. With iron all these conditions are fairly easy to fulfil. With copper one encounters the difficulty that it must be raised to a much higher temperature, and that it then oxidises very readily. Moreover, its welding heat is very little below its liquefying point. It will thus be seen that most careful adjustment is necessary. With brass these difficulties are still further increased by the tendency of the zinc to volatilise before the copper is hot enough, and by the brittleness of the metal when at the welding heat. A light pressure and a rapid weld are required for these and other metals which pass quickly from the solid to the liquid state. The results of recent experiments with the Thomson process seem to point to the conclusion that, given a machine capable of complying with the requirements as to pressure, temperature, &c., there is no metal or alloy which cannot be welded, and as its capabilities become better realised its field will be enormously extended.

As to working costs, local conditions would have a considerable modifying effect on almost any figures that might be quoted. A decided saving in working costs can generally be shown, varying from 80 to 10 per cent., by the use of electric welding instead of the forge.

TURBO-COMMUTATORS.

BY R. J. ROBERTS.

Simple as a turbo-commutator seems to be, there are some knotty points in its design and construction that can only be seen in its progress through the shops, or appreciated when finished and actually running. Therefore, it is not my intention to enumerate any of the standard designs, but rather to indicate some of these points and how they may be met.

One rather serious drawback I have met with in high-speed commutators, though certainly not with the shrink-ring type, is caused by the mica segments rising between the bars, with the resulting sparking trouble. Now, I believe it is in the desire to eliminate this, rather than to give the bars any additional strength, that some firms have gone to the expense and pains of giving the commutator bars a kinked or a kindred section. These kinked bars act by reason of their contours as an anchor for the mica segments. Of course, if the tightness of the shrink rings is to be relied upon, and very little deflection is permitted in the bars by designing these deep enough or by providing a sufficient number of rings, then even with plain segments there will be ample friction between the mica and copper to keep the former well in place.

There is a very serious objection to the kinked form of segment. Of course it is usual, probably on account of the higher voltage per segment, or the use of copper brushes, or possibly on account of the lower expansion stresses so obtained, to make the mica segments much thicker than in ordinary machines, 0·06 in. to 0·08 in. being quite a common thickness. It would appear difficult to make good micanite segments of this thickness even when plain, without employing an undesirable amount of varnish, and on account of the necessity of moulding them to shape, the kinked segments come out rather badly in this respect. Now, superfluous varnish causes considerable trouble during manufacture, as it is only with difficulty removed from the mica. It requires the influence of great heat and pressure in the clamps applied for a long time to do this, and even after much stoving and pressing some of it will still be pressed out when the shrink rings go on, sometimes taking part of the mica with it as it passes outwards. This is undesirable, for besides the extra work involved, there is a danger of the rings being slack after shrinking. Therefore, where the mica makers are unable to guarantee a good product in the form of kinked segments, it would seem better to give up all thoughts of special segments and to stick to the plain one.

Perhaps the greatest problem that confronts the shop foreman is the insurance of a really good shrink. The bars when assembled must be pulled together as tightly as possible, but too much reliance can be placed on a strained steel wire to pull them together. It is only after repeated bakings and tightenings, which help to get rid of the superfluous varnish, that the steel wire bands are put on and the clamps taken off. Then the bars are turned for the shrink rings.

The insulating bands under the rings are made in several ways. Sometimes they are built up out of ordinary micanite strips held in place with shellac. They are then bound, with steel wire by preference, and baked. The wire is then removed, and the bands are trimmed before the rings are put on. The most objectionable feature in this method is the shellac, which produces the same defects that I have already noticed in the segments. Another deleterious feature is the need of using the utmost clearance to make it possible to get the shrink ring over, for the heat of the ring loosens the laminæ of the micanite, which will in all probability cause several pieces to be misplaced. Another method is to build up the insulating bands of pure mica, or even commutator mica strips, with no shellac, holding it all down with a fine string band. The ring being put over this burns away the string, and then shrinks down on to the hard pure mica. The only objection to this is the somewhat large ultimate clearance caused by the burnt string, but the pure mica forms a much more solid bed for the ring and should result in a tighter commutator.

In calculating the shrinkage allowance I prefer to investigate each particular case rather than trust to any empirical formulæ. It is very seldom that two designs are identical; even if the diameters, length and depth of bars and integrated area of

rings are the same, the total relative lengths of mica and copper in the mean circumference are very unlikely to be the same. I prefer to neglect the initia pressure on the segments due to the clamps, as it is most often small compared with what that of the shrink rings should be, and I also presume that the insulating bands are solid. A modifying factor could easily be obtained from experience, and, if necessary, added to this result.

As an example, I shall take the following commutator :—

Outside diameter, 12 in. bars ; 40 in. by 2 in. deep.
Total ring section = 28 sq. in. ; mean diameter, $15\frac{1}{2}$ in.
Length of mica in mean circumference = 5·56 in.
Length of copper in mean circumference = 25·85 in.
E. steel = 30×10^6. E. mica = 10^6. E. copper = 16×10^6.

Compression stress on segments due to 12,000 lb. stress in rings $= \frac{12,000 \times 28}{40 \times 2} = 4,200$ lb. per square inch.

Compression strain on segments in diameter of commutator = Compression strain of mica + compression strain of copper.

$$= \frac{5{\cdot}56 \times 4,200}{10^6 \times \pi} + \frac{25{\cdot}85 \times 4,200}{16 \times 10^6 \times \pi}$$
$$= 23,400 \times 10^{-6} + 6,800 \times 10^{-6}$$
$$= 0{\cdot}03 \text{ in.}$$

Strain on rings in diameter

$$= \frac{15\frac{1}{2} \text{ in.} \times 12,000}{30 \times 10^6 \times \pi}$$
$$= 1,480 \times 10^{-6} = 0{\cdot}00148 \text{ in.}$$

Total shrinkage needed

= Sum of strains in diameter
= 0·00148 in. + 0·03 in.,
= 0·0315 in. on diameter.

If we add the necessary clearance for string, &c., of 0·02 in., we obtain the total requisite expansion of ring = 0·0515 in. This is 0·0043 of the diameter, and may easily be obtained. This matter of clearance is conveniently made as great as possible, and it does not matter, as a rule, if the rings are heated to a bright cherry red—*i.e.*, if their section will permit of them being handled at this temperature.

The method usually employed for fixing the balance weights seems to be by means of a set screw through the outer rim of the shrink ring and screwed into a weight put into the annular space. This method is objectionable as it permits a limited amount of movements being given to each weight. As in this case, where the movement is limited by the pitch of the holes in the rim, it may take a complicated system of weights to obtain the balance, as $\frac{1}{8}$ in. movement to a weight may put it right or wrong. A very simple and effective method of fixing these weights is to make them of a split dovetail section, with a grub-screw between the two halves ; these weights have quite an unstricted amount of movement.

The magnitude of these weights is best left to the discretion of the designer, as he will know from experience and the construction of the complete rotor what sized weights are necessary. One point that greatly facilitates the balancing is to make all the weights relative to their radii of gyration—*i.e.*, $W \times R =$ constant.

Many points in the lugs or risers call for consideration. If these lugs are made so that they may be put on after the rings it makes it very much easier to assemble the whole commutator. This may easily be done by making an eye in the extremity of the double lug, which fits into a similar one in the end of each bar of the commutator. A brass pin driven into this eye fixes the lug firmly in place, and a drop of solder on the pin also prevents any inclination it may have to come out. A blow lamp should not be used to thoroughly sweat the whole into the bar. This simple method is found most advantageous on long commutators, where otherwise the rings would have to be passed over several feet before getting into place. In any commutator of more than two rings it is always best to put on the middle rings first and the end ones last.

The lugs should also be given a certain flexibility from end to end, as it is wise to allow the winding belts to take all the load of the winding and its connections. An easy method of accomplishing this is to make a kink in the lugs. Then, if there happens to be any bar not held by the belts, when the centrifugal pull comes on it will only straighten out the lug without throwing any great stress on the neck of the lug.

The question as to whether a spring collar is or is not necessary between the end taper ring and the lock nuts, has always been a vexed one. The only argument I have heard in its favour is that it takes up any longitudinal expansion of the bars ; but this argument takes no account of the fact that the bars can expand diametrically as well as longitudinally.

Supposing now a hypothetical case of where the shaft remains cold whilst the commutator gets hot. Here it is easily seen that the line of expansion of a point on the taper of the bars will follow a path such that diametrical expansion ÷ longitudinal extension = tan ϕ_1 where ϕ is the angle of this path to axis of shaft. It also follows that, supposing the shaft to get hot as well, a point on its taper ring will also follow a similar path. It naturally follows that if these two angles are the same, and we make the angles of our tapers to this angle, then there will not be any movement given to the end taper ring, hence the spring collar would be quite superfluous.

Let us represent these two angles by ϕ_1 and ϕ_2 and investigate the various expansions.

$$\text{Tan } \phi_1 = \frac{\text{Diametrical extension}}{\text{Longitudinal extension}},$$

both being measured at a point on the taper.

$$= \frac{\text{Ring strain} - 2 \text{ depth expansion of 1 bar} + \text{ring expansion}}{\text{Longitudinal expansion of bars}}.$$

$$\text{Tan } \phi_2 = \frac{\text{Diametrical expansion}}{\text{Longitudinal expansion}}$$
$$= \frac{\text{Diameter of tapers}}{\text{Length between tapers}}.$$

To obtain some idea of what these angles may be, let us investigate the following commutator :—

Diameter 12 in., bars 36 long and 8 in. diameter at tapers.
Total ring section = 28 sq. in. : mean diameter $15\frac{1}{2}$ in.
Expansion stress in rings = 2,000 lb. square inch.
Temperature rise of rings 30°F. and in bars 60°F.

Tan ϕ_1

$$= \frac{\text{Ring strain} + \text{ring expansion} - 2 \text{ depth expansions of 1 bar.}}{\text{Long expansion of bar.}}$$

$$= \frac{\left(\frac{2,000 \times 15\frac{1}{2}}{30 \times 10^6}\right) + 12 \times 30 \times 7{\cdot}3 \times 10^{-6} - (2 \times 60 \times 1{\cdot}5 \times 10{\cdot}3 \times 10^{-6})}{60 \times 36 \times 10{\cdot}3 \times 10^{-6}}$$

$$= \frac{1,030 + 2,630 - 1,850}{22,200}$$

$$= \frac{1,810}{22,200} = 0{\cdot}0815 = \tan 4{\cdot}6 \text{ deg.}$$

$$\text{Tan } \phi_2 = \frac{\text{Diameter expansion}}{\text{Long expansion}}$$
$$= \frac{\text{Diameter}}{\text{Length}}$$
$$= \frac{9}{36} = 0{\cdot}25 = \tan 14 \text{ deg.}$$

Here it is plainly seen that there is likely to be a good deal of difference in these two angles. In order to keep the bars always rigid on the shaft on account of the different times of heating in the bars and shaft, it follows that we must make the angle of our tapers at least that of ϕ_1.

It seems to be the rule to make the taper of about 5 deg.—*i.e.*, taper of 1 in 10. Supposing, therefore, that we make our angle 5 deg., and also that we put a spring collar between the outside one and the lock nuts. First of all the bars will expand and push the end taper ring back, though very little. The shaft will then warm, and expanding in both directions should push the end ring still further against the spring washer. This is rendered impossible, however, as the coefficient of friction between mica and iron is far greater than 0·1 (which is tan 5 deg.) and is nearer 0·25. Therefore, it would appear that to obtain a perfect adjustment of all expansions we should always make the tapers more than 14 deg., and put

a spring collar behind. Of course, if $\tan \phi_1 = \tan \phi_2$ we should be perfectly justified in making our tapers of that angle and leaving out the spring collar.

It will be found that in most cases 14 deg. is too abrupt a taper to allow a good seating for the bars, which should seldom be less than 4 in. long and should preferably be more; in fact, I should never advise it as it weakens the bars greatly at the end shrink rings.

There are many machines now running, however, that have not this spring collar, and there has never been any complaint made of either the commutator buckling or twisting that I know of. Further, perhaps the best manufacturers of these machines leave it out, so it seems to be proved by experience that one is not absolutely necessary.

As to whether a taper is necessary, I believe it is, as a case has come to my knowledge where a machine was always going out of balance, and although I had not the opportunity of personally investigating the case, I have no hesitation in putting it down to an improper support of the commutator.

With the tapers usually employed, it appears that in most cases it will not much matter whether a spring collar is used or not; the two angles will seldom agree for it does not matter in ordinary cases you are caught if you compensate for either.

These taper rings are usually insulated by a micanite sleeve, which should extend beyond the ring on the inside. It is convenient to make these insulation sleeves about $\frac{1}{8}$ in. thick. With a small taper these micanite sleeves will help greatly to take up the inequalities in expansion, if any, by straining.

A method of making a spring collar that strikes me as being rather novel is to place a circular spiral spring between two washers, something like an ordinary ball-thrust bearing, excepting that the spring is placed in the position usually occupied by the balls.

THE DEFECTS OF ENGLISH TECHNICAL EDUCATION AND THE REMEDY.*

BY DR. R. POHL.

Summary.—The author shows that the defects of English technical education are due, not to the lack of money or effort, but to the absence of national organisation, resulting in competition between existing colleges. He considers it essential that the Board of Education should establish a national system of technical education.

Exceptional opportunities have fallen to my lot of becoming acquainted with technical education as it affects, not only the lecturer and the student, but also the employer of labour, in this country as well as in Germany. Standing as I do, outside the teaching profession, and having no private interests to serve, I thought that, whatever criticism I might experience, I should not be suspected of any ulterior motive if I came forward to point out what, to my mind, are the weaknesses and faults of the present system, and to advocate what appears to me the only right course to adopt.

The importance of technical education for any modern nation, but most particularly for England, cannot easily be overestimated. There is not a student of national economy who fails to realise that Germany and the United States, now serious rivals to English trade, owe their rapid industrial and commercial development largely to the magnificent system of technical education which they have established. Indeed, the recognition of this fact by all thoughtful men has led to vigorous efforts being made during the last 10 years or so, and to a prodigious amount of money now being annually spent in this country, for the purposes under discussion.

No one will deny that a very great deal has been accomplished, and personally I should be the last to underrate the value of the work now being done in numerous institutions, or to belittle the services of so many pioneers, to whom, indeed, the nation owes a debt of gratitude. Nevertheless, it must be, and is, widely recognised that technical education is only in its infancy, that it is as yet far from exercising to the full and in an efficient manner that propelling influence on the industries of the country which is its aim and duty. Almost invariably, however, when this fact is recognised and pointed out, the conclusion is drawn from it that the people of England must be prepared to spend more money in erecting and thoroughly equipping technical colleges and universities.

The main object of this Paper is to prove the fallacy of that conclusion, and that every new college erected is another stone round the neck of technical education. It is, in my opinion, certainly not lack of money which is to blame for the admittedly unsatisfactory state of affairs. From the statistical data contained in the Government blue books and budgets I have made a calculation as to the total expenditure of public money in England and Wales as compared with Prussia. The two countries are similar in industrial activity, and in the character of their population. Prussia, with its highly efficient educational system and its technical institutions admired by all the world, spends roughly £600,000 per annum on current expenditure. The statistics available for England, particularly as to local contributions, are rather scanty, but from a very moderate estimate I find that at least £1,000,000 is annually spent for equivalent purposes. Taking into account the larger population of Prussia, we arrive at the result that England already spends about twice as much money as Prussia, reckoned per head of population, with educational results which—I say it without hesitation—will not bear any comparison. If one would compare the extraordinary expenditure incurred in building and equipping new institutions, the result, I believe, would be even more unfavourable to England.

Neither lack of money nor of effort is the fault, but the fundamental principle is wrong on which rests the whole structure of technical training in this country. Technical education is not a private or local, but by its very nature a national affair, and the most essential condition for efficiency and economy is that it should be established on the basis of systematic national organisation, and that it should be nationally managed.

The numerous objections raised by employers and the general public against technical colleges, and the still more numerous grievances of those actively engaged in technical training, are largely, if not solely, connected with the present unsound foundation. The complaints referred to are:—(1) The number of day students in all institutions, and consequently the attendance at the majority of classes, is far too small. (2) The average education of day students entering for technical instruction is poor, and the diversity of their previous training so great, that the gravest educational difficulties result. This is only partly due to the unsatisfactory state of primary and secondary education. The chief reason is the scarcity of students, which leads to little regard being taken of the previous education of a would-be day student. (3) The undue importance attached to external examining bodies, and the consequent variety of examinations to which the training must be adapted, detract from a concentration of effort and uniformity of purpose. (4) The usual management of municipal institutions by a committee, the constitution and policy of which may change every year, and which only too often consists of a number of private gentlemen more or less strangers to technical education, is unsound and wasteful. (5) The equipment provided in individual institutions cannot be kept up-to-date, owing to lack of funds and of students. All these serious obstacles result in financial wastage as well as educational inefficiency, the latter all the more, as they make it exceedingly difficult for a teacher to find that amount of satisfaction in his work necessary to keep alive his enthusiasm and that of his students.

Coming to the attitude of the employers of labour towards technical education, it is not altogether surprising to find that little importance, as a whole, is attached to college training. A comparison of the advertisements for vacant posts appearing in English and German technical papers will prove this better than anything else. Generally speaking, there appears to be amongst employers a lack of interest in technical education, and not much willingness to co-operate with technical institutions. Specific complaints there are few; I have occasionally heard it stated that day technical training is not of a sufficiently practical character, that day colleges not rarely fail sufficiently to impress on the minds of the students the importance of practical experience, that technical teachers are often recruited from the ranks of those day students who have found it too difficult a task working themselves up to a good position in practical life, that too little original work, especially such as requires experimental research, is carried out by the staffs of day colleges.

My personal opinion as to these points is that none of them is quite without justification, though specific cases are often exaggerated and unduly generalised. The main cause for such complaints, however, lies in the fact that even in the technical universities the number of students is not sufficient to permit of a number of specialised experts being appointed in each department, as is the practice in Germany. The professor or lecturer in an English college is expected to deal with a variety of subjects, each of which is a science in itself, and his spare time is very limited. Personally, I think it is surprising that so much original work is done in spite of such adverse circumstances.

Evening classes stand in greater favour with employers, being considered a necessary complement to the day work of apprentices.

* Abstract of a Paper read before the Association of Teachers in Technical Institutions (West Yorkshire Branch)

Complaints are made, however, on account of the heavy nervous strain imposed on youths. Proper co-operation between the employer and the college is absolutely necessary in connection with all evening work.

Coming finally to the general public and its attitude towards technical education, I need hardly refer to the cry heard throughout the length and breadth of the land that the technical schools impose a far too heavy burden on the ratepayer, a burden altogether out of proportion to the work accomplished, both qualitatively and quantitatively. In my opinion these complaints of the ratepayer are fully justified. I consider some of the figures which were recently published as to the cost of technical education per student-hour are absurdly high, and a conclusive proof of the inefficiency of our present system; but, apart from that consideration, the ratepayer contributes about 75 per cent. of the cost of technical education, whereas it is only just that the bulk of it should come from national sources. This list of defects of technical education could be still further extended, but I have only referred to the most important ones.

Now, I venture to submit to you that all these defects could be removed by placing technical education on a national basis.

Day technical teaching, to be efficient, must be thoroughly organised all over the country, so that a limited number of excellently equipped colleges, with a very large number of students and a corresponding number of specialised lecturers in each department, will satisfy the needs of their correspondingly large districts. That is the secret of Prussia's success. Very rarely have I found that the English admirers of Charlottenburg understood the real difference between the German and any corresponding British technical college. It is this: technical education being nationally organised in Prussia, there exist only four technical universities in the whole country, with a population of 38,000,000 people. The average number of day students is about 2,500 per day. Charlottenburg, the largest of them, is the technical university, not only for the whole of Berlin, but in addition for a district of some 40,000 square miles. The number of its students, which, of course, are all day students, is about 5,000, and the most stringent regulations as to their previous training are in force. With such an attendance the State can afford to appoint for each department a number of professors, each of whom is a recognised authority in some branch of that department. As an example, I may mention that there are at Charlottenburg not less than 17 professors and lecturers in electrical engineering subjects alone.

Instead of this, what do we find in England? The British Government has chosen the easier course of leaving the founding and management of technical institutions to the enterprise of charitable private persons, corporate bodies, and the local authorities. As a result, there are—not in greater London, but in the Administrative County of London only—at least six colleges of university standing and six day colleges recognised by the Government as technical institutions competing with one another, not to mention 10 other institutions with day technical classes and 18 schools of art. Similarly, in the provinces quite a number of lavishly equipped university colleges have been founded, and technical day schools have sprung up like mushrooms, their number now being many times in excess of the well-understood needs of the country. Many of these institutions are in close proximity to and competing with one another.

The educational consequences require no repetition. You may go through all the defects which we have considered, and you will easily see that every one of them is directly attributable, not to lack of energy or ability on the part of the technical teacher or to unwillingness of the British rate and taxpayer to part with his money, but to the absence of national organisation and the consequent disastrous competition between the existing schools. Money can build the most beautiful edifices and buy the most excellent equipments, but it will not cure this evil. Technical education will, in my opinion, never exercise to the full its highly important functions in the life of the nation until the Board of Education awakens to its duty and establishes a sound national system of technical education; and such system will require to be enforced, as the petty jealousies invariably found to exist between neighbouring corporations do not permit of any hope that a similar result may be obtained by voluntary co-operation.

The establishment of a national system of technical education may perhaps be considered a revolutionary and almost impossible step in England. I beg to disagree, and to believe that technical education can be far more easily organised on the basis of a national system than, for instance, primary education. In fact, I even doubt as to whether any new legislation would be required for the purpose. The pressure which the Board of Education, by means of the grant alone, can bring to bear on the governing bodies will prove sufficient to bring the majority, if not all, of the existing schools into line with a national scheme, and to make them take up the position assigned to them in it. I will go further, and venture to prophesy that before many years have passed the Government will have to take this matter up, under the combined pressure of the two parties chiefly interested in efficiency and economy, *i.e.*, the technical teacher and the ratepayer.

The author then considers briefly an ideal system for England.

Far from condemning the present English system root and branch, he considers that some of its features are most excellent, and should be maintained and further developed, namely, the evening courses, which are doing exceedingly good work and are deserving of the highest praise, and, secondly, to its democratic spirit, which shows itself in the low fees for evening instruction and in the extensive system of scholarships. However, unless English primary education is put into a much more satisfactory condition, technical education must remain severely handicapped, and in this connection it almost amounts to a national crime that many thousands of children are permitted to leave school when only 12 years of age, and when the instruction is just becoming most valuable. In addition to the extension of the school age, primary education should be rounded off by compulsory attendance at evening continuation schools for three years.

On the basis of sound primary education, the structure of technical training suggested is as shown in the following diagram, which indicates the various ways leading up to the technical university:—

Years of age.				
20	Technical University	Second year Technical University	Technical University	
19 18 17	Apprenticeship and Evening Technical School	Apprenticeship and Evening Technical School	Pupilage	Pupilage
16 15 14	Apprenticeship and Evening Continuation School	Trade School	Trade School	Grammar School or Equivalent Secondary School and Primary School
13 12 11 6–10	Primary School			

A boy of fourteen, leaving the primary school and wishing to go in for a technical trade, has two courses open to him. If his parents cannot afford to let him continue in the day school, he should be apprenticed and should attend the evening continuation school up to his seventeenth year. He may then obtain a more specialised technical education, according to his requirements, by attending the technical evening classes for another three or four years, proper co-operation with the employers being an essential condition if success is to be obtained; and should his teachers find that his is a brain of exceptional ability, deserving and desiring to be developed as highly as possible, an extensive system of national maintenance scholarships should enable him then to enter the technical university. The greatest stress is laid on the desirability of extensively drafting the very best evening students into the technical universities.

The second alternative for the boy of 14 is to continue his school life in a trade school to his seventeenth year, when the final certificate will give him access to the technical university after an apprenticeship or pupilage of at least one, better two, years. This would be the easiest and the more general road to the technical university; but, again, on leaving the trade school the student may be apprenticed for three years, attending also the evening classes, and he may qualify for the second year of the technical university, or even obtain a maintenance scholarship.

The third way of reaching the technical university would be through the grammar school or equivalent secondary schools. The certificate of having passed a certain standard either on the modern or the classical side would, again, without further entrance examination, be accepted as sufficient proof of adequate education, though for engineering, building, and textile departments at least one, but preferably two, years' practical work should precede the university studies.

Let us, in conclusion, consider the most important question as to how the general introduction of any such national scheme would affect existing schools, and also the position of the technical teacher. The majority of the existing technical day institutions would cease to exist as such; they have given conclusive proof that they have no right of existence. They would be transformed into trade schools for the daytime. The evening technical classes, however, would not only be maintained, but further developed, as they would grow

enormously in general importance. A number of the existing colleges and universities, spread at sufficiently large intervals over the country, would be developed into technical universities of the highest order, challenging comparison, not only as regards equipment, but in every other respect, with the very best institutions of other nations. According to the nature of the district, such technical university might be split up, where necessary, and an engineering college be established in one centre, a textile college in another, a mining college in a third, &c.

As to the position of the technical teacher, at present he is overburdened with day and with evening work, in addition to which he must spend a great deal of spare time in private study, but, in spite of this, his salary, on the whole, is hardly better than that of the elementary teacher. In fact, his position is far from being in accordance with the importance of his work with regard to the life and development of an industrial nation. The reason is that as yet technical education itself occupies a position far below that which is its due. By lifting technical education up to its proper level and making it a national affair you would make the technical teacher a national, or, to use the ordinary term, a civil servant, and the technical teaching profession would receive the recognition which it deserves, and which it receives in other countries.

That is, in my judgment, the only way in which English technical education may be enabled to exercise that amount of guiding and enlightening influence which it must possess if this industrial country wishes to maintain its front seat in the council of the nations.

THE APPLICATION OF THE NO-LOAD AND SHORT-CIRCUIT DIAGRAM TO THE DESIGN AND TESTING OF INDUCTION MOTORS.

BY STANLEY P. SMITH, B.SC.

Summary.—The first part of the present Paper contains a description of a diagram for induction motors by means of which the efficiency, torque, power factor, slip, &c., can be *accurately* determined, and an actual example is given showing how the same can be drawn from the no-load and short-circuit currents and losses. The second part of the Paper is devoted to a new and important application of this diagram, whereby the efficiency of induction machines, when tested by the modified Hopkinson method, is accurately obtained for both motor and generator. Lastly, a method for calculating these results is deduced, and checked by means of the diagram.

In the first part of the present article, which is a description of the use of the no-load and short-circuit diagram,* there is much that is not really new, but it may, nevertheless, be ofr interest to many who require a diagram of greater accuracy and wider application than the more commonly used forms of the circle diagram, such as the Heyland. The author ventures to think that such a comparison will show that the present diagram admits of the simplest possible construction, whilst it is vastly superior in point of utility, for from it all the various characteristics of the motor, such as the power factor, efficiency, slip, torque and so on, can be *accurately* determined.

For our present purpose, where it is only intended to deal with its practical side, it is merely necessary to mention that the diagram can be developed from the equivalent electric circuit of the magnetically interlinked system of the asynchronous machine, the working condition being obtained by the superposition of the no-load and short-circuit conditions, just as in the case of a transformer. In this way the electric circuit shown in Fig. 1 is deduced from the magnetically interlinked system of the induction motor, the secondary or rotor constants being reduced to the primary or stator by introducing the respective ratios of the number of turns, number of phases and winding factor of stator and rotor windings in the usual way.

To find the *equivalent electric resistance of the mechanical load* we can proceed as follows :—

Let E'_2=E.M.F. induced in rotor when at rest, reduced to primary.

E'_{2s}=E.M.F. induced in rotor at slip s, reduced to primary.

Then, since the E.M.F. induced in the rotor is proportional to the slip, we get $E'_{2s}=sE'_2$.

Further, let X'_2 denote the rotor reactance when at rest $=2\pi cL'_2$, where c=frequency of applied E.M.F. and L'_2=inductance of rotor circuit, reduced to primary. Then at slip s, when the frequency of the rotor current is sc, the rotor reactance will be $X'_{2s}=2\pi scL'_2=sX'_2$. If, then, r'_2 denotes the effective rotor resistance (reduced to primary) under working conditions, the current in the rotor at slip s will be

$$I'_2=\frac{E'_{2s}}{\sqrt{r'^2_2+X'^2_{2s}}}=\frac{sE'_2}{\sqrt{r'^2_2+(sX'_2)^2}}$$

$$=\frac{sE'_2}{s\sqrt{\left(\frac{r'_2}{s}\right)^2+X'^2_2}}=\frac{E'_2}{\sqrt{\left(\frac{r'_2}{s}\right)^2+X'^2_2}} \quad . \quad . \quad (1)$$

or, symbolically, $$\dot{I}'_2=\frac{\dot{E}'_2}{\frac{r'_2}{s}+jX'_2}.$$

Hence, r'_2/s is the *total equivalent resistance* in the rotor circuit at slip s But r'_2 is the *actual ohmic resistance* in the rotor circuit; consequently the difference

$$r_l=\frac{r'_2}{s}-r'_2=r'_2\left(\frac{1}{s}-1\right)$$

corresponds to the mechanical load, and can, therefore, be termed the equivalent load resistance. Hence, the *equivalent load resistance* in ohms is given by $r_l=r'_2(1/s-1)$.

From Fig. 1 it will at once be seen that the rotor current I'_2 is zero when the rotor is open. This corresponds to making

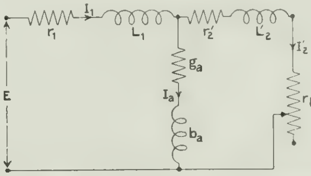


FIG. 1.—EQUIVALENT CIRCUIT OF POLYPHASE INDUCTION MOTOR.

E = Terminal pressure. r_1, L_1 = Stator resistance and inductance. r'_2, L'_2 = Rotor esistance and inductance, reduced to stator. r_l = Equivalent load resistance = $r'_2\left(\frac{1}{s}-1\right)$. I_1 = Stator or supply current. I_a = Magnetising current. I'_2 = Rotor current, reduced to stator, at slip s.

r'_2 infinitely large. Also $I'_2=0$ at synchronism ($s=0$), for then the load resistance $r_l=r'_2(1/s-1)$ is infinite. In either of the above cases, therefore, only a magnetising current, I_a, will flow into the stator. When, however, the rotor is closed, a current, I'_2, will flow in the rotor circuit, the value of I'_2 being determined by equation (1), which shows that this current is practically proportional to the torque within the working limits of the motor—that is, for low values of s. The primary or stator current I_1 then equals the geometrical sum of I_a and I'_2, or $\dot{I}_1=\dot{I}_a+\dot{I}'_2$. At standstill, with the rotor circuit closed (exclusive of any external resistance), the slip s $=1$, so that the equivalent load resistance $r_l=r'_2(1/s-1)=0$, and the short-circuit current, which we will denote by I_k, flows into the stator.

Coming now to the diagram for the circuit in Fig. 1, we need, for its construction—

1. The no-load current and losses.
2. The short-circuit current and losses.

Whence the name of the diagram. In addition to these, it is also well to know the magnetising current and iron losses. The above can be regarded as constants for any particular motor, and may be either calculated or measured, according to whether the machine is being designed or tested.

To obtain the *no-load* current and losses. When *designing* the machine, we find the watt component of current from the sum of the iron and windage and friction losses, whilst the wattless component is given by the number of ampere-turns required to drive the main flux through the motor. When

* The present form of this diagram—which was originally developed by Ossanna—is largely due to the work of La Cour, Bragstad and others. For the theory of the same, the reader may refer to Arnold's "Wechselstromtechnik," Vol. V., Part I., whilst a comparison of Ossanna's diagram with Heyland's can be found in Pichelmayer's "Dynamobau."

testing the machine, the no-load current and losses are measured directly. The *magnetising* current and losses are similarly measured when the machine is driven at synchronous speed, or calculated from the stator iron losses and the ampere-turns required for the main flux.

To find the *short-circuit* current and losses. In the case of a *design*, the resistance and reactance of the stator and rotor are calculated, and those of the latter are reduced to the primary as mentioned above. In this way the short-circuit impedance Z_k is obtained and the short-circuit current $I_k = E/Z_k$ is calculated. When the machine is being *tested* it is usually inadvisable to apply the full pressure E at the stator terminals; consequently we apply a reduced pressure and measure the current and input at this pressure. It is then but a matter of arithmetic to find the normal short-circuit current I_k and power factor $\cos \phi_k$. It may be pointed out that in taking this measurement it is well to move the rotor slowly by hand or otherwise to nullify any tooth effects, &c.

Construction of the Diagram.—We can now proceed to draw the circle diagram to a convenient scale. Taking the ordinates to represent the watt components of the current, and the abscissæ the wattless components, we set off P_0, P_a and P_k respectively to represent I_0, I_a and I_k with respect to the origin O in Fig. 2. P_0 is then the no-load point, P_a the magnetising

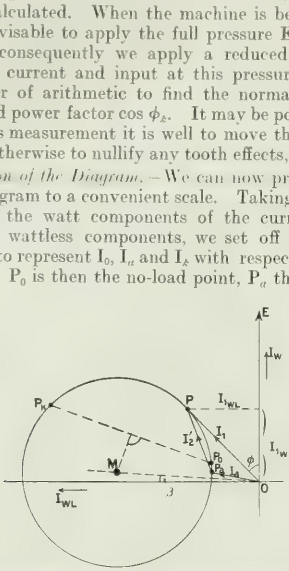


FIG. 2.—CONSTRUCTION OF NO-LOAD AND SHORT-CIRCUIT DIAGRAM.

$\overline{OE}$—Terminal pressure. Iw = Watt component of current. I_{WL} = Wattless component of current. $\overline{OP_k}$ Short-circuit current. $\overline{OP_0}$ = No-load current. $\overline{OP_a}$ Magnetising current.

$$\beta = \tan^{-1} \frac{I_0W \sin \phi_k + I_0WL \cos \phi_k}{I_k + I_0WL \sin \phi_k - I_0W \cos \phi_k}.$$

and P_k the short-circuit point. The centre M of the circle can be found from the following expression, giving the angle β which the line OM makes with the abscissa axis :—

$$\tan \beta = \frac{I_{0W} \sin \phi_k + I_{0WL} \cos \phi_k}{I_k + I_{0WL} \sin \phi_k - I_{0W} \cos \phi_k}.$$

Thus β is determined from the no-load and short-circuit constants of the motor (*see* illustrative example). The position of M on OM is then found straightaway by bisecting the line $\overline{P\,P_k}$, since both of the points lie on the circle.

In passing it may be mentioned that the centre M of the circle is never very far removed from the abscissa axis, especially in the case of large motors, and it is often sufficient to take M as the point where the bisector of P_0P_k cuts the abscissa axis. A little experience will soon enable the designer to judge whether it is necessary to calculate the angle β or not.

Having found the centre M, the circle passing through P_a, P_0 and P_k, over which the current moves, can be drawn, and we can at once proceed to find the various characteristics of the motor.

Pressure.—Since the watt components of the current have been set off along the ordinate axis and the wattless along the abscissa axis, it follows at once that the applied pressure E—which is in phase with the watt component of the current and leads the wattless component by 90 deg.—must also act along the ordinate axis. Since E is constant, the applied pressure will merely be represented by a definite length set off along this axis.

Current.—The stator or primary current I_1 supplied to an induction motor is made up of two components: the magnetising current I_a and the working current which is equal and opposite to the rotor or secondary current I'_2, just as in a transformer. Let $\overline{OP}$ in Fig. 2 represent the stator current I_1, which moves over the circle and about the origin O as axis, then, so long as the current I_a is constant $= OP_a$ (which is practically the case under all working conditions), $\overline{P_aP}$ will represent the rotor current I'_2 (reduced to stator current) both in magnitude and direction, just as $\overline{OP}$ represents the stator current I_1 both in magnitude and direction.

The Power Factor. In drawing the diagram, the watt component I_w of the supply current was always set off along the ordinate axis and the wattless along the abscissa axis to the left of O, the direction of rotation of the diagram being taken as clockwise. Further, we have seen that the phase of the applied pressure E must also be along the ordinate axis, in order that EI_w represents the total input to the motor. Hence the angle of lag ϕ of the current I_1 behind the pressure E is given by the angle the current I_1 makes with the ordinate axis, which, of course, can be read off directly and the power factor ($\cos \phi$) obtained (*see* Fig. 2). Similarly $\cos \phi_2$ for rotor current I'_2 can be found.

The Electrical Input.—This equals EI_w. The supply pressure E is assumed constant. When $I_w = 0$ the input will be zero. By taking, then, the ordinate of the current to represent the input, we at once get a scale for EI_w in kilowatts, since E remains constant. The *abscissa axis will then represent zero input.* Hence, to measure the electrical input W_i at any load we have merely to measure off the ordinate to the corresponding scale.

The Mechanical Output or Load. To find a similar datum line for the output, we first find two points for which this is zero. Two such points are P_k and P_0, the short-circuit and no-load points respectively. At both these points the output at the motor pulley is zero, the total input being absorbed by losses. The line P_0P_k then represents the conditions for zero output. Hence the ordinate drawn from any point P (Fig. 5) on the circle to this line P_0P_k represents the output W_0 of the motor. To find the maximum output $W_{0\ max.}$, it is only necessary to bisect the arc P_0P_k, whence the maximum overload capacity of the motor can be obtained directly (*see* Fig. 5).

The Losses.—In drawing the diagram the several ordinates of P_a, P_0 and P_k were made to represent the watt components of the magnetising, no-load and short-circuit currents. By multiplying these watt components by the constant pressure E the respective ordinates will represent the total losses W_L at these points to the same scale as the ordinate axis represents the input W_i to the motor. Similarly, at any point, P, on the circle (Fig. 5) the ordinate at P represents the input W_i, of which the part between P and $\overline{P_0P_k}$ is the output W_0; hence the difference the ordinate and W_0 denotes the total losses W_L. Thus, the total losses at any point on the circle is given by the part of the ordinate at that point which is intercepted between the abscissa axis and the line P_0P_k. Since, however, the input and output are not of necessity to the same scale, it is better and simpler to determine the losses from the efficiency, to which we shall turn presently.

The Torque.—To find a line for zero torque we need two points on the circle for which the torque is nil. These can be found quite simply by merely considering the expression for the torque. This we can do as follows :—

Since $\frac{r_2}{s}$ = equivalent resistance per phase in rotor circuit, then total power supplied to rotor $W_2 = I^2_2 \frac{r_2}{s} m$, where m = number of rotor phases. Now, ohmic loss in rotor $W_R = I^2_2 r_2 m$. Whence, total mechanical power (including windage and friction)

$$W_M = W_2 - W_R = I^2_2 m \left(\frac{r_2}{s} - r_2\right)$$

$$= I^2_2 \frac{r_2}{s} m(1-s) = W_2(1-s);$$

hence $\qquad W_2 = W_M/1-s.$

Again, torque = force × radius,

i.e., $T = FR$,

$= \dfrac{W_M}{v_2} R$, since $W_M = F v_2$;

$= W_M/\omega_2$, since $v_2 = 2\pi n_2 R = \omega_2 R$;

$= W_M/\omega_1(1-s)$, since $\omega_2 = \omega_1(1-s)$.

Then $\delta = T\omega_1 = W_M/1-s$, or $\delta = W_2$.

This quantity—$\delta = T\omega_1 = W_2$—has the dimension of a power and is defined as the torque in synchronous watts, being the output of the motor at synchronous speed ω_1 with the torque T.

We can at once se from the above consideration when the torque will be zero. First at synchronism, when $s=0$, for

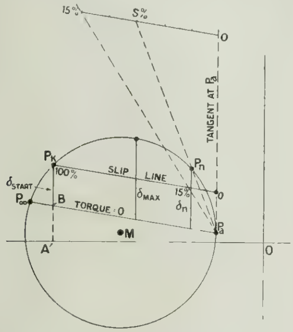


Fig. 3.—Diagram of Torque and Slip.

then $I_2=0$, there being no E.M.F. induced in the rotor under these conditions. Thus, P_a is one point where the torque is zero. The other case when the torque is zero is at infinite speed—that is, when $s=\infty$. This, though a purely theoretical point, nevertheless provides us with the second point on the circle for which the torque vanishes.

To find this point, which we will call P_∞, it is only necessary to remember that the rotor resistance is in effect neutralised by the load resistance at $s=\infty$, for we then have

$$\delta = W_2 = mI_2^2 \frac{r_2}{s} = mI_2^2 r_2 + mI_2^2 r_l$$
$$= 0;$$

that is, when $s=\infty$, $r_2 = -r_l$.

Consider now the copper losses at short-circuit P_k. These are due to r_1 and to r_2 (or, rather, to r'_2, since we now come to

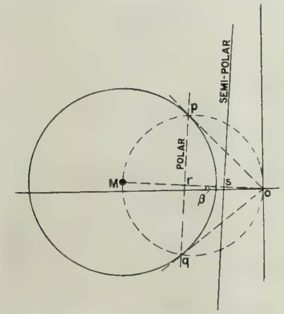


Fig. 4.—Diagram showing Construction of Semi-polar.

the diagram). Draw the ordinate $\overline{P_k A}$ (Fig. 3), and make $\overline{P_k B} : \overline{BA} = r'_2 : r_1$. If, then, we produce $P_a B$ to cut the circle, the point of intersection will practically satisfy the condition $r'_2 = -r_l$, so that this point will be P_∞. Further, since in induction motors r_1 and r'_2 are usually of the same order, it is generally sufficient merely to bisect the vertical from P_k to the abscissa and produce the line joining P_a to this point backwards until it cuts the circle. *Hence the construction of P_∞ usually amounts to bisecting the ordinate at P_k in B and producing $\overline{P_a B}$ backwards to cut the circle in P_∞* (see Fig. 3).

The line $\overline{P_a P_\infty}$ then represents zero torque, and the ordinate from any point on the circle to this line will be a measure of the torque at that point. Thus, δ_{start} represents the starting torque, and δ_n the torque at P_n in Fig. 3. The maximum torque the motor can exert (assuming constant normal pressure applied at the terminals) is $\delta_{max.}$ midway between P_∞ and P_a.

Slip.—We can now proceed to show how the slip can be found from the diagram. This is quite a simple matter. At P_a the slip is zero, at P_k it is unity or 100 per cent., and at P_∞ it is ∞. Draw, then, a line through P_k parallel to $P_\infty P_a$ to meet the tangent drawn at P_a, and divide this line, which we call the slip line, into 100 equal parts (Fig. 3). Then on the

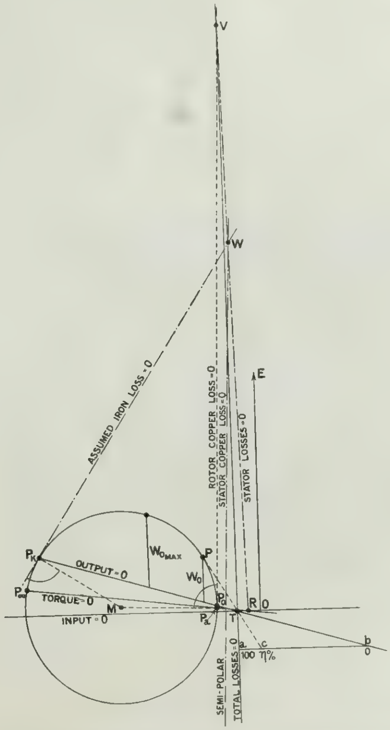


Fig. 5.—Showing Determination of Efficiency from Power and Loss Lines.

Note.—A simplified and closely approximate construction of required line "total losses = 0" is obtained by merely drawing ordinate through the point T, where $\overline{P_k P_0}$ produced cuts abscissa axis. This procedure makes the construction of the several loss lines unnecessary, and enables the efficiency to be determined straightaway.

tangent the slip is 0 per cent. and at P_k 100 per cent. Now these points fall on the lines joining P_a to the points considered. Similarly, the line $\overline{P_a P_\infty}$ cuts the parallel to it through P_k in $s=\infty$. Hence, *to find the slip at any point on the circle—e.g., at P_n—join P_a to P_n and produce $P_a P_n$ to cut the slip line; then the slip s is read off directly.* In order to make this more easily readable over the working part of the diagram, the part $s=0$ per cent. to $s=15$ per cent., for example, can be magnified to any desired extent, as shown in Fig. 3.

Efficiency.—This also can be found directly from the diagram. To do this we find two lines, one of which shall represent zero efficiency—*i.e.*, all loss—and the other 100 per cent. efficiency—*i.e.*, no loss. Now the former line we know already

—viz., $\overline{P_0P_k}$*—for here the output is zero and the total input is consumed in losses. To find the other line, which is to represent 100 per cent. efficiency, it is at once clear this must lie outside the circle, for at no point on the circle are the losses zero. Now, one such point where the losses are zero is the intersection of the line P_0P_k, denoting zero output, with the abscissa axis, denoting zero input, in the point T (Fig. 5); for where both output and input are nil the losses must be also nil.

To find another such point, where the losses are zero, consider the several electric and magnetic losses in the motor. Take first of all the stator copper loss. Now, this varies as the square of the stator current. Since, then, this current moves over a circle with respect to the origin O, it is only necessary to find a line such that the length of the perpendicular on to this line from any point on the circle varies as the square of the corresponding current. Such a line is the semi-polar of the circle with respect to the origin O. (The proof of this is quite simple, but would lead us too far here.) The construction of this line is shown in Fig. 4, which simply consists of drawing tangents $\overline{op}$ and oq to the circle, and drawing a line parallel to the polar $\overline{pq}$ through the point s, the mid point of or, where r is the point of inter-section between the polar $\overline{pq}$ and the line $\overline{OM}$. The line through s is then the *semi-polar* to the circle with respect to the origin O, and represents the line for which this copper loss is zero. Any line drawn from the circle at right angles to the semi-polar thus serves as a measure for the stator copper loss.

Turning now to the other component of the stator losses —viz., the iron loss—let us see if it is possible to find a similar line which shall represent zero iron loss. For this purpose it will be sufficient if we consider the two extreme cases. First, when the iron losses at short-circuit are negligible compared with the copper losses; secondly, when the iron losses are constant at all loads. Now, if the first assumption were correct—viz., that the iron losses vary inversely as the copper losses—the tangent at P_k could be taken to represent zero iron losses, whereas the second assumption of constant iron losses would imply a line removed to an infinite distance from the circle in order that all distances from the circle to this line are equal. These, then, can be regarded as the limiting cases, and the correct line of zero iron losses will lie somewhere between. Now draw the tangent at P_k and let it cut the semi-polar (representing zero stator copper loss) in the point W. This is shown in Fig. 5, which, however, is merely an explanatory diagram, and has had to be largely exaggerated in order to bring the point W near the circle. Actually the conditions will be much more like those in Fig. 6, where the point P_k is seen to fall much lower on the circle, so that it is usually necessary to use a simple geometrical construction to find the point of intersection W, which generally lies a considerable distance away from the diagram. The point where the other line, which represents constant iron losses at all loads, cuts the semi-polar, is of course indeterminable, since such a line must be removed an infinite distance away from the circle.

Now assume for a moment that the point W in Fig. 5 (which we know is much too near the circle) is actually the point where the lines of zero stator copper loss and zero iron loss meet, then W will be one point where the stator losses are zero. A second point where the stator losses are zero is R, the point of intersection between $P_\infty P_a$ (representing zero torque or stator output) produced, and the abscissa axis (representing zero input).

If, then, the points W and R are joined by a straight line, this latter will represent zero stator losses. Now a glance at Fig. 5 at once shows the effect of taking W too near the circle. As is seen, the slope of WR is not much altered if the point W

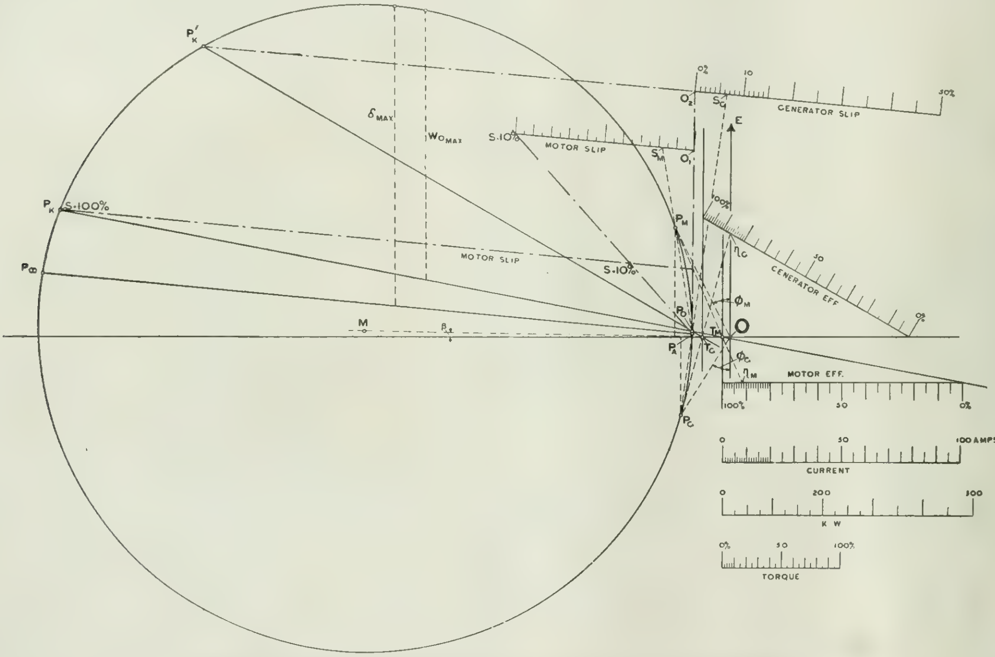


Fig. 6.—No-load and Short-circuit Diagram of Three-phase Induction Motor.
300 h.p., 2,750 volts, 40 ~, 10 poles, 480 revs. per min. (syn.)

Note.—The points P_a, P_0 and P_k are the magnetising, no-load and short-circuit points respectively of the normal motor. The point P_k' is the short-circuit point for the special case of the machine working with a definite resistance inserted in the rotor circuit.

* If electric and magnetic losses alone were present, then the line of zero output would be P_aP_k, but actually mechanical (windage and friction) losses are also present, so that the line of zero output is taken through P_0. In this way the mechanical losses are taken into account in the determination of the efficiency.

were taken much higher than the tangent at P_k gives it. Even when we reach the other limit, where W is at infinity, the line $\overline{WR}$ only becomes *parallel* to the semi-polar. In the actual diagram of an induction motor, as given in Fig. 6, the difference between drawing WR as in Fig. 5 (where W is the point where the tangent at P_k cuts the semi-polar) and drawing it parallel to the semi-polar is scarcely appreciable, so that we can take WR as representing zero stator losses.

Now for the *rotor copper loss*. This is zero at P_a, the point of synchronism. The corresponding semi-polar therefore becomes the tangent to the circle at this point. Hence any line from the circle drawn at right angles to the tangent at P_a serves as a measure for the rotor copper loss at this point on the circle. Let, then, the tangent at P_a (representing zero rotor copper loss) cut the line $\overline{RW}$ (representing zero stator losses) produced in V. Then V is one point where the electric and magnetic losses in the motor are zero.

A second point where the electromagnetic losses are zero is R the intersection of $\overline{P_kP_a}$ produced with the abscissa axis, but, as mentioned above, it is better to produce P_kP_0 to cut the abscissa axis in T, in order that the windage and friction losses may be approximately allowed for. Then VT is the line for which the total losses in the motor are zero, and consequently the efficiency is 100 per cent.

We have now the line representing zero total losses, so that if it were possible for the current to move along this line the efficiency would be 100 per cent. In a similar way we have seen the line P_0P_k represents all loss—that is, zero efficiency. If now we draw a line, $\overline{ab}$, parallel to the abscissa axis, and divide this into 100 parts, the efficiency at the point P can be read off directly by producing $\overline{PT}$ backwards to cut the efficiency line in *c*, Fig. 5, for we have : efficiency

$$\eta = \text{output/input} = W_r - W_L/W_r.$$

In this way the efficiency can be found.

Usually, however, this construction of VT is by no means necessary, for a little experience soon shows that in most cases *an ordinate through the point* T *very nearly coincides with* VT.

Hence *to find the efficiency at any load* :

Produce $\overline{P_kP_0}$ to cut the abscissa axis in T. Then draw any line *ab* parallel to the abscissa axis to cut the ordinate through T in the point *a* and $\overline{P_kP_0}$ produced in *b*. Divide *ab* into 100 parts. Then the efficiency at any point P on the circle is found by producing $\overline{PT}$ backwards to cut *ab* in *c* (Fig. 5).

This simple construction will be found to give the efficiency with an accuracy which is quite sufficient for all practical purposes.

We can now illustrate all the above by means of an actual example.

(*To be concluded.*)

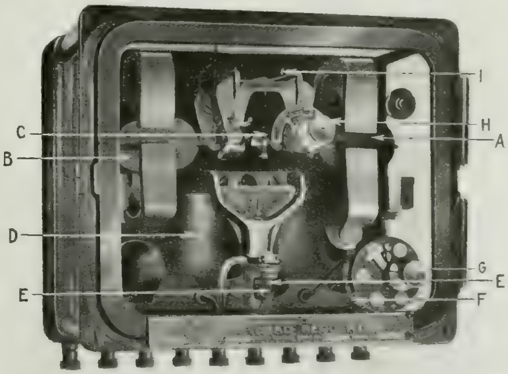
REVERSIBLE BOOSTER RELAY REGULATOR.

In the application of accumulators to traction and lighting systems a very important part has been played by the reversible booster. Many modifications have been introduced to obtain the necessary flexibility in excitation, but so far relay methods have not received much favour. The following description of a relay regulator, which is being successfully employed by the Westinghouse Machine Co., of East Pittsburg, U.S.A., will, therefore, be of interest.

The feature of the system is the simplicity of the booster field winding, the E.M.F. of the booster, or boosted rotary in the case of a battery employed on an alternating-current supply system, being changed by varying the excitation of a single separately-excited field winding. This field winding receives its energy from a small exciter which has, in addition to a self-excited shunt winding, two equal and opposite pilot field windings. The current in these two windings is controlled by the making and breaking of the double relay contacts E in the illustration herewith. These contacts are in turn controlled by the primary relay of the regulator, which consists of a current member A, working in conjunction with the potential member B, to close or open the energising circuit of the relay magnet D.

The current coil A works in a permanent magnetic field, and is balanced by an adjustable spring tension. The amount of current flowing through the coil A is proportional to the current flowing through a shunt in the circuit to be controlled, to the ends of which the terminals of the coil are connected. This is equivalent to an ordinary ammeter movement, with the exception that the range of motion is exceedingly small. The voltage coil B is exactly equivalent, except that its position varies according to the voltage of the booster exciter. The primary relay contact C is established by the conjunction of the current and potential coil levers. This contact, therefore, intermittently energises the electro-magnet D, which operates the main relay contacts E. The lower contact E energises one of the pilot fields, while the other contact E energises the equal and opposite field. These pilot fields act in opposition, so that with the same amount of current flowing through both there would be no voltage upon the exciter. If, however, one of them receives current it will start up the voltage of the exciter in a given direction, and the shunt winding of the exciter will carry the field to full saturation. This will be checked by the potential coil of the relay. It will, therefore, be seen that, as the external load on the system rises, one contact is broken, and the booster voltage rises so as to cause the battery to discharge. This discharge will continue at an increasing rate until the operating equilibrium of the system is again restored, and is entirely independent of the condition of battery charge or discharge as long as there is enough booster pressure behind the battery to give the required discharge to maintain the load constant. Similarly, if the load drops, the opposite effect is obtained and the battery charges.

Practically no energy is handled by the regulator, since the voltage produced by the pilot coils is only 20 per cent. of the total voltage of the exciter. Therefore, since the exciting energy of the booster



Load Regulator.

will not be over 8 per cent. at a maximum, and the energy handled by the regulator will be a fraction of 1 per cent of the booster field energy, the regulator as a result operates with absolutely no sparking at the contacts, which means that there is practically no wear.

A high resistance, F, consisting of five steps, is connected in series with the lead from the controlling shunt. This resistance is cut into or out of circuit by means of the rotary switch G. Thus, the effective drop across the current coil A can be varied by cutting in or out resistance, which will mean a greater or less current flowing through the shunt, in order to produce a given deflection of the current coil arm A, as the case may be.

The generator load will, therefore, be varied through five steps by shifting the switch G. The load can further be adjusted anywhere between these steps by changing the tension of the current coil spring by means of the handle H. This covers the entire range of capacity of the generating system, so that the average load can be held anywhere from full load to 10 per cent. of full load.

The degree of regulation with this type of regulator is limited entirely by the speed of the booster, and does not depend in any way upon the regulator, as the speed of action of the regulator is far beyond the speed of magnetisation of any commercial type of booster. A booster, of course, could be built to change its voltage with exceeding rapidity, but as the cost increases with the speed of magnetisation, beyond a certain point such refinement of regulation is neither commercial nor necessary.

The best test of a regulator is to consider the fluctuation of the average generator load with the maximum variation of the external load. In the case of an installation for the Southern Colorado Power & Railway Co., a test for 1½ hours showed a variation in the external

load from 0 to 630 amperes, and in the generator load from 153 to 210 amperes, with an average of 181 amperes; whilst in the case of a test over 80 seconds the external load varied from 14 to 434 amperes, and the generator load from 177 to 194 amperes, with an average of 187 amperes. It will be seen that the maximum current fluctuation on the generating system in the case of the long test is 9 per cent. of what the current fluctuation would have been if the battery and regulator had not been used, and is 4·1 per cent. in the case of the short test. Furthermore, in the case of the long test, the energy fluctuation is 1·9 per cent. of what it would have been if the regulator and battery had not been used, and is 2·2 per cent. in the case of the short test. When it is taken into consideration that the maximum variation above the average generator load is 248 per cent. in the case of the long test and 132 per cent. in the case of the short test, and the maximum variation of the external load below the average generator load is 100 per cent. in the case of the long test, and 93 per cent. in the case of the short test, the closeness of this regulation will be appreciated.

In the case of the alternating-current regulator, the direct-current coil A is replaced by a polyphase wattmeter movement. For controlling the average load the transformer ratio will be changed by moving the handle G instead of cutting out resistances, as in the case of the direct-current regulation. In all other respects the two regulators are identical.

The advantages claimed by the Westinghouse Company for the above system of regulation are as follows: (1) Great efficiency, due to an inappreciable amount of energy being required to operate it; (2) it will allow of adjustment of generator load over wide range while maintaining close regulation at all loads; (3) it will maintain the average generator load nearly constant, irrespective of the condition of the battery; (4) only two adjustments are necessary to effect any desired change in operating conditions; (5) the station 'bus bar system does not require extensive alterations, such as the insertion of energy-absorbing resistances or solenoids.

"WIRELESS" ON A RAILWAY TRAIN.

At one time the jaded traveller who undertook a sea voyage considered that one of the greatest advantages of his journeyings was the entire freedom which he experienced from the doings of the outside world. During the past few years this has, however, been

FIG. 1—MARCONI STATION INSIDE PULLMAN CAR.

changed, and the traveller on board ship every day receives, through the medium of "wireless," news from all over the world.

In this country railway journeys are comparatively short, and there is, therefore, no necessity for any arrangements to be made for the carrying out of business work during the time they are being undertaken. Moreover, the stopping places are so close together that the traveller is always kept well acquainted with the news of the outside world. In America, however, things are different, and the time is probably not far distant when "wireless" will be fitted on all railway trains in that country. A beginning has already been made in this direction, a special train running from Buffalo to Chicago on the New York Central Railway having been equipped with some more or less experimental apparatus. The arrangements were carried out by the Marconi Wireless Telegraph Co. of America, under the direction of Mr. F. M. Sammis. The train was timed to leave Buffalo at 9:30 a.m. on February 27th, and carried the "Via Wireless" and "Polly of the Circus" theatrical companies from that town to Chicago. Since it was impossible to assemble the train before 7 a.m. only 2½ hours were available in which to fix the necessary installation.

The antenna used was of the horizontal type, since the overhead clearance from the bridges was only 6 in. Each car was fitted with vertical iron pipe supports, and between these and over the car roof was stretched a stranded copper wire. This copper wire was fitted with hard rubber strain insulators at each end, and the 10 cars were connected together electrically by slack wires, so that curves could be rounded without danger to the antenna. The wireless station was erected in a Pullman car, which was in the centre of the train. Two leading-in insulators were passed through the ventilator and a lead brought in through these from each portion of the antenna, thus forming two uni-directional aerials working in opposite directions. An earth connection was made by carrying the lead through the window and connecting it to one of the main journal boxes of the car.

FIG. 2. HORIZONTAL ANTENNA ON ROOF OF PULLMAN CAR.

The day before this train was used four Marconi operators were sent to four points along the line, and instructed to rig up temporary stations. The special, which during the journey ran at speeds exceeding 70 miles an hour, was able to communicate with these stations over distances varying from 60 to 80 miles.

The experiment seems to have been attended with great success, for while there was a heavy snowstorm, and some insulation difficulties were experienced, due to the insulators becoming coated with soft coal mud, good communication was maintained with all the stations. In the accompanying illustrations we show views of the Marconi station inside the Pullman car and the horizontal antenna on the roof.

SIEMENS BROTHERS & CO.'S SWITCHBOARD INSTRUMENTS.

At one time the switchboard was a comparatively unimportant accessory of the generating station, but of recent years this part of the equipment has grown enormously in importance, and it has sometimes been questioned whether so large an expenditure in this direction is justified. In this advance it may perhaps be said that attention has been paid rather to the switchgear for the manipulation of the power, than to the instruments for its measurement. Indeed there is frequently room for much improvement in the design and accuracy of those instruments used for measuring the output, &c., of generating plant, and although cheap and approximately accurate instruments are all that is necessary for some installations, the extra cost of reliable and well designed apparatus is, in many cases, fully justified.

In July last we described the series of testing instruments which have been introduced by Messrs. Siemens Brothers & Co., and we

have recently had the opportunity of inspecting the new switchboard instruments which are being placed on the market by the same firm. The features of both series of instruments are the excellent design and workmanship, high accuracy under all ordinary conditions, and neat finish. As an instance we may mention that the scale of every instrument is hand marked, no printed scales whatever being used. In spite of the high quality of the Siemens instruments, an inspection of the new switchboard instrument catalogue will show that the prices are by no means high, and, doubtless, the many excellent features of the instruments—some of these features being unique—will result in many engineers deciding in favour of the slightly more expensive instruments, and also in a desire for increased accuracy in all cases. The catalogue in question gives detailed particulars of practically all instruments installed in connection with modern switchboards, and should be in the hands of every engineer interested in electrical plant.

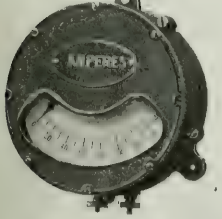


Fig. 1.—Moving Coil Watertight Ammeter.

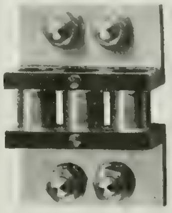


Fig. 2.—Shunt for 1,500 Amperes.

The Siemens measuring instruments can be divided into three distinct types, viz.: (1) those for use with continuous currents only; (2) those for use with alternating currents only, and (3) those for use with both continuous and alternating currents. The first class are of the moving coil type; the second of the Ferraris type; and the third of the electromagnetic type.

In regard to the moving coil instruments, these are of the well-known Deprez d'Arsonval pattern. We need scarcely remind our readers that in this type a permanent magnet and moving coil are employed, and as the field is practically uniform the deflection is proportional to the current passing, so that an evenly spaced scale results. These characteristics, combined with good damping properties and immunity from disturbance by extraneous magnetic fields, are the main features of moving coil instruments. The general construction of such instruments is so very well known that a lengthy description of those supplied by Messrs. Siemens is unnecessary. It may be remarked, however, that temporary cores are provided for the permanent magnets during the construction of the instruments, and that particular attention is paid to the handling of the magnets so that they shall be rendered as permanent as possible. Every instrument is tested for insulation resistance with a pressure of 1,000 volts between case and windings, with the exception of instruments on pedestals and brackets, which are tested with 2,000 volts.

Fig. 3.—Edgewise Ammeter.

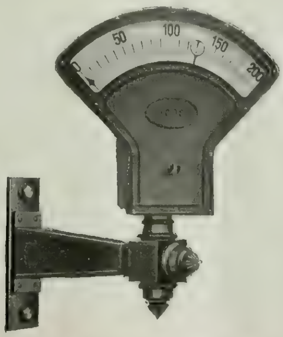


Fig. 4.—Moving Coil Voltmeter on Bracket.

Fig. 1. shows a moving coil ammeter of a watertight pattern, and Fig. 3 an edgewise instrument, the latter pattern being of considerable advantage where space has to be economised. The even spacing of the scales of both instruments will be noticed. It may also be mentioned that these moving coil instruments are made in a portable type, as described in our issue of July 24th last.

Moving-coil ammeters reading up to 50 amperes have self-contained shunts; for larger currents they have separate shunts, which are fixed in a vertical position, as shown in Fig. 2, and are therefore kept cool by natural draught. These shunts are not adjusted for any fixed drop of pressure unless specified; and each one can only be used with the ammeter which has been calibrated with it. They are deserving of special mention, as they are the result of lengthy experiments. Many shunts in common use give incorrect readings on the instruments to which they are connected, due to thermo-electric E.M.F.s generated at the point of contact of the resistance metal, with the copper or brass blocks forming the terminals. Heat is, of course, necessary to produce such an E.M.F., but it is a by no means infrequent occurrence to find one terminal of a shunt warm, due to expansion and bad contact caused by heavy currents flowing in the neighbouring 'bus bars and connecting links of a switchboard at times of heavy load. With a combination of certain alloys and copper the thermo-electric effect is often very marked, and may result in an error of several scale divisions. Manganin is used for the tube part of the shunt seen in Fig. 2, and is so applied that we observed no electrical effect whatever when one end of the shunt was heated over a bunsen burner flame, so that Messrs. Siemens are to be congratulated on having overcome any liability to errors due to thermo-electric effects in the shunts.

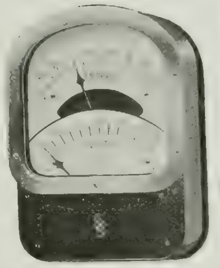


Fig. 5.—Combined Voltmeter and Ammeter.

Fig. 6.—Ferraris Watertight Ammeter.

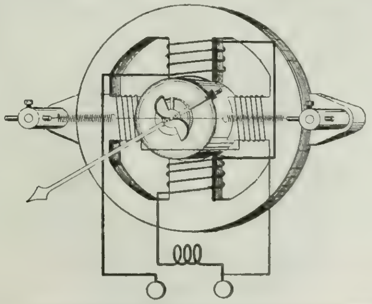


Fig. 7.—Diagram showing Principle of Ferraris Instruments.

The voltmeter shown in Fig. 4 is also of the moving coil type, and is fixed on a bracket, thus giving a form of construction much appreciated by switchboard attendants. The substantial nature of the construction will be noticed from the illustration.

Another type of moving coil instrument to which we need refer only briefly is that shown in Fig. 5. It represents a combined volt and ammeter, and has been specially designed for use with motor cars and for similar purposes. When required these instruments are provided with watertight covers and terminals.

Turning now to the second class of instruments, those intended for use with alternating currents only, and termed Ferraris instruments,

these are constructed on the rotary field principle. The theory of their action will be understood from the diagram, Fig. 7. It will be seen that the rotary field is produced by the well-known phase-splitting device, an inductance being inserted in series with one pair of magnetising coils, so as to produce a difference in phase between the two circuits. The moving member, or rotor, consists of an aluminium drum to which a pointer is fixed, and the instrument may be considered as a squirrel cage motor, the movement of the rotor being restricted by a special spring control. This spring is one of the features of the instrument, and will be noticed passing horizontally across the centre of the diagram, Fig. 7. The arrangement consists of

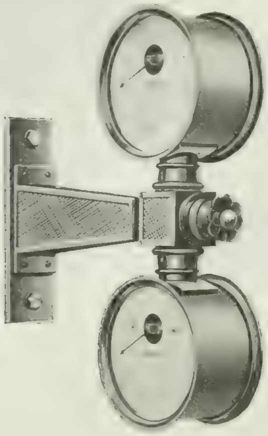


Fig. 8.—Ferraris Ammeter and Voltmeter on Fixed Bracket.

two spiral springs joined together by a wire; this wire passes over two cams fixed on the axis of the needle and arranged so that, as the needle deflects, the wire is pushed to one side, and the springs extended.

The springs and cams are designed so that, although in such an instrument the deflecting force increases as the square of the current, a practically uniform scale results. Particular attention may be drawn to this feature, as it is not a usual characteristic of alternating current instruments. That the arrangement adopted by Messrs. Siemens leaves little to be desired in this respect, can be seen from Fig. 8, which shows a Ferraris ammeter of a watertight pattern. The

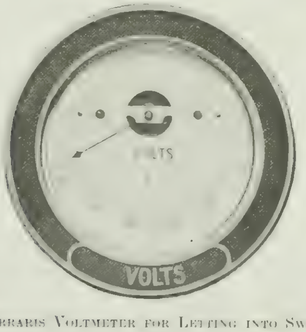


Fig. 9.—Ferraris Voltmeter for Letting into Switchboard.

scales usually extend over a range of 120 deg., and are divided almost evenly, except for readings below 15 per cent. of full load. The magnets are, of course, laminated, and damping is provided by two permanent magnets, eddy currents induced in the rotor serving to bring the needle rapidly to rest. In fact, the damping is practically as good as in a d'Arsonval instrument. Another and most important feature is that the instruments are practically unaffected by any change in the power factor, at any rate over a range of power factor from 0·3 to unity; and it is also worthy of note that they are for all practical purposes uninfluenced by neighbouring heavy currents or magnetic fields. In regard to frequency, it is desirable that the instruments should be used on circuits of the frequency for which they have been calibrated, but variations of 10 per cent. are permissible in the case of voltmeters and ammeters, and 5 per cent. in the case of wattmeters, without influencing the readings to any extent.

We have referred above to the more important features of these instruments, viz., accuracy, open scales, good damping and extreme sensitiveness; in connection with the latter it may be mentioned that the torque with a given current is about 12 times that usually associated with a moving coil instrument.

Voltmeters, ammeters, and wattmeters are constructed on the Ferraris principle, and in this connection attention may be drawn to Fig. 8, which shows an ammeter and voltmeter on a fixed bracket. This form of construction is rather unusual, but as it possesses some advantages it is likely to find favour in special cases. Fig. 9 shows an interesting modification of the standard voltmeter, the instrument shown being arranged for letting into a switchboard. Ferraris voltmeters are only made for working pressures up to 500 volts; with higher pressures transformers must be used.

In regard to Ferraris wattmeters, these are made for single-phase circuits, for three-phase circuits with branches equally loaded, and for three-phase circuits with branches unequally loaded. An interesting feature is that the scales are extended below zero with a negative range of about 15 to 20 per cent. of the positive range. This should prove very advantageous, since it enables the fluctuation of power between machines running in parallel to be observed, whilst the freedom from external magnetic disturbances is a point which will be much appreciated, as many wattmeters are liable to inaccuracy from that cause.

Fig. 10.—Electromagnetic Ammeter with Front Connections.

Considering, finally, the third type of measuring instruments, viz., electromagnetic, which can be used for continuous or alternating currents, the principle of the movement is that of a soft iron core attracted into a solenoid. The iron core is treated by a special process by which hysteresis is reduced to a minimum, so that the instrument when used for continuous current gives practically the same readings, whether the current has been increased or decreased to its particular value, whilst with alternating currents they are independent of frequency and wave form. The majority of the instruments of this class are nearly dead-beat, and owing to the care taken in shielding the moving parts they are practically uninfluenced by external magnetic fields. When the greatest degree of damping is required—ordinarily the pointer comes to rest after one or two oscillations—an oil damping device is fitted at a little extra cost.

As regards mounting, the instruments are arranged for either front or back connections—Fig. 10 herewith shows an ammeter (600 amps.) with front connections—and the terminals of voltmeters and of ammeters reading up to 300 amperes can be changed without opening the case, so that an instrument with front connections can be converted into one with back connections by the substitution of the necessary terminals. An iron case is usually fixed. Where a brass case is desired, a special iron screen is fixed for protecting the moving part from external magnetic fields.

Another striking feature of these instruments is the uniform scale. This is obtained by suitably designing the iron plunger attracted by the solenoid. The instruments are intended to be fixed in a vertical position, but it is worth noting that they are also made in a portable form (described in our issue of July 24 last), in which case a spring control is employed instead of gravity.

For further information in regard to the types of instruments here described we must refer our readers to the new catalogue of Messrs. Siemens Brothers & Co., which is one of the most complete publications that has been issued in connection with switchboard apparatus.

(*To be concluded.*)

THE ELECTRIC MOTOR AND THE BELT DRIVE.

It will, no doubt, be agreed that the electric motor shows a great flexibility in the way it can be adapted to work under very varying and often trying conditions. It has to run without breaking down or overheating in atmospheres which are sometimes explosive, and which even by the greatest stretch of the imagination cannot be called healthy. Again, it is often necessary, owing to economical and other similar reasons, that the motor should be placed in some position where it cannot work so efficiently as it might. It overcomes these difficulties, however, and generally emerges satisfactorily from the ordeal.

In some cases where the electric drive is employed the use of a belt is absolutely necessary, and this use often means difficulties when for other reasons the motor must be placed almost vertically below the line shafting. That these difficulties can also be successfully overcome, if need be, is shown by the accompanying photographs, for which we are indebted to Mr. F. V. L. Mathias, borough electrical and tramways engineer, of Warrington. Fig. 1 shows a belt in operation, and also indicates the extraordinary curves taken by the slack side when running. It is of Whittle leather and of the V-link type, its thickness being $\frac{3}{8}$ in. It is shown running on a 5 H.P. motor, the speed being 1,000 revs. per min. and the pulley diameter 12 in. We understand that the pulley groove where the belt runs is comparatively dull, showing that the slip is very small. This belt has been in use for four years without having been touched in any way. Fig. 2 shows the motor at rest, and well indicates the slackness of the belt.

Fig. 1.—5 H.P. Motor running at 1,000 revs. per min., and driving through "Whittle" Belt.

Fig. 2.—5 H.P. Motor, showing slackness of "Whittle" Belt when stopped.

SOME CONSIDERATIONS IN THE MANIPULATION OF DRY-CORE TELEPHONE CABLES.*

BY F. G. C. BALDWIN.

Summary.—The author describes the various operations which a telephone cable undergoes after its manufacture, and the methods adopted by the National Telephone Co. to secure the greatest working efficiency. A few of the chief appliances and fittings used are also described.

The superiority of the dry-core, air-space or paper-core cable is now universally accepted, and as the "duct" or "conduit" system of installation best facilitates repairs, renewals, inspections, &c., it only will be considered. A table, which has been extracted from the National Telephone Co.'s specification for dry-core cables with 10 lb. conductors, gives details of the number of pairs in the core and several layers. One or more "marked pairs" are usually provided in each layer.

The various methods adopted in drawing cables into ducts are as follows: (1) Directly by hand (restricted to short lengths of small cables); (2) by means of pulley blocks and chain or rope tackle (used in special cases only); (3) by means of a manually operated winch (most commonly used); (4) by means of a power-driven winch.

Opinions differ as to whether a rope or a chain is the best for hauling. The difference in prime cost is negligible. For large and heavy cables a $4\frac{1}{2}$ in. rope is usually used. The attachment of the cable to the rope or chain is a matter of considerable importance. For this purpose a wire "grip" has been universally adopted, which avoids mutilation and consequent scrapping of the cable end. The grip consists of a woven cylinder of steel wire, interlaced in such a manner that contraction ensues upon the application of tension. In use it is simply slipped over the end of the cable, and tightens up when hauling is commenced. Some preliminary preparation of the end of the cable is necessary, and in some cases where heavy lengths are being dealt with it is advisable to open the end of the cable, and, laying bare the conductors for a few inches, to plumb them solid with the lead sheath. This ensures the tension being equally distributed amongst the conductors, and avoids the possibility of the lead sheath parting. A lubricant in the form of petroleum jelly is usually applied to the cable as it enters the duct. The speed of travel of cables varies from about 3 ft. to 8 ft. per minute. By judicious arrangement it is in many cases possible to deal with cables of small diameter (not exceeding $1\frac{1}{2}$ in.) without cutting or jointing in the maximum lengths in which they can conveniently be manufactured.

During jointing and its attendant operations precautions are taken to secure (1) Minimum number of faulty circuits in the completed cable, (2) immunity from crossed pairs, (3) lead sheath perfectly air and water-proof, (4) electrical properties up to the standard.

Preliminary Test.—Each length of cable after being laid is subjected to a preliminary test by bunching the wires together and earthing on to sheath of cable at one end, the wires at the other end of cable being carefully separated and tested (1) individually with battery and galvanometer for continuity, (2) for earth, contact and short-circuit, by bunching wires at first-mentioned end and testing each individual wire, with those untested earthed on cable sheath.

Jointing.—In jointing especially is it necessary to observe cleanliness and to exclude moisture. In large joints where the core is exposed for a period of 20 hours or more the moisture absorbed by the dielectric from an atmosphere of varying humidity may be considerable unless proper precautions are taken. While jointing is progressing, heat is applied either constantly or at frequent intervals to expel moisture. After the lead has been stripped off for the requisite distance, jointing is performed as indicated in Fig. 1. For conductors under 70 lb. per mile the wires are tightly twisted together as shown, and insulated by a dry paper sleeve. Conductors of 70 lb. per mile and over are similarly twisted, but are insulated by their paper covering, reserved for the purpose, and secured, as illustrated, by a binding of cotton thread. In both cases the paper is included in the first two twists to prevent it running back, and the joint is not soldered.

Wires of respective colours should be jointed together. The sleeved or paper-insulated joints should be distributed to secure uniform diameter of completed joint, and the wires should be only moderately taut. After a thorough drying the joint is served with a binding of dry cotton tape without overlap, and immediately afterwards the plumbing is executed, 6 lb. sheet lead, or preferably an unseamed sleeve, being used. A brass nozzle with screwed cap and leather washer is permanently plumbed into the sleeve, and by connection thereto of a flexible tube, air, dried by passage through a small portable desiccator, is forced into the joint by means of a hand pump. A defect in the plumbing is shown by the continued appearance of air bubbles on the application of soapy water. The introduction of crosses is guarded against by proving each pair as jointed.

Labelling.—It is customary to assign a number to each pair of a completed cable for purposes of distinction. The method of testing out is well known, and explanation is unnecessary.

Test for Crossed Pairs.—Every completed section is subjected to a test for crossed pairs which may have escaped notice during the loop tests made at each joint. The test is diagrammatically illustrated in Fig. 2, and consists in sending round the whole of the pairs connected in parallel an alternating current, each pair being taken one at a time and connected to a telephone receiver. In the diagram it is assumed that a cross exists, and if the circuit be traced it will be apparent that when the receiver is connected to a pair that is crossed with another one a hum will be heard on placing it to the ear.

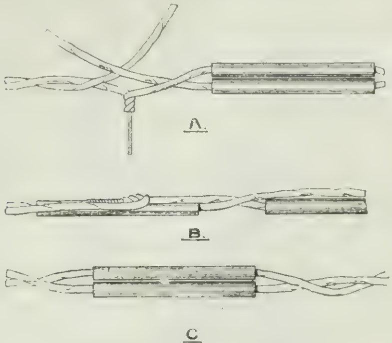
Terminating Dry-core Cables.—The effectual termination of dry-core cables is a matter presenting some difficulty. Provision has to be made for termination in positions fully exposed to all climatic influences as well as in protected places, but in all cases there exists

* Abstract of a Paper read before the Birmingham Local Section of the Institution of Electrical Engineers.

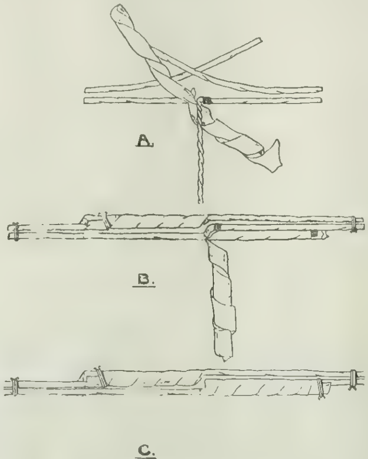
the possibility of penetration of moisture to the cable core. Three typical methods of termination in present use are as follows:

1. *Cable Heads or Terminals.*—In these the end of the cable is hermetically sealed within a metal or other chamber, connection being made to the external circuit by means of suitable insulated terminals. Details of a terminal of this type, designed by Mr. S. P. Grace, of Pittsburg, and made by the Western Electric Co. for external use, are given in Fig. 3. It consists of a cast-iron chamber with suitable lugs for attachment to its support and a cast-iron lid hinged at the top. In a recess in the box there is fitted a porcelain block, through which brass pins extend, provided in the inside with soldering tabs and on the outside with screwed nuts and washers. The cable enters through a brass nozzle to which its sheath is plumbed

diameter and length is slipped over them and secured at such a point that it encloses the stripped portions, sufficient only being left protruding for jointing to the dry-core cable. At this end the lead sleeve is beaten on to the stripped leaders, which are protected from injury by a binding of insulating tape. Insulating compound at a temperature of from 250°F. to 280°F. is then run into the sleeve in



For 70 lb. Conductors and under.



For 70 lb. Conductors and over.

Fig. 1.—Details of Jointing.

and the wires are soldered to their respective tabs. The rear compartment is subsequently filled with molten insulating compound through a hole at the top, which is afterwards sealed by a screwed plug. Connection to the external circuit is made by rubber insulated leaders as shown.

2. *Potheads.*—The cable is sealed by jointing its wires to vulcanised indiarubber leaders enclosed in a lead sleeve—to which the cable sheath is ultimately plumbed—impregnated with a molten compound, which, when set, forms an air-tight plug. Potheads are usually manufactured locally as follows: The requisite number of V.I.R. leaders are cut to the proper length, and at one end of each

such a manner as to ensure it being well filled and the leaders being thoroughly enveloped. When cold, an air-pressure test is applied the mouth of the sleeve and the leaders being immersed in water so that a leak may be indicated. If sound, the pothead may be used

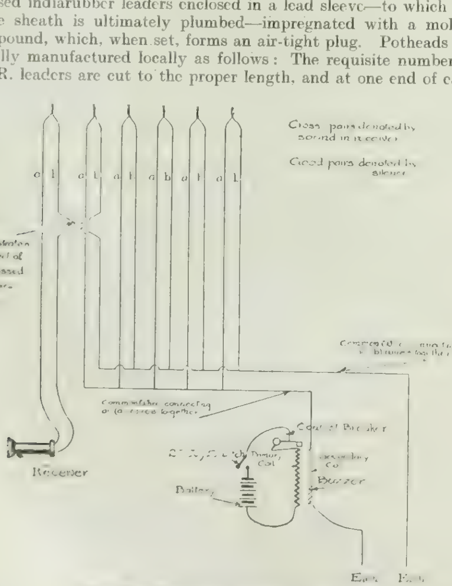


Fig. 2.—Test for Crossed Pairs.

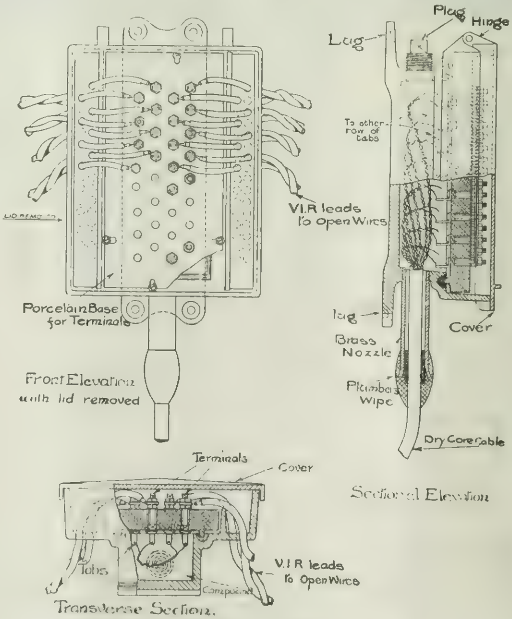


Fig. 3.—Cable Terminal. W.E. Type.

[illegible] and braiding is very carefully removed for a distance [illegible] the size of the pothead being made. It is essential [illegible] should be stripped clean and be free from injury. The leaders are then tightly and neatly bunched, the stripped portions [illegible] together, and a lead sleeve of the proper

as it is for sheltered situations, but for exposed positions it should be fitted with a lead cap of suitable dimensions. The inverted cap is partly filled with melted compound, and after the leaders have been doubled back and uniformly arranged along the pothead sleeve containing them, the same is inserted and forced well into the cap,

superfluous compound being expelled. When cold the pothead is complete and may be jointed to the dry-core cable in the usual manner.

3. *Silk and Cotton Lead-covered Cable.*—For inside positions the present practice in terminating a cable of over 50 pairs is to joint it to a special length of silk and cotton insulated lead-covered cable, the intervening joint being filled solid with paraffin wax as a means of isolating the paper core from the atmosphere. The end of the silk and cotton cable, which is to be connected to the terminal apparatus and will be permanently exposed, is stripped of its sheath for the necessary distance, and the exposed core is immediately well saturated with beeswax. The beeswax should be maintained at a temperature of not less than 200°F., preferably by means of a water-jacketed waxing tank, and the cable should not be withdrawn from the wax until the cessation of bubbling shows that all moisture has been expelled. The wax is allowed to penetrate under the lead sheathing as far as possible, so that air is excluded from the cable core. Afterwards the waxed wires are formed out in a manner consistent with the disposition of the terminals to which they are ultimately to be connected. The joint between silk and cotton and dry-core cables is made in the usual manner except that the wires are left a little looser and that the ends of the joint are packed with dry cotton-wool interposed between the layers. The taping is omitted, and after being thoroughly dried the joint is plumbed. If the respective tests for insulation and plumbing are satisfactory the joint is immediately filled solid with pure paraffin wax. When cold another insulation test and an air-pressure test are applied.

Air-pressure Test.—To prove that the sheath of all jointed cables is sound an air-pressure test is desirable. Air which has been chemically dried is applied under pressure to one end of the cable until a pressure of about 12 lb. per square inch is registered by special pressure gauges fitted at its extremities. The air supply is then shut off, both gauges being left connected. If the pressure is maintained without appreciable drop for, say, 10 hours, it may be taken as proof that the cable sheath is air-tight and the cable may with safety be brought into use.

Test for Insulation, Conductivity and Capacity.—The capacity test is usually dispensed with. The conductivity test serves as a check as to length, and proves the resistance of the twisted joints. The insulation test is of greater importance as the insulation resistance is liable to considerable variation; 500 megohms per mile of circuit may be taken as an average standard, and when the dielectric consists of dry paper core only it should be much in excess of this. Potheads, cable heads, and silk and cotton cables with filled joints detrimentally affect the insulation.

Desiccation.—An improvement in the insulation of air-space cables is readily accomplished. Atmospheric air, from which all moisture has been extracted by being passed through tubes containing calcium chloride, is forced at a pressure of from 15 lb. to 20 lb. per square inch through the cable of low insulation. The moisture is absorbed by the dry air and expelled along with it at a vent opened in the cable at a suitable point. In a desiccating apparatus which is being fitted by the National Telephone Co. at its important exchanges, a motor-driven air compressor supplies air at regulated pressure to a chamber which is connected to four vertical cast-iron cylinders. The cylinders are connected in series, and the chloride of calcium is distributed within them on perforated brass trays supported at equal intervals by a central rod. Each cylinder is provided at the top with a flanged lid secured by bolts and made air-tight by a rubber washer, and at the bottom with a blow-off cock for drawing off the extracted moisture. The first and last cylinders are fitted respectively with a lever valve for regulating and a gauge for indicating the pressure.

DISCUSSION.

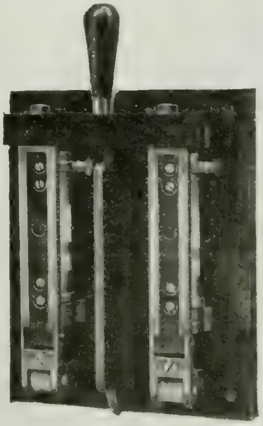
Mr. DUDLEY STUART wished the author had referred to the developments that had taken place in the construction of dry-core cables. It was now about 15 years since the first 100-pair dry-core cables for 3 in. ducts were introduced. At present, owing to the rapid strides which manufacturers had made in this country, 600-pair cables could be drawn into 3 in. ducts. Every one would appreciate the advantages in the matter of price per duct circuit. One reason for this advance was that they had been able to introduce a wire cable of 10 lb. per mile. By this means they obtained a 600-pair cable which, starting in 1905 with 2·55 in. diameter, had now been cut down to 2·34 in. diameter. He thought that engineers generally—both power and telephone—were apt to bind down suppliers too much to specification, with the result that manufacturers had been trying to cut down expenses to get orders. The National Telephone Co. had in recent years made a deep study of the question of the sheathing of dry-core cables. There had been much controversy, which was the most advantageous, lead or alloy? The speaker gave a summary of the results of investigations on lead as against an alloy of lead and 3 per cent. of tin. The deduction which he made was that the alloy was cheaper and had general advantages over lead. If the price of tin went to a very high figure, of course they would need to reconsider the question. As to conductors of 70 lb. and upwards, these were used for long circuits, trunks and junctions. There had been a novel design introduced, for which it was claimed that a 10 lb conductor with twin duct would give something like the same transmission, but tests did not give the results claimed. The speaker showed further diagrams and tables giving much valuable information respecting various systems of telephone cables and their cost.

The AUTHOR, in reply, tendered his thanks to Mr. Stuart for supplementing the Paper with such valuable information. He pointed out, however, that the Paper was intended to put forward the methods adopted in performing various operations, and as carried out by the National Telephone Co., and the means they found secured the best results. As a practical Paper he had purposely omitted everything on the design and construction side. Of course, a great deal of importance was attached to the design of these cables, but if those operations to which he had alluded were not carried out in practice in a proper manner he was afraid that much of the time spent in design would be wasted. Mr. Stuart had mentioned the relative qualities of lead and alloy. He agreed that they did get a greater mechanical strength from an alloy of something like 3 per cent. This certainly seemed the best, because they must needs have a certain amount of tensile strength. In pulling in the cables there was a great strain imposed on the lead. It would be a serious matter if it parted, and the break would be difficult to locate.

Prof. KAPP, in proposing a vote of thanks, said that the short discussion was not an indication of their interest. It must rather be taken as a proof of the great merit of the presentation of the question by Mr. Baldwin.

COMBINED SWITCH AND FUSE.

The British Electric Calibrated Fuse Co., of Harpenden, have recently introduced a new form of combined fuse and switch. The design is particularly neat, and embodies several new features for this class of apparatus, which should appeal strongly to all users of



COMBINED SWITCH AND FUSE.
(British Electric Calibrated Fuse Co.)

electricity. As will be noticed from the illustration, the fuse blades are actually the switch blades, and there is no way of making circuit with anything but the correct size of fuse. It is also, it is claimed, impossible to insert wire either in parallel with a fuse or alone. Therefore, the circuit in which one of these fuse switches is inserted is absolutely ensured against any excessive overload, to which it might otherwise be subjected, either through negligence or ignorance.

This point alone should appeal to all engineers. The consulting engineer can rest assured his design will not be abused; the contractor does not risk an unfair slur upon his reputation, and the consumer knows he will not experience a breakdown due to bad treatment of his plant. It should also be noticed that there is only one thumbscrew for fixing each fuse, and the saddle is dead, so that a novice can replace a blown fuse in under 10 seconds, without any fear of a shock.

On the face of it, it would seem that this appliance merits investigation and trial, and the company are, for this reason, offering to send on approval a fuse switch, either of the open or enclosed type, to any responsible applicant, with a catalogue giving full particulars of both sizes and prices.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The thirty-fifth issue of the Supplement was published (Gratis) with the last number of "THE ELECTRICIAN."

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RAILLESS ELECTRIC TRACTION.

There is not much doubt that railless electric traction will receive an impetus in this country through the report of the deputation appointed by the Tramways Committee of Sheffield. This Committee recently went to the Continent for the purpose of investigating the value of railless electric traction as a method of feeding tramways. They inspected the Mercedes-Stoll system at Vienna and the Max Schiemann method at Mulhausen, and in the report a description is also given of the Filovia system in use in Italy. The latter is operated by a trolley pole and special form of four-wheeled trolley, two wheels running on each of the two overhead wires rendered necessary in this form of traction. The operating costs are said to be 6d. to 7½d. per car-mile. This seems low, though it must not be forgotten that single-deck cars are in use, as is customary on the Continent, with seats for 24 passengers, and the lightness of the car is rendered evident by the statement that the equipment consists of two 10 H.P. motors. At Mulhausen also trolley poles are used, but the trolley is of a simpler design. The cars there are characterised by a front drive. Although this form of drive has been used on Kriéger electric automobiles, we are not aware that it has been tried to any extent on heavy vehicles. The effect of such a drive is to render the steering somewhat difficult; no object is stated for the adoption of this method, though it may be that greater freedom from side-slip is a sufficient reason. The working costs are about 5d. per car-mile.

The Mercedes-Stoll system is worked with a flexible cord, as opposed to a trolley pole, and a four-wheeled trolley carriage which runs on the top of the pair of overhead wires. Apparently this form of trolley runs satisfactorily and with little wear. The omnibuses are char-

acterised by the special form of Mercedes construction in which the motors are more or less incorporated with the wheels, as described in THE ELECTRICIAN of April 17, 1908. With a car weighing $2\frac{1}{2}$ tons the running cost is said to be $4\frac{1}{2}$d. per car-mile. This system is favoured by the deputation in preference to the other methods, and also to the ordinary motor omnibus, and the opinion is expressed that the system can be worked at a profit. It is pointed out that the cost of overhead lines, &c., will be about £3,000 per mile, though it is not stated whether one pair or two pairs of overhead wires will be used. This figure compares with £9,000 per mile for single track with overhead lines and £15,000 for double track. The cost of the cars is taken as £600 per car, which seems a high figure compared with £650 for the ordinary tramcar. Any such system is, of course, at a considerable advantage as regards upkeep, as there is no charge for maintenance of roadway.

It is not unnatural to consider whether the electric omnibus does not offer a rather promising solution to a problem of this kind. As against the capital charges on £3,000 per mile the upkeep of the accumulators has to be set. For heavy omnibuses $2\frac{3}{4}$d. per mile seems a working figure, and for light omnibuses it is difficult to say to what this might be reduced. Means for charging the accumulators could be arranged without great difficulty at the end of any tramway line, and such a system of accumulator cars would have the advantage of greater flexibility than the trolley omnibus. The cars need not be housed at the end of the line, but might be accommodated with the tramcars, if the car shed were not at any great distance from the terminus to be served. If battery maintenance could be reduced to a reasonable figure such a system certainly offers advantages. On the other hand, although the trolley omnibus lacks flexibility and must be kept absolutely to the route that has been equipped for it, the overhead system can be modified very simply at any time when the service warrants the extension of the tramway along routes served by the trolley omnibus.

The pros and cons will be more easily weighed when the Sheffield Corporation have equipped some lines, and had their cars running for some time. We do not doubt that the experiment will be watched with very considerable interest by tramway managers, for every tramway network is terminated by routes which would not be remunerative for tramway working, but which, nevertheless, it is desirable to develop.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Experimental Elasticity. By G. F. C. SEARLE, F.R.S. (Cambridge: University Press) Pp. xvi.—183. 5s. net.

This book is a development of manuscript notes prepared by the author for use in the Cavendish Laboratory. The present volume is the first of an intended series on all the branches of practical physics.

There are two schools of teachers in practical physics; one teaches chiefly or entirely by text books, the other believes in the more flexible method of manuscripts. The author, after considerable experience with the latter method, appears now to be developing the former. The first half of this book is devoted to the theory of elasticity, in which are the well-known theorems of stresses and strain, and also some methods for tensional and torsional stresses recently published by Dr. Filon before the Royal Society.

In the second half of the book are the standard experiments, 14 in number. These should be very helpful to advanced students. In addition to the well-known experiments on Young's modulus and rigidity, we find the author's own methods on elastic hysteresis, torsional and tensional, the torsion of a blade, the energy dissipated in torsional hysteresis, also the author's now well-known method of comparing Young's modulus and rigidity for a wire dynamically by vibrations. This method the author also uses to determine Poisson's ratio.

The book ends with useful appendixes on mechanical principles and notes on practical students' work in general. We do not remember seeing elsewhere some methods here used—*e.g.*, the ratio of the two radii of curvature of a uniformly bent beam, also Rayleigh's reciprocal relations between force and displacement. One or two passages appear to us obscure; the theory might be expanded in places with gain in clearness; while, on the other hand, there seems to be unnecessary fulness on some of the practical details and directions in the latter part of the book. In the experiment on the measurement of Young's modulus by stretching a wire horizontally on a kind of monochord apparatus, no mention is made of the friction of the pulleys, by which the tensions in the vertical and horizontal portions of the wire are, in general, unequal.

To sum up, we find here an original, practical book, which should be of considerable value in the physical and engineering laboratory, and we shall look eagerly for the succeeding volumes in the series, which promise to enrich our shelves.

P. E. SHAW.

The Management of Dynamos. By C. W. LUMMIS-PATERSON. 4th edition. (London: Crosby, Lockwood & Son.) Pp. viii.—295. 4s. 6d. net.

This book now appears in its fourth edition, after being revised and partially re-written. Its title is rather misleading, as the book also deals with theory and construction, in so far as these relate to the management of continuous-current dynamos and motors, and is specially written for those in charge, or who expect to have charge, of such machines.

The book is divided into three parts—the theory, the construction and the management of the dynamo. In the first place the book discusses in a very simple and readable manner the electrical principles underlying the action of all dynamos and motors. Occasionally, however, some of the author's remarks are rather misleading. For example, in drawing an analogy between flow of water and flow of electricity, he states that a current is analogous to the volume of water passing through a pipe, which is obviously wrong, and we fear may puzzle some readers. We must challenge the statement that a machine designed for 100,000 watts may be arranged to give 1,000 amperes at 100 volts, 10,000 amperes at 10 volts or 100 amperes at 1,000 volts. These outputs would require considerable modification in any modern design of machine, and it would be by no means such a simple matter as the author indicates.

The theory of the dynamo is very simply explained, but we are very disappointed with the author's treatment of the construction of the dynamo. In this section those types of machines which were in vogue when the book was first written in 1895 are given quite a prominent place, the modern types being only briefly mentioned. This is especially evident in the author's description of commutators. In the same way, carbon brushes and holders are merely referred to, whilst the old-fashioned wire and gauze brushes with their holders are described at length.

Coming to the practical part of the book, we congratulate the author on his simplicity of language and clearness of expression, though, again, he mentions some rather old-fashioned methods, such as cutting out one or more field coils to regulate the voltage of dynamos; but, on the whole, the part dealing with the various types of dynamos and the method of regulating them is as satisfactory as can be expected in an elementary book. The chapters dealing with the management of the

dynamo and the faults which may arise are very well written, and the methods explaining how the many difficulties which occur with these machines are got over should be of great assistance to any person having such machines in his charge. The last two chapters are devoted to motors and motor starters, and to the troubles likely to arise in connection with them and the method of curing their ills.

On the whole we think this book should be of great help to the mechanic who has no complete knowledge of dynamos or motors, but wishes to have sufficient knowledge to enable him to get over the various difficulties which occur. The worst feature of the book is in the diagrams and sketches, which are wanting in neatness and clearness.

Electric Furnaces. By WILHELM BORCHERS. Translated by H. G. Solomon. (London: Longmans, Green & Co.) Pp. ix.—218. 7s. 6d. net.

The author sadly lacks the discriminating power which one is accustomed to expect from the historian, and, in our opinion, greatly over-estimates the importance of his own work. Very full descriptions are given of the numerous laboratory devices employed from time to time at Aachen; but these are interwoven with accounts of industrial furnaces in a manner not easy to follow. Another weakness of the author is his apparent inability to recognise the relative value of the inventor who sketches out some form of furnace construction and the patient investigator who concentrates his attention upon employing the simplest means to attain the object in view. This is apparent throughout the whole book, but is nowhere more marked than in the short section (plentifully interspersed with marks of exclamation) devoted to Moissan's work, in which his great scientific achievements in laying the foundation of our knowledge of high-temperature chemistry are scarcely mentioned.

The chapter dealing with electrodes and their connections contains much useful information, and it is unfortunate that the author has not devoted more of the space available to generalities of this kind connected with furnace construction. It is noteworthy that no mention is made of artificial graphite, nor of the devices used for the automatic control of the energy consumption in the furnace; almost every industrial furnace at present in use is provided with mechanism for regulating the supply of current, and a description of this auxiliary plant would have made a valuable addition to the book. Again, five pages are devoted to the mercury vapour lamp (which is scarcely to be classed as an electric furnace), but no account is given of the important types of furnace in use for the manufacture of the oxides of nitrogen.

The printing and illustrations are excellent, and the translation appears to have been carefully carried out. There is, moreover, a great deal of information which, with due discrimination, will prove of value to those interested in the use and application of electric furnaces. R. S. HUTTON.

THE MEASUREMENT OF THE INSULATION RESISTANCE OF A LIVE THREE-WIRE SYSTEM.*

BY DR. GISBERT KAPP AND DR. DENNIS COALES.

Summary. Two methods of ascertaining the joint fault resistance of a three-wire system without disconnecting the earth connection are first described. The authors then proceed to describe a method whereby the insulation of each wire may be ascertained separately.

The well-known Russell test gives the combined insulation resistance of the three wires, but not that of each wire separately. It moreover necessitates interrupting the earthing connection whilst the test is being made. This is not necessary in Frœhlich's modification, but the latter also does not allow of a separation of the joint conductivity of the three faults. The following two methods for finding the joint fault resistance do not require the earthing connection of the middle wire to be broken.

1. Let, in Fig. 1, *ab* represent a potential slide, the resistance of which need not be known. The ends are permanently connected to the outer wires, and the slider is connected through an ammeter, A, to earth. The middle wire is connected through a voltmeter, V, of resistance ρ to earth. R is the usual earthing connection with its ammeter A_0. To measure the total fault resistance push the slider into such a position that A reads zero, and note the reading of V which we shall call e. Then push the slider into such a position that V reads zero, and note the reading on A which we shall call i. The fault resistance is then $f = \frac{e}{i - e/\rho}$.

2. The middle wire has besides its usual earth connection a connection with a graduated resistance with sliding contact, and the latter is connected to earth through a low-reading ammeter (Fig. 2).

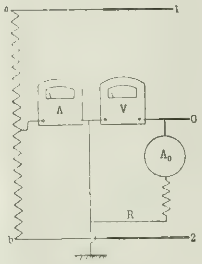


FIG. 1.

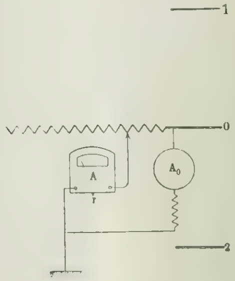


FIG. 2.

We found it convenient to use for this purpose a Siemens milliampere meter of 1 ohm resistance, but any other instrument of known resistance will do. To make a test set the slider so that the pointer of the ammeter reads a little under half its total range, and note the corresponding resistance in circuit between the slider and middle wire. Let this be ρ and the current i. Then shift the slider so as to reduce the resistance to such a value ρ_1 that the current is exactly doubled. This will bring the pointer to near the end of the scale. Thus both currents can be read with great accuracy. If r is the resistance of the ammeter the combined fault resistance is $f = \rho - 2\rho_1 - r$. The above methods are very simple and do not interfere with the earthing connection; also they can be applied at any point of the system.

The proof of these formulæ is simple and is given in the Paper.

Since all the methods for finding the fault conductivity proposed up to the present give the sum of the conductivities, it is obviously

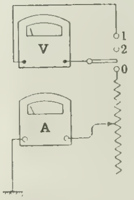


FIG. 3.

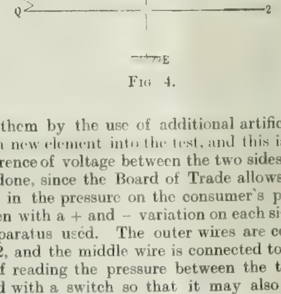


FIG. 4.

hopeless to try separating them by the use of additional artificial faults. We must introduce a new element into the test, and this is a slight variation of the difference of voltage between the two sides of the system. This may be done, since the Board of Trade allows a variation of $\pm$ 4 per cent. in the pressure on the consumer's premises, and readings are taken with a + and − variation on each side.

Fig. 3 represents the apparatus used. The outer wires are connected to the terminals 1, 2, and the middle wire is connected to o. V is a voltmeter capable of reading the pressure between the two outer wires. It is provided with a switch so that it may also be used to measure the pressure between one outer and the middle wire. A is the low-reading ammeter used in No. 2 test above, and ρ is its series resistance. This is not altered during the test. The pressure between the two outer wires is also kept constant, but E_1

* Abstract of an original communication accepted by the Council of the Institution of Electrical Engineers for publication in the "Journal."

and E_2 are varied so that $E = E_1 + E_2 = E_1' + E_2'$; $E_1' - E_1 = E_2 - E_2'$ being the permissible variation of about 8 per cent. of the declared pressure. If K is the combined conductivity of the three faults and the ammeter with its series resistance, we have—

$$E_1 c_1 - E_2 c_2 + eK = 0,$$
$$E_1' c_1 - E_2' c_2 + e'K = 0,$$
$$(E_1' - E_1)c_1 + (E_2 - E_2')c_2 + (e' - e)K = 0,$$
$$(E_1' - E_1)c_1 + (E_1' - E_1)c_2 + (e' - e)K = 0,$$
$$c_1 + c_2 = \frac{e - e'}{E_1' - E_1} K.$$

Since $c = c_1 + c_2 + c_0$ is known from the test made according to method 2, we find the conductivity of the fault on the middle wire $c_0 = c - K \frac{e - e'}{E_1' - E_1}$. The other two conductivities are then determined, giving

$$c_1 = K\left(\frac{E_2}{E} \cdot \frac{e - e'}{E_1' - E_1} - \frac{e}{E}\right) \text{ and } c_2 = K\left(\frac{E_1}{E} \cdot \frac{e - e'}{E_1' - E_1} + \frac{e}{E}\right).$$

This test can also be made at any point of the system—for instance, in the engineer's office. It is important that the voltage over the outer wires should be unaltered during the few minutes required for the test.

On consideration of the above formulæ it will be observed that the values of the fault conductivities of the outer mains depend for their accuracy upon the determination of the small differences between the large voltages E_1' and E_1. To render this measurement sensitive two methods may be employed: (*a*) in which a voltmeter having an initial spring tension, and, say, of 10,000 ohms resistance, reading from 230 to 270 volts, is used; (*b*) in which a low-reading voltmeter is connected to a sliding contact on a slide wire connected to the outer mains, the other terminal of the voltmeter being connected to the middle wire. Both these methods may be extended to the measurement of the voltage between the middle wire and earth upon the same instrument. When the insulation of the outer mains is high compared with that of the neutral main, and especially when the earthing resistance is low, the value of $(e - e')$ is very small compared with e. That is to say, a given change $(E_1' - E)$ in the mains voltages produces a very small change on the voltmeter reading between the neutral and earth, and, therefore, for this reading also a voltmeter with initial spring tension is desirable. By varying the series resistance of such a voltmeter, one instrument may be used to measure sensitively both $E_1' - E_1$ and $e - e'$.

The second method (*b*) of using a low-reading voltmeter for measuring $E_1' - E_1$ is as follows: A graduated potential slide, PQ (Fig. 4), is connected between the outers, and a low-reading voltmeter is connected alternately between the sliding contact M and the middle wire, and between earth and the middle wire by means of a plug swith. When the plug is in hole 1, let v be the voltage indicated, and let k_1 and k_2 represent the reciprocals of the resistances PM and QM, and let k_0 be the reciprocals of the resistance of voltmeter and its series resistance if any is used when connected to M. Then the authors show that $\Delta E = -\Delta v \cdot \frac{k}{k_1 + k_2}$, where $k = k_0 + k_1 + k_2$ and ΔE and Δv are the changes produced by altering the balancer. The sensitiveness of the measurement of Δv is governed by the sensitiveness of the voltmeter, because v may always be made zero by adjusting the position of the slider M. It is thus possible to measure Δv with very much greater accuracy than $E_1' - E_1$, when a voltmeter without initial spring tension is used.

The authors finally show how the measurement of the mains' voltages may be obviated, so that only one indicating instrument is required to make all the measurements for determining the fault resistances of the three mains of a three-wire system.

By setting the slider M (Fig. 4) in its middle position we may use the voltmeter, with the plug in hole 1, to indicate the condition $E_1 = E_2$. For when this is attained, by adjusting the shunt regulator of the balancer, the voltmeter will indicate zero. Having made this adjustment of volts, we are at liberty to move M without in any way affecting the values of E_1 and E_2. It is proved that where γ = conductivity of the voltmeter when connected to earth,

$$c_2 + c_1 = \frac{\Delta e}{\Delta v} \cdot \frac{k_1 + k_2}{k}(c + \gamma).$$

$$c_2 - c_1 = \frac{k_2 - k_1}{k} \cdot (c + \gamma).$$

This last method has, however, the disadvantage that the use of an instrument reading from zero renders the measurement of Δe likely to be unsensitive. By the use of a simple compensating potential slide the difficulty may be overcome.

THE DESIGN AND REQUIREMENTS OF ELECTRIC POWER WORKS.*

BY HORACE BOOT.

In regard to the necessity of a good site a great many works are suffering from the early mistakes made. In many municipal works, the site was chosen on account of the corporation owning the land—often in the middle of well-populated districts—and as the works have grown this bad selection has cost them thousands of pounds. This applies to fuel, which should be obtainable to-day either by rail or water, preferably by both, to a supply of water for boiler feed and condensing purposes, to the question of nuisance, annoyance or injunctions, to foundations, and to space for extensions.

The author then enumerates the various buildings required for an electric power station, and shows how the cost of land and buildings varies in different undertakings. Thus, at Newcastle these items work out at £8·48 per kilowatt of plant, at Brighton £27·67, and at Chichester £3 (buildings only). Generally speaking, for small power houses, nothing beats brickwork with the cantilever roof and lantern lights running along the top. For very large power houses, concrete and steel construction is the best; that is to say, the whole of the building is constructed of steel work and filled in with concrete walls. Provided there is sufficient land, it is advisable to build a dwelling-house for the engineers-in-charge and cottages for the principal workmen, so that the men are always near if required.

In regard to the question of nuisance, if it is impossible to get a site away from the residential property, it is advisable to buy up the property first, as afterwards the prices asked may become greatly enhanced.

The type of plant makes a very great difference to the size of the works. Thus two 800 kw. reciprocating sets, considered by the author, required 48 ft. by 46 ft. of ground space, whereas two 1,500 kw. steam turbines only required 28 ft. by 50 ft. Power stations do not lend themselves to architectural embellishments: (*a*) since capital cost has to be kept down; (*b*) in that their general shape cannot be very sightly. The materials used are best left to local conditions. Inside the walls should be lined to a height of about 10 ft. with white glazed bricks and finished off with ornamental chocolate or other bricks. The style of the flooring for the engine-room is very difficult to settle, but so far as pattern goes it is hard to beat mosaic or tessellated paving, but it should be set up in squares, as otherwise there will not be sufficient give, and it will crack, owing to the variations in temperature. In many works tiles are used, but the trouble is, that when heavy tools are dropped the tile is usually broken. Hard wood flooring has been tried, but with oil and grease about it is difficult and expensive to keep clean, and when dirty becomes very slippery. For the boiler-house the author is in favour of using blue bricks placed sideways on account of their lasting properties.

A site should not be chosen where a great deal of money has to be wasted on levelling; also, great care must be taken to see that the flues and economisers are not placed below the ground water level. It is very difficult to keep the boilers and generators in a line with one another, on account of the boilers requiring so much more room for the same output. In America they often place the boilers on different floors, but this practice has not been copied over here, as there are undoubtedly objections to it.

Refuse destructors are sometimes situated alongside the electricity works, but where a works has only a lighting load the saving obtained by combining the two is not so apparent as it would be in the case of combining a refuse destructor with a waterworks or works requiring a constant amount of power. Anyhow, the author thinks the practice will increase rather than diminish.

A few particulars are then given of the Greenwich generating station of the London County Council. The buildings are of steel framework enclosed with brick walls having stone dressings for ornamentation. The boiler and engine houses are faced with ivory white glazed bricks and a brown glazed dado. The floors throughout are of concrete, covered with terrazzo or granolithic.

Should gas engines (either suction, producer or power gas) be used, then a boiler-house is not required. A diagram in the Paper gives a very good idea of the requirements of a producer gas engine building, together with the space required for the gas plant. In the works designed by the author for the city of Chichester, which are, of course, small, but which will probably be followed by all small towns where an electricity supply is not at present given, the buildings only comprise an engine-house. The walls are brickwork, the roof steel framework and slated, the flooring terrazzo, and the generating plant is interesting as one of the first (if not the first) employing engines of the Diesel type for prime movers.

* Abstract of a Paper read before the Institution of Municipal Engineers.

The cost, as mentioned above, comes out, from the building point of view, very low, which is one of the advantages of using Diesel oil engines for generating electric power. The author is of the opinion that for small towns, where coal is dear, nothing can beat the results obtained by these engines; and with metallic filament lamps reducing the cost of electricity below that of gas (in small towns), there is no reason why many towns, which hitherto have been too small to put down works, should not follow the example of Chichester.

CORRESPONDENCE.

PARALLEL RUNNING WITH EARTHED NEUTRALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: By a perhaps not unnatural coincidence, the idea I suggested during the discussion on Mr. Rider's Paper, on the 22nd ult.—viz., to connect the neutral point of each alternator through a choking coil to a common 'bus bar which is connected to earth through a resistance, appears to have occurred quite independently to Dr. Sumpner, and I am pleased to note from his letter to you, dated the 26th ult., that he considers the idea a sound one.

I entirely agree with Dr. Sumpner that, for reducing the current between the neutral points of the machines, the choking coil arrangement is far simpler than the device for connecting only one machine to earth at a time, but I cannot endorse his opinion when he further states that the choking coils should be made large enough to prevent serious earth currents. I think that the choking coils should be designed to deal with the currents circulating between the neutral points, and that they should not oppose, to any very appreciable extent, the normal frequency currents going to earth, these being dealt with by the main resistance.

I venture to suggest that, both as regards cost and limiting of current to earth, the arrangement of carbon powder resistances, which I described at the meeting on the 22nd ult., possesses very considerable advantages over existing methods. An earthing resistance, if of the ordinary iron grid type (where the ohmic value is lowest when cold) with or without choking coils in series, must be of such a value that when the fault occurs on the longest feeder, sufficient current will pass to trip the automatic switch on that feeder. Mr. Rider states that, in his system, the value of the resistance must not be more than 3·5 ohms, and it is therefore possible to get $3{,}700 \div 3{\cdot}5 = 1{,}050$ amperes to earth, if the fault is so close to the station as to make its resistance negligible.

With carbon powder resistance, on the other hand, the ohmic value is highest when cold, and decreases as the resistance heats up. Taking a resistance which decreases to $\frac{1}{5}$th of its original value, at which figure it remains practically constant, it is clear that we can afford to have a resistance which will be five times $3{\cdot}5$ ohms $= 17{\cdot}5$ ohms when cold. The maximum current that will pass to earth when a fault occurs is then $3{,}700 \div 17{\cdot}5 = 212$ amperes. If this is not sufficient to trip the automatic switch, the resistance will automatically decrease until just sufficient current passes to cause the switch to break circuit, and this latter current (250 to 300 amperes) should be the maximum which will pass to earth under any circumstances, assuming that the automatic switches work properly.

It is therefore clear that with the carbon powder resistance the greatest current when a fault occurs will be 212 amperes, and the maximum that the automatic switches will have to break will be 300, whereas with ordinary resistances the current in both cases will be anything between 300 and 1,050, and probably will most often be nearer the latter figure.—I am, &c.,

Beckenham, May 3. H. BRAZIL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest the letter which you publish in your last issue from Dr. Sumpner on the neutral line currents flowing between two or more similar alternators coupled in parallel. I have recently had an opportunity of [illegible] these currents in the case of a station containing a number of 2,000 kw. sets. The magnitude of the neutral line current may be surprisingly large; in one case it rose to as much as 20 per cent. of the line current from the machine when coupled to another of different type, though the wave shapes of E.M.F. on the two machines were very slightly dissimilar. The largeness of the circulating current is, I think, due to the comparatively small inductance of the local circuit round which the currents are flowing. I am not quite clear as to what Dr. Sumpner means when he speaks of the inductances of the three branches of the three-phase generator cancelling out. The inductance of the armature due to "armature-reaction flux" will be partly neutralised by the effects of mutual induction, but the inductance of the armature due to "slot-leakage flux" must be constant and is the same, or very nearly so, for all frequencies. I have made a careful comparison between the E.M.F. waves in the case I have referred to above, and I estimate that the total triple frequency voltage cannot have been much greater than 3 per cent. of the full voltage of the machine. Taking this figure, I get a value of the reactance for the armature seven times the resistance, which is a reasonable figure. The largeness of the circulating current with such a small difference between the two E.M.F. waves is most interesting. The only harmful effect of these currents is the tendency to overheat the armature coils, though, as Mr. Peck has pointed out in a letter to one of your contemporaries, the actual heating effect as compared with that due to the main armature current is unusually small. In the case I have mentioned, where the circulating current per phase was 20 per cent. of the main current, the extra heating effect at full load will only be 4 per cent. of that due to the main current.

I was further interested in Dr. Sumpner's letter from the recommendation that he makes as to the best method of getting rid of these currents, since it was precisely the same as the suggestion I made in an unpublished report written at the beginning of April. The same suggestion has also been made by Mr. Peck in a letter to which I have already referred. It seems obvious that an inductance must be the best method of getting rid of a high-frequency current; that is, that it must be more effective than a resistance, for the same purpose. A drawback to its use is that, if there is any out-of-balance current, it would act as an additional apparent inductance to the armature and thus tend to spoil the pressure regulation. With a power station feeding sub-stations the out-of-balance current is always negligible, and hence the use of an inductance coil should not prove harmful. The ideal plan would be to have a circuit for the neutral currents coming from the feeders, which was resonant for the main frequency, but which would present a great impedance to local currents of triple frequency. There seems, however, so little possibility of serious harm resulting from these triple frequency currents that a circuit of this kind would probably give more trouble than it was worth. One fact which is worth noting is that two machines of exactly similar type may produce no triple frequency currents when they are running at the same power factor, but when the excitation of one of them is altered so as to change the power factor, quite large circulating currents (almost entirely of triple frequency) will flow. Sometimes harmonics as high as the 21st are present, but these are relatively unimportant.—I am, &c.,

E. W. MARCHANT.

The University, Liverpool, May 3.

THE THIRD RAIL IN ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is impossible to allow the statements *re* the third rail made by Mr. Dawson in your issue of April 16th to to pass without comment, since if the statements made by him in the preceding articles of the series are equally biassed the value of an otherwise excellent treatise on electric traction on railways is greatly diminished.

The single-phase system, the three phase system and the third rail system are each of value in their proper applications, but none of these systems are of universal application to every problem of steam railway electrification: the third-rail system has proved itself, both in this country and in the U.S.A., to be eminently suitable for suburban electrification, and it is the

universal experience of those engineers who have had to operate lines equipped with third rail that the objections raised by Mr. Dawson, by that chief engineer of an important English railway, and by Mr. Williams are purely imaginary.

Dealing with the objections seriatim : In three out of five cases of derailment the third rail is undisturbed ; in cases where it is disturbed, the disturbance is confined strictly to the immediate locality of the wreck ; the disturbed third rail can be reinsulated temporarily, or cut out completely, in a few minutes with the ordinary tools carried by every railway breakdown crew.

The packing of line can be done, and is done daily, on every third-rail railway without risk. I enclose a photograph which speaks for itself. [This shows such operations in progress on the Albany & Hudson Railway.—Ed. *E.*]

Material for repairs and renewals can easily be unloaded at any time ; it is not compulsory to unload it on to the third rail. The third rail is fixed in numbers of stations and sidings both here and in the U.S.A., which are used as much by steam trains as by electric trains, and yet no serious accidents have occurred.

In the case of a heavy fall of snow sufficient to cover the third rail, brushes fixed to the shoe beams easily remove it. Such snow falls are rare in this country ; in America, however, heavy snow falls are common and are easily dealt with. A more serious difficulty in a snow fall is that of the car wheels failing to make contact with the rail.

As regards structural alterations to platforms to permit of the installation of a third rail, the necessity for running the third rail on the platform side is far from obvious, and, to a railway man, it would seem improbable that many platforms encroach on a line 18 in. from and 3 in. above the running rails.

Signal rodding is not as a rule run on the sleeper ends, and the writer has, in the course of fairly extensive railway travel, seen very few places where the installation of a third rail would involve appreciable alteration to signal rodding. Again, water and gas mains do not, as a rule, run so close to the running rails as to foul a third rail.

Reverting to the case of wrecks, as dealt with generally on page 11 of your issue of April 16th, it is impossible to glean whether these remarks are Mr. Williams's or Mr. Dawson's, but the conditions pictured are not those in this country. Single-line working is the usual method adopted when one road is blocked by a wreck ; few railways have room to run a temporary track round a wreck blocking both roads, and, in any case, the wreck would be cleared before the necessary points and material could possibly be obtained. No railway operator would ever contemplate bringing up a crane to a wreck by any means except steam, or would use any crane except a steam crane, particularly if the use of an electric crane and an electric locomotive involved the possibility of the wreck having brought down the whole overhead structure on the presence of which the possibility of current supply depended.

How a third rail could hide dwarf signals is a puzzle, and, again, derails need not derail the train on to the third rail.

Finally, the third rail has this great advantage over an overhead conductor, that it can be inspected, and, with very ordinary precautions, repaired, while traffic is running ; and, indeed, this is done daily on every third-rail railway.

Mr. Dawson should make a careful inspection of some of the third-rail systems in this country, after doing which I am sure he would be the first to acknowledge that his present impressions are erroneous. RAILWAY ENGINEER.

We have submitted the above letter to Mr. Dawson from whom we have received the following reply :—

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In reference to the letter signed "Railway Engineer," regarding the articles I am contributing to your columns, there are a few points to which I should like to refer.

The criticisms on the third rail to which he objects are those of two railway engineers, the first the chief engineer of one of our large railway companies, than whom, probably, few have had greater experience in constructing and maintaining permanent way, signals, bridges, station platforms, &c., in this country ; the other, Mr. Williams, as far as I know an independent American engineer, not connected with, or interested in, any electrical manufacturing concern.

No one has, or can, doubt that the continuous-current third-rail system has given very good results in the past, and I have always been a staunch upholder of it against systems such as the three-phase and the Ward-Leonard, where these have been proposed for dealing with suburban traffic. It is the hard facts with which I have been faced when dealing with railway electrification which have brought me to adopt the single-phase system for the electrification of the South London line of the L.B. & S.C. Railway Co., and I think I can go as far as to say that, had there been no other alternative but the third rail, the electrification on this line would never have taken place.

I should like to take this opportunity of saying that the details involved in third-rail construction and examples of its application have been most carefully investigated and considered by me, and will form, I hope, not one of the least interesting chapters of my book on "Electric Traction on Railways" now in the press.

As regards the objections to the third rail which your correspondent derides, they are those which have been made to me by English and Continental railway engineers of great experience, and no simple denial that such difficulties do exist will obviate them. The great advantage as regards maintenance, which your correspondent alleges exists in the case of the third rail, appears to me to be of minor importance, and and I do not fear comparison with the overhead system as such, where it has been properly designed and erected.

Had your correspondent seen fit to sign his name, instead of writing under a *nom de plume*, I venture to think his letter would have carried more weight, and would have been of greater interest to your readers.

I cannot leave this subject without pointing out that Herr Geheimrat Wittfeld, the chief engineer of the Prussian Ministry of Public Works, under whom the whole of Prussia's large and excellent railway system is operated, has expressed himself in no uncertain terms, and goes so far as to say that, for railway work, both main line and suburban, only one system can possibly be considered, and that the single-phase system. This expression of opinion has been given after he has had practical experience of both systems, extending over several years, on the third-rail system between Berlin and Gross-Lichterfelde, and on the single-phase system at Hamburg.

In conclusion, I regret exceedingly that your correspondent should suggest that I am unduly biased in favour of any particular system *qua* system, or doubt the spirit in which I have attempted to deal with the very difficult problem of railway electrification, which has rarely been treated at length by any impartial or disinterested engineer. My only interest is to attempt to find a system of electric traction which, whilst possessing all the essential features necessary for its successful operation, should meet, as far as possible, the many objections which most railway engineers, locomotive superintendents and general managers as a rule bring up against railway electrification. My experience has shown me that the third rail and its adjuncts are held in abomination by most railway men, and it is for this reason that I have been brought to adopt the single-phase system. There are no doubt many cases, such as tubes and lines like the District and Metropolitan Railways, where the third rail will give, in future, as it has already done in the past, every satisfaction, and possibly other cases where there may be urgent reasons to adopt it, and I entirely agree with your correspondent that every case must be investigated on its merits, but only by those who are fully acquainted with all the different systems.

I shall be quite prepared, if your correspondent will give me his name, and is open to conviction, to show him lines on which many, if not all, the difficulties I have referred to are to be met with, and for this purpose I should not have to take him to America, or even to the Continent.—I am, &c.,

London, May 3. PHILIP DAWSON.

A NEW SYSTEM OF WIRELESS TELEGRAPHY USED BY THE TELEFUNKEN COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In view of the claims of Count Arco and Dr. Kiebitz, of the Telefunken Company, to the invention of a new system of wireless telegraphy, as published in your last week's issue, we wish, with your permission, to make the following statement:—

In 1892, Elihu Thomson, using metal electrodes, produced a type of discharge intermediate between the spark and the arc, but was unable to obtain either constancy of action or a sufficiently energetic current for practical purposes. These difficulties have been overcome by arrangements described in the patents of Baron von Lepel, which have quite recently been laid open for inspection. His apparatus produces practically uniform electrical oscillations without the use of an arc. It is equally suitable for wireless telegraphy or telephony; it is more efficient than either arc or spark, and the energy supply may be either from a direct or alternating-current circuit.

Baron von Lepel commenced his work on the subject in 1906, at first at his own expense, and later with the assistance of a small private company, and applied for his first patent in the summer of 1907. His inventions were so far developed that in the beginning of 1908 he was able to give the German War Office a successful demonstration of wireless telegraphy on his system between Berlin and Brunswick, a distance of about 120 miles. At that time, however, it was not possible to raise the capital necessary for the further development of his patents in Germany. In the autumn of last year, through the kindness of the British War Office, he was permitted to carry out extensive trials at Aldershot, and gratefully acknowledges the assistance he received from the officers in charge, in the elaboration of a portable station for military use. The apparatus of both stations tested was bought by the War Office, and shortly afterwards this syndicate was formed.

We have at present two experimental stations in England, our German syndicate having three in Germany. We own a number of valuable patents, among which, in addition to the principal patent, may be mentioned those for a tuned receiver, suitable for use in any wireless system, and for a new method of transmitting a musical note.

Shortly after the success of his first experiments, Baron von Lepel approached the Telefunken Company with a view to selling his inventions. Negotiations were, however, broken off by the company, after they had reached an advanced stage. A year later the same firm renewed these negotiations through the agency of the Allgemeine Elektrizitäts Gesellschaft, but they again came to no result. A few weeks ago the Telefunken Company succeeded in establishing wireless communication between Berlin and Vienna by means of the system they call the "singing spark," a performance which elicited a congratulatory telegram from the Emperor of Austria. The Telefunken Company achieved this result with an oscillation generator which differs only in name from that of von Lepel.

Owing to the fact that the details of the Lepel system were shown to them during the protracted negotiations of 1907-1908 it is impossible to speak of their apparatus as an independent invention; it is rather a consciously spurious imitation, which, on publication of the Lepel patents, ceased to have any just claim to originality.—We are, &c.,

THE LEPEL WIRELESS SYND. (LTD.).
ADRIAN SIMPSON, General Manager.

5, Albany-courtyard, Piccadilly, W., May 4.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Messrs. The Lepel Wireless Synd. (Ltd.) who are clients of mine, have asked me to forward to you the above statement. They have also promised to give you an opportunity of publishing a technical description of their system in the course of a week or two.

I may say that from personal observation I can testify that the advantages claimed by Count Arco and Dr. Kiebitz for the "singing spark" are just those of the Lepel System; but naturally the Telefunken imitation appears to be inferior to the original in several important respects.—I am, &c.,

34, Norfolk-street, London, W.C., May 4. J. ERSKINE-MURRAY.

WIRELESS TELEGRAPHY IN THE GERMAN ARMY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of April 23rd some remarks on wireless telegraphy in the Territorial Force, in which it is stated that the German Army has up to the present used the Telefunken spark system, but that the Lepel continuous-wave system is coming into extensive use.

Allow me to say that, after severe and exhaustive tests, the Poulsen continuous-wave system was accepted by the German Government two years ago, and the use of the Poulsen system has been greatly extended since then.—I am, &c.,

London, April 29. T. VINCENT SMITH.

THE BREAKING DOWN OF INDUCTION MOTOR WINDINGS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to Mr. Rider's Paper, in which he describes the breakdown of the stator coils of an induction motor with squirrel cage rotor at the time of switching on to the 'bus-bars, I should like to point out one source of trouble which is not commonly known. Apart from the dangers which accompany any switching in of inductive windings, owing to the concentration of the line pressure over a small number of turns, the stator coils of such a motor are subjected to transient mechanical forces which might cause a breakdown.

The method of bringing a squirrel cage motor up to synchronous speed and then connecting it to the line presupposes that an induction motor at synchronism will only take its no-load current. This is correct for the stationary state, *i.e.*, when a rotating field is established, as only then have the various E.M.F.s in the rotor a zero resultant. But during the time which elapses between the closing of the switch and the establishment of the stationary condition the rotor winding can be regarded as a short circuit for the stator coils and a current reaching the magnitude of the single-phase short-circuit current might flow in the windings.

In motors with a big output per pole the ampere-turns in the coils will reach very high values owing to this current rush, and if the end connections are not well supported they will be attracted toward the stator iron, and thereby frequently cause a breakdown. Inserting a reactive coil in series which can be gradually short-circuited is best suited for overcoming this trouble. It ought to be well understood that this current rush, although also depending on the state of saturation of the iron, must not be confounded with the current rush which might occur when throwing in an induction motor with open circuited rotor.

I should add that the same phenomenon is met with when starting a squirrel cage motor by aid of an ordinary starting transformer. For in this case, too, after disconnecting the motor from the fractional voltage taps no field any longer exists and, in throwing it over to full voltage, the field has to build up gradually again. With high-speed induction motors for larger outputs, tremendous current rushes occasionally can be observed. In order to avoid these it is imperative not to disconnect the motor from the line when changing from one voltage to another.

Those further interested in the matter will find in an article published by me in the "Zeitschrift fur Maschinenbau und Elektrotechnik," XXVI., Jahrgang, Heft 3, oscillograms showing the current rushes.—I am, &c.,

Berlin, May 3. LIONEL FLEISCHMANN.

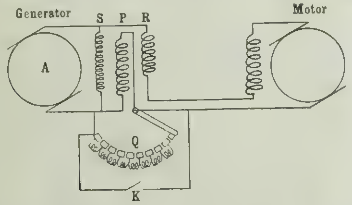
NEUTRALISATION OF REMANENCE IN GENERATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of last week, April 23rd, you described a starting machine with a device for the neutralisation of remanence for use in the Ward Leonard system, which has been patented by the Felten & Guilleaume-Lahmeyerwerke A.-G., of Frankfort-on-Main. The North German Automobile Works of Bremen, with which the writer is connected, have for some time made extensive use in their benzine electric

automobiles of the Kriéger system of control, which attains the same end very simply and has the advantage of greater flexibility in adaptation over the system you describe, as it reduces the controlling gear to its minimum.

As shown in the diagram, A is the generator driven by a benzine motor. This generator is provided with three separate field windings, a main series winding, shown at R, a main shunt winding shown at S, and an auxiliary series winding, shown at P. This latter is wound so as to oppose the action of the two other field windings. Under full load conditions the small diverter Q is short-circuited on the auxiliary winding, thus causing the latter to be inactive. To slow down, the switch K is open circuited, the full current flows through P, and as this winding is rated very highly a powerful demagnetising effect is obtained, which quickly reduces the voltage and brings the motor to rest. To start again it is necessary to remagnetise the generator field. This is very simply done by closing the lighting battery momentarily on the winding R. A very slight amount of power only is necessary as the generator immediately builds up for itself.



It will be noticed too, with this method, that speed regulation is made very simple. On a gradient, for example, the diverter resistance is diverted, the benzine motor is allowed to run at a higher speed but the generator voltage is not increased. Thus the motor now gives an increased torque without increase of speed which is just what is desired.—I am., &c.,

Bremen, April 28. P. A. Mossay.

ELECTRICAL TRADES' BENEVOLENT INSTITUTION.

On Friday last week the first annual general meeting of this Institution was held at the Hotel Cecil, London, and was presided over by Sir William Preece, K.C.B., F.R.S.

Mr. W. Davenport (secretary) read the report on the past year's work, which stated that the year had been one of considerable activity in different directions. The Manchester Exhibition had proved successful, and a sum of about £350 was coming at an early date to the Institution. It was felt that the announcement of that sum, together with others, could be most appropriately made at a festival dinner, and a committee was appointed to arrange that function. A special collection both before and at the dinner was made, resulting in the receipt of over £660, so that there had been an increase of the funds of the Institution of over £1,100. The dinner, apart from its immediate direct results, was a great success, and may be regularly repeated in the future. During the year two cases of relief came before the committee, and, both proving deserving ones, were promptly attended to with most satisfactory results. Other cases were now before the committee for consideration. The invested funds were sufficient to pay one or more pensions, but by the rules no pensions can be allotted before next year. They had had to relinquish the offices at 2, Queen Anne's Gate, Westminster, S.W., kindly loaned free of all charge by Mr. C. S. Northcote, but there was every probability that the Institution of Electrical Engineers would, in its new home on the Thames Embankment, provide accommodation for meetings in connection with this Institution, also free of charge. The executive offices remain at Ridler-place, Blackfriars, S.E. The committee took the opportunity of thanking Mr. Northcote for kindly providing them with office accommodation. The thanks of the Institution were also due to the Press for support on many occasions. The Olympia Electrical Exhibition Fund, in which the Institution had a contingent interest, would fall in in March, 1911, and would amount to about £400. As mentioned in the report, a sum would accrue to the fund almost immediately from the Manchester Electrical Exhibition, 1908, of about £350, making the funds in hand or certain to accrue £2,464.

Sir William Preece proposed the adoption of the report, and expressed his regret at having been unable to be present at the dinner. He was bound to confess that, although he heard on all sides sounds of satisfaction and success at the dinner, it would have been even more cheerful if there had been a greater number present and the subscriptions had been larger and more numerous. However, they had made a start, and could hope that in successive years there would be an even more satisfactory response. He had been associated with the electrical industry now for 57 years, and if he only lasted until 1912 he would be able to celebrate his diamond jubilee of service as an electrical engineer. That would be a unique position, and he confessed he felt proud of it, and also of the fact that he had been associated, either directly or indirectly, with nearly every branch of electricity for engineering purposes. Like any other business and industry, it was subject to periodical changes. There was a time of joyous success and a time of depression. It was now gradually passing from the latter stage, and therefore the future could be looked forward to more hopefully. He thought the depression was not solely due to bad trade, but much of the misfortune they were now undergoing was the offspring of Parliamentary action. They had suffered from the very opposite treatment from what they ought to have received from those who had brought them into existence. Despite this treatment, the success of their industry was so great that at the present time there was somewhere about £370,000,000 invested in the electrical industry. It was, however, a difficult thing to get money for any new electrical enterprise. As to the Electrical Trades' Benevolent Institution, the field of the Institution was to look chiefly after those who were not, and could not be, members of trade unions. Their purpose was to provide for a rainy day. They wanted to encourage thrift and to avoid in the Fund the effect of charity. He thought that everybody who at any time was likely to receive assistance from the Fund should be a contributor in some form or other, and that the Institution should be as self-supporting as possible. Every branch of skilled labour had its own trade union to support it in times of stress. What they wanted to do was to provide something for the administrative and clerical side of the industry. They had a capital of £2,464, and he did not see why in time that should not be tens of thousands.

Sir William then proposed a vote of thanks to Mr. W. M. Mordey for his courtesy in presiding at the festival dinner, and to Mr. R. K. Gray and Mr. J. H. Rosenthal for their assistance as vice-presidents.

The motion was carried unanimously.

The retiring members of the committee of management, Mr. H. H. Berry, Mr. H. Bevis, Mr. Guy Burney, Mr. E. J. Clark and Mr. Justus Eck, were then re-elected, and the following were elected as new members: Sir Irving Courtenay, Mr. T. E. Gatehouse, Mr. R. J. Wallis-Jones, Mr. E. Garcke, Mr. W. B. Esson and Mr. G. Skinner.

Messrs. Hextalls were elected hon. solicitors to the Fund, and Mr. Henley Smith was re-elected auditor.

In a general discussion which followed, Mr. Geo. Tucker suggested that the rule relating to the qualification for membership of the Fund should be more clearly defined. The rule as it stood provided that applicants must have been subscribers for five years, and have been engaged in the electrical trade. That was a very wide qualification, and he thought something ought to be done to define the connection of subscribers with the electrical trades, which would entitle them, if the occasion arose, to apply for assistance from the Fund. The rule, as it stood, did not exclude the skilled labourer or the trades unionist.

After discussion, it was agreed that the matter be put before the committee for consideration.

The proceedings terminated with a vote of thanks to Sir William Preece for presiding.

With a view to encouraging subscriptions and donations to the Electrical Trades Benevolent Institution we make the following extract from the rules, and we shall be pleased to either forward subscriptions to the Institution or to answer inquiries:—

Object.—Rule 2.—The object of the Institution is to grant pensions and to dispense temporary relief to deserving and necessitous persons who are or have been engaged in the electrical trade in the United Kingdom, or to their widows and families.

Qualification for Pensions.—Rule 3.—Applicants must have been subscribers for at least five years, and have been engaged in the electrical trade. Must not be less than 50 years of age, unless it shall be proved to the satisfaction of the committee that, although less than that age, they are incapacitated from earning a living by reason of mental or bodily infirmity. Widows of subscribers who are in necessitous circumstances during widowhood. No one shall be eligible who may be in receipt of indoor parish relief.

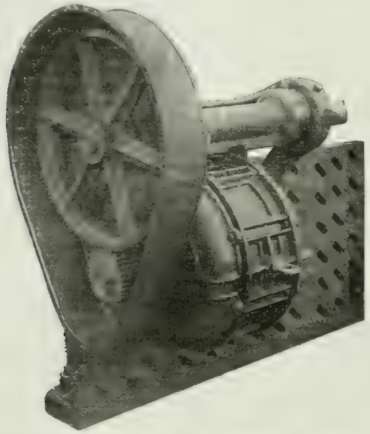
Temporary Relief.—Rule 4.—The committee may from time to time make immediate grants of money out of the funds of the Institution to relieve temporary or urgent necessity occurring amongst deserving persons who are or have been engaged in the electrical trade, or amongst the children or widows of such persons, but no grant shall exceed the sum of £20, and the names of the persons so relieved shall not be published.

BACK GEAR CRADLES FOR B.T.-H. MOTORS.

In some applications of the motor drive it is necessary to have a considerable speed reduction between the motor and the driven machine, and also to have the whole arrangement as compact as possible. A positive drive is besides sometimes essential. These conditions are fulfilled by using spur wheel reduction gear, which is more compact than a belt drive, and more efficient than worm gearing.

The British Thomson-Houston Co. has developed a special method of applying back gear to small motors, which, it is claimed, requires no alteration to the motor itself other than fitting a pinion to the

shaft and two dowel pins to the feet. The device as shown in the accompanying illustration consists essentially of a strong cast-iron cradle, to the base of which the motor is bolted. Two brackets, one at each end of the cradle, support a bearing housing for the countershaft, and a sheet-iron case to enclose the gear wheels. The base of the cradle is machined flat above and below so that the motor can easily be set with its shaft exactly parallel to the countershaft, and the outfit is mounted on slide rails when used in connection with a rope or belt drive. The countershaft bearing housings are made in one piece to ensure accurate alignment, and can be rotated in the cradle brackets to allow of the cradle being fixed in various positions. The motor end shields can also be rotated, so that the whole can be mounted on floor, ceiling, or wall. In the latter case the motor may be either above or below the countershaft. Cast-iron bearings of liberal dimensions are provided for the countershaft. They are lubricated by means of oil rings, and fitted with oil overflows and drain plugs. To ensure smooth working and long life, the teeth on the cast-iron gear wheels and steel pinions are accurately machined. Black fibre packing pieces are interposed between the



B.T.-H. Motor and Positive Gear Cradle.

gear case and the cradle, and these, together with correctly designed and well-made gears, reduce the noise to a minimum. The side of the gear case can readily be removed for inspection of the wheels without disturbing any other part of the equipment. The back gear cradles are made in different sizes, suitable for various B.T.-H. motors, continuous and alternating current.

THE IMPROVEMENT OF POWER FACTOR IN ALTERNATING CURRENT SYSTEMS.

At a meeting of the Birmingham Local Section of the Institution of Electrical Engineers on April 21st two Papers were read and discussed. An abstract of the first of these, on "Manipulation of Telephone Dry-core Cables," is given elsewhere in this issue. The second was by Mr. Miles Walker, on "The Improvement of Power Factor in Alternating-Current Systems," and had previously been read and discussed before the Manchester Local Section, an abstract of the Paper appearing in our issue of January 22nd last, and of the discussion in our issue of January 29th. We give below an account of the discussion at Birmingham :—

Dr. Sumpner considered that there were two possible ways of improving the power factor of an alternating-current machine: (1) By means of compensators (this method was rather theoretical, because compensators could not be made cheap enough; (2) by some special kind of machine, such as the one described by the author. All successful examples of these methods were those which were directly attached to the machine which was to be compensated. This was an unfortunate fact, because if these machines could not be made on a large scale to compensate the whole system at once the commercial advantage would be comparatively small. Being fixed to the motor the difficulty was greater. Generators tended to become larger, motors did not. The scheme was a means of inducing by a dynamo with low frequency excitation, an E.M.F. of the right frequency into the rotor. The important point, which had not occurred to him until it was mentioned by Mr. Walker, was that in order to produce the right amount of compensation for a particular machine they had to induce a certain number of kilovolt-amperes, and the number depended entirely upon the frequency. The whole question was one of cost. What was the cost of the compensator as compared with the machine ?

Mr. A. M. Taylor pointed out that the compensator machine could not be used in mines and such places on account of the sparking. Also, that although the device improved the power factor of the current taken by the motor, yet it did not allow for the power factor of the whole system being brought up to unity. Had Mr. Walker any suggestions for getting over that ?

The Chairman, Dr. G. Kapp, referred to the statement that "the induction drop in mains is also increased when the current lags, &c." He found that the reactive drop was not 18 per cent., but only 15 per cent. It was 18 per cent. if he took the delivery pressure. He considered that the author had taken the complicated method of Leblanc and worked it out practically. He was afraid that even now it was only practical as applied to very large motors. Such motors could be built with a power factor of about 0·96. This was not much to cavil about, and it was doubtful whether the 4 per cent. was worth Leblanc's methods ; but it was worth the arrangement of the author, which was much cheaper. He agreed that it was a commercial subject. They would be interested to hear—perhaps in a future Paper—what were the practical results obtained with the machines which the author was now building. It would be a great advantage if he could get the apparatus fitted to small motors, and still more important if it could be attached to a single-phase motor.

Mr. Miles Walker, in reply, thought it was too early to speak about prices, although he could speak positively about results. When machines came to be manufactured on a commercial scale, deductions as to what the cost would be could then be made. It had been said that the compensators could only be used in conjunction with large motors. But if they had a number of motors in a mill where there was a large motor and several small motors, they could get a current from the large motor that would compensate for that taken by the small ones. It was essential that any improvement of the power factor must not be accompanied by sparking, and the machine must require practically no attention. When this had been attained he thought that there would be considerable use for it. As to the size of the commutators, the one they were building was for an 800 H.P. motor and was about 9 in. diameter. The mere fact that they had an open-circuit armature did not mean that they would be troubled with sparking. In further reference to Mr. Taylor's remarks, the author pointed out that it was possible with the compensator machine, not only to bring the power factor to unity, but also to take a leading current, and in this way bring up the power factor of the whole system. As to the chairman's reference to his figures, Mr. Walker said that these were approximate results. There would always be a certain amount of ohmic drop, but the total drop might be less than 18 per cent., as had been stated. He thought it would be possible to apply the method to a single-phase machine.

THE POST OFFICE TELEGRAPH STAFF.

The retirement of Mr. J. W. Willmot, I.S.O., M.Inst.C.E., from the position of Controller of the Post Office Telegraph Factories took place on May 1, and marks the close of a useful career, extending over a period of 49 years, in the service of telegraphy. Born in 1849, Mr. Willmot was educated at a school presided over by Mr. Penley (father of the famous comedian), and entered the service of the Electric & International Telegraph Co. in 1862, receiving a thorough training in the company's workshops. It was not long before he became attached to the Engineer in-Chief's department as one of the technical officers, and in this position served under Mr. Latimer Clarke, Mr. Cromwell Varley, Mr. R. S. Culley and Sir William Preece, being transferred to the Engineer-in-Chief's department on the acquisition of the telegraphs by the State in 1870.

Mr. Willmot was intrusted with the important work of installing the first pneumatic tube system at the General Post Office, which necessitated not only a knowledge of pneumatics but also of engines and boilers. He subsequently installed similar systems of less magnitude in the principal commercial cities of the provinces.

In 1880 Mr. A. Stroh, who had been supplying the Post Office with automatic and A.B.C. instruments invented by Sir Charles Wheatstone, signified his intention of retiring from business, and in order that the body of skilled workmen whom Mr. Stroh had trained should not be dispersed, his workshops were taken over by the Government, and Mr. Willmot was selected to make the necessary arrangements and to be superintendent of those shops. He continued to hold the position of superintendent of the instrument factory until a rearrangement brought about the creation of the position of Controllers of Factories, to which position he was appointed in 1902.

Mr. Willmot's abilities as an engineer were recognised some years ago by his election as a member of the Institution of Civil Engineers, and he also holds a Diploma of Honour from the Chicago Exhibition for skill as a designer. The appreciation of his services to the State was marked by the conferring upon him of the Imperial Service Order.

In the early days of telegraphy Mr. Willmot designed a single and double sluice valve for use in the pneumatic system, by which carriers conveying the messages were rapidly inserted and removed from the tubes and the necessary vacuum or pressure turned on. Another of his inventions was an intermediate signaller, by which the carrier, having passed a certain point, actuated the apparatus which signalled to the sending station that the distance had been covered, and that, therefore, it was safe to insert a second carrier. This was somewhat on the lines of the block system on railways, and resulted in a considerable increase in the working capacity of the tube. On the telegraph side Mr. Willmot invented a magnetic bias for the high-speed Wheatstone transmitter, a hollow punch for perforators, and a pneumatic motor for the Hughes instrument, besides which numerous instruments have been improved in certain details by his practical knowledge and originality.

In retiring from the public service Mr. Willmot takes with him the best wishes of a great number of friends in the Post Office and outside who have been associated with him in his work.

Mr. Willmot is succeeded in his position of Controller of Factories by Mr. W. G. Hinton.

PARLIAMENTARY INTELLIGENCE.

Electric Lighting Acts (Amendment) Bill—On the report stage of this bill in the House of Lords yesterday (Thursday), Lord Hamilton of Dalzell moved to insert the following new sub-section: A company, local authority, or body receiving a supply of electricity under this section shall not use the electricity in such manner as to cause, or to be likely to cause, any interference with Government observatories or laboratories, but this sub-section shall not apply to any such company, local authority, or body who by any Act of Parliament or order confirmed by or having the effect of an Act of Parliament containing provisions for the protection of such observatories or laboratories, are authorised to use electricity for the purposes for which a supply is authorised to be given under this section.

Submarine Cables and Trawlers.—In the House of Commons on Tuesday Mr. J. P. Boland asked the Postmaster-General whether he was aware that the cable repairing ship "Buccaneer" had lately repaired two breaks in one of the main transatlantic cables, at distances of 54 and 58 miles respectively, from Waterville, and that the damaged parts of the cable which were recovered proved conclusively that the breaks were caused by trawlers; and whether, seeing that no less than 11 trawlers were reported as operating in the immediate vicinity of the repair, he would take any, and, if so, what steps to prevent this destruction of private property in time of peace.

In reply, Mr. S. Buxton said that it had been reported to him that injuries to one of the transatlantic cables had recently occurred in the locality mentioned, and that they were attributed by the Cable Co. to trawlers. He appreciated the seriousness of those interruptions, and he trusted that the steps which it was proposed to take with a view to minimise them would prove effective. In consultation with the President of the Board of Trade, he appointed a Committee last summer which carefully investigated the whole question. The Committee had before it a proposal made by certain of the cable companies that trawlers should be excluded from an area extending some 70 miles from the shore, in which damage attributed by the companies to trawlers had occurred, The Committee considered that proposal impracticable, a view in which His Majesty's Government concurred. It had reported, however, in favour of an alternative proposal made by certain cable companies for the inspection of trawling gear, and steps were now being taken to give effect to the recommendation. An inspector had been appointed, and the matter was before the Treasury at present.

LEGAL INTELLIGENCE.

Seebold v. Page & Miles.

Last week Mr. Justice Bucknill commenced the hearing of an action for damages for alleged breach of contract. Defendants denied the breach and counterclaimed for £25. 6s. 8d. for work done and materials supplied.

Mr. Low, K.C., said plaintiff (lessee of the Worthing Theatre Royal) was taking electric current from the local electricity department. Later, negotiations were opened with defendants for putting down independent generating plant. Several estimates were submitted. Plaintiff had also been in communication with Tangyes Limited and, subsequently, a fourth estimate, which was the foundation of the contract, was submitted by defendants. There was a dispute as to whether or not Tangyes' specification accompanied that estimate. The tender, however, did not provide for a Tangye, but for a National gas engine, and plaintiff was told that the same conditions applied to it as to Tangyes' as to simplicity of working, &c. The estimate (dated July 31, 1906) was for £410, subject to $3\frac{3}{4}$ per cent. discount for cash within one month of delivery; and it provided for supplying, fixing and erecting on plaintiff's foundations one 34 H.P. National gas engine (with magneto ignition, starter, tanks, &c.) one National suction gas producer and one Crompton dynamo (80 to 85 amperes at 250 volts). That tender was accepted, and the work completed in January, 1907. There was from time to time considerable trouble with the belting connecting the engine with the dynamo, and there were also, it was alleged, several gas explosions. Ultimately, plaintiff, who all along had acted on the advice and suggestions of defendants and their manager, called in expert assistance. He did not find fault with the engine, the dynamo or the gas producer, though he did not think they were really of the latest or most effective kind; but of the way in which the plant was put together and the way in which the various accessories were constructed by defendants. Since certain alterations had been made the plant had worked smoothly and had done its work satisfactorily. Plaintiff consequently complained that defendants had not, under the terms of their contract, installed plant fit, proper and suitable for lighting the theatre.

Plaintiff gave evidence in support of his claim, but in cross-examination admitted that having laid down the plant the Corporation had offered to supply him at 4d. per unit instead of 6d. It was likely the dynamo was returned to Messrs. Crompton & Co. in a very dirty condition, and the young man whom he employed as electrician had previously had charge of the electric machinery of some "roundabouts." He did not know that defendants complained of the way the exhaust pits were constructed.

Alfred Hughes, employed by plaintiff to look after the plant, attributed the cause of the explosions to misfiring of the magneto and there was not sufficient allowance made to enable the gases to get away. He had had no experience of gas engines until he took over plaintiff's machine.

Mr. Robert Woodley, who was instructed to examine the plant, said that it was in fairly good condition. Had plaintiff been properly advised he would never have put down such a plant for the lighting of his theatre. The best plant for the purpose would have been a direct-coupled plant. In cross-examination he said that exhaust pits were condemned by the whole engineering world. He did not know that plaintiff used for a time ordinary household coal. The engine was built for anthracite coal. He had not altered the foundations of the engine at all. He suggested that the original belt was bad, and not large enough for the work it had to do.

For the defence, Mr. Geo. Phillips, for many years in defendants' service, said he submitted various estimates to plaintiff in regard to the work, and the fourth estimate was accepted. The plan put in showed all the work that was done by the builder, and a plan was left at the works all the time they were on. The whole of the work was carried out in accordance with the plan. While he was there the machinery worked satisfactorily in every way. He ran it for about three weeks. Plaintiff never expressed dissatisfaction then. Plaintiff took possession of the machinery in May and paid the balance of defendants' account.

Capt. H. R. Sankey said that, in his opinion, there was nothing to show that the plant had been badly installed, but it had not been properly looked after. On examining the dynamo he found the field magnets were in a dirty condition. He did not agree with the suggestion that the narrowness of the belt had necessitated such a high tension that the armature spindle of the dynamo had been pulled sideways owing to the wearing of the bushes. In cross-examination, he said that in plaintiff's design there was no iron silencer at all. It was called an exhaust pipe. The pits were the silencer. He did not think that the width of the belt was of any importance at all in that particular case.

Mr. George Phillips, local manager of defendants at Worthing, was re-called and further cross-examined by Mr. Low. He said that the suggestion to have the pits was made by the Naitonal Co. He knew that there were other means of silencing besides doing it by pits. He never gave plaintiff any opportunity of choosing whether he would have pits or other means of silencing. He did tell plaintiff that the National Co. said that iron covers were necessary. He quoted him £18 as the price of the iron covers.

The case had not concluded when we went to press.

Bristol Gas Co. v. Bristol Tramways Co.

Last week Mr. Justice Phillimore heard a special case stated by an arbitrator for the opinion of the Court.

Sir Alfred Cripps, K.C., said the question raised depended upon a point of construction, all the facts answered having been found by the arbitrator. The question was whether, as the tramway lines were laid down in Bristol, certain inconvenience and additional expense were thrown upon the Gas Co. when they went to deal with their mains for repairs, &c. The arbitrator had found partly in favour of the Gas Co. and partly against them. A clause in the Tramway Act provided that any additional expense imposed upon the Gas Co. by reason of the existence of the tramway in any road or place where any such mains, pipes, &c., should have been laid before the construction of the existing tramway, should be borne by the promoters. The first contention was that that proviso only applied to additional expenses, where there had been actual interruption of their tramway traffic. The arbitrator found in favour of the Gas Co. on that point. The other issue was that the Gas Co. claimed they were entitled to additional expenses when it was thrown upon them by reason of the existence of a tramway in a road which should have been laid before the construction of the tramway. On that issue the arbitrator found against the Gas Co. The Gas Co. claimed £115, and the arbitrator gave them £37. Counsel contended that, as the Gas Co. was the first comer, having prior legislative powers, they should

not be put in a worse position than the second comer, the Tramways Co. who had subsequent legislative powers.

Mr. Simon, K.C. (for the Tramways Co.) denied that the tramway service had caused the interruption alleged by plaintiffs to the work they desired to carry out, and further that they should have given the Tramways Co. proper notice when they desired to work on any pipes underneath the tram rails. Had they done so, defendants would have been able to regulate their traffic so as to cause plaintiffs a minimum of inconvenience.

His Lordship thought the arbitrator was right and had arrived at a right conclusion on the issues before him. It might be said that the Gas Co. had incurred considerable capital expenditure and were under many statutory obligations and restrictions; therefore it was only fair that they should be allowed to fully develop. The laying of such pipes, in his opinion, must be regarded as new developments on the part of the Gas Co. If the main had to come up, or the position of the main had to be altered, the company would be entitled to any additional expense of the work, or if any existing pipes had to come up they would also be entitled to recover additional expense on that work: but the cost of laying of additional service pipes, which were feeders to new houses, ought to be borne by the company itself, and the Tramway Co. ought to be considered to that extent as being in occupation before the Gas Co. The award must be upheld, and the appeal would be dismissed without costs.

Consolidated Nickel, Tin & Copper Mines v. Crompton & Co.

Mr. Muir Mackenzie, K.C., Official Referee, commenced the hearing of this action by plaintiffs for damages for alleged breach of contract in connection with an electric pumping plant which defendants undertook to erect at plaintiff' mine. It was contended that by a contract in writing in February and March, 1907, it was agreed that Messrs. Crompton should instal in the Wheal Busy Mine, Cornwall, for £1,640, an electric pumping plant for pumping the mine free from water. The installation was to be capable of delivering 1,000 gallons of water per minute against a total head of 120 ft., including friction. Plaintiffs also alleged that it was agreed that defendants would deliver and fix the plant and machinery at the mine on or before May 24, 1907, and that in the event of their failure to do so, defendants would pay plaintiffs, by way of liquidated damages for the non-completion of the installation, a sum equal to 1 per cent. of the contract price for every week's delay for the first three weeks, and 10 per cent. for every additional week. When defendants made the contract they were quite aware that under the terms of their licence plaintiffs were bound to instal a pumping plant of the above capacity in the mine by June 20, 1907, and if they failed to do so they were liable to forfeit their lease. In entering into the contract plaintiffs left it to defendants' skill and judgment to supply plant and machinery reasonably fit for the purpose of pumping the water out of the mine, and plaintiffs alleged there was an implied warranty that they would do so. They declared, however, that defendants, in breach of the contract, had failed to deliver the plant and machinery, or to complete the same and set it in proper working order by May 24, 1907; that they had not yet completed their contract, and were liable to the penalties mentioned. Further, that defendants had failed to supply machinery capable of doing the work stipulated, and what they had supplied was not reasonably fit to pump the water out of the mine. By reason of this plaintiffs alleged they had been unable to use the plant, were unable to pump the water out of the mine, and had, in consequence, been unable to win the mineral in the mine.

For the defence, Messrs. Crompton declared that they did deliver the machinery, and that the pump and plant so supplied was able to fulfil—and, in fact, did fulfil—all that was stipulated by the contract. Alternatively, they contended that, if the pump and machinery failed to fulfil all that was required, the failure was due to the negligence of plaintiffs in not providing skilled and competent workmen to work and manage the installation, and was not due to any breach of contract on their part. They counterclaimed £1,040, the balance of the price agreed, plaintiffs having paid only £600 of the £1,640.

Mr. C. A. Russell, K.C., with Mr. Schiller were for plaintiffs, and Mr. Abel Thomas, K.C., and Mr. J. Sankey for defendants.

Mr. Russell, K.C., said: On June 20, 1903, three gentlemen, named Adler, Norbett and Williamson, acquired the lease of the mine in question from Lord Falmouth. The mine since 1866 had been shut down, and it had become filled with water. Before operations could be resumed the various adits or levels had to be pumped out. Under the licence plaintiffs were to search for tin and tin ore and all other metals, &c., for 21 years. They were also bound to procure and have in working order a modern pumping plant as set out by or before June, 1907. In default of so doing they were liable to forfeit their lease. After obtaining quotations from Messrs. Crompton & Co., whom they accepted as being skilled in such matters, they left it to them to propose what would be an efficient plant to instal. After negotiations, Messrs. Crompton suggested that an electrically-driven pump with gas engine would be a suitable plant, and plaintiffs finally adopted their suggestion. The specification which was put forward by defendants, and which was finally adopted, stated that they proposed to supply "a 75 B.H.P. to 80 B.H.P. suction gas engine and producer plant suitable for use with anthracite coal, the engine to be capable of that output at 180 to 200 revs. per min., with heavy flywheel for belt driving." He wished to call attention to the description of the generator. The specification described it as "having stationary armature and revolving field system." The sinking pump, said the specification, was of the turbine multi-stage vertical spindle pattern, direct coupled to one of defendants' standard vertical spindle totally-enclosed three-phase induction motors, 55 H.P., running at 1,456 revs. per min. on a 550 volt 50 cycle circuit. This pump might have been all very well had it had a sufficiently powerful motor to drive it, and had all the other portions of the plant been such that the motor could have obtained current which would have been requisite to drive it. But such was not, plaintiffs urged, the case. The whole virtue of the pump depended upon whether it was properly driven. Plaintiffs contended that the pumping set as a whole was not capable of performing the duty allotted to it, and their complaint was directed principally against the motor. In one of their letters defendants told his clients that they had "put forward" a three-phase alternating-current scheme because, with this arrangement, there would be no commutator or rubbing contacts whatever on the motor and no attention would be required for the electrically-driven sinking pump other than lubrication. That showed beyond a doubt that plaintiffs left it to defendants to put forward the plant they thought would be the most suitable and efficient. Defendants placed a great deal of the work with sub-contractors, and whether it was through defective arrangements with those sub-contractors or not he could not say, but on May 24 only a portion of the plant was on the site. Considerable correspondence ensued, and plaintiffs got very anxious, because they began to run a risk of losing the lease by a breach of its conditions. However, they managed eventually to get the lease extended, but progress was retarded by a series of breakdowns. A man named Craig, who was in charge of the work on behalf of the contractors, with his assistants, tried their best to get the plant to run, but unavailingly. Plaintiffs were advised that they had not got what they had stipulated for from defendants, and therefore they commenced the present action.

Mr. E. H. Williamson, manager of the mining company, said plaintiffs gave defendants thoroughly to understand the importance of having the plant installed and working by a certain date. No suggestion was made as to what plant should be used; they left that to Messrs. Crompton & Co., who proposed putting in electric plant. He could not say when the plant did actually arrive, but he thought the last piece of machinery came about July 23. Negotiations with some French engineers fell through, and the mine was not unwatered sufficiently to commence work in it until March, 1908. He did not think it had ever been unwatered completely, generally speaking. He agreed that the specification stated that defendants intended to supply a "sinking pump of the turbine multi-stage vertical spindle type, to deliver 1,000 gallons of water per minute against a total head of 120 ft., including friction." By that he did not understand that the head of 120 was an "ideal head," and that it would not raise it because of the friction. The contract said "including friction," and therefore he took it to mean that the head of water was a real head, and not an ideal one. However, he was not an engineer. Plaintiffs' electrical engineer, Mr. Garner, sent them reports of the working of the motor, &c., and that gentleman eventually advised them that it would not be safe to pump to the full depth of 120 ft. If they did the plant might break down, and so they issued instructions that the water level should be kept at about 90 odd feet.

The case was proceeding when we went to press.

Macaulay and Wife v. Great Northern, Piccadilly & Brompton Rly. Co.

The Court of Appeal (the Lord Chief Justice and Lords Justices Moulton and Farwell) on Thursday last heard this appeal of plaintiffs from a judgment of Mr. Justice Lawrance, after trial with a special jury. The action was brought to recover damages for personal injuries. On April 12, 1907, plaintiffs entered one of defendants' lifts at Holborn station, but after the cage of the lift had risen a few feet a man named Tomlinson fell from the top of the shaft of the lift on to the roof of the cage and through the roof into the cage, being killed on the spot. Both plaintiffs sustained serious injuries through being struck by Tomlinson in his fall. The facts were given in The Electrician for Dec. 4 last. The jury found that Tomlinson went to the station on the legitimate business of the company, and as he had not left the company's premises they considered he was in the service of the company, and that the company did not supply reasonably safe appliances to the doors of the lift. They assessed the damages at £750 for the male plaintiff and £200 for the lady. Upon these findings the learned judge entered judgment for defendants, and plaintiffs appealed upon the ground that upon the findings of the jury they were entitled to judgment.

At the conclusion of legal arguments, their Lordships held that there was abundance of evidence to justify the findings of the jury, allowed the appeal, and entered judgment for plaintiffs.

Patent Revocation.—The Comptroller-General of Patents (Mr. Temple Franks) has given his decision on the application for the revocation of letters patent No. 4,391 of 1904 on the ground that the patented process was carried on exclusively or mainly outside the United Kingdom. The patent was granted to Dr. E. Weber (of Schwepnitz, Saxony) for "improvements in the preparation of clay for the casting of clay ware."

In giving his decision, Mr. Temple Franks said it was admitted that the "patented process" was in use in 14 or 15 factories in Germany and Austria, two in Sweden, one in Belgium and one in America, and that it was not in any way used or carried on in this country. The patentee was, therefore, confined to resisting the application on the ground that he could give satisfactory reasons why the process was not carried on to an adequate extent in the United Kingdom. The reasons given were that the patentee had made repeated efforts to sell or licence the patented process in this country, that he had treated this country fairly and had

not given any preference to Germany or other foreign countries, that the failure to work here was due to "the conservatism of English manufacturers," and that he had now entered into a bona fide contract giving an option to purchase the patent rights for England. He was not wholly satisfied with the evidence adduced in support of those allegations, and he had decided to revoke the patent—not forthwith, but on Dec. 31 next, unless in the meantime it was shown to his satisfaction that the patented process was carried on to an adequate extent in the United Kingdom. From the evidence it appeared that there was a bona fide mistake in the way in which the patent rights were offered to purchasers in this country. Taking into consideration all the circumstances of the case, he gave no costs to either side.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant engineer is wanted by Liverpool Corporation to take charge of erection and maintenance of overhead equipment of electric tramway. Salary, £250 per annum. Applications to the resident electrical engineer, 24, Hatton-garden, Liverpool. See an advertisement.

The appointment of lecturer in the physics and electrical engineering departments at the Sunderland Technical College is now vacant. Salary £150 per annum. Applications to the Secretary, Mr. T. W. Bryers, 15, John-street, Sunderland, before Monday, May 31. See also an advertisement.

An engineering master (mechanical and electrical) is wanted in September next by the Plymouth Education Authority for their science, art and technical schools. Forms of application from Mr. E. Chandler Cook, 18, Princess-square, Plymouth.

Coventry Corporation require a station superintendent. Commencing salary £3. 3s. per week. Applications to the manager by 15th inst.

Blackpool Cleansing committee require an engineer (with experience of mechanical and electrical plant) at their refuse destructor works. Wages 35s. Applications by May 12.

Mr. G. W. Butler, deputy director general of stores at the India Office, has been appointed director general, in succession to Mr. E. Grant Burls, C.S.I. Mr. J. W. Fry succeeds to the position hitherto held by Mr. Butler.

The appointments of Mr. Bemrose and Mr. Bush as chief electrical assistant and junior assistant at Tunbridge Wells have been confirmed.

Accrington.—The Electricity committee will give a 12 months' trial to a bonus scheme for the employés at the Electricity works.

Aston.—On Wednesday the Electricity committee reported that for the year ended March 31 the total income of the electricity department, after deducting discounts and allowances, was £24,565, against £21,140 in 1907-8.

The total working expenditure was £13,273, against £11,414, the gross profit being £11,292, against £9,730. After paying interest the balance profit was £3,156, against £3,083.

The salary of the electrical engineer (Mr. Robert Foster) has been increased to £500 per annum.

Battersea Polytechnic, London.—The special summer classes at this Polytechnic include courses of lectures on testing of materials, engineering drawing office practice, electric traction and high tension transmission, &c. The fees are moderate. Prospectuses may be obtained from the Secretary, Battersea Park-road, London, S.W.

Blackburn.—The profit on the past year's working of the electricity undertaking was about £1,000, but the deficit on the tramways will be about £4,800.

Bournemouth.—Mr. Cecil Barber has retired from the position of works engineer and traffic manager of the Corporation tramways, consequent upon the appointment of Mr. C. W. Hill to the position. Mr. Barber had occupied the position for the past seven years.

Mr. C. W. Hill, chief assistant in the Birmingham Corporation tramways department, has this week taken up his duties as general manager of the Corporation tramways. It will be remembered there were 103 applications for this position, but this number was reduced to 10, and afterwards to a short list of four:—Mr. Hill, Mr. P. J. Pringle (tramways manager and borough electrical engineer at Burton-on-Trent), Mr. F. Ayton (chief engineer and manager of Ipswich Corporation's electric supply and tramways departments), and Mr. C. Barber. A long discussion took place at the Council meeting, and to the motion that Mr. Hill be appointed, an amendment was put that the appointment be given to Mr. Barber, but this was defeated, and another amendment that the matter be referred back to the committee was defeated by two votes. Notice was given of a motion to rescind this resolution, but this has been dropped.

Chelmsford.—The Electric Supply Corporation has been instructed to erect 11 new incandescent electric lamps in the Springfield ward.

Cork Tramways Strike.—For some days there has been a serious strike of the employés of the Cork Electric Tramways & Lighting Co., with the result that the tramway service has been entirely suspended. The following official statement gives the state of affairs at the time of going to press:—

The present position of the strike in connection with the employés of the Cork Electric Tramways & Lighting Co. is practically the same as when it started—that is, the men are still all out, and there are no trams running in the city. The power station, however, is being run by members of the engineering staff and some of the employés who remained loyal at the time of the strike, and the power and lighting supply is being maintained as heretofore. Although there were rumours that there was a possibility of failure of the lighting supply, these are absolutely unfounded, as, fortunately, the company have only recently taken in a very large supply of coal, and are, in consequence, well able to maintain the supply without the slightest difficulty.

We learn that the strike was started without a moment's notice, and this action has considerably minimised any little sympathy which the public might have felt for the men. A conference between the directors and representatives of the strikers took place on Tuesday. Many demands were conceded, but the acceptance was dependant on the reinstatement of the hands, which the directors would not assent to.

Customs Duties.—A list of decisions recently published shows that imports of holders (including handles for portable incandescent electric lamps) into New Zealand are subject to a duty of 30 per cent. ad val (20 per cent. if of British make), and that dynamos, regulators, rheostats, ampere and volt meters, meter bridges (declared to be for teaching purposes), and high frequency apparatus and electrodes used in electrotherapy (British or foreign) are admitted duty free.

Edinburgh.—At the meeting of the Corporation on Tuesday, the chairman of the Electric Lighting committee (Councillor A. A. Murray) moved a recommendation in favour of the acceptance of the tender of the Lahmeyer Electrical Co. for the supply of cables, tender for cables.

He stated that the choice of the committee lay between the offer of the Lahmeyer Co. and one of £6,905 made by a British company. The latter had made a reduction from their first tender.

Councillor Leishman said a firm should not have been allowed to make a reduction after their estimate was in.

Councillor Murray said in a case like that the offer was subject to adjustment and checking of schedules, which accounted for the reduction.

Councillor Lyon said although everyone sympathised with the want of work, it was not their province to interfere. The Lahmeyer Co. had been contractors there for many years and had done satisfactory work.

Mr. Rawson moved as an amendment that the committee's recommendation be not accepted. He said that if there ever was a time when they should consider their own people it was now.

The committee's recommendation was adopted by 35 votes to 9.

Electrical Exhibitions.—Accrington Electricity committee propose to hold an exhibition of electric motors, fittings, &c., in the Town Hall, and the Council are recommended to grant £100 towards expenses.

An exhibition of electric light fittings, electric motors, cooking and heating apparatus, &c., is being held at the Shire Hall, Hereford, between the 10th and 15th inst.

Hereford.—Application is to be made for sanction to a further loan of £8,000 for extensions of the electricity undertaking.

Huddersfield.—At the last meeting of the Council Ald. Woodhead announced that on the past year's working of the tramways there was a surplus of £2,061, compared with £6,514 for 1907-8. The Tramways committee proposed to transfer the amount in relief of the rates.

The committee had set aside £12,387 for depreciation, interest and contribution towards redemption of debt. The reserve or renewals account stood at £35,155. 1s. 3d. He stated that to be able to strengthen the undertaking to the extent of over £25,000 without adding to the annual outlay for interest and repayment of principal, and still to leave between £30,000 and £40,000 as a reserve against contingencies, was a most satisfactory state of affairs.

India.—The "Indian and Eastern Engineer" states that the Calcutta jetties are to be lighted in future entirely by electricity from the Port Commissioners' own power station. It is intended to use "Excello" flame arcs, and the Howrah Bridge lighting is to be included in the scheme. It is expected that about £500 per annum will be saved compared with present cost.

Italy. At a recent meeting the Departmental Traffic Commission at Genoa recently passed a resolution recommending the adoption of electric traction on the Genoa–Spezia State Railway.

Leith.—The Council are to consider a motion to extend the tramways from Seafield to Portobello.

Leyton.—As the Electrical Company refuse to accept the conditions specified as to the cost of carbons for the Blondel arc lamps they offered for trial, the electrical engineer (Mr. F. Harman Lewis) is to draw up a specification of the requirements for proposed new flame arc lamps and invite several arc lamp makers to tender and submit a sample series on approval.

Mechanical stokers are to be fitted to two of the cylindrical boilers on approval, and if they are satisfactory the other two boilers will be similarly fitted.

Liverpool.—On Wednesday the Tramways committee recommended the City Council to apply for sanction to a loan of £11,112 for widening Netherfield-road and the construction of a double line of tramways. The L.G. Board has sanctioned the borrowing of £58,000 to provide additional generating plant at Lister-drive No. 2 electric power station, and the committee asked to be allowed to borrow £10,000 for prospective expenditure on sub-station equipment. The report was adopted.

Loch (Isle of Man).—The Loch Parade Tenants' Protection Society s considering a scheme for the electric lighting of the promenade.

London County Council.—On Tuesday it was agreed to lend Southwark Council £8.500 for electric lighting.

Tramways over Blackfriars Bridge.—A recommendation to incur expenditure to join up the tramways from the Thames Embankment over Blackfriars Bridge was agreed to.

Highgate-road Tramways.—A further adjourned report to expend £24.580 on the reconstruction of the tramways in Highgate-road was submitted.

Brockley-road to Forest Hill Tramways.—The Highways committee recommended a capital expenditure of £61,710 for the construction of authorised tramways from Brockley-road to Forest Hill.—Postponed.

Feed Pillars.—Authority was given the Highways committee to expend £825 for 12 additional feeder pillars required in connection with existing electric tramways.

L.C.C. Tramways.—The traffic receipts on the Council's tramways during the year ended March 31 were £1,801,477, an increase of £176,582 over the previous year. £263,514 was received on the horse tramways, the remainder being electric.

Stepney Council decided on Wednesday to consent to the use of the overhead trolley system on the small portion of the tramway route between Burdett-road and Coborn-road.

Manchester.—An interesting report by the Tramways committee on halfpenny stages, extension of time for workmen's fares and special fares forworking women and children, was before the Corporation on Wednesday.

The committee were of opinion that the general introduction of halfpenny stages on the main routes of the tramway system would result in serious financial loss, that the interests of the travelling public and the citizens generally were best served by adhering to the minimum fare of 1d., that it was not desirable at the present time to grant further concessions as regards workmen's fares or to grant special privileges for working women, and that the existing regulations as regards children's fares be amended so that children under five years of age and not occupying a seat may be carried free, and those over five and under 12 years at half-fare, no fare to be less than 1d. A list of suggested alterations of th long-distance fares was also submitted for approval.

In moving the adoption of the report, the chairman of the committee (Ald. Bowes) said that it proved conclusively that the adoption of halfpenny fares would mean a loss of £107,020 per annum, and instead of the committee subsidising the rates to the extent of £75,000, the ratepayers would have to subsidise the tramways.

After discussion the report and recommendations were approved.

Marylebone (London).—In the estimates of the Electric Supply committee for the current year the anticipated increase in units sold is put at 1,000,000, and, after allowing for all expenses (including interest and sinking fund charges), there will be a profit of £1,341.

National Electrical Manufacturers' Association.—A committee meeting of this association will be held at the offices, Balfour House, Finsbury-pavement, London, E.C., on Monday next at 2 p.m.

Nottingham. The Corporation propose to apply for additional Parliamentary powers for the construction of the Carlton-road tramway.

Personal.—Mr. H. Brownscombe, shift engineer at Dover, has resigned.

The staff at the generating station at Devonport Dockyard have presented a marble timepiece to Mr. R. D. Spanton, electrical engineer, on his marriage.

Mr. M. Fare, resident engineer of the Twickenham and Teddington Electric Supply Co., was recently married to Miss Jennie Stone, of Broadstairs.

Plymouth. The Electricity committee recommend the Corporation to carry out extensions of the plant at the electricity works at a cost of £2,500.

Provisional Orders.—The Board of Trade have granted provisional orders for Stourbridge and for Staines and district.

Provisional Orders Revocation.—The Board of Trade have revoked as from April 30 the Glastonbury Corporation Electric Lighting Order, 1904, and the Walmer Electric Lighting Order, 1904.

Southampton.—Owing to the low price of copper, tenders are to be invited for the supply of heavy cable for trunk main purposes, delivery to be made in June, 1910.

The borough electrical engineer (Mr. H. F. Street) is to furnish alternative estimates (1) for the supply and erection by Messrs. Babcock & Wilcox of a new boiler and (2) for the erection of the boiler by the department's staff.

Application is to be made for sanction to borrow £3,000 for mains and services.

A sub-committee has been appointed to consider recommendations by the manager for doing away with a number of short pieces of single tramway track. It is estimated that the revenue is adversely affected by these short pieces by upwards of £2,000 per annum.

Southwark.—On Wednesday the Establishment committee reported that they had had under consideration the question of the appointment of an electrical engineer, for which 119 applications had been received. Having regard, however, to a reference the committee had received from the Electric Light committee, and to the fact that the Special committee appointed by the Council in January with reference to the electric light undertaking had not yet completed its negotiations, they had deferred making an appointment for three months.

Canon Horsley said there seemed to be an impression abroad that an electrical engineer was not likely to get fair treatment in Southwark, and he had been asked by a gentleman desirous of becoming a candidate for the post, if it was true that the Borough Council were taking steps to sell the undertaking. If that was so how could they expect good men to compete for the post?

Mr. R. C. Davis said negotiations were now going on with regard to the undertaking, but nothing definite had been arrived at. It was, however, thought the appointment of an engineer should be postponed to see what decision was arrived at.

The report was adopted.

Spain.—The Spanish Government have introduced a bill for reforms of the post and telegraph services at a cost of about £148,000 for material and £839,300 for the erection of central post and telegraph offices, in the provincial capitals and other towns.

The Malo de Molina and Ahlemeyer companies have formed a new company and acquired a waterfall at Villa de Bes which is to be utilised for operating electric generating plant to supply current for use in Cartagena, about 99 miles distant.

Stoke-upon-Trent.—During the past year the electricity department sold 693,367 units of electric current, and the revenue was £4,927, compared with £3,925.

The generating expenses were £2,826, against £2,003, and the gross profit £2,100, compared with £1,921. After paying interest and sinking fund (£1,959), the net profit was £141, against £157. 6s. 11d. Owing to the reduction in the price of current and the extended use of metallic filament lamps the results had been adversely affected. The average price worked out at 1·70d. per unit sold, against 2·51d., and the cost of generation at 0·98d., against 1·28d.

Telephone Rates in Australia.—Regulations recently issued by the Commonwealth Postmaster-General contain the following provisions with regard to telephone rates :—

The charges in telephone networks in districts with a population of or under 10,000, and for an area with a radius of five miles, £3 for exclusive service, £2. 10s. for each subscriber on a two-party and £2 on a three or more party service. For 10,000 to 100,000 population and 10 mile radius the charges are £3.10s., £2. 15s. and £2. 5s. Over 100,000 population with 10 mile radius £4, £3 and £2. 10s. The toll charge for all effective originating calls is ½d. per call for the first 2,000 calls per half-year and ¾d. for each call in excess. These charges only apply to lines up to 2 miles in length ; for lines of greater length 10s. extra per ¼ mile per annum will be charged for exclusive lines, 5s. per subscriber for two-party and 2s. 6d. for three or more party lines. These rates apply to all new subscribers from March 19 last, and all subscribers will be brought under the new rates by March next.

Tramway and Light Railway Officials' Association.—At a meeting of the executive council at Birmingham, on Saturday, the acting president (Mr. A. R. Fearnley, Sheffield) said the meeting had been called to wind up the association in accordance with the resolution passed at Leeds on March 13 owing to the growth of the Municipal Tramways and the Tramways and Light Railways Associations.

In order to show appreciation of the services rendered to the association by Mr. R. W. Cramp (general manager of the Birmingham and

Midland Tramways Joint Committee), who had been hon. secretary for upwards of seven years, the members presented him with a canteen of cutlery.

Tramway Lease.—Burton-on-Trent Corporation intend to lease to the Midland Railway Co. (for 21 years from July 1, 1906) at a rent of £825 per annum, a tramway forming a junction at the borough boundary with the Company's light railway and a tramway forming a junction with the Corporations tramways. The company are to use no motive power other than electrical, except in case of emergency, are to take all electrical energy from the Corporation (c.c. at not less than 500 volts) at 1·3d. per unit, with power to agree from time to time on new prices or refer the question to arbitration. The Corporation are to have power to run cars over the lines on payment of 4½d. per car-mile, including the charge for electrical energy.

Tunbridge Wells.—On Wednesday the Council adopted the recommendation of the Lighting committee to retain Mr. Horace Boot as consulting electrical engineer from August 31st next.

Mr. Boot is to be paid a commission of 5 per cent. upon capital works undertaken by the Corporation in respect of which he may be employed: a minimum sum at the rate of £100 per annum to be paid Mr. Boot during the time he holds the appointment, and £100 to be also paid to Mr. Boot in discharge of all commission and other payments, except actual out of pocket expenses in respect of all capital works already sanctioned by the L.G. Board.

West Bromwich.—The Electricity committee report that for the year ended March 31, the sales of electricity for private lighting realised £3,374. 2s. 7d., an increase of £45. 0s. 5d. over 1907–8; for public lighting £677. 2s., an increase of £39. 12s.; for traction, £6,599. 1s. 3d., a decrease of £552. 4s. 10d.; and for power, £2,797. 12s. 3d., an increase of £1,037. 5s. 8d. The total sales realised £13,461. 8s. 11d., compared with £12,877. 14s. 3d., an increase of £583. 14s. 8d., or 4·53 per cent.

West Hartlepool.—Ald. Macfarlane reported to the Council on Tuesday that the gross income of the electricity department during the past year was £15,300, an increase of £500, and the expenditure was £8,800. After paying interest and sinking fund, the balance (£584) was transferred to reserve.

Will.—The late Mr. Geo. E. Belliss, founder of the well-known firm of Belliss & Morcom, left estate valued at £285,254. 4s. 10d. gross and £276,823. 4s. 7d. net.

Wimbledon.—In future the charge for energy for power will be as follows:—

Up to 750 units per quarter 1¾d. per unit, 1,250 units 1⅝d., 2,500 units 1½d., 5,000 units 1⅜d., 12,500 units 1¼d., 25,000 units 1⅛d., 62,500 units 1d., and over 62,500 units per quarter special rates. 2d. per unit is to be charged for current supplied for heating and cooking

Application is to be made for sanction to borrow £5,000, the estimated capital expenditure upon mains and house services during the year ending March 31, 1910, and £800 for meters.

Wireless Telegraph Notes.—Mr. Marconi wields a ready pen, and demolishes in a few words the various "discoveries" of some medical cranks, who seem to delight in finding opportunities for airing their Latin derivatives. This is Mr. Marconi's way of pulverising the alarmists:—

My attention has been called to one or two articles which have recently appeared in the authoritative medical Press dealing with certain noxious physical effects alleged to be produced upon wireless telegraphic operators in the course of their employment. The text for these articles seems to have been furnished by the report of a medical officer in the French navy, who is pleased to attribute to the practice of wireless telegraphy the occurrence within his observation of various cases of conjunctivitis, keratitis, corneal ulceration, leukoma, functional cardiac, and other formidable-sounding maladies. As I am not ambitious to be associated with any new addition to the already sufficiently sorrowful list of occupational diseases, perhaps you will kindly allow me the courtesy of your columns to state most emphatically that, whatever may happen in conditions with which I am not acquainted, my own experience and that of the companies associated with my name, both here and in other parts of the world, supplies no evidence whatever in support of these suggestions.

Just as it is necessary to protect the eyes from the effects of any source of intense light, so, in our high-power stations, we find it convenient to surround our sparks and discharges with a non-translucent screen or box; but no other precautions have been found necessary, and the health of our operators and other employés has, I am glad to say, been uniformly satisfactory. During the 12 years or so of our operations we have had to deal with no single case of compensation for any injury of this origin, nor, so far as I can ascertain, has any such injury been suffered. Speaking for myself, I may remark that my own good health has never been better than during the often extended periods when I have been exposed for many hours daily to the conditions now challenged, and in the constant neighbourhood of electrical discharges at our Transatlantic stations, which I believe are the most powerful in the world.

I observe that at least one daily newspaper seems to have pressed the reports to which I have alluded into the service of a further theory that electric waves as used in wireless telegraphy may be harmful not only to the operators, but to the world at large. This suggestion is a very familiar one to me, but hitherto, I confess, it has reached me only through the letters of the insane persons who occasionally besiege me with accusations and threats in respect of the tortures which they imagine me to be continually and of malice aforethought inflicting upon them by the practice of wireless telegraphy. G. MARCONI.

From several sources news has come to hand that wireless telegraphic communication has been successfully established between New York City and Chicago, but the distance between these two chief American cities have in the accounts published varied between 700 and 1,000 miles! It is related that considerable difficulty was experienced in establishing effective communication owing to the very large number of messages of varied kinds with which the atmosphere between the two cities is charged. In New York the station is established on the roof of the Waldorf–Astoria Hotel, and the Chicago station is on the Auditorium Annex Hotel. The first messages were exchanged between the leading newspapers of the two cities. The large number of amateur installations (the erection of wireless stations forms a favourite pastime of the gilded youth of America), were responsible for considerable loss of time in "getting through."

The number of vessels of the leading steamship lines which are being equipped with wireless telegraph apparatus is increasing in a very rapid manner. The P. & O. Company have added a number of their principal vessels to the wireless equipments, and the Royal Mail Steam Packet Co. have also decided to equip another group of their steamships with the Marconi Company's apparatus.

York.—The result of the poll of the citizens on the tramway question was announced on Saturday as follows:—

For tramways constructed and worked by the Corporation 6,297 votes, for tramways constructed by the Corporation and leased to a company 78 votes, and for tramways constructed and worked by a company 3,734 votes.

At the meeting of the City Council on Monday, Ald. MEYER said that the Tramways committee would be called together in a week's time to make a recommendation as to the acceptance of a tender. The overhead system would be adopted, because the surface-contact system would cost about £20,000 more, and in order to make it pay they would have to earn another £1,000 a year. Then there was the element of risk, for the system was not satisfactory in every place in which it was used.

The revenue of the electricity department for the year ended March was £18 248, including £12,857. 10s. 1d. from the sale of current.

The expenses were £9,477. 18s. 3d., leaving a gross profit of £8,770. 1s. 11d. After paying interest (£4,529) and sinking fund (£3,259. 12s 1d.), the net profit is £981. 9s. The net capital expenditure is £105,381. During the year 1,671,702 units were generated, of which 1,342,815 were sold.

The Electricity committee have placed on record their appreciation of the services of Mr. J. W. Hame (city electrical engineer) and the staff.

Electrical Football League.—The annual general meeting of the Electrical Football League will take place on May 19 (at 7 p.m.) at the offices of the St. James' and Pall Mall Electric Light Co., 19, Carnaby-street, Golden-square, W.

Representatives of clubs wishing to join should attend this meeting. The past season has been a very successful one and it is hoped to make next season even more so by introducing new clubs. The hon. sec. (Mr. J. W. Fraser), 39, Wearside-road, Lewisham, S.E., will supply information. The following was the position of the clubs at the end of the season:—

	Played.	Won.	Lost.	Drawn.	Goals For.	Goals Agst.	Pts.
Metropolitan Electric	12	11	0	1	49	7	23
County of London	12	8	3	1	24	9	17
St. Pancras	11	5	3	3	25	17	13
Robertsons	11	4	6	1	22	25	9
General Electric	12	3	6	3	19	22	9
St. James	12	3	6	3	13	23	9
Ediswan	12	0	10	2	5	55	2

Dinner.—On the 29th ult. the staff of the Aberdeen Corporation electricity department gave a dinner at the Imperial Hotel to Mr. Richard B. W. Pirie, their erstwhile colleague, who has been successful in securing the important position of chief internal auditor to the British Columbia Electric Railway Co., in Vancouver City.

Mr. J. ALEX. BELL, city electrical engineer, presided over a company of 18, and dinner was followed by an excellent musical entertainment. In giving the toast of "Our Guest," Mr. Bell referred to Mr. Pirie's connection with the department and the happy memories of his associations with the staff at the old Cotton-street works and at Dee village. Since then he had gained valuable experience at Weston-super-Mare and Cardiff, and with the Clyde Valley Electric Power Co., which would fit him admirably for the important position he was now about to fill. For his ability, his natural courtesy and his evergenial good nature Mr. Bell ventured to predict for him further success in the near future. Mr. Pirie, who replied in suitable terms, sails from Liverpool to-day, Friday.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

WIGAN Corporation invite tenders for the supply and erection of 750 kw. engine and generator, two water-tube boilers, steam and water piping, motor-driven feed pumps, economiser, separators, feed water filter and meter, exhaust steam and water piping, motor-driven pumps and condenser, coal-handling plant and bunkers, h. and l.-t. cables, h. and l.-t. switchboard, removal of plant from Pemberton generating station to Wigan, constructional steelwork for the boiler house extension and switchboard gallery. Copies of specification, &c., from the borough electrical engineer, Mr. Jas. Slevin, Bradford-place, Wigan. Tenders to the town clerk, Mr. Harold Jevons, by May 17. See also an advertisement.

MANCHESTER Tramways committee invite tenders for the supply and delivery of main switchboard and auxiliary distribution boards, steel girder tramway rails, steel tiebars for tramway rails, copper trolley wire, and tramway rail bonds. Specifications from the general manager, Mr. J. M. McElroy. Tenders to the Chairman of the Committee, 55, Piccadilly, Manchester, must be received by 10 a.m. on Tuesday, May 18. See also an advertisement.

Tenders are invited for supply of 50 coin attachments (suitable for coins of different values) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for eight sections of common battery switchboard and subscribers' apparatus for Hawthorn Exchange for the Postmaster-General's Department, VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are also invited for supply of telephone material to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of one d.-c. steam-driven generating set for MELBOURNE (Victoria) electricity works. Tender form, conditions, specification and plans can be obtained from the agents for Melbourne City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C. Tenders to the Town Clerk, town hall, Melbourne, by Wednesday, July 14. See also an advertisement.

Tenders are also invited for supply of 1,125,000 flame and 70,000 [illegible] lamp carbons for MELBOURNE Corporation. Tender form, specification, conditions, &c., from the agents for Melbourne City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon, Tuesday, May 25. See also an advertisement.

ST. PANCRAS (London) Borough Council invite tenders for supply of arc lamp carbons. Copies of specification, &c., from the Electricity Department offices, 57, Pratt-street, Camden Town, N.W. Tenders by noon July 10 to the town clerk, Mr. C. H. F. Barrett, Town Hall, Pancras-road, London, N.W.

WOODBRIDGE Urban Council, who are desirous that a company should establish electricity works in the district, announced that they would support a company in an application for a provisional order and would enter into a contract for public lighting from April 1, 1912. The population is 4,600 and gas is 4s. 6d. per 1,000 ft. Tenders by June 1.

The Postmaster-General's Department, NEW SOUTH WALES, want tenders by May 19 for supply of two multiple magneto switchboards, by June 30 for a photometer (similar to Simmance-Abady steel-tube photometer) with two spare sighting wheels, and by Sept. 29 for supply, &c., of branching multiple magneto switchboard for Edgecliff Exchange.

The BELGIAN Ministry of Railways, Posts and Telegraphs require tenders by 11 a.m., May 12, for supply of high-tension cables, &c., for the Spa to Verviers railway. Specifications from the Société National des Chemins de Fer Vicinaux, 14, rue de la Science, Brussels.

The invitation issued by the Italian Ministry of Marine for supply of electric lamps at the Royal Arsenals (referred to on pp. 904 and 984 of our issues of March 19 and April 2) has been withdrawn.

TENDERS RECEIVED AND ACCEPTED.

Bermondsey (London) Council have accepted the tenders of Ferranti Limited for meters, indicators, fuses and switches; of the General Electric Co. for two-rate meters and time switches combined, standard fuses, &c.; and of W. Geipel & Co. for Davy enclosed arc lamp carbons at 6s. per 100 pairs.

Salford Council have accepted the tenders of Ferranti Limited, Chamberlain & Hookham, the General Electric Co., and the Reason Mfg. Co. for the annual supply of meters, of the Siriuswerke for arc lamp carbons, and of Matthews & Yates for maintaninig electric fans at two Council schools at 13s. per fan per quarter.

The City of London Wood Wool Co., Plover Works, Hackney Wick, London, N.E., have secured contracts for this year's supply of the company's Elastene fibre for packing from the India Office and the Admiralty.

Wolverhampton Corporation have accepted the tender of G. P. Trentham for the construction of tramway track, &c., from Queen-square to Penn-road, at £5,404. There were 13 tenders, varying from £5,404 to £13,200.

Chester Council have placed an order with the Tudor Accumulator Co. for removal of the traction battery to a new battery room at the electricity works at £129. 10s.

Nottingham Corporation have placed an order with Messrs. Willans & Robinson for two 400 kw. reciprocating engines, to be direct coupled to Siemens d.c. dynamos.

Bridlington Council have accepted the tender of Waring & Gillow (Manchester) for a scheme of electrical illumination on the Royal Prince's Parade at £540

Cumberland County Council have placed an order with Gibson & Cairns for three years' maintenance of the electric light installation at the county offices.

St. Helens Corporation have placed an order for low-level jet condensing plant with Willans & Robinson.

Douglas (I.M.) Council have accepted the tender of Walter Scott (Ltd.) for 25 tons of tram rails at £7. 10s. per ton.

Eastbourne Council have placed an order with Ferranti Limited for supply of 100 meters.

Kingston-on-Thames Council have placed orders with Siemens Bros. & Co. and W. T. Glover & Co. for supply of cables.

Poplar (London) Council have placed an order with Fraser & Fraser for hotwell tanks at £48. 5s.

Dartford Council have accepted the tender of Johnson & Phillips for feeder cable at £351.

On Tuesday Edinburgh Corporation accepted the tender of the Lahmeyer Electrical Co. for the supply of insulated cables at £6,544.

Gloucester Council have placed an order with Crompton & Co. for Conradty carbons for one year at £105. 2s. 7d., less $2\frac{1}{2}$ per cent.

Derby Council have accepted the tender of A. A. Andrews for wiring the refuse destructor at £21.

A contract for the provision of electricity supply works for the supply of current for light and power in the Port of Tarragona has been given to the Sociedad Maquinista Terrestre y Maritima, of Barcelona, at 347,886 pesetas (about £5,073). The tender of G. Bruck, on behalf of the A.E.G.-Thomson-Houston Iberica, at

286,768 pesetas (about £4,182) was not admitted, on the ground that the material to be employed was not of national manufacture and therefore not in accordance with the law of Feb. 14, 1907, and the regulation of March 23, 1908.

The Industria Electrica Company, of Barcelona, has secured a contract for the construction of an electric tramway in Jerez.

Commonwealth Tenders.—The Postmaster-General's Department, Melbourne, have accepted the tender of the British Insulated & Helsby Cables for 12 miles of h.d. copper wire.

The Postmaster-General's Department, Sydney, have accepted the tender of the India Rubber Co. for three nauts of single core submarine cable at £350.

Large Battery Contract.—We learn that the Tudor Accumulator Co. have secured a contract from Manchester Electricity Supply department for the supply and erection of a large storage battery. The capacity of the battery, which is to consist of 210 cells, is to be 11,700 amp.-hours at a three-hour rate of discharge, 8,400 amp.-hours at a one-hour rate, and a current of 15,000 amperes is to be obtained for a period of five minutes. It is proposed to use the battery in the evening for the lighting supply, and it is to be charged in the daytime from the traction generators. The weight of each cell will be about 3 tons, and its dimensions 6 ft. $1\frac{1}{2}$ in. by 2 ft. $2\frac{1}{4}$ in. by 3 ft. $4\frac{1}{2}$ in. high. Each cell will contain 77 plates, each plate being $20\frac{3}{4}$ in. by 29 in. In connection with the battery three boosters are to be supplied. These will be used in parallel on the lighting load, and two in series on the traction load, in the latter case one running at constant voltage and the other being automatically reversible. These boosters are to be supplied by the Lancashire Dynamo & Motor Co. A feature of the contract is that the battery is to be maintained at full capacity for a period of no less than 15 years. It is believed that this battery will be the largest in this country.

BUSINESS NOTICES.

The offices and showrooms of the Jandus Arc Lamp and Electric Co. are now at their Holloway works, additional premises having been acquired. The Company have terminated the sole agency agreement with Messrs. Drake & Gorham, and, in future, will sell direct from their works, at Holloway, which will be their sole address. Additional workshop space has also been secured to cope with the increasing demand for their regenerative flame lamp. The Jandus Co. was formed to manufacture the first enclosed arc lamp, and as they were the first with the carbon enclosed lamp, so they have (it is claimed) been the first to solve the problem of the enclosed flame arc. Licensed concessions have been granted to various large foreign firms to manufacture enclosed flame lamps in all European countries, the United States and Canada. A special factory has also been laid down for the manufacture of the patented carbons used in conjunction with the Jandus enclosed flame lamp.

Fredk. Chas. Geary and Frank S. Rippin (trading as Geary, Rippin & Co.), electrical engineers, 25, Central Arcade, Wolverhampton, have dissolved partnership. Debts by Mr. Geary, who continues the business.

Geo. Morrison and John Wm. Roebuck, electrical engineers, 4, Birley-street, Blackpool, have dissolved partnership.

Geo. Bingham and Alfd. Hy. Hall, electricians, Parkstone, Poole, have dissolved partnership. Debts by Mr. Hall.

Frank Fearnside and Harold Glover, electrical engineers and contractors, Burke's-buildings, John-street, Bradford, have dissolved partnership. Debts by Mr. Fearnside, who continues the business.

The Electrical Industries Supply Co., 12, Macdonald's-lane, Corporation-street, Manchester, have acquired the business of Scholes & Co.

On May 10 Messrs. Crews & Handford will remove to Clarence Chambers, 4, Piccadilly, Manchester. Telephone 4565 City.

Condensing Plants.—Messrs. Willans & Robinson, of Rugby, who, during the past few years have paid considerable attention to the manufacture of surface condensing plants, have extended this department of their business to include condensers of the jet type, particularly condensers built on the counter current and barometric column principles. Due to the large number of instances where condensers of the jet type are required, in connection with exhaust steam turbines, special arrangements have been made for the manufacture of this class of condenser.

Plant for Sale.—Messrs. G. Elliott & Co., 186-188, Long-lane, Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

Two alternator-gas engine sets (250 kw. each), direct coupled, are advertised for sale.

A second-hand Ke Peache high-speed engine, 340-365 B.H.P., made by Davey, Paxman & Co., is offered for sale in another column.

Plant Wanted.—The Sandycroft Foundry Co. (Sandycroft, near Chester) advertise that they require a second-hand high-speed engine, suitable for driving an alternator of about 600 kw.

Electrochemical Laboratory Premises Wanted.—An advertisement contains particulars of the requirements of consulting engineers, who wish to lease or purchase premises for an electrochemical laboratory, within reach of cheap electric supply, gas and water.

Patent Development.—The proprietors of the following patents are desirous of entering into arrangements by way of licence and otherwise for exploiting same in this country :—

No. 15,243/1903 for "Improvements in Means for Automatically Regulating Electric Currents generated by Dynamos."

No. 17,314/1905, for "Improvements in Automatic Regulators or Rheostats for Electric Currents."

No. 28,159/1897, for "Means for use in Lighting Railway Cars or Carriages by Electricity and for regulating the Current for same."

No. 17,601/1901, for "Improvements in Apparatus and Devices for controlling Electric Currents."

No. 16,962/1902, for "Improvements in Electric Switches or Cut-offs."

Communications in regard to the above to Messrs. Haseltine, Lake & Co., chartered patent agents and consulting engineers, 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

No. 2,274/1904, relating to "Improvements in Telegraphic Transmitters," and No. 5,944/1902, relating to "Improved Telegraphic Systems." Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

"The Journal."—Part 194 of the "Journal of the Institution of Electrical Engineers" is now ready, price 5s. Particulars of the contents are given in an advertisement.

"Simplex."—Simplex Conduits (Ltd.) have decided to make an important departure in connection with the Imperial International Exhibition, to be opened at Shepherd's Bush this month. As this departure is at variance with the company's policy of strictly limiting their dealings to contractors, they have sent the following letter to Mr. L. G. Tate, secretary of the Electrical Contractors' Association:—

As you are aware, we are erecting a model Electrical Home at the forthcoming Imperial International Exhibition, and for this purpose we have secured a large space in the grounds of the White City, our object being to popularise the name "Simplex" in connection with metal filament lamps, electrical cooking, heating, and ventilating apparatus, and other electrical goods sold by our company. In order to secure the maximum advantage from this undertaking it will be unavoidable that a certain number of transactions will take place with the general public. As this is a departure from the policy which we have always pursued, and which we intend to continue, of dealing only through the contractor, we have given the matter some consideration, and as evidence of good faith our directors have decided to pay into your central fund a sum, to be disposed of in any manner your board may think fit, equivalent to 5 per cent. upon the gross value of all such sales as may be effected at our exhibit above mentioned. We trust this will meet the views of your members and be acceptable to them.

We may mention that, as you will readily understand, the expenses in connection with this departure are very heavy, and consequently we are unable to offer you a larger percentage than that named. Further, we have no doubt that our enterprise in this direction cannot fail to be to the ultimate advantage of the electrical contractor.

In connection with the Simplex exhibit, the site occupied is situated between the Garden Club and the Grand Restaurant in the Elite Gardens, and has an area of over 1,000 sq. ft. In addition to a large showroom, there is an electrically-equipped dining room, drawing room, bedroom and kitchen.

A.E.G.-Zeitung.—We have received from the Allegemeine Elektrizitts Gesellschaft, a copy of their journal, which deals with the various advances made from time to time in the electrical industry, and the application of electrical energy to industrial work. The present number contains articles on "Twenty-five years of the Berlin Electricity Works," "New Problems in the Electrical Industry," "Steam Installations, Then and Now," "Electrically-Driven Tools," and the "Electric Drive in Agriculture." The number is well illustrated throughout and special attention may be called to a full page illustration showing an example of illumination by Nernst and A.E.G. Arc Lamps.

L. & S. W. Railway Guide.—The London & South Western Railway Co.'s Official Illustrated Guide and List for 1909 has just been issued, edited by Mr. W. T. Perkins. The book contains much matter of interest to those seeking information concerning eligible holiday resorts for the tired brain worker. The L. & S.W. Railway and its ramifications tap many beautiful places not only in England but across the water. A large map, specially prepared, is included. 50,000 copies of this "Guide" have been issued, under the direction of Mr. Henry Holmes, Superintendent of the line, and these are being distributed gratuitously.

CATALOGUES, &c.

ELECTRO MEDICAL APPARATUS—Messrs. Siemens Brothers & Co., Caxton House, Westminster, have issued the March supplement to their Electro-Medical catalogue, dealing with switchboards for adding to ordinary X-Ray outfits in order to make them suitable for rapid and instantaneous radiography. These boards are made of various types, with automatic as well as with hand control, and Messrs. Siemens Brothers & Co., are prepared to design suitable boards for connecting to any existing plants.

"A FLEET IN BEING."—A firm noted for the solidity of its equipment and the general utility of its apparatus for the work which it has to do is Callender's Cable & Construction Co. It is, therefore, not surprising that its cables are employed to a large extent on His Majesty's ships. The use of electricity in the Navy becomes more and more extended as each new ship is launched, and in the more modern ships Callender cables have found a wide application. For this reason an excellent sketch has been prepared by Mr. C. J. Greene showing the various warships on which the main electrical distribution has been effected either entirely or in part by means of Callender cables and boxes. The ships illustrated include the "Bellerophon," "Invincible," "Inflexible," "Indomitable," "Vanguard," "Defence," "Boadicea," "Bellona," "Superb" and "Temeraire." The arrangement of the ships in the picture gives a good idea of their readiness for action and illustrates the conception of a "fleet in being."

JOINT-BOX COMPOUNDS.—Messrs. Wm. Geipel & Co. forward a copy of a descriptive pamphlet dealing with joint-box compounds, in which are set out various points in connection with these useful substances which it is necessary to remember in making a choice of them for electrical work.

ELECTRICAL CO.'S SPECIALITIES.—The Electrical Co. have issued a set of pamphlets dealing with their specialities, including motors for massage purposes, cigar lighters and similar accessories, oil and knife switches. In their oil switches the Electrical Co. make a point of interlocking the equipment so that the switch case can only be opened and the fuse withdrawn when the switch is in the "off" position.

SWITCHBOARD INSTRUMENTS.—From Messrs. Siemens Bros. & Co. we have received a very complete catalogue illustrating and describing their range of switchboard instruments. The instruments, of which details are given in this catalogue, are illustrated and dealt with at some length in another portion of this issue, and we need only here call the attention of our readers to the fact that any amplifications of the points raised in this article can be obtained by applying to Messrs. Siemens Bros. & Co., and that a perusal of this catalogue will amply repay the time spent over it.

"Z" TIME SWITCH.—Messrs. Marsh, Son & Co., of London and Birmingham, have issued a show card illustrating their new "Z" time switch, whereby it is claimed you can "Light your Windows and Save your Light Bill." This card is well calculated to catch the eye, and we commend it to those of our readers who are engaged in selling this class of apparatus.

BANKRUPTCIES, LIQUIDATIONS, &c.

A meeting of creditors of the Buenos Ayres Grand National and La Capital Tramways Joint Committee, Ltd. (in liq.), will be held at 62, London-wall, London, E.C., on May 14. Claims by June 1, to Mr. Fortescue Thursby, 62, London-wall, E.C.

Claims against the Eastern Electrical Synd., Ltd. (in liq.), by June 14 to Mr. W. H. Stentiford, 1, Broad-street-place, London, E.C.

A dividend is to be paid to the creditors of Hy. John Furniss, electrician, 5A, Queen-street, Derby, and claims are to be sent by May 19 to Mr. F. Stone, 47, Full-street, Derby.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

January 12, 1909.

747 [illegible]. Trolleys for electrically-driven vehicles.*
759 [illegible]. Controlling electric motors.*
764 MUNRO & RAILLESS ELECTRIC TRACTION CO. Trolley arms for electric traction systems.
769 [illegible]. Secondary batteries or accumulators.
786 B.T.-H. CO. (A.E.G., Germany.) Alternating current dynamo-electric apparatus. (Addition to No. 23,288/02.)*

January 13, 1909.

803 FULLER. Electric hand lamps.
837 FANE & NEWHOUSE. Electrical heating apparatus.
843 BOWDEN, ANDERSON & ATCHLEY. Supports of overhead electric cables and the like.
875 MCLEAN. Supporting electric lamps.
893 NICOL. Collecting current in connection with electric traction.

January 14, 1909.

977 LAMPMANN. (Carl Engel and Oskar Schröder, Germany.) Winding for electro-magnets and the like.
986 DENNIS. Telephone service meters.*

January 15, 1909.

1,009 BANDFIELD. Attachment of telegraph and similar land wires to insulators.
1,029 BOOTH & HAMER. Maintaining the circuit of electric lamps burning in series on failure of one or more such lamps.
1,067 and 1,078 MUNRO & RAILLESS ELECTRIC TRACTION CO. Electric traction systems.
1,077 MUNRO & RAILLESS ELECTRIC TRACTION CO. Trolley-heads for electrically-propelled vehicles.
1,086 CHILDS & HILL. Electric control of lifts.*
1,092 TAYLOR. Accumulator sub stations. (Date applied for, 29/11/07 Comprised in application No. 26,381, dated 29/11/07.)

January 16, 1909.

1,136 BRADLEY & BICKERTON. Electrolytic cells.
1,157 ANDRE. Regulating the voltage of electrical machines.

January 18, 1909.

1,263 SIMMS & SIMMS MFG. CO. High-tension magneto-electric apparatus.*
1,270 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*

January 19, 1909.

1,305 CARRICK & PROCTER. Rail-sanding apparatus.
1,316 GEBRUDER. SIEMENS & CO. Electrode for searchlights. (Date applied for, 9/4/08. Addition to No. 13,071/07.)*†
1,327 BOECKEL, GRUNBERY, KRUKOWSKY & LUXEMBOURG. Dynamo-electric machines. (Addition to No. 20,098/08.)*
1,340 ST. LAURENT, LANCASTER, MCNEALE & COLLINS. Secondary batteries.
1,345 B.T.-H. CO. (G.E. Co., U.S.). Aluminium electrolytic cells. (Date applied for, 4/9/08. Comprised in No. 18,619/08, 4/9/08.)*

January 20, 1909.

1,386 HINTZE. Switch-holders.
1,414 & 1,415 BERRY. Electrical heating apparatus.
1,419 MUIRHEAD. Electric telegraphy.
1,422 W. R. SYKES INTERLOCKING SIGNAL CO. & TARRANT. Locking-gear.
1,425 HUTCHINS. Insulation of electric conductors and compounds therefor.

January 21, 1909.

1,509 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke, G.m.b.H., Germany.) Regulation of current and voltage in dynamo-electric machines.*
1,510 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke, G.m.b.H., Germany.) Electric fuse holders.*
1,541 TIMAR & DREGER. Preventing flickering in arc lamps with parallel carbons. (Date applied for, 18/7/08. Addition to No. 12,656/08.)*†
1,548 BOULT. (International Telechronometer Co., U.S.) Telephone apparatus.*

SPECIFICATIONS PUBLISHED.

1908 SPECIFICATIONS.

7,674 DAWSON. Means for attaching shades and reflectors to incandescent electric lamps.
7,844 B.T.-H. CO., HASTINGS & WISE. Electric motor controllers.
7,854 HALL. Cooling or ventilating dynamo-electric machnes.
8,425 EVANS. Elektrochemische Werke.) Production of electrical discharge.
8,904 BOUNEAU. Electrical furnaces. (Date applied for, 24/4/07.)
10,341 B.T.-H. Co. (Allgemeine Elektricitäts Ges.) Incandescent electric lamps.
10,614 HOOKHAM & HOLDEN. Electrolytic meters. (Addition to No. 3,327/05.)
10,699 MAXSE. (Piat.) Telegraphic relays.
10,893 CHAMBERLAIN & HOOKHAM & HOLDEN. Electricity meters.
11,068 SOC. FRANCAISE DES PROCEDES J. L. RONTIN POUR LE COMPOUNDAGE ELECTRO-MECANIQUE DES GROUPS ELECTROGENES. Electro-mechanical regulators or governors for electric generators, electric furnaces and the like. (Date applied for, 24/5/07.)
11,161 B.T.-H. Co. (A.E.G.) Dynamoelectric machines.
11,161 B.T.-H. Co. (A.E.G.) Dynamo electric machines.
11,460 B.T.-H. Co. & ROBERTSON. Incandescent electric lamps.
12,170 HEADLEY, WALTON & LAWLEY-PINCHINO. Electric switches.
13,100 MIERTSCHKE. Arc lamps.
13,257 HELBERGER. Electric furnaces.
13,299 CURRAN & KELLY. Trolleys or collectors for electric tramcars.
13,515 GROSE & LAMBERT. Electric fuse boxes and fuse holders therefor. (Addition to No. 6,849/07.)

13,678 Wolff. Conductors for alternating electric current.
14,982 Veritys Limited & Worsley. Electric arc lamps having inclined carbons.
15,641 British Insulated & Helsby Cables & Cole. Armouring of flexible electric trailing cables.
15,742 Siemens & Halske Akt.-Ges. Time limit relays. (Date applied for, 8/10/07.)
15,874 Rowe. Electro-magnetic device.
15,898 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Indicating faults in the circuits of electrical transmission systems.

COMPANIES' MEETINGS AND REPORTS.

Great Northern Telegraph Co. (Ltd.)

At the general meeting at Copenhagen on April 24, under the presidency of Mr. F. Zahle, Commodore E. Suenson said that during the past year their cables had suffered more than usually from interruptions, of which there had been 24 on 11 cables in Europe and 10 on six cables in the Far East, without reckoning five interruptions necessitated in connection with extensive renewals of the cables between Hongkong, Shanghai and Nagasaki with heavier types. Those repairs and renewals had kept their cable steamers occupied: the "H. C. Orsted" in Europe for 98 days, the "Store Nordiske" and "Pacific" in the Far East for 192 days, of which, however, 64 were for the account of other administrations. No other system of submarine cables suffered so much from damage by fishing vessels as that of the company, and particularly the cables in the North Sea connecting Great Britain and France on the one side with the Scandinavian countries on the other side, and they were glad that, though the Committee of Enquiry appointed by the British Government could not recommend the drastic measures proposed by the Transatlantic companies for prohibiting trawling in a certain area of the Atlantic, the Committee advised the adoption of the regular inspection of trawls, which the Great Northern Co. had advocated in vain many years ago. The continual struggle against the havoc wrought by fishing vessels was very expensive to the cable companies, which were at the same time constantly called upon to reduce their tariffs, regardless of the greater cost of submarine cables and their maintenance, compared with that of aerial lines, not to speak of wireless telegraph systems. The service by the Wladiwostock and Kiachta routes, which connected the company's cables in Europe with those in the Far East, had never reached a higher standard than during the past year. In January they took possession of their new building at Shanghai; in October the head office accommodation at Copenhagen was considerably extended; in December their station at Newcastle (England) was installed in the Scottish Provident Institution's-building, Mosley-street; and at the beginning of this year, their office and station in London were removed to 15, St. Helen's-place. All these changes were effected without any delay or interference with the traffic. The reductions introduced by the International Telegraph Conference, at Lisbon, in 1908, were too small to be of any appreciable value to the public, but the loss of revenue to the telegraph administrations would be considerable. When, therefore, Utopians who are not satisfied with reasonable reductions demand a uniform rate of 1d. a word, they were asking for the impossible. Fortunately, however, the sensible merchants prefer a good service to low rates, a fact which could not but assist cable companies in a possible competition from wireless telegraph companies, a competition to which holders of shares in cable undertakings are perhaps inclined to attach too much importance. The more extensive use of wireless telegraphy had accentuated the great defects of the new invention, particularly the facility with which telegrams can be tapped, whereby the secrecy of the telegrams becomes more or less illusory. The experience of the last year had, therefore, only tended to confirm their confidence in the absolute superiority of the old system of telegraphy by wire wherever practicable. The cable and wire manufacturers would hardly have had such a prosperous year if those views were not shared by the Governments and private administrations who adhered to the use of wires, submarine, underground or overhead.

The company had received notice from the Norwegian Government that the concession for the Norwegian-Danish cable, granted in 1868, prolonged in 1880, and expiring at the end of 1910, would not be renewed. Although no definite information has yet been given us with regard to the Norwegian concession for the cables to Great Britain, which expired simultaneously, they were under the impression that the authorities were not disposed to entertain any proposals from the company for a prolongation, although they felt convinced that they could offer a solution more favourable, both to the Norwegian Government and to the telegraphing public, than would be obtained by the termination of the company's concession. The Norwegian Government had, jointly with the Danish Government, offered to purchase the Norwegian-Danish cable. The loss of all the Norwegian traffic after 1910 would mean a considerable decrease in their receipts. A similar fate might sooner or later befall other of their cables at the expiration of the concessions, proving how absolutely necessary it was not to touch their reserve funds so long as the dividends (and bonus) exceeded a standard which they might hope to be able to maintain with the assistance of the dividend equalization fund. The negotiations in the Far East entered into with the Japanese Government in 1907, had not made much progress in 1908; they were resumed at the Lisbon Conference, but no result was arrived at, and the premature departure from Europe of the Japanese delegates prevented the contemplated continuation of the negotiations elsewhere in Europe, so they were still awaiting the pleasure of the Imperial Government. The Chinese landline system, which was formerly the property of a private Chinese company, although managed by a Government administration, has in the course of the year been completely transferred to the Government, the latter having purchased all the shares.

There had been a further decline in traffic receipts during 1908 of some £18,000. Interest had decreased by about £640, whilst sundries had increased by nearly £400. Salaries and wages had increased by £8,800; and altogether ordinary expenses had increased by £11,800. The directors proposed to make the bonus 2 per cent. less than that for the last two years, thus making the dividend and bonus 18 per cent. for the year, of which 5 per cent. had already been paid as interim dividends. The alterations in the administration of the company at Copenhagen had been effected in September last by his resigning the position of managing director and the appointment of a board of management, consisting of the following four members: General managers, Messrs. K. Suenson (formerly secretary) and P. Michelsen; engineer-in-chief, Mr. K. O. A. Gulstad; and inspector of telegraphs, Capt. H. Rothe, D.R.E. This board of management took charge on Oct. 1 last, and has since then conducted the business of the company to the entire satisfaction of the board.

AUCKLAND ELECTRIC TRAMWAYS CO. (LTD.)—Mr. C. G. Tegetmeier stated at the meeting on Tuesday that the capital expenditure was £690,320, an increase during the year of £52,611. They had further considerable capital expenditure in view. It had been decided to instal an additional 600 kw. set. Other improvements and additions were in course of being carried out at the power station. Their total revenue was £165,655, against £140,451; and their expenses were about £18,000 more. Power and running expenses showed an increase of £14,553, due to the largely increased car-mileage run and to the increased cost of coal. The net profit was £32,754, against £29,722. They proposed to pay a dividend on the ordinary shares at the same rate as last year (6 per cent.) and to carry forward £3,920. 7s. 8d., against £2,165. 8s. 7d. Their traffic receipts continued to show very gratifying expansion.

CLYDE VALLEY ELECTRICAL POWER CO.—The directors report that the credit balance on the half-year's working is £1,030, which is carried forward. Contracts for supply of current to the extent of 24,381 H.P. had been entered into at Dec. 31 last, an increase of 4,351 H.P. on the half-year. At the meeting on Monday the report and accounts were adopted on the motion of Mr. A. Bonar Law, M.P.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—Mr. J. T. Tullis presided at the meeting on Monday, and stated that there had been an increased output in cables. The machinery for the manufacture of the different classes of cables was in good working order, and capable of a large increase in trade. While the results last year were not apparently so good financially the volume of business was much greater than in any previous year. Their manufactures now included every class of cable required in the electrical industry, including bitumen, gutta-percha, indiarubber and paper-covered cables.

EASTERN TELEGRAPH CO. (LTD.)—The directors' report for the six months ended Dec. 31, 1908, states that the revenue for the period amounted to £566,100. 19s. 3d., from which are deducted £202,364. 15s. 6d. for ordinary expenses and £51,278. 3s. 8d. for expenditure relating to maintenance of cables, sundry differences in exchange, and income tax payable abroad, leaving £312,458. 0s. 1d. added to £53,765. 2s. 5d. from preceding account, making a total available balance of £366,223. 2s. 6d. After providing for income tax payable in England, interest and preference dividends (which absorb £81,788. 10s. 2d.), there remains £284,434. 12s. 4d. The directors have placed £70,000 to general reserve and have paid an interim dividend of 1¼ per cent. on the ordinary stock, amounting to £50,000. They now recommend a final dividend on the ordinary stock of 1¼ per cent. and a bonus of 2 per cent., amounting together to £130,000, both payable on May 12 (tax free), and making, with the three previous payments on account, a total distribution of 7 per cent. for the year 1908. It is proposed to carry forward the balance of £34,434. 12s. 4d.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO (LTD.)—The report of the directors for the half-year ended Dec. 31 last states that the gross receipts amounted during that period to £306,889. 10s. 7d., against £304,416. 3s. 11d. for the corresponding half-year of 1907. Working expenses, including £25,203. 14s. 7d. for maintenance of cables, absorb £151,507, against £154,203. 10s. 8d. for the corresponding period of 1907, leaving a balance of £155,382. 10s. 7d. From this is deducted £3,105. 17s. 10d. for income tax payable in England, and £15,048 for interest on debenture stock, leaving as the net profit for the half-year £137,228. 12s. 9d. Adding £65,777. 3s. 4d. brought forward from the previous half-year, there is an available balance of £203,005. 16s. 1d. One quarterly interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount on 12th prox., making a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for 1908. £50,000 has been transferred to general reserve fund, and the balance of £18,005. 16s. 1d. carried forward.

LEWES & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—Capital expenditure during 1908 amounted to £3,671, bringing the total of £30,206. Gross revenue was £2,294. Expenditure, including £307 interest, and £150 for new negative plates for the battery was £2,065, leaving a profit of £229, £250 is to be placed to depreciation and renewals.

MUSSELBURGH & DISTRICT ELECTRIC LIGHT & TRACTION CO. (LTD.)—The net revenue balance at the end of 1908 was £4,024. After accrued

interest was paid there remained £1,611. The directors recommend that £400 be placed to tramways reserve and renewals fund, and £200 for lighting, and a dividend on the preference shares of 2 per cent. £880.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—At the meeting last week, Mr. L. B. Schlesinger said that, notwithstanding the depression in trade, the past year's results were not unsatisfactory, except that no dividend was recommended. The financial position of the company must be strengthened until the capital locked up in investments was realisable. They were carrying forward a substantial balance, which would enable a 5 per cent. dividend to be paid directly their finances permitted it. After reviewing the position of the company's various undertakings the chairman said the heavy expense in maintaining the surface contact system of the Torquay tramways was hampering the progress of that undertaking. The surface-contact system having proved a failure elsewhere, he was glad to say that satisfactory terms had been arranged with Oxford Corporation, whereby only a small portion of the tramway to be electrified would be constructed on the conduit system and the rest on the overhead system. Owing to the difficulties in the way of tramway enterprise, he could say that they, as a company, would not again attempt the promotion of tramways in this country under present conditions.

LISBON ELECTRIC TRAMWAYS (LTD.)—The result of the operations for the past year, after deducting interest, &c., shows a net profit of £89,863. 4s. 9d., added to £12,011. 9s. 1d. brought forward, making £101,874. 13s. 10d. £35,000 has been placed to depreciation reserve and £5,000 to exchange reserve. The available balance is £61,874. 13s. 10d. Preference dividend (£25,533. 3s. 8d.) has been paid, and the directors recommend a dividend of 5 per cent. for the year, on the ordinary shares (£31,701. 6s.), leaving £4,640. 4s. 2d. to be carried forward. The traffic shows an increase of Rs.26,540.144, but owing to the fall in the rate of exchange the net result in English currency is a decrease of £2,716. 18s. 8d. During the year the directors purchased an interest in the Nova Companhia dos Ascensores Mechanicos de Lisboa, so as to enable the company to consolidate its system and to offer greater facilities to the travelling public.

SUBMARINE CABLES TRUST.—The revenue for the year ended April 15 amounted to £25,433. 12s. 11d. and the expenses to £1,167. 4s. 5d., leaving £24,266. 8s. 6d., to which is added £49. 1s. 4d. brought forward, making an available balance of £24,315. 9s. 10d. After providing £18,105 to meet payment of the coupons, £5,982. 1s. 6d. has been transferred to redemption fund, leaving £228. 8s. 4d. to be carried forward. During the year 50 certificates have been redeemed by purchase in the open market, with the surplus funds of the Trust, costing £5,982. 1s. 6d.

URBAN ELECTRIC SUPPLY CO. (LTD.)—Mr. P. D. Tucket stated at the meeting on Wednesday that the results of the past year had not realised the expectations entertained a year ago. The returns had been adversely affected by the exceptionally fine weather, trade depression and the increased use of the metallic filament lamp. Increase of £4,543 in eight of the towns served by the company was offset by a decrease of £2,161 at the remaining five.

WEST AFRICAN TELEGRAPH CO. (LTD.)—The revenue for the year ended Dec. 31 amounted to £56,316. 11s. 11d., from which is deducted £16,682. 14s. 6d. for ordinary expenses and £8,147. 1s. 11d. for expenditure relating to maintenance of cables, leaving £31,486. 15s. 6d., added to £831. 6s. 6d. brought forward, making £32,318. 2s. £1,343. 6s. 3d. has been provided for income tax, £20,000 transferred to general reserve, and an interim dividend of 2 per cent. (tax free) (£4,621. 16s.) was paid on Dec. 1 last. The directors recommend a final dividend of 2 per cent. (tax free), making 4 per cent. for the year, the balance of £1,731. 3s. 9d. being carried forward.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—The gross receipts for 1908 amounted to £52,612. 13s. 2d., against £61,854. 7s. 8d. in 1907. Working expenses were £33,193. 7s. 10d., compared with £34,616. 11s. 6d. After providing £6,800 for interest and £531. 15s. 7d. for income tax, there remains £12,087. 9s. 9d., added to £1,354. 15s. 6d. brought forward, making £13,442. 5s. 3d. £8,000 has been placed to general reserve and £2,000 to maintenance ship's reserve, and the directors recommend a dividend of $2\frac{1}{2}$ per cent. (tax free), amounting to £2,813, leaving £629. 5s 3d. to be carried forward.

WESTERN TELEGRAPH CO. (LTD.)—The revenue for the half-year ended Dec. 31 last amounted to £343,668. 0s. 11d. and the working expenses to £133,673. 4s. After providing £16,000 for debenture stock interest and £5,661. 0s. 6d. for income tax, there remains £188,333. 16s. 5d., to which is added £4,259. 13s. 11d. brought forward, making a total of £192,593. 10s. 4d. First and second interim dividends (amounting to £62,379) have been paid, and after transferring £100,000 to general reserve, £5,000 to maintenance ships' reserve, £10,000 to marine insurance and £10,000 to land and buildings depreciation, there remains £5,214. 10s. 4d., which is carried forward.

NEW COMPANIES, STATUTORY RETURNS, &c.

NEW COMPANIES.

CARDWELL, BOORMAN (LTD.) (102,674.)—Reg. April 26, capital £1,000 in £1 shares, to acquire business of Cardwell, Boorman, Ford-Lloyd (Ltd. in liquidation), and to carry on the business of electricians, electrical and mechanical engineers, manufacturers of and dealers in electrical telegraphic and telephonic apparatus, &c. Private company. First directors, C. Stirling (chairman) and A. F. Ward (managing director). Reg. office, Boswell-court, Devonshire street, London, W.C.

CHORLEY & DISTRICT TRAMWAYS (LTD.) (102,751.)—Reg. April 29, capital £300,000, to carry out the construction and equipment of tramways, tramroads and other works authorised by the Preston, Chorley and Horwich Tramways Acts of 1903, 1904 and 1906, &c. First directors, Lord Lyveden, R. C. M. Pooley and C. Looker (all permanent). Reg. office, 154, Finsbury Pavement House, London, E.C.

COWPER COLES ENGINEERING CO. (LTD.) (102,724.)—Reg. April 28, capital £40,000 in £1 shares, to adopt an agreement with Sherard Cowper-Coles & Co., A. E. Tugwood (the liquidator), S. O. Cowper-Coles and J. Macgregor-Laird, and to carry on the business of iron and steel workers, electricians, consulting and electrical engineers and technical consultants or advisers, &c. Private company. First directors, J. M. Laird and S. O. Cowper-Coles.

RADIUM LAMP (LTD.) (102,710.)—Reg. April 27, capital £100 in £1 shares, to carry on the business of manufacturers of and dealers in lamps and parts thereof for lighting, heating or otherwise by electricity or other means, and to adopt an agreement with R. Schreiber and J. F. Wakelin. Private company. First directors, R. Schreiber (chairman and managing director) and J. F. Wakelin.

WARDLE ENGINEERING CO. (LTD.) (102,714.)—Reg. April 27, capital £5,000 in £1 shares, to carry on the business of electrical and mechanical engineers, suppliers of electricity, &c. Private company. Reg. office, 112, Portland-street, Manchester.

STATUTORY RETURNS.

LONDON ELECTRIC SUPPLY CORPN. (LTD.)—The capital in return to Feb. 23 is £1,050,000 in 200,000 ordinary shares of £3 each and 90,000 preference shares of £5 each, of which 111,000 ordinary and 69,840 preference have been taken up. £3 per share has been called up on 110,000 ordinary and £5 per share on 69,840 preference, and £632,360 has been received, including £160 on 160 forfeited shares. Mortgages and charges, £387,355.

NEW IGNITION SYND. (LTD.)—In return to April 12 capital is £6,000 in £1 shares, all of which have been taken up. £2,027 has been received and £3,973 is considered as paid. Mortgages and charges, £3,000.

A. REYROLLE & CO. (LTD.)—In return to April 9 capital is £40,000 in 20,000 ordinary and 20,000 preference shares of £1 each, of which 17,500 ordinary and 18,819 preference have been taken up. £29,319 has been received and £7,000 is considered as paid. Mortgages and charges, £14,400.

SMITHFIELD MARKETS ELECTRIC SUPPLY CO. (LTD.)—Return to April 2 gives capital as £100,000 in £5 shares, of which 12,000 have been taken up. £60,000 has been paid. Mortgages and charges, £54,700.

CITY NOTES.

MEMORANDA (May 6).—**Bank rate $2\frac{1}{2}$ per cent.** (since April 1, 1909). Price of silver, $24\frac{7}{8}$d. per oz. Consols $85\frac{3}{8}$—$85\frac{1}{2}$ for money and $85\frac{7}{16}$—$85\frac{1}{2}$ for account. Consols Pay Day, June 1; Stock and Shares Continuation Days, May 11 and 25; Ticket Days, May 12 and 26; Pay Days, May 13 and 27; Mining Shares Carry Over Days, May 10 and 24.

PRICES OF METALS (London).—*Copper*, cash, $57\frac{13}{16}$; three months $58\frac{9}{16}$. *Lead*, English, $13\frac{1}{2}$—$13\frac{5}{8}$; foreign, cash, $13\frac{1}{4}$; three months, $13\frac{1}{2}$. *Spelter*, cash, $21\frac{13}{16}$—$21\frac{7}{8}$; three months, 22—$22\frac{1}{4}$. *Tin*, English, 132—134; foreign, cash, $131\frac{1}{4}$—$132\frac{1}{2}$, three months, 132—$132\frac{1}{4}$. *Iron*, Cleveland, cash, 48/1, and three months, 48/9. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BRITISH ELECTRIC TAACTION CO. (LTD.)—The Hon. Albert Stanley, M.P., has joined the board to fill the vacancy caused by the death of the Right Hon. H. O. Arnold-Forster.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The directors recommend a final dividend for 1903 at the rate of $9\frac{1}{2}$ per cent. per annum (making 8 per cent. for the year) on the ordinary shares.

DUDLEY, STOURBRIDGE & DISTRICT ELECTRIC TRCTION CO. (LTD.)—Mr. S. R. Blundstone stated at the meeting on Monday that there was a decrease in traffic receipts of £2,777.

ELECTRICAL ENGINEERING IN JAPAN.—The "Japan Chronicle" announces that the incorporation into one concern of the Shibaura Engine Works (Tokyo), the Tokyo Electrical Works Co. and the local branch of the General Electric Co. of America has become an accomplished fact. The capital of the new company is 4,000,000 yen, 51 per cent. of which has been contributed by American capitalists and 49 per cent. by Japanese. Of the seven directors four are Americans and three Japanese.

RICHARDSONS, WESTGARTH & CO. (LTD.)—The directors announce that no payment in respect of the dividend on the preference shares is being made.

TRAMWAYS & GENERAL WORKS CO. (LTD.)—The profit for 1908 was £979, and a dividend of 1s. per share (tax free) is recommended.

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The directors recommend payment of the following dividends: 6s. per share on the first preference shares (dividend for six months to Dec. 31) and 18s. per share on the second preference shares (on account of dividends accrued to Dec. 31.)

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	April 28	1,254	+ 46	48	64,672	+ 3
Airdrie	,, 23	223	− 6	16	3,427	− 63
Anglo-Argentine	,, 29	41,290	+ 5,231	17	678,523	+ 47,730
Ayr Corporation	May 1	211	− 18	51	13,062	− 366
Baker St. & Waterloo Ry.	,, 1	3,495	+ 335	17	57,445	+ 5,155
Barnsley	April 23	154	− 78	16	2,635	− 82
Barrow	,, 23	233	− 41	16	3,293	− 256
Bath Electric Trams, Ltd.	,, 28	712	+ 88	17	10,759	+ 431
Birmingham Corporation	May 1	6,480	+ 232	5	29,751	+ 298
Birmingham & Mid.	April 16	1,054	+ 260	15	12,011	+ 256
Blackburn Corporation	,, 23	1,010	+ 60	5	5,900	+ 132
Blackpool and Fleetwood	May 1	379	+ 76	17	1,621	− 175
Bolton Corporation	,, 2	2,327	+ 50	5	11,444	− 45
Bombay	April 1	R39,366	+ R1,591	13	R510,716	+ R37,452
Bournemouth Corporation	,, 28	1,608	+ 84	4	7,295	+ 22
Bradford Corporation	May 1	4,633	+ 158	5	22,158	+ 495
Brighton Corporation	,, 2	845	+ 20	5	4,302	+ 407
Bristol Trams & Carriage	April 30	6,159	+ 337	23	113,566	+ 9,929
Burnley Corporation	May 1	1,225	+ 26	5	6,105	+ 238
Burton Corporation	,, 2	253	− 25	5	1,225	+ 17
Bury Corporation	,, 2	1,104	− 13	§5	4,545	− 38
Calcutta Tramways Co.	,, 1	R46,196	+ R450	17	R849,402	+ R23,462
Camborne-Redruth	,, 1	117	− 1	18	2,031	− 102
Cardiff Corporation	...	...	...	...	...	...
Cavehill	April 23	77	− 217	16	1,034	− 167
Central London Railway	May 1	5,575	− 211	17	93,334	− 8,136
Charing C., Euston & H'stead	,, 1	4,000	+ 780	17	65,400	+ 11,275
Chatham & Dist. Lt. Rys.	April 29	804	+ 65	17	12,363	+ 1,318
City & South London Rly.	May 2	3,161	+ 42	17	56,361	+ 444
City of Birmingham	April 23	2,656	− 313	16	42,725	− 506
Colchester Corporation	,, 23	165	+ 1	...	...	...
Cork Electric Trams Co.	,, 24	397	− 33	17	7,128	+ 237
Croydon Corporation	,, 30	1,424	+ 101	4	6,599	+ 574
Devonport & Dist. Trams	,, 23	365	− 114	16	5,894	− 101
Dover Corporation	May 1	176	− 9	5	884	+ 4
Dublin & Lucan Railway	April 30	123	+ 15	17	1,938	+ 144
Dublin United	,, 23	5,257	+ 105	17	84,033	+ 1,131
Dudley-Stourbridge	,, 16	731	− 363	15	11,681	− 295
Dundee Corporation	,, 23	1,118	− 26	‡50	53,977	+ 2,102
East Ham Council	May 1	1,001	+ 206	§4	4,531	+ 832
Exeter Corporation	April 30	200	+ 3	5	1,405	+ 65
Gateshead & Dist. Trams	,, 23	949	− 114	16	15,623	− 185
Glasgow Corporation	May 1	17,424	+ 278	48	812,837	− 16,909
Glossop Trams	...	...	...	...	...	...
Gravesend—Northfleet	April 23	194	− 39	16	2,911	− 130
Great Northern & City Rly.	May 1	1,458	− 161	17	26,316	− 3,217
Gt. Northern, Piccadilly, &c.	,, 1	5,915	+ 540	17	98,765	+ 6,825
Greenock & Port Glasgow	April 23	554	− 34	16	7,424	− 176
Hartlepool Tramways	,, 23	204	− 30	16	3,217	− 155
Hastings Elec. Trams Co.	,, 23	951	+ 86	17	13,661	− 379
Hong Kong	May 1	$5,183	+ $1,544	17	$139,235	+ $9,866
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation	,, 1	2,462	+ 98	4	11,401	+ 113
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	April 28	122	+ 2	4	541	+ 6
Ipswich Corporation	May 1	347	+ 6	5	1,708	+ 165
Isle of Thanet Co.	,, 1	358	...	§22	8,950	+ 299
Jarrow	April 23	111	− 9	16	1,694	+ 134
Keighley Corporation	,, 29	151	+ 10	4	697	+ 28
Kidderminster & District	,, 23	94	− 56	16	1,352	− 58
Kilmarnock Corporation	May 1	147	+ 2	50	7,428	− 354
Lanarkshire Trams Co.	April 29	1,292	− 70	17	20,275	− 1,320
Lancashire United	,, 23	1,205	+ 94	17	20,930	+ 341
Leamington	,, 23	156	− 69	15	2,354	+ 165
Leeds Corporation	May 1	6,384	+ 138	5	30,984	+ 2,089
Leicester Corporation	,, 1	2,155	− 23	...	...	...
Leith Corporation	April 24	521	+ 32	49	25,406	+ 70
Lincoln Corporation	...	...	...	...	...	...
Liverpool Corporation	,, 24	10,670	− 2.5	‖16	169,113	− 551
Liverpool Overhead Rly.	May 2	1,232	− 154	18	23,201	− 1,638
*London County Council	April 24	35,636	+ 3,586	§3	123,745	+ 14,119
London United	May 1	5,883	− 333	‖20	90,030	− 4,515
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 1	171	− 3	4	804	− 27
Manchester Corporation	,, 1	14,716	+ 339	5	67,803	+ 2,331
Mersey Railway	,, 1	2,053	+ 152	17	33,324	+ 787
Merthyr	April 23	204	− 102	16	3,268	+ 9
Metropolitan Dist. Railway	May 1	10,050	+ 1,179	17	165,255	+ 14,631
Metropolitan Elec. Trams	April 23	6,160	+ 253	16	88,227	+ 9,830
Middleton	,, 23	307	− 179	16	4,894	− 243
Nelson Corporation	May 1	130	− 9	†4	655	− 23
Newcastle-on-Tyne Corp.	,, 1	3,841	+ 3.0	5	17,813	+ 25
Newport (Mon.)	,, 1	612	− 31	5	3,279	+ 31
Northampton Corporation	April 30	452	+ 75	§5	2,013	+ 195
Oldham, Ashton & Hyde	,, 23	5 5	− 2.0	16	8,637	− 635
Oldham Corporation	May 1	1,857	− 33	5	10,909	− 420
Perth (N.B.) Corporation	April 23	149	− 1	50	7,605	− 99
Perth (W.A.) Elec. Trams	,, 30	1,328	− 13	17	25,200	+ 94
Peterborough	,, 23	10.	− 11	16	1,624	− 101
Portsmouth Corporation	...	...	...	..	...	...
Potteries	,, 23	1,717	− 262	16	27,828	− 1,166
Preston Corporation	,, 23	7.0	+ 91	4	2,999	+ 136
Rotherham Corporation	,, 29	597	+ 69	4	2,557	− 30
Rothesay	,, 23	170	− 177	15	1,154	− 17
Salford Corporation	May 3	4,407	− 146	§5	21,776	+ 121
Sheerness	April 23	47	− 20	16	694	− 92
Sheffield Corporation	May 2	5,6 6	+ 219	§5	30,423	− 50
Singapore Trams	,, 1	$8,915	+ $360	17	$163,555	+ $3,988
South Metropolitan	April 23	813	− 59	16	11,071	+ 317
South Staffs	,, 23	797	− 297	16	13,040	− 797
Southend Corporation	,, 28	406	+ 95	4	1,842	+ 417
Southport Tramways	,, 23	264	− 148	16	3,748	+ 123
Stalyb'dge, Hyde, &c., Jt. Bd.	May 1	670	− 18	§4	3,653	− 26
Sunderland Corporation	,, 2	1,054	+ 31	[illegible]	5,144	− 105
Sunderland District	April 28	489	+ 22	26	11,530	− 295
Swansea Trams	,, 23	967	− 94	16	14,039	+ 349
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 23	40	− 13	16	553	− 53
Tynemouth and District	,, 23	171	− 48	16	2,254	− 107
Tyneside Trams Co.	,, 23	301	+ 96	17	6,779	+ 488
Wallasey District Council	May 1	855	+ 11	§4	4,171	+ 234
Walsall Corpn.	,, 1	501	− 3	17	8,514	− 659
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	April 22	2,222	− 252	3	7,661	+ 500
Weston-super-Mare	,, 23	93	− 90	16	668	+ 95
Wolverhampton Co.	,, 23	382	− 232	16	6,318	− 712
Wolverhampton Corpn.	,, 28	750	− 68	17	12,515	− 776
Worcester	,, 23	262	− 57	16	3,831	− 4
Wrexham	,, 23	102	− 11	16	1,480	− 45
Yorkshire W.R. Trams	May 2	1,030	− 69	18	20,185	...
Yorkshire Woollen District	April 23	854	− 314	16	13,585	− 493

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share.	Last Dividend	Name.	Price Wed. May 5.	Rate % Yielded.	Dividend Due.	Business Week to May: Highest.	Business Week to May: Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	7 0	Bournemouth & Poole Elec. Sup. Ord.	9½ –10	6 0 0	Mar, Sept	9	9½
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞ –10⅛	4 9 0	Feb, Aug	.	—
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10½ –10¾	5 11 6	Feb, Aug	10⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 –105	4 5 6	Jan, July	..	..
5	3 6	Bromley (Kent) El. Lt. & Power Shares	4½ –4¾	5 15 9	April, Oct	..	..
St.	4½%	†Do. Do. 1st Debs.	93 –96	4 16 0	May, Nov	..	..
5	5 6	Brompton & Kensington Elec. Sup. Ord.	8½ –9	5 11 0	March	..	..
5	3 6	Do. 7 per Cent. Pref.	8 –8½	4 2 ..	Mar, Sept	.	..
St.	4%	Cent l Elec. Sup. Co. 4% Guar. Db. Stock	99 –102	3 18 6	June, Dec	1[illegible]	—
5	2 6	Charing Cross (W. End & City) El. Sup. Co.	3¾ –4¼	5 19 0	Feb, Aug	.	—
5	2 3	Do. 4½ per Cent. Pref.	4¼ –4¾	4 15 0	Feb, Aug	4½	4⅝
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98 –101	3 19 0	Jan, July	99	98½
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 –101	4 9 0	..	100	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ –4½	5 8 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅝ –4⅛	4 9 3	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 –105	4 7 6	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10¾ –10⅞	5 10 3	Feb, Aug	10[illegible]	10[illegible]
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼ –12¼	4 16 0	Jan, July	11⅞	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 –123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 –104	4 6 6	Jan, July	..	..
5	2%	County of Durham Elec. P.D. Ord.	1 –2	6 13 4	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3½ –3¾	6 17 19	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅜ –8⅝	5 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾ –11¼	5 6 6	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (red.)	106 –109	4 2 6	Jan, July	..	..
St.	4½%	†Do. Second Deb. Stock	99 –102	4 8 0	May, Nov	101	..
5	3 6	Folkestone Electricity Supply Co. Ord.	4½ –5	5 10 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	95 –99	4 11 0	Feb, Aug	—	..
5	4 6	Hove Electric Lighting Ord.	7½ –7¾	5 11 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7⅛ –7⅜	5 5 0	Feb, Aug	7¼	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ –6⅜	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93 –96	4 3 6	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 –100	4 0 0	April, Oct	..	—
St.	4½%	Kent Elec. Power Co.	85 –89	5 1 0	Jan, July	..	—
3	1/9⅜	London Electric Supply Ord.	1⅞ –2¼	3 6 8	Mar, Sept	2[illegible]	—
5	3/0	Do. 6 per Cent. Pref.	5 –5⅜	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92 –96	4 3 6	Jan, July	.	..
5	3 0	Metropolitan Electric Sup. Ord.	4⅝ –5⅛	5 17 6	April, Oct	..	—
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾ –5¼	4 6 0	Jan, July	4⅞	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107 –110	4 2 0	June, Dec	—	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock red.)	86 –88	3 19 6	Jan, July	..	—
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98	4 12 0	June, Dec	..	..
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	5 –5¼	3 18 0	Feb, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	88 –90	5 0 7	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	3⅞ –4⅛	10 0 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 –5⅛	4 13 9	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red 1907.	94 –96	4 4 3	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 –101	4 19 0	..	—	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91 –93	4 17 10	Jan, July	—	..
10	8 0	Notting Hill Electric Ord.	11 –12	5 16 6	March	—	..
5	4 6	Oxford Electric Ord.	6 –6½	5 8 0	March	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 –97	4 2 6	Jan, July	..	—
5	5 0	St. James' & Pall Mall Elec. Ord.	8⅞ –9⅜	5 7 0	Feb, Aug	9[illegible]	..
5	3 6	Do. 7 per Cent. Pref.	7 –7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	83 –90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	⅝ –⅞	—	Feb	.	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 –70	5 14 0	Feb, Aug	—	..
5	4/0	South London Electric Supply Ord.	2¾ –3⅛	6 8 0	April	..	..
St.	..	Do. 5 1st Mort. Stk. Red.	101½ –103½	..	—	103	102½
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	..
1	0 8⅜	Do. 7 per Cent. Cum. Pref.	1[illegible] –1[illegible]	5 11 6	Feb, Aug	1¼	—
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 –103	4 7 6	April, Oct	102½	—
5	2/6	Urban Electric Supply Ord.	¾ –1¼	—	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	2 –2½	10 0 0	April, Oct	2[illegible]	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 –84	5 7 3	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9½ –9⅞	5 2 6	Mar, Sept	9¾	9½
5	2/3	Do. 4½ per Cent. Cum. Pref.	5¼ –5⅝	4 0 0	Jan, July	5[illegible]	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	97 –99	4 1 0	Jan, July	97¼	97⅜
1	..	Bath Elec. Trams Pref. Ord.	⅛ –½	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ –¾	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88 –92	4 18 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 –92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	9 –9½	6 6 0	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ –9	4 9 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99 –100	4 1 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	½ –¾	..	June, Dec		⅝
10	3/0	Do. 6 per Cent. Cum. Pref.	2¾ –3¼	9 4 9	Feb, Aug	3[illegible]	2[illegible]
St.	5%	Do. 5 per Cent. Perpetual Debs.	84 –86	5 14 0	April, Oct	8[illegible]	85½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	66 –71	6 6 6	May, Nov	69½	68½
St.	3½%	Central London Ordinary Stock	68 –70	5 0 0	Feb, Aug	70	69½
St.	4%	Do. 4 per Cent. Pref. Stock	85 –87	4 12 0	Feb, Aug	85½	..
St.	2½%	Do. Deferred Stock	52 –54	4 11 6	Feb	5[illegible]	53⅜
100	4%	Do. 4 per Cent. Debs.	102 –104	3 16 6	Jan, July	..	—
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 –94	4 5 0	Jan, July	93½	9[illegible]
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4⅝ –4⅞	5 2 6	April, Oct	..	—
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 –101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	30½ –31½	4 15 0	Feb, Aug	3[illegible]	3[illegible]
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 –112	4 9 0	Feb, Aug	11[illegible]	..
St.	5%	Do. (1895)	103 –109	4 11 0	Feb, Aug	..	..
St.	5%	Do. (1901)	102 –105	4 15 0	Feb, Aug	[illegible]4½	—
St.	5%	Do. (1903)	93 –93	5 4 0	Feb, Aug	..	..
St.	4%	†Do. 4 per Cent. Perpetual Debs.	99 –101	3 19 0	May, Nov	..	—
10	6/0	Dublin United Trams. Ord.	—	4 16 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	12½ –13½	4 9 0	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	[illegible] –⅝	..	Feb, Aug	..	—
10	—	G. Northern, Picc. & Brompton 4% G.P.	8½ –9¼	—	Feb, Aug	..	.
St.	4%	Do. 4 per Cent. Deb. Stock	94 –96	4 3 6	Jan, July	..	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2 –3	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	81 –86	5 4 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	6½ –7½	8 0 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	7 –7½	8 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	83 –93	5 0 0	Jan, July	..	—
5	1 3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ –1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	54 –59	6 16 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	[illegible] –10[illegible]	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 –93	5 7 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1 –1[illegible]	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	4½ –5¼	9 10 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82 –4	4 15 3	Jan, July	—	..
10	2 6	London United Trams. 5% Cum. Pref.	3 –4	12 10 0	Jan, July	3[illegible]	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	70 –75	5 6 8	Jan, July	73	72
St.	—	Mersey Con. Ord. Stock	1 –2	—	Feb, Aug.	—	—
St.	..	Do. 3 per Cent. Perp. Pref.	2 –3	—	..	.	..
1	10[illegible]	Metropolitan Elec. Tramways Ord.	[illegible]	—	..		[illegible]
1	—	Do. Deferred	[illegible]	..	April	[illegible]	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	[illegible]	[illegible]
St.	4½%	Do. 4½ per Cent. Deb. Stock	95½ –97½	4 12 6	Jan, July	97	96½
St.	½%	Metropolitan Railway Consolidated	36 –37	1 7 0	Feb, Aug	39¼	36[illegible]
St.	3%	Do. Surplus Lands Stocks	69 –71	4 4 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Preference	88 –90	3 15 0	Feb, Aug	89¾	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	78 –80	4 7 6	Feb, Aug	78[illegible]	78
St.	3½%	Do. 3½ per Cent. Convertible Pref.	76 –78	4 10 0	Feb, Aug	77½	76[illegible]
St.	3½%	Do. 3½ per Cent. Debenture Stock	93 –95	3 13 3	Jan, July	91¼	93[illegible]

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed., May 5.	Rate % Yield-ed.	Dividend Due.	Business Week to May 5 High-est.	Low est.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*		£ s. d.			
St	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	93½	92
St	..	Metropolitan District Railway Ord.	15 —15½	—	Feb, Aug	15½	14½
St	..	Do. Extension Pref. (5 per Cent.)	39 —42	..	Feb, Aug	41	35½
St	3½%	Do. Assented Ext. Pref. Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	67 —70	5 0 0	Feb, Aug	..	..
	3%	Do. 3 per Cent. Consolid. Rent-charge	78 —80	3 15 0	Jan, July	..	..
St	4%	Do. 4 per Cent. Midland Rent-charge	102 —105	3 16 0	Jan, July	..	..
St.	4%	Do. Guar Stock 4 per Cent.	87 —90	4 9 0	Mar, Sept	87	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	133 —141	4 5 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	91 —94	4 5 0	Jan, July	93	92
St.	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	..	May	..	—
5	0/9	Potteries Electric Traction Ord.	½—¾	8 0 0	April, Oct	..	..
1	0/6	Do. 6 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
1	4½%	Do. 4½ per Cent. Deb. Stock	88 —91	4 19 0	May, Nov	..	..
St.	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
1	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
St.	5%	Sunderland Dist. Elec.Trms.5% 1stMt.Db.	80 —84	5 19 0	Jan, July	..	..
100		UndergdE.Rys.Lon.6% In.bds.with coup.3	34 —36	..	June, Dec	..	..
..		†Do. 5% Prior Lien Bonds	101½—102½	4 17 6	..	103⅛	..
..	4½	Do. 4½% Bonds with coup. 2	86 —88	5 2 0	..	..	..
—	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	..	..	..	..
5 St.	4½	Do. 4½ per Cent. 1st Debs.	84 —88	5 2 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	[illegible]	..	..	..	..
1	0 7½	Do. 6% Cum. Pf.	[illegible]	6 12 0	April, Oct	..	..
1	2/4½	†Babcock & Wilcox Ord. (ex and and bonus)	4⅛—4¼	4 10 6	April, Oct	4½	4⅛
1	0/7½	†Do. Pref.	1⅛—1⅜	4 10 0	..	..	..
5	6 0	British Insulated & Helsby Cables Ord.	6⅞—7⅛	7 0 0	July, Feb	7⅛	7
5	3 0	Do. 6 per Cent. Pref.	4⅛—6⅛	4 10 5	Jan, July	—	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5		British Westinghouse 6 per Cent. Pref.	½—¾	..	Feb, Aug	1⅛	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	94 —96	6 5 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —43	9 4 0	Jan, July	40½	40½
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	40 —50	9 0 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	..	..
1	5 0	Callender's Cable Con. Ord.	9¼—10½	6 13 6	Jan, July	10½	9¼
5	2/6	Do. 5 per Cent. Cum. Pref.	5½—5⅞	4 7 0	Jan, July	5⅞	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106 —107	4 4 0	Nov, May	..	..
1	1/6	Castner-Kellner Alkali Co.	1⅝—1⅞	6 16 0	May, Nov	1⅝	1⅝
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	102 —106	4 4 0	Feb. Aug	103½	103
	0 7½	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	7 10 0	March	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 13 0	April, Oct	..	..
1	0/9	Consolidated Electrical Co.	⅞—1	7 0 0	August ..	..	..
1	1/0	Consolidated Signal Co.	1⅜—1⅝	7 12 0	April, Oct	1½	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	2¾—3¼	6 4 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 56,000)	1 —1½	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	95 —98	5 2 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1⅜	8 0 0	Sept	—	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 9	Sept	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	—	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅜—⅝	..	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	76 —78	5 2 9	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	[illegible]	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 3 0	Jan, July	..	..
2	..	Electric Construction Co.	¾—1	..	Jan, July	..	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1 —1½	9 6 9	July	..	..
St.	4	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 —64	6 5 0	Jan, July	61½	..
10	5,0	General Electric 1900 5% Cum. Pref.	7½—7½	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	84 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11½—12½	6 0 0	Feb, Aug	12⅛	11⁹⁄₁₆
5	2/3	Do. 4½ per Cent. Pref.	4⅞—5⅛	4 3 6	Feb, Aug	5	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 2 0	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c.,Wrks.	14¼—15¼	6 9 0	Feb, Aug	15⅛	14⅞
10	..	Do. 5 per Cent. Cum Pref.	10 —11	..	..	10⅞	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	—	..
1	..	National Elec. Construction Co.	⅝—⅞	..	April	—	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—⅝	..	Nov	..	..
1	7½	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1¼	..	—	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	—	..	..
12	14/0	Telegraph Construction & Maintenance	32 —34	5 9 0	Mar, July	33½	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	102	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2¼—2⅜	4 10 6	..	2⅜	2⅜
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1⅜	4 8 0	..	1⅜	1⅜
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	109½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red	104 —106	3 14 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 6	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 9	..	107½	107⅛
10	6	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	9½	..
1	1/0	Willans & Robinson Ord.	⅛—⅜	3 15 0	Apr, Oct	⅜	..
5	3/0	Do. 6 per Cent. Cum. Pref.	3⅛—3⅜	8 18 0	Apr, Oct	3⅛	3⅛
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅜—3½	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	92 —95	5 5 0	June, Dec	..	..
St.	15/0	Anglo-American	58 —61	5 9 6	F,My,Ag,N	103½	102
St.	30/0	Do. Preferred	102 —104	5 16 6	F,My,Ag,N	103½	..
St.	3 0	Do. Deferred	17½—17½	2 6 0	F,My,Ag,N	18⅛	17½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91 —93	4 6 6	Jn,Ap,Jy,O	91½	91
10	6 0	Cuba Submarine Ord.	8 —9	6 13 6	Feb, Aug	8½	8⅛
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
1	2/0	Direct Spanish Ord.	3 —3½	5 16 0	April, Oct	—	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9½	5 8 0	April, Oct	—	..
St.	4½%	Do. 4½ per Cent. Deb.	100½ —102½	4 8 0	Jan, July	—	..
20	4 0	Direct United States Cable	12 —13½	6 8 0	Ja,Ap,Jy,O	13⅛	13
100	4½%	Direct West India Cable4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
10	15 0	Eastern Ordinary	134 —137	5 2 0	Ja,My,Jy,O	136	134½
St.	17 6	Do. 3½ per Cent. Pref. Stock	87½—91½	4 0 0	Ja,My,Jy,O	88½	..
St.	4%	†Do. 4 per Cent. Mort. Deb. Stk. (red.)	103½—104½	3 16 6	May, Nov	102½	..
10	2 6	Eastern Extension	12½—13	5 8 9	Ja,Ap,Jy,O	12½	12½
St.	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	102½	102
25	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	99 —101	3 19 0	May, Nov	99½	..
1	..	G.N. (of Copenhagen), Ex. Coupon 75	27 —29	6 4 3	Jan, July	27½	27⅛
..	4½	Halifax & Bermudas 4½% 1st Mt. Db.(red.)	100 —102	4 8 0	June, Dec	..	..
..	..	Indo-European Teleg.	61 —64	6 0 0	May, Nov	..	..
..	81	Marconi Companies Common	78 —82	4 17 6	Ja,Ap,Jy,O	—	..
..	81	Do. Preference	73 —76	5 5 6	Ja,Ap,Jy,O	—	..
..	..	Marconi's Wireless Teleg. Co.	1½—1⅝	..	April	..	..
..	4	Pacific & European 4½% Guar. Dbs. (red.)	100 —102	3 18 0	June, Dec	..	..
..	1 3	West Coast of America	1¼ —1½	4 5 6	May	1¼	..
..	4	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
..	..	West India & Panama	[illegible]	..	May, Nov	..	..
..	6,0	Do. 6 per Cent. Cum. 1st Pref.	8⅛—9⅛	6 13 6	May, Nov	..	..
10	6,0	Do. 6 per Cent. 2nd Pref.	8⅝—9⅝	..	May, Nov	..	..
1	5	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	103	..
..	3 0	Western Telegraph	13½—14	5 0 0	Mr,Jn,S,D	13½	13⅜
..	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
...	4%	Western Union Teleg. 4½ $1,000 4% Bonds	95 —98	4 5 0	..	..	..

Share	Last Dividend	NAME.	Price Wed., May 5.	Rate % Yield-ed.	Dividend Due.	Business Week to May High-est.	Low est.
		TELEPHONES.		£ s. d.			
100	2⅛	Amer. Teleph. & Telegh. Cap. St.	141 —145	6 13 8	..	141⅞	14[illegible]
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98 —100	4 0 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	98 —100	5 0 0	Mar, Sept	..	..
5	3 0	Chili Telephone	8 —8½	4 14 0	August ..	—	..
1	0/7½	†Monte Video Telephone Ord.	1 —1	6 0 0	Nov	..	..
1	0/6	†Do. 6 per Cent. Pref.	1⅛—1⅜	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106 —108	5 11 0	Feb, Aug	107	10[illegible]
St.	6%	Do. Def. Stock	123 —125	4 16 0	Feb, Aug	126⅝	12[illegible]
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11½	5 6 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11½	5 6 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅞—6	4 3 4	Feb, Aug	5¾	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	93 —100	3 10 0	June, Dec	98½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	101½	..
1	1/0	†Oriental	1⅜—1⅝	5 7 8	April, Oct	1⅝	..
1	0/7½	†Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 17 6	April, Oct	1⅜	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	89½	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	..
5	3/0	United River Plate	6⅞—7⅛	6 11 6	July	6⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.	105½—105½	4 5 0	Jan, July	—	..
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅝—3⅞	7 14 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10⅞—11⅛	5 6 0	Sp,DcMrJu	11⅛	1[illegible]
10	3/0	Do. 6 per Cent. Pref.	12⅞—13⅛	4 10 6	SpDcMrJu	13⅛	1[illegible]
10	6%	Submarine Cables Trust (Cert.)	127 —130	4 12 0	April, Oct	12[illegible]	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅜—6⅝	4 14 0	April, Oct	6⅜	6
5	5/0	Do. 10% Non-cum. 2nd Pref.	9⅛—9⅜	5 5 6	Jan, July	9⅛	..
St.	4%	Do. 4% Deb. Stock	90 —92	4 7 0	June, Dec	92½	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 0	Jan, July	104	10[illegible]
1	3 6	†Brisbane Electric Trams. Invest. Ord.	5⅞—5⅞	3 7 6	May	5⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 18 0	May, Nov	5⅛	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	102 —106	4 5 0	Jan, July	101½	1[illegible]
St.	8%	†British Columbia El.Ry.Df. Ord.	140 —144	5 11 0	Mar, Sept	141½	..
St.	6%	†Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	123⅛	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	108½—110½	4 10 0	Jan, July	110⅛	1[illegible]
100	4½%	Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 0	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 6 8	Jan, July	1[illegible]	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	98½—100½	4 4 6	—	..	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db	98½—100½	5 0 6	Mar, Sept	99	..
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96 —100	6 0 0	Feb, Aug	98	..
5	2/0	†Calcutta Tramways (1 to 137,610)	4 —4½	5 0 0	Mar, Sept	4¼	4
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 15 0	Jan, July	5	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	99 —102	4 8 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	⅜—⅝	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 4 9	F,My,A,N	5⅛	..
St.	4%	Do 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	..
..	5%	†Columbo Tr. & Ltg. 5% 1st Mt. Db.	90 —93	5 7 6	May, Nov	—	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 —88	5 13 9	June, Dec	85	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	89 —94	5 6 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	⅝—⅞	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	84 —88	5 11 0	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	58 —63	9 10 0	Jan, July	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 —1¼	4 9 0	July	—	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	94 —97	5 1 0	Jan, July	—	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	90 —93	5 7 6	Jan, July	—	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	92 —96	5 4 0	Feb, Aug	..	..
100	$1½	†Mexico Trams Co. Com. St.	147 —149	4 1 6	..	149	14[illegible]
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	96 —97	5 2 6	..	..	9[illegible]
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	103⅞	102
St.	4½%	†Do. do. (Nos. 1 to 4,000)	102 —104	4 6 8	May	..	..
1	1/0	Perth Elec. Trams Ord	1⅛—1⅜	6 12 6	Jan, July	..	..
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	..	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅝—5⅞	5 6 6	..	5⅞	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	100⅞	1[illegible]
100	..	Rio Janeiro Tram, Lt. & P. Co.	101 —105½	..	..	97⅞	..
..	5%	Do. 30 yr. Gold Bnds.	97½— 98½	5 2 0	..	98¼	9[illegible]
100	5%	Do. 10 yr. Mt. Bnds	80½— 87½	..	..	..	..
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	156 —158	6 7 6	..	157	155
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100 —101	4 19 0	June, Dec	100⅞	..
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5⅝	5 11 0	Mar, Sept	5⅝	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	90 —93	4 17 0	Jan, July	91½	9[illegible]
5	3/3	Calcutta Elec. Supply Ord.	6⅞—7⅛	6 12 0	April, Oct	7⅛	6[illegible]
100	$1½	Canadian Gen. Elec. Co. Com. St.	120 —124	5 13 0	..	1.5¼	12[illegible]
100	$3½	Do. 7% Cm. Pf. Stock	119 —121	..	..	121	11[illegible]
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —102	4 13 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	88 — 90	5 11 0	..	89	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1⅛—2¼	..	Feb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	80 —84	6 6 6	Jan, July	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½—89½	5 10 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	..	..	..	..
10s	0/3	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—⅜	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅝—⅞	7 10 0	April, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	70¼	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	88½—89½	5 11 6	..	88½	..
St.	$1	Mexican Lt. & Power Co. Com. St.	77 —79	5 17 0	—	77½	..
500	5%	Do. 5% 1st Mort. Gold Bnds.	92 — 93	5 7 6	—	93	..
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	118 —123	4 13 3	F,My,A,N	118	..
1	1/7½	River Plate Electricity Co. Ord.	1⅛—1⅜	4 3 6	April	1⅜	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref ex rights	1 —1¼	5 8 5	May	..	..
St.	6%	Do. 6 per Cent. Deb. Stock	102 —105	4 14 3	Jan, July	103½	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 11 0	April, Oct	..	..
100	$1	Shawinigan Water & Power Co. Ca	97 —97	4 1 0	..	99⅞	9[illegible]
..	5%	Do. 5 per Cent. Bds.	107 —109	4 11 6	Jan, July	108	10[illegible]
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 —99	..	..	98½	..
..	6%	Victoria Falls Power Co. Pref.	1⅛— 1⅜	5 6 9	Jan, July	..	..

* In [illegible] allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these

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NOTES.

New Systems of Wireless Telegraphy.

What is claimed as an entirely new system of wireless telegraphy was described in our issue of April 30th in a special article by Count Arco. The system is being exploited by the Telefunken Company, and has been developed by them during the past year. The article drew from the Lepel Wireless Syndicate a letter which was published in our correspondence columns last week; in this it was bluntly stated that the Telefunken syssem was "a consciously spurious imitation" of the method devised by von Lepel. In this present issue (p. 174) we print an article which describes fairly fully the working parts of the Lepel apparatus, and which the Lepel Syndicate think will substantiate their charge of copying. It will be seen from the article that the real novelty of the system lies in the parts concerned in the generation of electrical oscillations. The arc, or spark—whichever it may be called—is made to occur between two parallel metal plates kept separated to a constant amount by a distance-piece consisting of a ring of thin paper. The gap is very small, and thus the P.D. necessary to jump the gap need only be 400 or 500 volts. This P.D. may be supplied from direct or alternating-current mains, and since the gap is shunted in the Duddell manner by an inductance and capacity, electrical oscillations are generated when the discharge occurs between the plates. The prime advantages of this parallel plate arrangement are, first, the exactness of the setting and the maintaining of the arc-length, and, second, the possibility of signalling by kindling and extinguishing the arc. Constancy of arc-length is needed to obtain constancy of wave length, and the kindling method of sending Morse signals reduces the current consumption.

Of the Telefunken method described by Count Arco, all we know is that it depends on the use of small sparks so short-lived that the primary circuit in which they are formed ceases, at a very early stage in the train of oscillations in the secondary circuit, to react upon this circuit the secondary oscillations are thus but slightly damped. This kind of spark is called the "quenched spark," and the principle has been so perfected by the Telefunken Company that the sparks follow each other regularly enough to give out a clear musical tone—the so-called singing spark. We do not know precisely how all this is done, and thus we are quite unable to compare the working methods of the rival systems of wireless telegraphy. This plentiful lack of particulars of the new Telefunken method is, unhappily, supplemented by the reserve shown by the Lepel Syndicate as regards the electrical theory of their method. If only we knew the scientific basis of their method, we should be in a much better position and our readers also, to compare the competing systems. With the available data just comparison is impossible. But especially as regards the Lepel system the thought that leaps to the mind is that the method of generating is at the bottom merely a mechanical variant of the cooled Poulsen arc in a hydrogenous atmosphere produced by the burning of paper; but it is an adaptation in which the mode of ensuring a constant arc length and of supplying the necessary atmosphere is of surpassing ingenuity and perfection.

Halfpenny Tramway Fares.

Although halfpenny tramway fares are in operation in but few towns, the subject is one of the most important

with which tramway managers have to deal, and proposals for the adoption of such fares have frequently to be considered by municipal tramway committees. The most recent report on the subject, to which we briefly referred in our last issue, is by Mr. J. M. McElroy, general manager of the Manchester Corporation tramways, and is one of the most valuable yet presented, as it contains a careful analysis of the whole question. It is pointed out that the working classes are not largely benefited by halfpenny fares, as is often supposed, since those who mainly derive benefit are business people frequently moving about the city, and a more satisfactory result, at any rate as regards the housing question, is obtained if the working classes have the advantage of cheap fares for long distances. Tramway undertakings are not unacquainted with peak loads, and in this connection Manchester seems to suffer particularly. The conditions, however, appear to vary very considerably in different towns, for at Glasgow, which is always referred to as an example of the success of halfpenny fares, the load is more evenly distributed throughout the day, and there is always room for halfpenny passengers, even at rush hours. It is interesting to notice that of the many tramway managers whose views, often culled from experience, on the adoption of halfpenny fares, are referred to in the report, only those at Sheffield and London believe them to be a success. The conditions on the London County Council tramways are unusual, and it is probable that the exceptional facilities of the workmen's and halfpenny fares are provided at the expense of the ordinary passenger, or, perhaps, the ratepayer. The difficulty of the problem is that the full effect of these fares is not always felt in the early years of their trial, when agitation for lengthy halfpenny stages is not infrequent, and the gradual growth of this class of traffic may lead to considerable expense when the cars provided are only sufficient in number or carrying capacity for the longer distance traffic.

Continuous Oscillations in Surgery.—Last week, at the Royal Institution, Dr. Horace Manders described an interesting application of high-frequency discharge to the treatment of rodent ulcers and the like. The operating knife is connected to a source of continuous oscillations, with the result that as tissue is removed cauterisation takes place and the tendency to bleed is reduced.

Glasgow Section of the Institution of Electrical Engineers. At the annual general meeting of this section held on Tuesday, May 11th, the report of the council of the section was submitted, and the following officers were elected to serve during the coming session: *Chairman*, E. G. Tidd; *Past Chairmen*, F. G. Baily and W. W. Lackie; *Vice-chairman*, Wm. McWhirter; *Chairman of Students' Section*, H. A. Mavor; *Hon. Sec. and Treasurer*, J. E Sayers; *Members of Committee*, J. K. Stothert, Jos. Taylor, R. Robertson, J. A. Robertson, J. T. Bottomley, Magnus Maclean, Sam Mavor, Councillor W. C. Martin and Campbell M'Millan.

Wireless Telegraph Licences.—As there appears to be some impression that a wireless telegraph installation for receiving purposes only does not require a licence, the Postmaster-General directs the attention of the public to the wording of sec. 1 (1) of the Wireless Telegraphy Act, which is as follows: "A person shall not establish any wireless telegraph station, or instal or work any apparatus for wireless telegraphy, in any place or on board any British ship except under and in accordance with a licence granted in that behalf by the Postmaster-General." This provision covers receiving as well as transmitting stations.

Cable Interruptions.	Date of Interruption.
Obock—Djibouti	Apr. 15, 1909
Jamaica—Colon	May 6, 1909

University of Liverpool.—Among the honorary degrees conferred by this University on the occasion of the installation of the Earl of Derby as Chancellor were the following: *Doctor of Laws*, Mr. Marconi; *Doctor of Science*, Mr. Francis Darwin, and *Doctor of Engineering*, Hon. C. A. Parsons.

Corps of Electrical Engineers.—The Sergeants' Mess of this section of the Territorial Force held a most successful Bohemian concert at the headquarters of the corps in Regency-street, Westminster, on Saturday evening last. A large number of members and guests were present, who thoroughly enjoyed the musical fare provided by the Entertainments Committee. The artistes included Company Sergt.-Major Mathews, Sergt. White and Sergt.-Drummer Etches on the military side, while others who contributed were Mrs. S. Mathews and Miss M. Spashett, as well as Messrs. W. S. Robinson, L. J. Took, V. G. Brooke and H. West. The decorations of the hall were quite "splendiferous," and reflect great credit on Company Sergt.-Major (Inst.) Stone, R.E., under whose direction they were carried out.

Electricity in Naval Gunnery.—It is announced that important experiments have recently been carried out in home waters, under the personal supervision of Vice-Admiral Sir Percy Scott, in order to test a new type of director, Sir Percy Scott's invention. It is claimed that by this invention any particular group of guns can be trained in any direction without the assistance of gunlayers. The barbette, or broadside guns are electrically connected with the fire-control station. Hitherto it has been necessary for the gunlayers to train these guns according to indicated directions from the officers in the tops, and then to fire them simultaneously from the conning tower. Under this invention the guns are both trained and fired by the operation of electrical apparatus. The experiments are reported to have been successful.

Energy Consumption on Single-Phase Railways.—According to the "Electrical Review and Western Electrician" during January of this year a power-consumption test was made on the Blankenese-Ohlsdorf division of the Prussian State Railways to determine whether the manufacturers had fulfilled the guarantees for the several sections. The single-phase portion of the route is 16·5 miles long, and is operated at a pressure of 6,000 volts, the frequency being 25. The equipments tested comprise 54 sets of Winter-Eichberg motors rated at 115 H.P. on the one-hour basis. The results of the tests were exceedingly gratifying, and the power consumption was found to average only 33·6 watt-hours per ton-kilometre (about 48·7 watt hours per ton-mile), while the guaranteed average was 41·3 watt-hours per ton-kilometre (about 59·8 watt-hours per ton-mile). These equipments were furnished by the Allgemeine Elektricitäts Gesellschaft, and 25 more are under construction for this railway.

Linking-up in London.—At a recent conference of borough councils owning electricity undertakings, and held at Shoreditch, the Associated Municipal Electrical Engineers of Greater London were asked to draw up a scheme of linking-up. The Associated Engineers have now done this, and their report shows that they have made careful inquiries as to the capacity and type of plant at present in use at the electrical stations of the several borough councils, and more especially of what is known as "spare or reserve plant." They have also collected a large amount of statistical data, and are in a position to submit an estimate of the cost of carrying out a scheme of linking-up, but they desire that details shall not be published at present.

At a joint conference on Wednesday of the Councils owning electricity undertakings and the London Electric Supply Companies at the Great Eastern Hotel, it was unanimously resolved:

That in the opinion of this conference it is advisable, providing a suitable scheme can be formulated, that the powers conferred under the London Electric Supply Act, 1908, shall be carried out by the local authorities and companies jointly.

It was agreed to appoint a joint consultative committee of 12 members, with secretaries representing both sides.

Birmingham Section of the Institution of Electrical Engineers.—The annual general meeting of the Birmingham Local Section of the Institution of Electrical Engineers was held at the Grand Hotel, on Wednesday, May 5th. Prof. G. Kapp, the chairman, in proposing the adoption of the report of the

committee for the session 1908-9 stated that although they had lost a few student memberships, yet their full membership list showed an increase. As to the Papers read, they had reason to be satisfied with their record. The Papers had been of a high order, and the members had shown a great interest in the discussions. The motion was seconded by Mr. A. Willmott. In proposing a vote of thanks to the authorities of the University of Birmingham for allowing them to hold their meetings in the University buildings, Mr. J. C. Vaudrey stated that the university had established one of the first schools of electrical engineering, and it had attached to it in Prof. Kapp one of the ablest demonstrators in electrical science. The vote of thanks was seconded by Mr. F. J. Moffitt. Dr. W. E. Sumpner proposed a vote of thanks to Prof. Kapp for his work during the two years in which he was chairman of the Local Section. On behalf of the members of the section he congratulated Prof. Kapp on having been elected President of the Institution. Mr. M. Railing seconded the proposal, which was carried with acclamation. The meeting closed with a brief reply by Prof. Kapp.

The Finlay Electrolytic Cell.—In the discussion on the Paper by Prof. F. G. Donnan and Messrs. J. T. Barker and B. P. Hill on this subject before the Faraday Society, Mr. Finlay gave some interesting information. He remarked that they had obtained (on a large scale) 98 per cent. current efficiency at 3·4 volts when making solutions of 8 grammes caustic soda per 100 cubic cm. There were certain points distinctly in favour of large cells as against small ones. For example, the joint round the edges of the diaphragms was comparatively unimportant in the former. In the latter a leakage, even if not sufficient to give a loss of effluent, accounted for a certain inefficiency. There was also a loss of current. In practice, when making 8 per cent. solutions of caustic soda, dilution was not necessary, although required in the tests for the sake of uniformity ; the voltage was, therefore, somewhat lower. The working voltage had also been further reduced by certain improvements since the experimental cells were made. It was possible to make solutions containing 8 grammes of caustic soda per 100 cubic cm. with a pressure of three volts, the brine being at ordinary temperature with a current efficiency of 98 per cent. This gave a yield of 490 grammes of caustic soda per kilowatt-hour, or about 40 per cent. more than the most successful process now worked in this country. The absence of secondary reactions was one of the chief features of the cell, and for this reason ammonium chloride might be electrolysed by its means without formation of nitrogen.

Royal Society.—The first of this year's soirées of the Royal Society was held last Wednesday evening, when there were a good many interesting things to be seen. It may, perhaps, be said that the greatest attention was given to the scientific fortitude displayed by a well-developed bull dog which stood with two of its feet in crystallising dishes to make the necessary electrical connections and thus to show the variations of its heart on an Einthoven galvanometer. So impressed was the bull dog with the seriousness of the occasion that probably half those who looked at the movements of the string galvanometer went away with the impression that the dog was stuffed Passing from this exhibit of Dr. A. D. Waller to those of a more usual kind, we think it may be said that the most interesting electrical exhibit was the device shown by Mr. Arthur Wright for solving algebraic equations. Having left behind the mystification of electricity consumers, Mr. Wright appears in the new rôle of providing simplicity in the form of a device for solving equations with the very greatest ease, even though they are of such a nature as to turn the hair grey of our best mathematicians. Powers of x in odd decimals without any particular relation between themselves present no terrors. The device is a combination of rheostats, slide rules and a Wheatstone bridge, the equation being solved when the bridge is balanced. Such an extension of the slide rule will, doubtless, open up possibilities of all kinds. Some pretty experiments were shown on gases and vacuum tubes. Thus Prof. J. N. Collie showed that when mercury is shaken up with pure neon in a glass tube a bright orange-red glow is seen, and if a silica tube with mercury and neon in it is boiled the mercury gives a bright green light. Sir William Ramsay showed that radium emanation under pressure in a capillary tube liquifies to a colourless liquid which phosphoresces strongly. The Rev. H. V. Gill showed vacuum tubes fitted up with small strips of palladium foil which give an unusual kind of glow. Several exhibits were shown from the National Physical Laboratory. Thus Mr. W. Rosenhain showed an electrical muffle furnance with a high degree of heat insulation, the resistance winding being of thin platinum foil. Messrs. C. C. Paterson and E. H. Rayner showed a quadrant electrometer built specially for alternating current power measurements of high precision. The construction is such as to admit of easy and accurate adjustments, and the accuracy of measurement may amount to two parts in 10,000. Messrs. Paterson and Rayner also showed examples of standard non-inductive water cooled manganin tube resistances, as described recently in THE ELECTRICIAN, and also metal glow lamps for photometric sub-standards. These lamps are made with the tungsten filaments in one plane, and are run at 1·5 watts per candle. Mr. A. Mallock showed an interesting little engine worked by stretched indiarubber, the idea being to take the energy out of the rubber piecemeal, and thus to maintain continuous effort by using a reel of stretched indiarubber. Prof. Silvanus Thompson showed that indiarubber in tensile stress contracts strongly when its temperature is raised, thus enabling this material to be used as the working substance of a thermal engine. Prof. Thompson also showed some of his standard permanent magnets for quantometric work. Mr. S. Cowper-Coles exhibited an apparatus for jointing aluminium, and specimens of parabolic reflectors made by electro-deposition, and Mr. C. E. S. Phillips showed some pretty experiments on the flow of sand through tubes. Electric splashes on photographic plates were shown by Mr. A. W. Porter ; and Dr. C. V. Drysdale exhibited his vacuum tube model illustrating the propagation of alternating currents in a helix, as described recently before the Physical Society, and also stroboscopic apparatus for measuring speed, &c. A string electrometer, made by the Cambridge Scientific Instrument Co., was shown by Messrs. T. H. Laby and Horace Darwin. It is intended for the measurement of minute quantities of electricity, and for use as an oscillograph. A silvered quartz fibre is stretched between two vertical plates, one of these being at +40 and the other −40 volts ; any change of potential of the fibre causes a lateral deflection, which is observed through a microscope. A sensitiveness of 600 eye-piece divisions per volt has been obtained. This instrument has been used for the counting of alpha particles, the string being deflected as the negative ions reach it.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 14th (to day).

PHYSICAL SOCIETY OF LONDON.

8 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda : (1) "On a Bifilar Vibration Galvanometer," by Mr. W. Duddell, F.R.S. ; (2) "Effect of Temperature on the Hysteresis Loss in Iron in a Rotating Field," by Messrs. W. P. Fuller and H. Grace.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Solar Vortices and Magnetic Fields," by Prof. G. H. Hale.

SATURDAY, May 15th.

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

7 p.m. Meeting at the Colonnade Hotel, New-street, Birmingham. Paper on "Illumination," by Mr. W. Smith.

THURSDAY, May 20th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Annual General Meeting at the Royal Society of Arts, John-street, Adelphi, W.C. ; to be followed at

8.30 p.m. by a Paper on "Some Tests and Uses of Condensers," by Mr. W. M. Mordey.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week :—

Monday, May 17th, "A" Company ......
Tuesday, May 18th, "B" Company ......
Thursday, May 20th, "C" Company ......
Friday, May 21st, "D" Company ......
} Infantry drill, 6.45 p.m. (Practice for Officers' drill cup competition.)

ECONOMICS OF MEDIUM-SIZED POWER STATIONS.*

A STUDY OF COMPARISONS BETWEEN STEAM, GAS AND OIL ENGINES.

BY A. J. J. PFEIFFER.

Summary.—A description is first given of the principle and operation of the Diesel oil engine; and a comparison is then made of the capital and operating costs of steam, gas and oil plants respectively to deal with a maximum load of 1,600 kw. Finally, a comparison is made of sub-station distribution and local oil-engine plants.

Much has been written and discussed on the comparative merits and demerits of gas *versus* steam prime movers in central station practice, but comparatively little seems to be generally known of the rapid development of the internal combustion oil engine working on the Diesel principle. To-day the largest single oil engine unit has an output of 800 H.P., but manufacturers are prepared to construct units up to 4,000 B.H.P., and engineers connected with very large supply or power companies may find it profitable to consider this type of plant for their central stations, as well as an alternative to sub-station plant, especially where transmission distances would necessitate large capital expenditure. The following references to "oil engines" cover only those working on the Diesel principle, since only that type up to the present is constructed large enough to be considered a factor in central-station design.

The author first mentions the principles of operation of the oil engine. The principal difference between the Diesel oil engine and the ordinary gas engine lies in the fact that only the air used for combustion is compressed, the fuel being gradually injected after this compression of the air has taken place, the resultant great advantage being the elimination of the possibility of premature ignition, no sudden increase of pressure, and, therefore, less strain on the working parts. Manufacturers of Diesel engines are now following closely in the footsteps of the gas engine development, and are adopting the two-cycle and also the double-acting principle for large units, giving one, two or four working strokes per revolution.

An outline of the arrangements of a complete plant, consisting of five 400 kw. units, is next given in the Paper, together with diagrams of a single unit and of the station.

Thermo-dynamic Efficiency.—An oil-engine plant burning crude petroleum of about 18,500 B.Th.U. per pound has a thermo-dynamic efficiency far exceeding that of a steam or gas plant, this efficiency remaining practically constant over a wide range of sizes of units, and is about as follows: Taking the calorific value of fuel as 100, the loss in exhaust, cooling and radiation will be 55, engine friction and air pump losses 11; the brake horse-power will, therefore, be represented by 34, and, assuming a generator efficiency of 91 per cent., the efficiency of the complete set at full load will be 31 per cent. The auxiliary plant losses in addition to the air pump are very small and do not reach ½ per cent. The efficiency at half load may be taken as 24·8 per cent., at three-quarter load 29·2 per cent., and at full load 30·5 per cent.

Reliability, Simplicity, &c.—As regards these two mentioned factors, this type of oil engine leaves nothing to be desired, and, so far as the second factor is concerned, the oil-engine plant is certainly much superior to either steam or gas. The costly stand-by losses of a steam or gas plant, especially at low load factors, are absent. All labour in connection with fuel handling and boiler or producer plant is done away with, and, in consequence, the wages bill is about one-half to two-thirds of that of steam or gas. On the advice of the writer a 1,000 B.H.P. plant was installed for the Howrah system of the Calcutta Tramways Co., the largest unit being 450 B.H.P. This plant has been running for almost a year without a hitch of any kind, having passed through the period of guarantee without requiring the slightest repair. Once the oil engine is thoroughly well installed and adjusted there is much less to go wrong than with either steam or gas plant, and it is, therefore, much more fool-proof, an important consideration in countries and places where skilled labour is scarce or very expensive. Like a gas engine, the overload capacity of an oil engine is limited to about 15 to 20 per cent.

The speed regulation approximates easily to that obtained in a steam engine, and can be made to come within 3 per cent., or even less, between no load and full load. As regards parallel running, a speed variation of 1/250th to 1/300th can easily be obtained with a four cylinder four-cycle single-acting engine with a small flywheel. To obtain the same result with three cylinders, however, requires a flywheel of cast steel, the use of the ordinary heavy cast-iron flywheel being advisable only for speed variations up to 1/160th.

The noise of the exhaust can be effectively done away with so as to make it possible to operate a plant in the heart of a city without its becoming a nuisance. Smoke must also be guarded against in working an oil plant in cities or towns, and it comes into evidence when engines operate below one-fifth to one-sixth full load, the cause being the imperfect combustion of the oil fuel. For plants having low load factors, therefore, it will be advisable, in addition to the advantage of economy, to put in at least one small unit to cope with light loads, or possibly to instal accumulators.

Fuel.—The type of engine under consideration can burn almost any liquid fuel; but generally, and especially in Great Britain, petroleum residue from the Dutch East Indies, Texas and Roumania is used, while on the Continent gas oils and paraffin oils are successfully employed. Of late a new source of oil fuel has been found, and that is gas plants. Carburetted water gas plants, of which there are a great many in Great Britain, give off an oil tar as by-product which lends itself admirably as oil-engine fuel, having a calorific value of about 0·9 that of crude petroleum, or about 16,500 B.Th.U. per pound. Such fuel oil has already been used for some time past on the Continent in connection with Diesel oil engines. Then, again, amongst the by-products of a retort gas plant using bituminous coal is a tar oil, this containing asphalt, which has to be removed before the oil can be used. As crude petroleum is found in a great many parts of the world (a map in the Paper shows the world's oil fields), and as new fields are being continually discovered, the reliability of supply and price fluctuations may be regarded as no worse than coal. Crude petroleum residue costs at present between 50s. and 55s. per ton at ports in England; in South America about 60s. per ton, and in Indian ports about 45s. to 50s. per ton.

COMPARISONS OF CAPITAL AND OPERATING COSTS FOR STEAM AND GAS VERSUS OIL PLANTS.

Let us assume the case of a plant dealing with a maximum effective load of 1,600 kw., and consider three types of loads having the following annual load factors: Lighting load, 17·5 per cent.; lighting

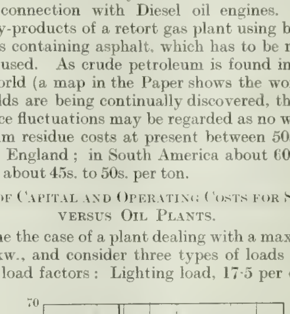


FIG 1.—TOTAL FUEL CONSUMPTION PER KILOWATT-HOUR GENERATED.

and power load, 33 per cent.; traction load, 52 per cent. Plant load-hour curves resulting from the ordinary daily load characteristics are given in the Paper for these three types of loads.

The divisions of engine units are assumed as follows: 17·5 per cent., load factor, five 400 kw. sets (1 reserve), one 100 kw. set. 33 per cent. load factor, four 400 kw. sets (1 reserve), two 200 kw. sets. 52 per cent. load factor, five 400 kw. sets (1 reserve). For these it is assumed that five (1 reserve) units are provided for both boiler and producer plants.

Estimates of capital costs may be made to diverge considerably. The following figures are based on high-grade plants throughout: (*a*) *Steam Plant.*—Machinery, &c., £16 per kilowatt. Buildings and foundations, £8·5 per kilowatt. Total, £24·5 per kilowatt. (*b*) *Gas Plant.*—Machinery, £17·5 per kilowatt. Buildings and foundations, £6 per kilowatt. Total, £23·5 per kilowatt. (*c*) *Oil Plant.*—Machinery, £19·5 per kilowatt (with vertical four-stroke engines), or £17·5 per kilowatt (two-cycle engines). Buildings and foundations, £5·5 per kilowatt. Total, £23 to £25 per kilowatt. It would seem, therefore, that the difference of capital outlay between the three high-grade plants is but nominal. Land values have not been taken into account, as they are variable and are usually comparatively small.

Fuel Consumption and Thermo-dynamic Efficiency.—(*a*) *Steam.*—A plant embodying most up-to-date characteristics to attain maximum economy has been assumed, including compound condensing engines, water-tube boilers, economisers, 100°F. superheat, steam consumption at full load, including auxiliaries, 20·5 lb. per kw.-hour; coal, 13,000 B.Th.U.; 8 lb. water evaporated per pound of coal. (*b*) *Gas.*—Vertical single-acting tandem engines, pressure producer; coal, 13,000 B.Th.U. per pound. (*c*) *Oil.*—Vertical single-acting four-cycle engine; oil, 18,500 B.Th.U. per pound.

From the fuel consumptions shown in Fig. 1 the following thermo-

* Abstract of a Paper read before the Institution of Electrical Engineers.

dynamic efficiencies are obtained at the three load factors assumed: Steam plant, 5·60, 7·30 and 8·70 per cent; gas plant, 11·7, 13·3 and 14·5 per cent.; oil plant, 25·7, 27·3 and 27·8 per cent. The superiority of the oil engine plant as regards thermo-dynamic efficiency is attributable to absence of stand-by losses and greater efficiency in the cycle of operation in the engine itself. The above advantages are to a certain extent offset, however, by the greater driving losses of the oil engine, the mechanical efficiency of which, inclusive of the air pump, is only about 76 to 77 per cent. If the overall thermodynamic efficiencies resulting from the assumed coal consumptions shown in Fig. 1 are plotted with respect to load factors, it will be found that the curves will pass very closely the points representing average results of 20 steam plants, and eight gas plants set out in the appendix to the recent Paper by Messrs. Andrews and Porter.

A table also shows how the fuel consumptions in Fig. 1 are obtained at the three load factors assumed—viz., by taking the pounds of fuel representing effective work done, adding the amount representing stand-by losses, boilers at 13 lb. per 1,000 lb. steam, producers at 20 lb. per producer hour, and then a further percentage to cover inefficient handling, loss in efficiency due to fouling of tubes, &c.

It will probably be possible to raise the efficiency of gas plants somewhat if the heat of the engine exhaust is made use of to aid in generating the steam required in connection with the producer plants.

Total Works Costs.—In Table I. are tabulated details of the comparative works cost per unit generated for the various load factors assumed.

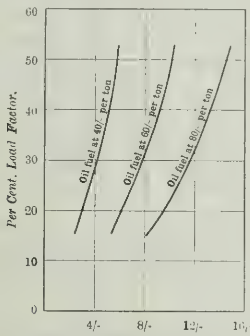


FIG 2.—STEAM VERSUS OIL "PARITY CURVES."

The "parity" curves given in Figs. 2 and 3 are based on Table I., and show the price of coal at which the total works costs of steam and gas plant are respectively equal to that of oil plant, with oil fuel at various figures.

Table I.

Load factor.	—	Steam. Pence per unit.	Gas. Pence per unit.	Oil. Pence per unit.
		At 15s. per ton	At 25s. per ton	At 60s. per ton
17·5 per cent.	Fuel	0·376	0·300	0·230
	Oil, waste, water, &c........	0·04	0·045	0·042
	Wages	0·16	0·015	0·100
	Maintenance and repairs	0·09	0·090	0·064
	Total ...	0·666	0·585	0·436
33 per cent.	Fuel	0·286	0·265	0·218
	Oil, &c............	0·035	0·040	0·036
	Wages	0·110	0·110	0·070
	Maintenance, &c.	0·070	0·070	0·050
	Total ...	0·501	0·485	0·374
52 per cent.	Fuel	0·247	0·243	0·212
	Oil, &c...........	0·030	0·035	0·030
	Wages	0·085	0·080	0·054
	Maintenance, &c.	0·060	0·060	0·042
	Total ...	0·422	0·418	0·338

The savings per kilowatt-hour effected by the oil-engine plant under certain assumptions of constant oil fuel costs and varying coal costs are plotted as curves in the Paper, and it is mentioned that as the capital costs of the three types of plant are practically equal, interest and depreciation will be the same for each, this also applies to management, whilst a small saving (due to land) will be shown in the item for rents, rates and taxes in the case of oil plant. So that the saving shown by the curves, and in Table I., may be considered as not only due to works costs, but also to total costs. Curves are also given in the Paper for steam plant of less efficiency and with coal of poorer quality.

Conclusions.—The above results show that the internal combustion oil engine working on the Diesel principle possesses advantages both from a technical as well as a commercial standpoint which will make this type of prime mover a most important factor in future central-station practice. Its limit of application depends primarily upon relative fuel costs, which for Great Britain would mean that it probably cannot compete with steam or gas engines in the immediate neighbourhood of coal centres. For colonial and foreign work, where coal costs are high, it undoubtedly possesses overwhelming advantages.

COMPARISON OF CAPITAL AND OPERATING COSTS OF SUB-STATION DISTRIBUTION VERSUS LOCAL OIL-ENGINE PLANTS.

The divergence of conditions governing sub-station practice is much greater than that for central station work, and, therefore, a general basis of comparison with oil-engine stations proportionately more difficult. Suppose we take the case of a large distributing system in London,* having an outlying central station feeding 10

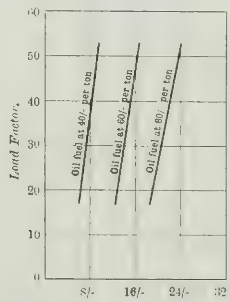


FIG. 3.—GAS VERSUS OIL "PARITY CURVES.

sub-stations, each sub-station having the output and size of the oil-engine plant considered in the foregoing. Transmission by means of high-tension underground cables, each station being debited with 5 miles of duplicate cable. Conversion by means of transformers and rotaries. Maximum load on each sub-station, 1,600 kw. Loss in transmission and conversion, 14 per cent.

Capital Costs.—If the sub-station plant is worked out on the assumption that the overload capacity of the converter sets is made use of to the extent of 15 per cent. in excess of the Diesel engine at the times of maximum demand, the normal rating of the running machinery required is 1,400 kw., and, allowing 25 per cent. for spare, the plant installed at each sub-station would be 1,750 kw., as against 2,000 kw. of oil-engine plant. The capital cost per kilowatt for the sub-stations will be: Plant, £4·75, buildings £2, land £3·25, total per kilowatt £10, giving a total amount for 10 sub-stations of £175,000. The cost of transmission mains—5 miles × 10 × £3,000 per mile of duplicate cable—gives £150,000.

Assuming a diversity factor of 1·25, the capacity of the central station would be: Running machinery 12,750 kw., plant installed (20 per cent. for spare) 15,500 kw. If the cost of the central station is taken at £20 per kilowatt (including £6 for buildings and £2 for land), the total for central station is £310,000, and the total cost with sub-stations will be £635,000.

Works Costs.—The sub-station cost in pence per unit of sub-station output will be:—

Sub-station load factor.	17·5 per cent.	33 per cent.	52 per cent.
Oil, waste, stores	0·005	0·004	0·003
Salaries and wages	0·070	0·055	0·040
Maintenance and repairs	0·025	0·020	0·015
Total per unit	0·090	0·080	0·060

* Some of the following figures for capital and operating costs wer based on figures given in the Paper by Mr. J. H. Rider on "The Electrical System of the London County Council Tramways."

and for the central station the pence per unit of central station output :—

Central station load factor.	25 per cent.	49 per cent.	76 per cent.
Coal at 14s. per ton	0·305	0·230	0·200
Oil, waste, water and stores .	0·010	0·008	0·007
Salaries and wages	0·050	0·035	0·028
Maintenance and repairs ...	0·055	0·043	0·037
Total per unit	0·420	0·316	0·272

The combination in pence per unit of sub-station output will be :—

Sub-station load factor.	17·5 per cent.	33 per cent.	52 per cent.
Pence per effective unit	0·580	0·447	0·376

If 5 per cent. be the interest. and if depreciation is charged at the average rate of 6 per cent. for machinery. 2 per cent. for buildings and 3 per cent. for cables. &c.. the additional charge per effective kilowatt-hour output of the sub-station will be 0·536d., 0·280d. and 0·180d. for the 17·5. 33 and 52 per cent. load factors respectively.

Conclusions—If in connection with the 10 local Diesel plants we allow £5 per kilowatt installed as the value of land, the total capital involved. based on two-cycle engines. would be £560.000. as against £635.000 for the central station sub-station scheme. Table II. shows the difference in total operating expenditure per effective unit including capital charges (management. rates and taxes, &c.. not included). Judging by these results. it is evident that under the above assumptions the local Diesel plants can be operated cheaper than a system of a large outlying central station distributing power by means of converting sub-stations. Engineers with higher central station and operating costs should. therefore. consider the Diesel engine.

Table II.

Local station load factor.	17·5 per cent.	33 per cent.	52 per cent.
Central station sub-station—			
1. Works cost—coal at 14s.	0·580	0·447	0·376
2. Interest and depreciation	0·536	0·280	0·180
Total	1·116	0·727	0·556
Diesel plant—			
1. Works cost—oil at 50s....	0·396	0·338	0·303
2. Interest and depreciation	0·500	0·267	0·169
Total	0·896	0·605	0·472

THE USE OF DIELECTRICS AND THE PRINCIPAL TESTS APPLIED TO THEM.*

BY T. GERMANN AND S. M. HILLS.

Summary.—The authors discuss the properties of insulating materials and describe the various tests they consider ought to be applied to the different substances. Particulars of a new method of testing are also given.

The properties—electrical, thermal and mechanical—of various insulating materials are first considered, and then the action of an electrical stress on a dielectric. A good insulator should possess the following qualities :—(1) High disruptive strength; (2) good insulation resistance; (3) physical properties permanent over a wide variation of temperature; (4) non-volatile; (5) non-hygroscopic; (6) able to resist the action of water, acids, alkalis and oils; (7) fireproof. Insulators for switchboards should also be of good mechanical rigidity with low surface leakage; whilst the additional qualities of insulators for dynamos are: pliability, freedom from fracture, toughness and ability to stand mechanical strain, and a high softening point; and for cables: flexibility, elasticity and low specific inductive capacity.

As no single substance fulfils all these requirements, in order to obtain a satisfactory insulator "mixtures" are resorted to. Such mixtures cause an unequal distribution of pressure in the dielectric, and this will probably account for a large number of insulation troubles. The experiments of Fessenden and Symons are instanced in this connection, and those of Dr. Baur, to determine the relation between the alternating-current breakdown voltage and the dielectric strength of an insulator—viz., $V=cd^{\frac{2}{3}}$ where d=thickness of insulation in millimetres and c=a constant termed "the electrical breakdown strength."

Insulators for high-tension power distribution are next considered. Glass or porcelain gives excellent results up to about 5,000 volts, but most of those of glass permit of surface leakage, even when new, and they weather very considerably. In time the surface becomes somewhat roughened, and then dirt and moisture begin to collect until a conductor is formed which is fairly good. Again, glass is slightly soluble in water, and this in itself is a reason for its hygroscopic nature. It should never be used in damp climates. Variations of insulating efficiency occur; a drizzling rain or a fog will be found to result in effects more detrimental than those due to a heavy rain. The latter tends to wash off any dirt from the outer surfaces, and has practically no effect upon the undersides of the petticoats.

In regard to porcelain, it is found that cheap material is often extremely hygroscopic; especially is this the case with some of the American porcelain, which will absorb 1 to 2 per cent. of its weight of water, this showing poor insulating properties. The best porcelain should absorb no moisture, and should show a brilliant vitreous fracture which will give no flowing stain on the application of ink. The glaze on the porcelain affects the properties. Glass is homogeneous throughout its thickness, but with porcelain it is a common experience to find that as soon as the glaze is damaged a porous and practically uninsulating porcelain is revealed. Thoroughly vitrified porcelain, in which the ordinary glaze is replaced by an actual fusing of the material itself, is much preferable to ordinary glass. It is strong and tough, non-hygroscopic, has very high insulating properties, the surface does not weather, and the insulation is practically permanent. If the vitrification extends considerably below the surface the resistance will not only withstand leakage, but puncture, better than glass.

A description is then given of the methods employed at the Hermsdorf Porcelain Works for testing insulators.* Tests on the breakdown voltage of dielectrics can be carried out: (1) Between two needle points; (2) between ball and plate; (3) between two parallel plates. The first mentioned is useful for testing oils and gases, the third for testing papers and such-like dielectrics, while the second does not appear to be of much value for practical purposes. The third method does to a great extent provide a method of testing under conditions analogous to those obtaining in actual practice, but the authors venture to think that the process for testing samples of dielectrics to be used for insulating armature coils, transformer coils, &c., described later in the present Paper, is to be preferred.

Oils.—There are two principal methods of testing the breakdown voltage of oil, viz., (1) between two spheres submerged in the oil and placed ½ in. apart; (2) between two needle points submerged in the oil and placed ½ in. apart. The results obtained by the latter method are lower than those obtained by the former, and since in a transformer or switch there are many sharp edges, if not points, the authors favour the use of the needle point method. Whilst the voltage is being increased, all the particles of dirt, &c., present in the oil collect between the two needle points. If the pressure is switched off, these particles can be removed on a piece of blotting paper and should be examined microscopically, when metallic particles can be distinguished. Metallic particles are, of course, most undesirable in an insulating oil, but the presence of moisture is the greatest evil, as 0·5 per cent. moisture will reduce the dielectric strength to one-half.

Varnishes—These play a very important part in the insulation of armature coils, field coils, &c., and are chiefly manufactured from linseed oil. Up till quite recently linseed oil was a very undesirable ingredient in an insulating varnish, as it rapidly absorbed oxygen and formed a tough elastic oxide; this oxidation continued until a viscid substance partially soluble in water was formed. Mr. R. C. Wamer made a series of experiments to illustrate this point, and the result of his experiments are mentioned in the Paper.

It is common practice to impregnate cotton and cambric with insulating varnishes. Cotton contains acid bodies derived from Pectin, which are soluble in water, and although water is only feebly ionised on the application of an electric current it helps other substances to ionise, and in so doing sets up electrolysis and chemical action. The production of green on the insulation of copper conductors is commonly termed verdigris, but this is a mistake, for the green formation is a compound resulting from the chemical action produced by acids in the cotton acting upon the linseed oil.

As regards the testing of insulating varnishes, three preliminary tests on the physical properties have to be made before the electrical properties are tested. The sample of the varnish must be distilled, and the following tests then performed: (1) Flash point in air (if any); (2) flash point as given by one of the many pieces of flash point apparatus now on the market; (3) place a small sample of the distillate on a watch glass and evaporate to dryness. No residue should be left.

The electrical tests are two in number, and show (1) the relation

* Abstract of a Paper read before the Junior Institution of Engineers. A short account of this Paper appeared in the Notes columns of our issue of April 9.

* A description appeared in THE ELECTRICIAN, April 24, 1908, p. 51.

between dielectric strength and specific gravity; (2) the relation between dielectric strength and the time of application of the voltaic stress. From the first the specific gravity at which the varnish is to be used is determined. The dielectric strength does not vary with the density, but this is probably due to the fact that there is a certain density at which the varnish can most easily percolate and soak into the pores of the paper and thus give a resultant insulator where the electric displacement is most uniform throughout.

For the time test several pieces of paper are treated with the varnish at the gravity just found to be the best. The paper is tested by the parallel plate or slot method, and the relation between the time of application of test and the voltaic stress applied is obtained by connecting an electric bell in the circuit. When the sample punctures the bell rings, rings being measured by means of a stop watch. This test is made at various voltaic stresses, and an application of 10 minutes is usually a long enough maximum period as at this point the curve runs into a straight line parallel to the axis. On dividing by a safety factor the running voltage of the insulation is obtained.

It is advisable to make the following supplementary tests: (1) Dip two pieces of copper strip in the varnish and dry for four hours at 70°C. Boil one of these samples in oil and one in water for a period of six hours. No signs of blistering should be visible if the varnish is suitable for withstanding the action of heat. A sample of varnish which is to be used in an oil-cooled transformer should always be tested in this manner; (2) Cut some of the dipped paper up into strips ½ in. wide, and test it for brittleness by bending a strip round pieces of iron rod. These rods should descend in diameters from 1 in. to $\frac{1}{16}$ in. in stages of $\frac{1}{16}$ in. A good varnish will bend round the smallest rod without cracking; (3) It is often found that when cambric or linen is treated with an insulating varnish its tensile strength diminishes. A piece of cambric should be dipped in the varnish, dried for four hours, and then tested; (4) Dip a piece of copper strip in the varnish, and heat at 70°C., for four hours. Heat the sample over a Bunsen flame and note the temperature at which the varnish becomes soft and tacky. The latter point should not be less than 80°C. Insulation often rapidly deteriorates with age, and it is necessary to store samples of insulation and test them after they have been stored about three months. Since insulation is a bad conductor of electricity, in most cases it is a bad conductor of heat, and this accounts for its deterioration with age. There are, however, insulating materials on the market which do radiate heat, a notable example being electro-enamel, a mixture introduced by Mr. Turner. These substances, however, being expensive and usually in the form of a paint, are not suitable for impregnating papers, cambric, &c.

Linen, &c.—A few tests are mentioned to which linen and cambric should be subjected. The first is to cut the linen up into strips ½ in. wide, and test both in the direction of warp and weft for tensile breaking stress and elongation. The average elongation is 8-10 per cent. for linen and cambric and 3-5 per cent. for brown linen, whilst the breakdown stresses are 90-120 lb. and 80-100 lb. respectively. The texture should be fairly fine, but not so fine that varnish cannot percolate and soak into the pores of the material. Dressing is a disadvantage, and should be avoided as much as possible, as it is liable to contain chlorine from the bleaching operation. Oiled cloths possess a high dielectric strength and are very flexible when new, but rapidly deteriorate with age, and it is imperative that "ageing tests" be made on this class of insulator.

Mica.—Mica is a very good insulator, as it not only possesses a high dielectric strength, but is also unaffected by heat. One great objection to its use is that it is not flexible, but this has been overcome to a large extent by preparations of mica such as micanite, mica cloth, &c. Most mica used in electrical work comes from India. The green shades are the softest, the variety known as "white amber," which comes from Canada, being the most flexible.

Marbles, &c.—The following tests are recommended: (1) Weigh a small sample and roast in an ash furnace for three hours. The loss in weight—*i.e.*, moisture—should not exceed 0·05 per cent. (2) Immerse in water for 24 hours. The gain in weight should not exceed 0·05 per cent. (3) Crushing stress should be ascertained. (4) Workability is usually determined by noting the time taken to drill a hole ½ in. deep and the temperature of the tool after the experiment. (5) The dielectric strength should be tested, the voltage at which moisture commences to evolve in the form of steam and also the voltage at breakdown being noted.

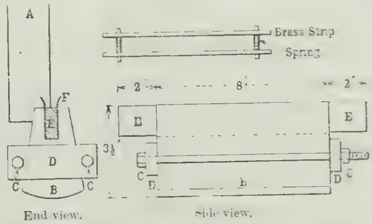
Though marble is preferable to slate on account of its greater freedom from metallic veins and more pleasing appearance, it is by no means an ideal switchboard material. It is always cold and consequently rapidly condenses moisture, causing surface leakage.

The authors have found by experiment that: (1) Mechanical properties of marble are good in the inverse proportion to the electrical properties. (2) The greater the specific gravity the lower the absorption of moisture. (3) The greater the specific gravity the lower the breakdown voltage. (4) The greater the specific gravity the greater the crushing stress. It will thus be seen that the specific gravity exerts considerable influence on the electrical properties.

Dynamo Insulators.—Rubber should never be employed, as it deteriorates so rapidly. A number of composite insulations are used, consisting of mica strip pasted on to sheets of another insulating material, amongst which the following may be mentioned: (1) Two sheets of red rope paper with one thickness of mica between them the whole being shellaced together. The average B.D.V. is about 230 volts per mil. (2) Mica and bond paper made in a similar way. Average B.D.V. 250 volts per mil. (3) Mica and canvas. B.D.V. 65 volts per mil. The B.D.V. above are R.M.S. values.

The process of insulating armature coils and field coils by taping them with cotton tape wound on the half-lap and dipping in an insulating varnish is then described by the authors. To obtain a high space factor the space occupied by the armature insulation must be reduced to a minimum. For lining the armature slot the following, arranged in order of toughness, are used: Leatheroid, presspahn, B.P., black paper, red rope paper and manilla paper. All slot lining material should be thoroughly dried and waterproofed, the best method being to submit the material to prolonged soaking in hot linseed oil. It should be noted that most papers have a grain, and where used for slot linings or for purposes where the paper has to be bent, that the paper should be bent along the grain.

The "Slot" Method of Testing.—This is a new method of testing dielectrics which are to be used in the insulation of armature coils. A number of tests by this method have been carried out by the authors in the laboratories of the Northampton Polytechnic Institute. The method essentially consists in testing a sample of the dielectric in a laminated iron slot, a sketch of the apparatus being



A—A.C. Supply. B—Iron Laminations. C—Clamping Bolts. D—Iron Plates. E—Brass Conductor. F—Dielectric Under Test.

FIG. 1.—APPARATUS USED BY THE AUTHORS.

shown in Fig. 1. Various sized conductors were used in order to test dielectrics of differing thicknesses, the size of the conductor being larger or smaller than the first conductor which was used in direct proportion to the thickness of the dielectric; thus the pressure on the dielectric was always the same. All samples were tested at a temperature of 60°C. A very accurate Brown and Sharpe micrometer, with ratchet attachment, was used for measuring the thickness of the sample at the point of fracture. The authors consider that this method of testing more nearly approaches practical conditions than the parallel plate method does, although they do not advocate the abolition of the latter method. At first, however, it seemed to possess the disadvantage that several conductors of various sizes were required. To obviate this the authors recommend the use of a conductor, as shown in Fig. 1, which consists essentially of two brass strips kept apart by two spiral springs.

Electricity readily discharges from points, and as in a laminated slot there are several points or ridges, it was expected that there would be considerable difference between the results of the open slot system and the parallel plates. This was found to be the case, and figures given in the Paper show a percentage of difference of from 17·5 to 59·5 per cent. The relation between dielectric strength and thickness does not follow a straight line law, but as the slope of the curves of the various dielectrics tested was about the same and not much different from a straight line, and also because many manufacturing firms use it, the authors adopted the term "B.D.V. per mil" as a convenient standard of comparison.

Present methods of raising the voltage are of a jerky nature, and in order to obtain a smooth and yet rapid regulation the authors employed the method illustrated in Fig. 2. A long range transformer is placed so that the secondary is in the supply circuit and the primary forms a circuit of its own through a variable resistance of carbon or water. This forms the regulation; another trans-

former, as shown, being employed in the usual manner for stepping up the voltage. The transformer, which should be leaky and able to withstand a short-circuit, resolves itself into a choking coil, and as the actual regulation is done in a separate circuit the increase in voltage must be gradual. To avoid a rush of current at first switching on, a rheostat resistance is introduced into the main circuit.

Conclusion.—Insulation is affected by so many conditions that testing is a matter of serious difficulty, and widely different results are obtained, the reasons for which are not definitely known. The authors' tests were made at a temperature of 60°C., but their experience leads them to consider that where speed is of importance it is far better to test at the atmospheric temperature, as it is very difficult to maintain a uniform temperature during testing. Many firms depend upon the figures of insulation makers, few taking the trouble to investigate for themselves. Those who do so jealously guard their knowledge that outsiders stand but little chance of profiting by it. This is not as it should be if British electrical engineering practice is to advance. All the present methods of coil nsulation, such as rubber, varnished paper, &c., are unsatisfactory,

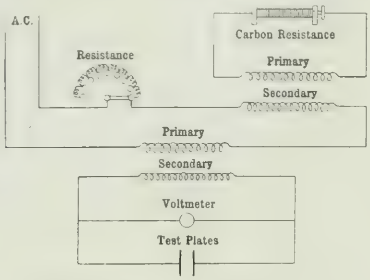


FIG. 2.—CONNECTIONS USED BY THE AUTHORS.

the ideal insulator being one which can be applied in the form of putty or paint, and one which is a simple substance and not a compound, so that the electric displacement would be the same throughout. Further, the study and improvement of insulation demands the attention of the scientific electrician and trained chemist rather than that of the practical engineer.

THE APPLICATION OF THE NO-LOAD AND SHORT-CIRCUIT DIAGRAM TO THE DESIGN AND TESTING OF INDUCTION MOTORS.

BY STANLEY P. SMITH, B.SC.

(*Concluded from page 129.*)

Summary.—The first part of the present Paper contains a description of a diagram for induction motors by means of which the efficiency, torque, power factor, slip, &c., can be *accurately* determined, and an actual example is given showing how the same can be drawn from the no-load and short-circuit currents and losses. The second part of the Paper is devoted to a new and important application of this diagram, whereby the efficiency of induction machines, when tested by the modified Hopkinson method, is accurately obtained for both motor and generator. Lastly, a method for calculating these results is deduced, and checked by means of the diagram.

Illustrative Example.—For this purpose we can use the test results obtained from two large 300 H.P. induction motors, built at Messrs. Siemens Bros. Dynamo Works, Stafford, to whom the writer is indebted for the following data. The motors were designed for 2,750 volts three-phase, with a frequency of 40 cycles per second. The number of poles was 10, thus giving a synchronous speed of 480 revs. per min. The data from which the diagram for these motors, shown in Fig. 6, was drawn was deduced from the test results given below, which are the mean of those given by the two motors.

1. *No-load Measurements* (*i.e.*, machine running light). No-load loss$=11\cdot7$ kw.; no-load current $I_0=16$ amperes.

Then $$\cos\phi=\frac{11\cdot7\times1000}{16\times2750\times\sqrt{3}}=0\cdot15.$$

No-load watt component

$$I_{0_W}=I_0\cos\phi_0=16\times0\cdot15=2\cdot4 \text{ amperes}$$

or $$=\frac{11\cdot7\times1000}{\sqrt{3}\times2750}=2\cdot4 \text{ amperes.}$$

No-load wattless component

$$I_{0_{WL}}=I_0\sin(\cos^{-1}0\cdot15)=16\times\sin 81^{\circ}$$
$$=16\times0\cdot99=15\cdot8 \text{ amperes.}$$

2. *Magnetisation Measurements.*—Iron loss$=6\cdot4$ kw. Hence watt component of magnetising current

$$I_{a_W}=\frac{6\cdot4\times1000}{\sqrt{3}\times2750}=1\cdot4 \text{ amperes.}$$

Wattless component $I_{a_{WL}}\doteq I_{0_{WL}}=15\cdot8$ amperes.

3. *Short-circuit Measurements.*—Measured: Current 95 amperes, pressure 920 volts, loss 28·5 kw. Then, power factor on short-circuit

$$\cos\phi_k=\frac{28\cdot5\times1000}{\sqrt{3}\times95\times920}=0\cdot19.$$

Short-circuit current

$$I_k=\frac{2750}{920}\times95=284 \text{ amperes.}$$

Watt component of short-circuit current

$$I_{k_W}=I_k\cos\phi_k=284\times0\cdot19=54 \text{ amperes.}$$

Wattless component of short-circuit current

$$I_{k_{WL}}=\sqrt{I_k^2-I_{k_W}^2}=\sqrt{(284+54)\,.\,(284-54)}=279 \text{ amperes.}$$

The points P_0, P_a and P_k are then set off to scale in Fig. 6. To find the line on which the centre M of the circle lies we have

$$\tan\beta=\frac{I_{0_W}\sin\phi_k+I_{0_{WL}}\cos\phi_k}{I_k-I_{0_{WL}}\sin\phi_k-I_{0_W}\cos\phi_k}$$
$$=\frac{2\cdot4\times0\cdot98+15\cdot8\times0\cdot19}{284+15\cdot8\times0\cdot98-2\cdot4\times0\cdot19}$$
$$=\frac{2\cdot35+3}{284+15\cdot5-0\cdot45}=\frac{5\cdot35}{299\cdot05}=0\cdot0179,$$

whence $\beta=1$ deg.

We then draw $\overline{OM}$ to make an angle of 1 deg. with the abscissa axis, and determine the position of M by bisecting the line $\overline{P_kP_0}$. The circle can now be drawn and the characteristic curves of the motor determined. These are shown in Fig. 7, which gives the curves of efficiency, power factor and slip. The several scales were determined as follows:—

Current Scale (to which diagram was drawn).—1 cm.$=5$ amperes.

Power Scale.—

$$W_s=\sqrt{3}EI_W=\sqrt{3}\times2{,}750I_W \text{ watts}=4\cdot763\,I_W \text{ kw.}$$

Now, 1 cm.$=5$ amperes in current scale; hence, in *power* scale, 1 cm.$=4\cdot763\times5=23\cdot815$ kw. These scales are shown in Fig. 6.

We then take a number of points on the diagram and read off the respective efficiencies, power factors and slips, which are shown plotted in Fig. 7, against their respective loads. The maximum output is $W_{0\,max.}=538$ kw.$=734$ B.H.P.

With regard to the *torque*, we can either reduce this to synchronous watts, as shown above, or give it as a percentage of full load torque, which is often more convenient, and is thus shown in Fig. 6. Thus, at short-circuit with normal pressure applied at the terminals of the motor, the starting torque would be about 56 per cent. of the normal torque, whilst the maximum torque the motor can yield is 255 per cent. of the normal torque.

As a check on the scales, take the point P_M on the circle (Fig. 6). The current I at this point$=OP_M=5\times10\cdot2$ cm. $=51$ amperes. Further, at this same point, we measure input $W_i=218$ kw. and $\cos\phi_M=0\cdot9$ per cent. Now, $\sqrt{3}EI\cos\phi_M=1{,}000W_i$, whence $$I=\frac{1{,}000\times218}{\sqrt{3}\times2{,}750\times0\cdot9}=50\cdot9 \text{ amperes,}$$

which agrees with the measured value OP_M* = 51 amperes.

Thus we see that the scales are correct throughout, and the diagram can be used for reading off the several magnitudes directly. In the reproduced diagram in Fig. 6 the scales are shown below the diagram reduced in the proper proportion.

Further Applications of the No-load and Short-circuit Diagram to Induction Motors.—Several problems arising in connection with induction motors can be solved, or partially solved, by means of this diagram. For instance, by its aid it is possible to find the amount of resistance which must be inserted in the rotor circuit in order to obtain a given torque at starting, and to examine the behaviour of the motor during running up.† An interesting case, and one that may not be out of place here, is when the induction machine acts as a *generator*—that is, when the watt component becomes negative. This happens whenever the negative slip becomes sufficiently large to carry the current below the abscissa axis.

An actual example of this occurs when two asynchronous machines are tested by the modified Hopkinson method, where one machine is made to pump back energy to the other. Moreover, since there is generally a great deal of uncertainty about the results when *calculated* from such tests, owing to the unsatisfactory nature of the assumptions which have to be made, it may be well worth while to show how simply accurate results can be obtained from the diagram, and also see if the latter cannot be of assistance in deducing some method of calculation which will give results in harmony with the actual, as given by the diagram.

Application of Diagram to the Hopkinson Method of Testing Asynchronous Machines.—For this purpose we can use the results obtained from the above 300 B.H.P. motors, which were also tested in this way. The connections for the test are shown in Fig. 8, and one set of readings is tabulated below (Table I.).

Table I.

Motor input.				Total loss in Kw. = P.	Generator output W_{go} = W_{mi} − P.	Loss in inserted resistance in generator rotor.	
Volts.	Amps.	Kw. = W_{mi}.	Cos ϕ_M.			Volts = E_2.	Kw. P.
2,760	50·6	218	0·9	60·5	157·5	33	11·5

Let us first consider the set of readings as they stand. The power factor cos ϕ_M for the motor at the input W_{mi} is obtained directly from the readings, but to what load do these readings refer? This, of course, involves the question of efficiency, which is always difficult to calculate from such test results owing to the uncertainty of the belt losses, &c., and we shall now see how the diagram comes to our aid. In passing, we may point out that, if there is any inaccuracy in the method we are about to employ, it is *entirely* negligible compared with that which has already gone before, viz., the experimental error in taking the readings, or when compared with any of the generally used methods of computing the efficiency from these results. Indeed, we may safely say that, not only the efficiency, but also the slip and power factor, can be found more readily from the diagram, provided only the above power readings can be relied on.

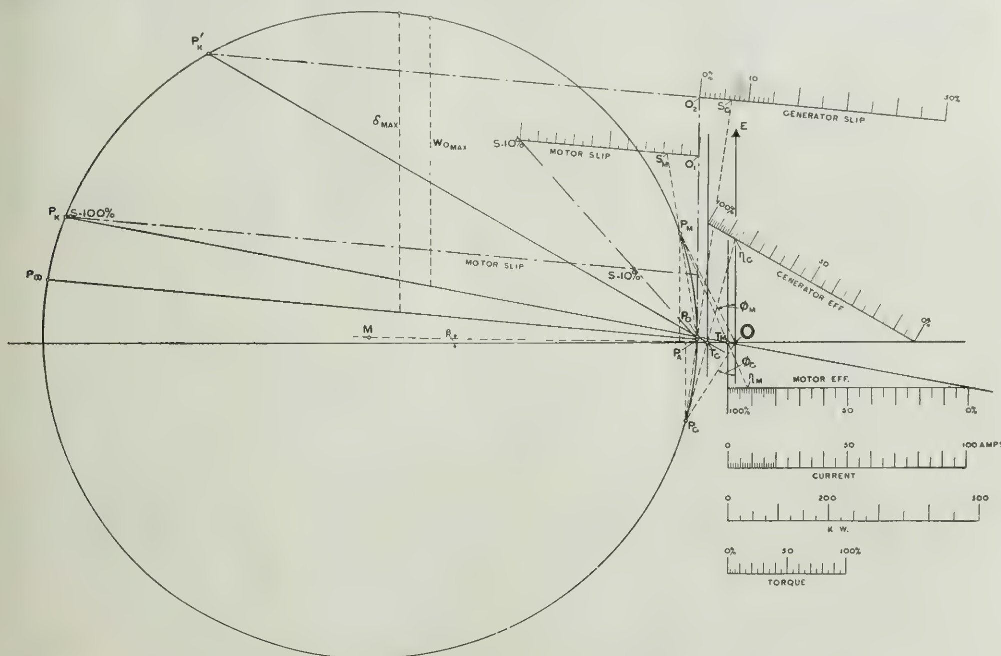


Fig. 6.—No-load and Short-circuit Diagram of Three-phase Induction Motor.
300 H.P., 2,750 volts, 40 ∼, 10 poles, 480 revs. per min. (syn.)

Note.—The points P_a, P_0 and P_k are the magnetising, no-load and short-circuit points respectively of the normal motor. The point P_k' is the short-circuit point for the special case of the machine working with a definite resistance inserted in the rotor circuit.

Now the *motor efficiency* is obtained straight away from the diagram by setting off the point P_M, as shown in Fig. 6, the ordinate representing the motor input W_{mi} = 218 kw., and OP_M the current = 50·6 amperes. As is seen, the power factor cos ϕ_M = 0·9; the slip s_M = 1·7 per cent.; whilst the efficiency η_M = 91·6 per cent., and therefore the *output* $W_{mo} = \eta_M W_{mi}$ = 200 kw. Thus the output to which the above efficiency,

* The current measured on test (*see* Table I.) at this input and 2,760 volts was 50·6 amperes, consequently the experimental error is not worth mentioning.

† Since this Paper was written, similar problems—solved by means of the Heyland diagram—were published in an article by Solomon in The Electrician, January 15, 1909.

power factor and slip of the motor correspond is accurately determined from the diagram, and equals 200 kw. = 268 B.H.P.

Now for the *generator efficiency*. It is equally simple to determine this also, but in doing so we must not forget that the generator rotor resistance is greater than the normal owing to the inserted resistance r_i, which will make the efficiency η_G much less than if the machine were working normally. This, however, introduces no difficulty provided we find the new short-circuit point P'_k corresponding to this case. This is simply done. We first find the inserted resistance per phase

$$r_i = \frac{3E^2_2}{1000P} = \frac{3 \cdot 33^2}{11500} = 0{\cdot}284 \text{ ohm.}$$

(*See* Table I.) Reducing this to the primary, we get

$$r'_i = 0{\cdot}284 \cdot 3{\cdot}62^2 = 3{\cdot}73 \text{ ohms,}$$

where number of stator turns/number of rotor turns = 3·62. Hence, total resistance per rotor phase reduced to primary

$$r'_2 + r'_i = 0{\cdot}47 + 3{\cdot}73 = 4{\cdot}2 \text{ ohms.}$$

Before finding the current, however, we must also know the reactance. Now, from the readings for the short-circuit constant P_k we have impedance per phase at short-circuit

$$Z_k = \frac{E}{\sqrt{3}\, I} = \frac{2750}{\sqrt{3} \cdot 284} = 5{\cdot}6 \text{ ohms,}$$

whence reactance per phase,

$$X_k = \sqrt{Z^2_k - r^2_k} = \sqrt{5{\cdot}6^2 - 0{\cdot}94^2} = 5{\cdot}5 \text{ ohms,}$$

where $r_k = r_1 + r'_2 = 0{\cdot}47 + 0{\cdot}47 = 0{\cdot}94$ ohms.

Hence, with the resistance r'_i inserted in the rotor circuit, the impedance per phase will be

$$Z'_k = \sqrt{\{r_1 + (r'_2 + r'_i)\}^2 - X^2_k}$$
$$= \sqrt{(0{\cdot}47 + 4{\cdot}2)^2 + 5{\cdot}5^2}$$
$$= 7{\cdot}2 \text{ ohms.}$$

From this we have short-circuit current at P'_k

$$I'_k = \frac{E}{\sqrt{3Z'_k}} = \frac{2750}{\sqrt{3} \times 7{\cdot}2} = 220 \text{ amperes.}$$

Now, provided we are not working in the neighbourhood of synchronism (where $r_i = \infty$), the magnetising current will not

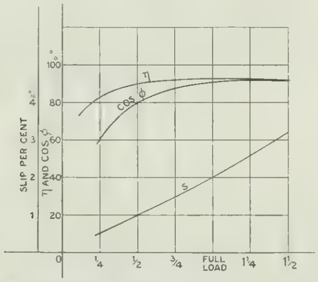


FIG. 7.—EFFICIENCY, POWER FACTOR AND SLIP CURVES AS GIVEN BY FIG. 6.

introduce any appreciable error, and P'_k can be set off directly on the circle. The point P'_k representing I'_k is shown thus in Fig. 6, whilst P_G, the point corresponding to the generator output, is drawn on the lower half of the circle. To obtain the power factor, efficiency and slip for this condition we have merely to find the corresponding lines, just as in the case of a motor. In this case, of course, the abscissa axis represents the line of zero output, whilst the line P'_kP_0 represents zero input, the conditions being just the reverse to those of a motor. The efficiency line is then drawn parallel to the line P'_kP_0, where the mechanical input is zero, and is bounded by the abscissa axis, representing zero efficiency, and the no-loss line passing through T_G, representing 100 per cent. efficiency. As seen from the diagram, the efficiency $\eta_G = 86{\cdot}7$ per cent and the power factor $\cos\phi_G = 0{\cdot}85$. For the slip—which is negative—a parallel to $\overline{P_aP_\infty}$ is drawn to pass through P'_k. This line $\overline{P'_kO_2}$ (Fig. 6) is produced backwards beyond the tangent at P_a, and a length $= \frac{1}{2}P'_kO_2$ is divided into 50 parts in a similar way to the slip line for the normal motor. The slip s_G is thus = 6·4 per cent.

It is thus seen that the diagram affords a complete insight into the behaviour of the machines during the above test, and at once gives the efficiencies, &c., without any correction whatever for belt slipping and such like difficulties met with in calculations. It must be remembered, of course, that η_G represents the efficiency of the generator at an output of 157·5 kw. with respect to the short-circuit point P'_k—*i.e.*, the efficiency of the generator as on test and not under normal conditions. Had the inserted resistance been zero, then, of course, the machine would have been working normally, with P_k as its short-circuit point. With a given ratio of pulleys, however, this desideratum is not always easy to be obtained.

Method of Calculating Efficiency from Modified Hopkinson Test of Induction Motors.—As seen from the foregoing, it is quite easy to measure the motor input and the generator output,

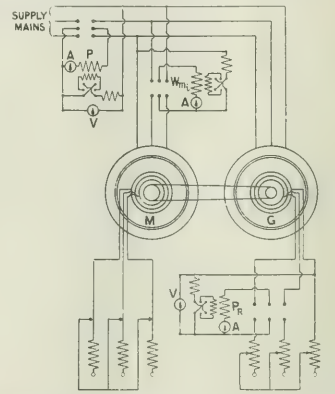


FIG. 8. SCHEME OF CONNECTIONS FOR TESTING INDUCTION MOTORS BY MODIFIED HOPKINSON METHOD.

M = Motor. G = Generator. W_{mi} = Motor input. P = Total losses. P_r = Loss in inserted resistance in generator rotor circuit.

but how are we to determine the loads to which these correspond? Now, although the above graphical method gives in a simple manner results the reliability of which only depends on the accuracy of the readings, yet it may not always be desirable or possible to construct such a diagram for obtaining these results. Since, however, we now have a useful check on any analytical method we may deduce, let us see if it is not possible to find some such means whereby the efficiency can be properly calculated. To do this we can proceed as follows :—

After adjusting the pulleys, &c., until the induction motor is able to drive the induction generator under the required conditions—the losses and wattless current being supplied from an independent electric source—let resistance be inserted in the rotor circuit of the generator until the input to the motor is as much above the load at which the machines are to be tested as the output of the generator is below this load. Since, then, the efficiency curve of an induction machine is practically a straight line over the working part, it is obvious that the efficiency of both generator and motor with respect to this mean load would be about the same if both machines were working under normal conditions.

We then measure—*

1. Total losses = power taken from supply mains = P.
2. Motor input = W_{mi}.
3. Losses in inserted resistance in generator rotor circuit = P_r.
4. Speeds of motor and generator and frequency of supply.

* In addition to these measurements, it is also well to measure the generator output W_{g0}, if instruments are available. In certain cases it may be better to measure W_{g0} than P; in the present test the generator output was obtained by deducting the total loss P from the motor input W_{mi}.

Starting, then, from the definition that the *combined efficiency* of the two machines is

$$\eta_{MG} = \frac{\Sigma \text{ outputs}}{\Sigma \text{ inputs}} = \frac{\Sigma \text{ outputs}}{\text{motor input}}$$

we get

$$\eta_{MG} = \frac{W_{g0} + P_{b0} + P_{bl} + P_r}{W_{mi}},$$

where W_{g0} = generator output = $W_{mi} - P$,
P_{b0} = belt loss on no load,
P_{bl} = additional belt loss on load,
P_r = loss in inserted resistance in generator rotor circuit.

We must now see how these several quantities can be determined.

To find the *no-load belt loss* P_{b0} we measure—

(*a*) The loss P when the motor is driving the generator and the rotor circuit of latter is open but its stator is connected to the mains. Denote this loss by P′. Any small iron loss in the generator rotor will be usually quite negligible.

(*b*) The loss P when the belts (or ropes) are thrown off and both machines are running light. Denote this loss by P″.

The *no-load belt loss* is

$$P_{b0} = P' - P''.$$

To find the *additional belt loss under load* P_{bl}:

For the *additional belt loss* which occurs on load due to increased belt slip we can proceed as follows: Let D_M and D_G equal the effective diameters of the motor and generator pulleys respectively after the thickness of the belt has been taken into account. Now, if there were no belt slip on load, we should have

$$\frac{\text{Speed of generator}}{\text{Speed of motor}} = \frac{D_M}{D_G}.$$

Actually, however,

$$\frac{\text{Speed of generator}}{\text{Speed of motor}} = \frac{D_M}{D_G} \cdot \frac{1-c}{1},$$

where c is a constant < 1 and represents the slip of the belt.

Further, let s_G and s_M denote the respective slips as measured on generator and motor under test. Then

$$\frac{\text{Speed of generator}}{\text{Speed of motor}} = \frac{1+s_G}{1-s_M}.$$

By substituting these two expressions for the ratio of the speeds, we can find c. Thus

$$\frac{D_M}{D_G}\,\frac{1-c}{1} = \frac{1+s_G}{1-s_M},$$

i.e.,

$$1-c = \frac{D_G}{D_M}\,\frac{1+s_G}{1-s_M}$$

or

$$c = 1 - \frac{D_G}{D_M}\,\frac{1+s_G}{1-s_M}.$$

In the present case, which was a rope drive—there being eight 1¾ in. ropes—the effective diameter of the motor pulley was 45 in. and of the generator 40 in., whence

$$c = 1 - \frac{D_G}{D_M}\,\frac{1+s_G}{1-s_M} = 1 - 0{\cdot}89\,\frac{1+s_G}{1-s_M}.$$

Now c represents the amount by which the generator speed is reduced owing to the belt slip, and since this is practically zero at no load, it may be taken as the correction for the reduced speed of the generator caused by the slipping or creeping of the belt on load. Since then only the $(1-c)$th part of the motor output is conveyed to the generator, it is obvious that c per cent. of the motor output must be consumed in producing heat at the pulleys. Hence we have for the *additional belt loss* on load

$$P_{bl} = cW_{mo} = cW_{mi}\eta_M.$$

The efficiency η_M of the motor can be estimated quite accurately enough for the purpose of finding P_{bl}, since c is always very small when the belts are properly tightened.

In this way the *combined* efficiency η_{MG} can be found, and it now remains to split up η_{MG} into the separate efficiencies, η_M and η_G. Before doing this, however, we will first calculate η_{MG} for the machines whose test results are shown in Table I.

For the slips we will take the values as given by the diagram, though these can equally well be measured. Then, motor slip $s_M = 1{\cdot}7$ per cent. and generator slip $s_G = 6{\cdot}4$ per cent.; whence constant $c = 1 - 0{\cdot}89\,\frac{1+s_G^*}{1-s_M} = 1 - 0{\cdot}89\,\frac{1{\cdot}064}{0{\cdot}983} = 0{\cdot}04$.

Motor Input.—Pressure = 2,760 volts. Current = 50·6 amperes. Input W_{mi} = 218 kw.; whence $\cos\phi_M = \frac{218 \times 1000}{\sqrt{3} \times 2760 \times 50{\cdot}6} = 0{\cdot}9$.

Total losses supplied to system P = 60·5 kw.

Hence, output of generator is

$$W_{g0} = W_{mi} - P = 218 - 60{\cdot}5 = 157{\cdot}5 \text{ kw.}$$

Measured loss in inserted resistance in generator rotor circuit P_r = 11·5 kw. No-load belt loss P_{b0} = 10 kw. Additional belt loss $P_{bl} = c \,.\, W_{mi}\eta_M = 0{\cdot}04 \times 218 \times 0{\cdot}9 = 7{\cdot}5$ kw.

We then get

$$\Sigma \text{ outputs} = W_{g0} + P_{b0} + P_{bl} + P_r = 157{\cdot}5 + 10 + 7{\cdot}5 + 11{\cdot}5 = 186{\cdot}5 \text{ kw.}$$

Then combined efficiency

$$\eta_{MG} = \frac{\Sigma \text{ outputs}}{W_{mi}} = \frac{186{\cdot}5}{218} = 0{\cdot}85.$$

We have now to analyse this combined efficiency.

To do this, consider the *losses in the two machines.* These are $W_{mi} - \Sigma$ outputs $= 218 - 186{\cdot}5 = 31{\cdot}5$ kw. But it is not known how these losses are distributed between the two machines, and the simplest procedure is not to trouble about the actual loads, but to take the load corresponding to which the generator efficiency equals the motor efficiency, so that $\eta_M = \eta_G = \sqrt{\eta_{MG}}$. Now, if there were no external losses in the belts, &c., this *corresponding mean load* would be $\frac{1}{2}(W_{m0} + W_{g0})$, but under actual conditions it will be better to find this load from the machine working under normal conditions—namely, the motor—by deducting from the output of the latter half the losses in the two machines. This procedure, though not strictly accurate, is quite good enough for all practical purposes. Taking, then, the corresponding mean load, $\eta_M W_{mi} - \frac{1}{2}(W_{mi} - \Sigma$ outputs), we have with respect to this load

$$\eta_M = \eta_G = \sqrt{\eta_{MG}} = \sqrt{0{\cdot}85} = 92{\cdot}2 \text{ per cent.}$$

where η_M and η_G both refer to the machine *working normally* with an output of $\{= 0{\cdot}922 \times 218 - \frac{1}{2}(218 - 186{\cdot}5)\}$ kw. = 247 B.H.P.

From the diagram the efficiency at this load (247 B.H.P.) is η_M = 91·5 per cent., *consequently the agreement between calculation and the diagram is within* 1 *per cent.*

We thus see that the above method of calculating the efficiency gives results which are in good agreement with those yielded by the diagram, and may, therefore—together with the latter method—be regarded as a satisfactory way of determining the efficiency of induction motors when tested by the modified Hopkinson method.

It may be useful to summarise briefly this method:—

1. Measure, in the way above described, motor input W_{mi}, generator output W_{g0}, no-load belt loss P_{b0}, additional belt loss P_{bl} and loss in resistance inserted in generator rotor circuit P_r.

2. Determine *combined efficiency*

$$\eta_{MG} = \frac{\Sigma \text{ outputs}}{\Sigma \text{ inputs}} = \frac{W_{g0} + P_{b0} + P_{bl} + P_r}{W_{mi}}.$$

3. Then the *separate efficiencies* η_M and η_G of the two machines are $\sqrt{\eta_{MG}}$ with respect to the corresponding mean load

$$W_{mo} - \tfrac{1}{2} \text{ losses in machines} = \eta_M W_{mi} - \tfrac{1}{2}(W_{mi} - \Sigma \text{ outputs})$$

as output.

In concluding this Paper, the author wishes to acknowledge his indebtedness to Mr. A. E. Clayton for his kind assistance and to Mr. Steinmetz for the care he has taken in drawing the diagrams. Valuable help and criticism has also been ungrudgingly given by Dr. Kloss and Mr. Marden, of Messrs. Siemens Bros. Dynamo Works, Stafford.

* It must be borne in mind that s_G is negative.

SIEMENS BROTHERS & CO.'S SWITCHBOARD INSTRUMENTS.

(Concluded from page 132.)

Having described the three series of measuring instruments, we shall now refer briefly to other switchboard apparatus of a new type which is being introduced by Messrs. Siemens Brothers & Co. In this connection we should like to draw particular attention to apparatus for the synchronising and parallel running of alternators. In regard to zero voltmeters little need be said, since all the electromagnetic and Ferraris voltmeters can be arranged for that purpose at slightly extra cost. Double voltmeters are of more interest; in these there are two independent movements but only one scale, over which both pointers move. They serve to show if the machine about to be switched in has the same pressure as the 'bus bars, in which case both pointers take up the same position on the scale.

Phase-comparers are supplied to indicate if the current of the machine under observation is in phase with the supply current, while phase-indicators give the approximate power factor of each machine,

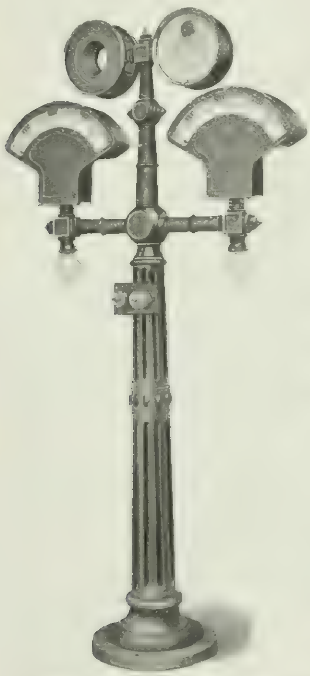


Fig. 11.—Synchronising Outfit.

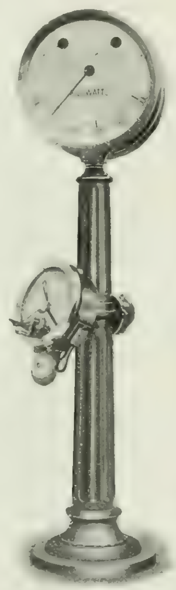


Fig. 12.—Instrument Pedestal with Telegraph.

and are only made for three-phase circuits with equally loaded branches, or for two-phase currents. Various combinations of all the above-mentioned instruments can be mounted on a bracket or pedestal for the purpose of synchronising machines. Messrs. Siemens are making a feature of this arrangement, and Fig. 11 shows a synchronising outfit on a pedestal, and consisting of Ferraris sector voltmeters for 'bus bars and for machines, zero voltmeter and illuminated synchroniser, two phase lamps, switch for synchroniser and two-way switch for generator, the whole forming, as can be seen, an artistic, compact and well designed piece of apparatus. In place of the pedestal a bracket can be supplied in which case, of course, the arrangement becomes even more compact.

A feature is also made of central station telegraphs for communicating orders between the switchboard gallery and engine-room, boiler-house, &c. Some such arrangement is indispensable in all large power stations, and the instruments are designed either for fixing on pedestals or on switchboards. Every instrument can be employed as a transmitter. Fig. 12 shows a suggested arrangement in which the signalling apparatus is fixed half-way down a pillar on which is mounted a universal instrument, comprising Ferraris voltmeter, ammeter and wattmeter. As can be judged, the readings of this latter instrument can be seen at some distance; the whole arrangement is compact and convenient.

Greater attention is now paid to the maintenance of the mains system of electric supply undertakings, and instruments for recording leakage currents are usually employed. The moving-coil voltmeters described in the first part of this article can be used on continuous-current circuits as leakage current meters if provided with resistance scales. Messrs. Siemens Brothers, however, recommend special instruments, having considerably higher resistance and sensitiveness, for use in such cases; and instruments are also made for use on single-phase or three-phase circuits. In the case of continuous current, the measurements are made with the supply pressure, but in the case of alternating currents a battery of dry cells is employed, and the supply pressure is superimposed on the testing pressure without affecting the readings of the instruments. The scales are arranged to read 0—2 megohms, or 0—1,000 milliamperes. The resistance scale shows the insulation resistance directly when the test is made on a "dead" circuit; but, if the circuit is "alive," the insulation-resistance can be calculated from the resistance shown, by connecting the instrument to the positive and negative conductors. All the instruments are provided with an adjustable magnetic shunt by means of which their sensitiveness can be so adjusted that the resistance or current scale remains accurate, although the testing or supply pressure varies as much as $\pm$ 8 per cent. from that with which the instrument was calibrated. Fig. 13 shows a complete leakage current meter out fit for two and three wire continuous-current circuits. The illustration indicates also the use of a pair of contact pliers for testing single "dead" conductors.

Of recent years relays have come into very extensive use, particularly in connection with switchgear Messrs. Siemens Brothers have an excellent selection of relays for various purposes, but these we cannot do more than mention. All the moving-coil and Ferraris instruments which we have described can be employed as relays, if fitted with maximum or minimum contacts. It may be mentioned that the relays are only made for low tension; in the case of high tension, series resistances and measuring transformers must be employed for continuous and alternating current respectively. Fig. 14 shows a maximum current time relay and Fig. 15 a pressure variation relay for an alternating-current circuit, the cover being removed in the latter instrument, which is provided with maximum and minimum contacts, adjustable for variations of $\pm$ 2 per cent. The maximum current time relay, Fig. 14, is intended for connecting to current transformers with 5 amperes secondary current, and the release can be adjusted from 3·5 to 7 amperes, whilst a second scale is provided whereby the time limit can be varied from 2 to 15 seconds; heavier currents than those mentioned, of course, cause the release to be quicker, approximately as the square of the current. Instantaneous releases can be fitted which, if desired, come into operation when the current in the secondary winding of the transformer exceeds 20 amperes. Other relays supplied are for reverse power, for single or three-phase circuits, and for three-phase

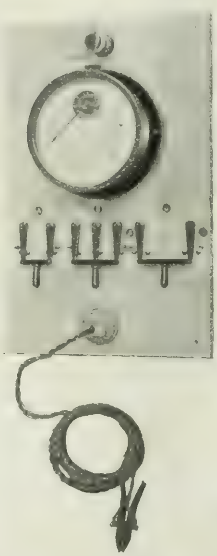


Fig. 13.—Leakage Current Meter Outfit.

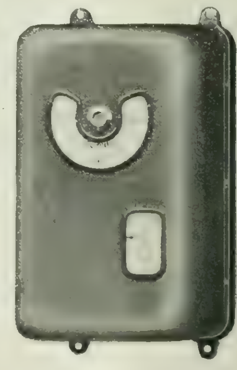


Fig. 14.—Maximum Current Time Relay.

high-tension overhead transmission lines. The last mentioned relay operates with at least 3 per cent. of the normal current, and above 30 per cent. inequality of load, and is intended for disconnecting an untapped distant feeder in the case of a broken wire or of great inequality of load.

Essential, and by no means unimportant, parts of a high-tension switchboard are the transformers for operating the various instruments. Apart from the necessity of using current transformers where very large currents have to be measured, it is very desirable to keep high-tension current away from the switchboard itself. It will be seen, also, that the design of these small transformers is of vital importance if the continuity of supply is not to be endangered. In regard to insulation, Messrs. Siemens take the greatest precautions to ensure that breakdown shall not result from pressure surges. Thus,

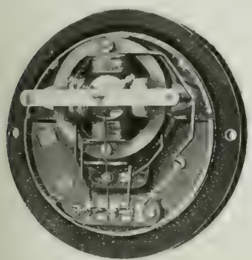


FIG. 15.—PRESSURE VARIATION RELAY.

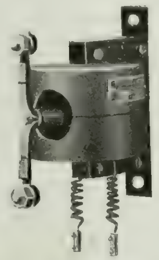


FIG. 16.—SMALL CURRENT TRANSFORMER.

transformers up to 30,000 volts are tested with twice the working pressure; and for higher pressures with one and a half times the working pressure.

It is interesting to notice that the normal maximum secondary current of all current transformers is 5 amperes, with the exception of two types in which a current of 1 ampere is used. The important characteristics of the Siemens transformers for measuring instruments were recently described in our columns (March 12, 1909, p. 846) and it will be remembered that whereas many of the instrument transformers hitherto available cannot be depended upon to maintain a constant ratio over a wide range, and that the phase difference betwe n primary and secondary currents is often excessive, these disadvantages have been eliminated in the Siemens transformers by constructing the stampings of the cores in one piece, thus prevent-

FIG. 17.—CURRENT TRANSFORMER.

FIG. 18.—CURRENT TRANSFORMER ON BRACKET.

FIG. 19.—PRESSURE TRANSFORMER.

ing errors due to the reluctance of an air-gap. It will be evident that this method of construction involves greater difficulty and expense in winding, but these have been overcome by Messrs. Siemens Brothers in a very ingenious way. That the results leave little to be desired will be seen by the tests, of which particulars were given in our issue referred to above; we may mention that the ratio of the transformer is adjusted accurately to within 1 per cent.

Fig. 16 shows a current transformer for use with electromagnetic ammeters for 1 ampere. The transformers for small currents can be fixed by means of two bolts whilst the larger ones can be suspended from the conductors. Fig. 17 shows a current transformer of a different type, the primary terminals being situated at the top and bottom instead of both on the same side. This enables a narrow form to be arrived at, and hence this type of transformer is specially suitable for fixing in narrow switchboard cells. It is fixed by means of a base-plate with lugs. A further type is shown in Fig. 18, in which a bracket system of suspension is indicated.

In regard to pressure transformers little need be said; in their main features they resemble those just described, but we may mention that a pressure overload 10 per cent. above the normal may be given and an overload of 20 per cent. is permissible for 15 minutes. All the transformers are completely enclosed, and thus protected from damp and other external influences, and the cases in every instance are arranged for an earth connection. Fig. 19 shows a typical pressure transformer fitted with a base.

Messrs. Siemens Brothers new switchboard instrument catalogue also contains particulars of other instruments, including recorders of various types, a general feature being the bracket type of construction. We may conclude this brief description of a most interesting series of apparatus by drawing attention to a useful addition to the customary catalogue. Towards the end of the new catalogue (page 61) the instruments are classified according to currents, pressures and sizes, so that the "would-be" purchaser can see at a glance the range of prices offered by the various types. For example, taking one particular capacity, we notice the list prices of ammeters range from £1 to £26. 10s., according to the size of the instrument and whether it is of the moving coil, Ferraris or electromagnetic type, so that it will be seen purchasers have practically unlimited choice, and can rapidly select those instruments most suited to their purpose and pocket.

THE REGULATION OF ALTERNATE-CURRENT FLAME ARC LAMPS.*

BY PAUL HÖGNER.

Summary.—Attention is called to the importance of the resistance variations occuring in alternate-current arc lamps in the arc gases, and to the fact that if choking coils are used in place of series resistances the efficiency is improved nearly 40 per cent.

The gases through which the arc passes have a very low heat capacity, and the temperature of these gases, therefore, varies from instant to instant, as the current passes through its cycle. These

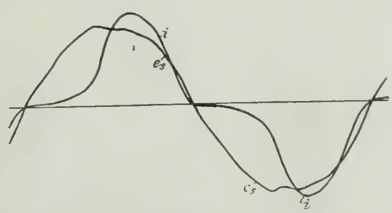


FIG. 1.

gases behave like a so-called conductor of the second class, and their resistance falls as the temperature rises. Consequently, their resistance passes through its cycle in the same way as the current does, and reaches its maximum value at the instant when the current is zero.

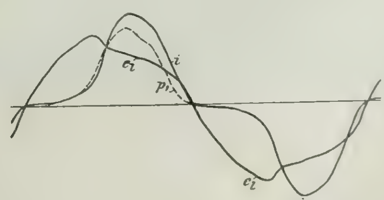


FIG. 2.

From this it follows that the current is met at the start by the maximum resistance; as soon as the gases are somewhat heated the current begins to increase more rapidly, owing to the lessened re-

* Abstracted from the "Elektrotechnische Zeitschrift,"

sistance. If the circuit is free from induction, the maximum value is reached some little time after the volts have passed through their maximum, and from this point the fall is very rapid until it reaches zero at the moment when the volts are also zero. The investigations of Blondel, Duddell and Marchant on these points are already well known.

These phenomena occur with any alternate current arc lamp; but their real importance is specially to be noted in the case of alternate-current flame arc lamps. In this case the variations of temperature and resistance are very great, and special attention must be paid to them, seeing that much depends on the way in which the lamps are run and coupled up. It is now known that the amount and nature of the regulating resistance has great influence on the results, and the present article is intended to show the extent to which the design of the regulating device affects the results obtained from the flame arc lamps at present on the market.

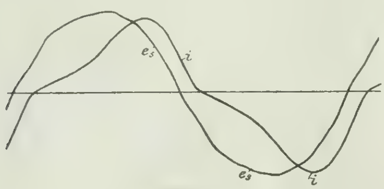


FIG. 3.

The tests, to which reference is made in the present article, were carried out by the firm of Körting & Mathiesen on the Excello flame arc lamp; the carbons were made by Conradty, of Nuremberg, the volts lost in the carbons being between 1 and 3. The alternators gave a voltage which practically followed a sine curve, and had an average value of 110 with a frequency of 50. Fig. 1 gives the oscillograph curves of the voltage of the alternator, and the current through the two Excello lamps in series; the current was 10 amperes and the

FIG. 4.

lamps had an ordinary inductionless series resistance. Fig. 2 shows the voltage across the lamps and the current. The net result in this case is that the power factor of the whole circuit is 0·857, and of the lamps 0·766. The consumer, unfortunately, knows and cares nothing about the power factor; but it will be of importance to consider it in the present investigation. Figs. 3, 4 and 5 refer to the same lamps when run with a choking coil. In Fig. 3 we have the current and the total voltage in the circuit; in Fig. 4 the current and voltage over the lamps, and in Fig. 5 the current and the voltage over the choking

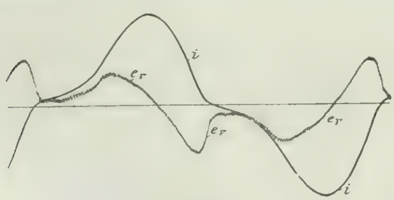


FIG. 5.

coil. In this case the power factor of the circuit was 0·712, and of the lamp 0·803. The power factor of the lamp is increased by 5 per cent., whereas that of the circuit is lower than before, owing to the increased lag. The dotted curve in Fig. 2 also shows the way in which the illumination varies from instant to instant as the current rises and falls.

It will, therefore, be seen that the power factor and efficiency depend on the nature and amount of the regulating resistance or choking coil, and it is of interest to see what effect is produced on the emission of light by a change from inductionless resistance to choking coil. Photometric determinations with the Ulbricht spherical photometer show that such change is very noticeable. For instance, in one case, where two lamps were run in series, on 110 volts, it was found that with an inductionless resistance the Hefner candle-power was 1,700; but when a choking coil was substituted for the resistance the candle-power rose to 2,270. In other words, the light was increased by 33 per cent.

Further tests with 6, 8, 10 and 12 amperes gave the following results:—

1. With a given type of lamp, coupled up in a definite manner, and supplied with carbons of a definite make, the power factor is independent of the current through the lamp. Tests show slight deviations, which are probably of the nature of experimental errors; in any case, it is not possible to trace any connection between the power factor and the current.

2. With a given type of lamp, and given electrical conditions, the power factor depends on the make of the carbons and on the nature of the regulating device. Thus, the following figures were obtained with two lamps run in series on 110 volts:—

Type of Carbons.	Power Factor with			
	Series resistance		Choking coil.	
	Lamp.	Circuit.	Lamp.	Circuit.
Excello 70; yellow..................	0·766	0·857	0·803	0·712
Excello 70; pearl white............	0·796	0·873	0·826	0·734
Excello 70; clear white............	0·864	0·914	0·896	0·792

3. The amount of light given by a lamp depends on the carbons and also on the nature of the regulating device. The light is greater if a choking coil is used than if there is a series resistance. This gain in light emission is proportionally more marked in those cases in which the carbons give the most intense light. On the other hand, with carbons giving a less intense light, the increase in power factor and efficiency is greater.

From the practical point of view, the most important thing is the improvement in efficiency which results from the use of the choking coil, as compared with the series resistance. This is evident from the figures in the following table:—

Type of Lamp.	Method of running.	Carbons: Excello 70. Diameter.	Amperes.	Volts.	Watts consumed including regulating device.	Hefner candle power with clear glass globe.	Watts per candle power.
		mm.					
Excello Munt, by Körting & Mathiesen ...	Two on 110 volts with series resistance.	7	8	24	377	1,120	0·34
		8	10	45	471	1,700	0·28
		9	12	46	564	2,310	0·24
Ditto	Two on 110 volts with choking coil	7	8	44	313	1,490	0·21
		8	10	25	392	2,270	0·17
		9	12	46	470	3,070	0·15

This table shows that the efficiency is increased by 38 per cent. if choking coils are used. This point is so noticeable that the use of choking coils becomes a much more important matter in these days, when flame arcs have replaced the plain carbon arc; for in the latter case, as, indeed, in all cases in which the arc emits a relatively poor light, the gain from the use of the choking coil is comparatively small, and in carbon lamps with the carbons one above the other the improvement is so small that the difference can scarcely be noticed. Therefore, in such cases the improvement is simply one of efficiency, and there is little difference in the amount of light emitted; if three are put in series on 110 volts the efficiency is only improved by 15 per cent.

These points must be noticed in the photometric examination of flame arc lamps. The usual plan is to put the lamp itself on a relatively high voltage. This plan is altogether wrong for flame arcs, and causes the lamp to give more light than is intended. It is much better to run the lamp on the voltage for which it is intended in actual practice, and the latest regulations, which have been laid down for the photometric examination of arc lamps, lay stress on these points, to which attention has been specially directed by the experimental work described in the present article.

ELECTRIC TRACTION ON RAILWAYS.*

XIV.—PRACTICAL CONSIDERATION OF OVERHEAD CONDUCTORS.

BY PHILIP DAWSON.

(*Continued from page 99.*)

Summary.—In this article the author first considers the many objections which have been raised against the use of the third rail for main line railway electrification, and then proceeds to discuss the use of overhead conductors, dividing the latter system into those where two overhead conductors per track are necessary and those where only one conductor per track is required. The construction of the overhead work is also considered in detail.

Having thus examined the double catenary form of construction, we will now proceed to consider the various forms of single catenary construction adopted both in Europe and America.

As already stated, there are two forms of single catenary construction, namely, what may be called the simple form

Fig. 17.—Single Catenary Suspension, showing Short Circuiting Device (B) which Comes into Action in case of Breakage of Wire, Swedish State Railways.

A, Tubular push-off and steadier.

and the compensated one, which is equipped with counterweights and which secures a constant tension on the trolley wire under all conditions of temperature.

As an example of the single catenary construction, we can again take a section of the experimental line constructed by the Swedish State Railways. Fig. 17 shows the ordinary single bracket arm straight-line construction. As shown in the illustration, at each bracket arm there is a light tubular push off (marked A) or steadier attached to a hinged swivel from a second insulator located under the bracket arm. In case of breakage of the trolley arm or supporting catenary, a pivoting metal arm, which is surrounded normally by an earthed metal hoop, will be brought into contact with this hoop (B), thus earthing and rendering safe the whole section. The arrangement thus shortly described is clearly shown in the illustration, Fig. 17.

A slightly different form of construction is shown in Fig. 18, which has been largely adopted by the Westinghouse Company in America for inter-urban lines. In this case the insulators are hollow corrugated porcelain sleeves slipped on to the tubular bracket arms, and, as shown in Fig. 19, the push-offs are supported from similar insulators. This last figure also shows the earthed loop which encircles the catenary line, and which would put the whole section to

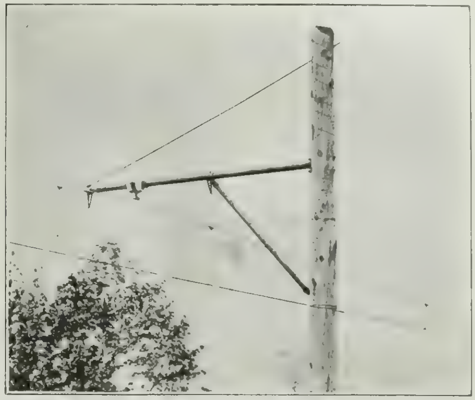


Fig. 18.—Westinghouse Single Catenary Bracket Arm Construction.

earth in case of breakage of either the trolley or the catenary wire. Instead of using iron tubes or wooden rods to push against the trolley wire in order, not only to keep it in its proper position in curves, but also to keep it from swinging laterally; it is also possible to use a pull-off arrangement, and this method of construction has been adopted by the American Westinghouse Company in connection with the Sarnia Tunnel section of the Grand Trunk

Fig. 19.—Westinghouse Single Catenary Construction, showing Earthed Safety Loop at Each Bracket Arm through which Catenaries Pass.

E.—Earthing loop.

Railway of Canada, which has recently been equipped by them on the single-phase system. This form of construction is very clearly shown in the illustration Fig. 20.

As will be seen from the photograph, Fig. 22, the main conductor wire is carried straight through, and the wire for the branch track converges on to the main wire, and then rises slightly above it at the point of crossing. The

space in the V thus formed is filled in with deflector wires to guide the collector bow, which in this case is of the Pantograph type, and to prevent it from catching in the overhead construction. It is customary in the Westinghouse American practice to use a flat pantograph with curved ends, and this deflector construction is, therefore, necessary.

Having thus generally examined the simplest form of catenary construction, we will consider one which presents some special features in that careful arrangements have been made to so sectionalise the overhead conductor that these are entirely interlocked with the signals, so that until a rail is made clear by this signal there can be no current in it and hence it is physically impossible for the train to start or go on running for any great distance. Such an arrangement has been perfected by the Maschinenfabrik Oerlikon, and adopted by them on a section of their experimental single-phase railway which they equipped for the Swiss Government between Seebach and Wettingen. On a portion of this line, and generally at stations, single catenary construction was adopted, as is clearly seen in Fig. 21.

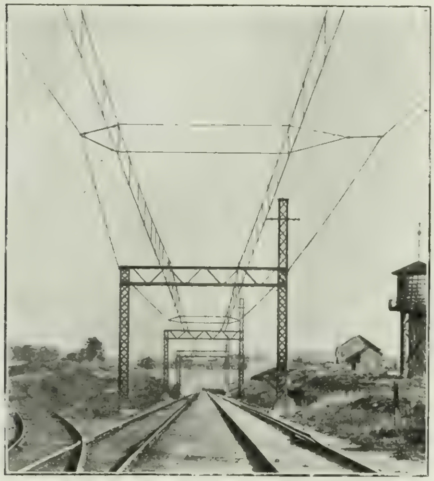


Fig. 20.—Showing Pull-offs on Curve, and Construction used to keep the Conductors from Surging Laterally. Sarnia Tunnel, Grand Trunk Railroad of Canada, under the St. Clair River.

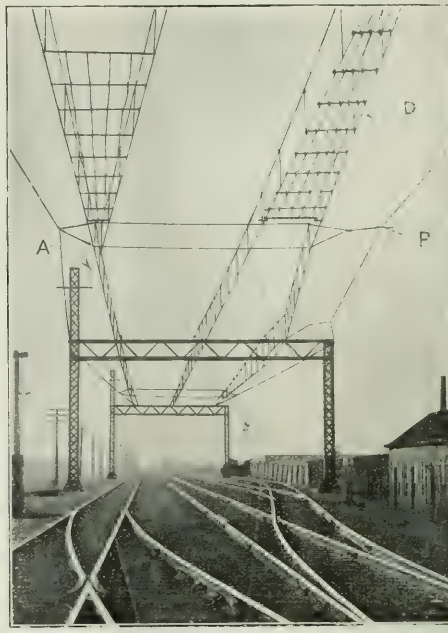


Fig. 22. Showing Deflector used in Single Catenary Construction at Points. Sarnia Tunnel, Grand Trunk Railroad of Canada, under the St. Clair River.
A and P, Pull-offs. D, Deflector.

It will be seen by examining this illustration that each of the signals shown on either side of the figure are connected to horn switches and that these are open when the signals are at danger. No current can be in the trolley wire section

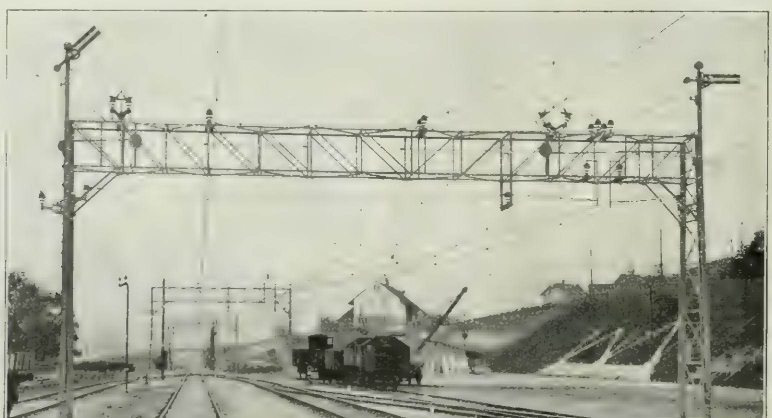


Fig. 21.—Overhead Construction of the Maschinenfabrik Oerlikon at the Station of Seebach, showing Interlocking of Signal and Switch.

to which the signals give access. Thus, the signals on the right being at danger the right horn switch is open, whereas the left-hand signal being up (which on the Continent corresponds to the signal being lowered in this country) the corresponding horn switch is closed, and the trolley line corresponding to it is therefore alive and supplied with current.

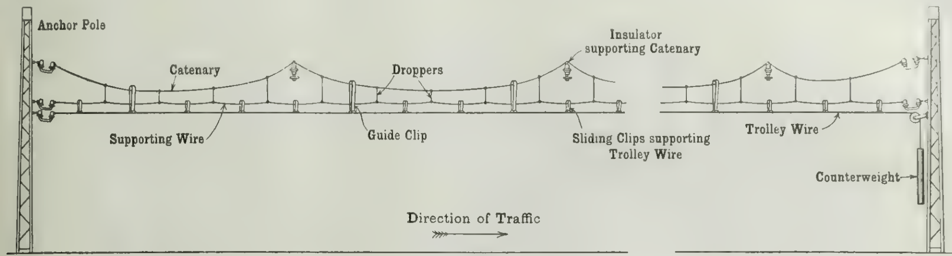


Fig. 23.—Diagram of Siemens-Schuckert (Hamburg-Blankenese)-Single Catenary Construction.

A more complicated form of single catenary suspension has been designed by the Siemens-Schuckertwerke and installed by them on the Hamburg-Blankenese line, and it was a slightly altered form of this construction which was adopted by Mr. Sayers, the electrical engineer of the Midland Railway. Briefly, the principle of this construction is as follows:—A single catenary is just hung, being run

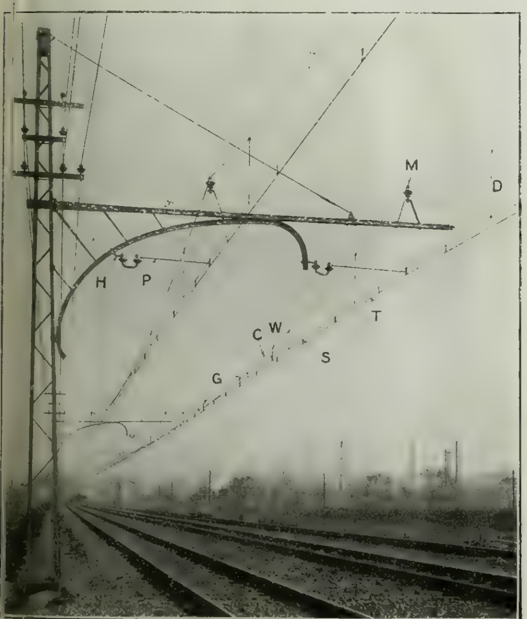


Fig. 24.—Hamburg-Blankenese Single Catenary Siemens-Schuckert Bracket Construction.

M, Main catenary porcelain insulator. H, Hinge. P, Push off. D, Dropper wire G, Trolley steadier or guide. C, Catenary. W, Supporting wire. S, Sliding clips supporting trolley wire. T, Trolley wire.

through and attached to the principal hangers located on the top of the bracket arm or cross girders as the case may be. From this, by means of droppers, the longer ones of which are made in two pieces, is hung a secondary wire from which the trolley wire itself is hung. But contrary to this usual practice the trolley wire is slung from this by means of loose clips which can slide along the secondary wire. The catenary and the secondary or supporting wires are anchored to insulators at both ends of a section, whilst the trolley wire itself whilst the clips holding the trolley wire slide up or down the supporting wire which, as well as the catenary lengthens or shortens according as the temperature goes up or down. In order to stiffen the trolley wire laterally, a special clip is fitted (two or three to each span), which after being attached to the supporting wire, go upwards and clip round the catenary in such a way, however, as to allow side clips. Fig. 23 shows diagrammatically this arrangement. As single catenary construction is liable to sway considerably it is necessary to anchor the wire at each support. The method usually adopted for doing this in the case of the single catenary suspension already described has been clearly illustrated. In this case the push or pull off is horizontal, so as to introduce no vertical stiffness into the trolley wire and to allow of a bow sliding smoothly along.

Fig. 24, from a photograph, clearly shows the Siemens-Schuckert single catenary construction on the Hamburg-Blankenese line and the push or pull offs and line steadiers. In this the single catenary, the supporting wire, the droppers from which the carrying wire is supported from the catenary and the trolley arm itself, as well as the loose clips which attach it to the supporting wires,

Fig. 25.—Dropper Wire, used on Hamburg-Blankenese Line.

can clearly be seen. The average span on the straight is 48 metres. The distance between the droppers from which the wire actually supporting the trolley wire is hung is 6 metres, and the distance between the clips supporting the trolley wire from the auxiliary supporting wire is 3 metres. The supporting wire in the case of Hamburg is of solid steel, having a diameter of 6 mm. The catenary is a steel cable composed of seven strands, and the total sectional area of the wires composing the cable is 35 sq. mm. The sag of the above catenary at mean temperature is for a 48 to 50 metre span taken at 1·50 metres. In the case of Hamburg the trolley wire has been hung at a uniform height, except under bridges of 5·20 metres above rail level. The vertical droppers already referred to for the centre part of the span are in one piece, and consist of steel wire 5 mm. in diameter. Towards the ends of the span, when they become of some length, they are in two pieces, and hinged at centre in order to give flexibility, as shown in Fig. 25. The sectional area of the trolley wire in Hamburg is 95 sq. mm.

(To be continued.)

THE LEPEL SYSTEM OF WIRELESS TELEGRAPHY.

Up till quite recently there have been only two practical methods of producing a continuous, or nearly continuous, high-frequency alternating current. About two years ago Marconi added a third, and now a fourth has been invented by Von Lepel. Of the first two, that most nearly approaching to ordinary engineering practice is the high-frequency alternator used by Fessenden for wireless telegraphy and telephony; the other system is really a group of methods, the members of which come under the generic term "arc" systems, although the characteristic curves of their currents are very different. They have one feature in common, however, which may serve to define the class—viz., that energy is taken from the supply circuit throughout some portion, or phase, of every cycle of the high-frequency current. This distinguishes the arc from the spark, in which latter no energy is taken from the supply circuit during the existence of the oscillatory current, which therefore dies out very rapidly, since its total energy was stored in the potential form in the condenser before the discharge commenced. In ordinary "arc" generators of high-frequency current, energy is taken from the supply circuit during one half of each cycle of the high-frequency current; in Marconi's generator it is taken during both halves of a cycle.

In ordinary spark systems the number of sparks per second has no relation to the frequency of the current produced, the spark rate being controlled by such external arrangements as an electromagnetic or mechanical break in the primary circuit, or by the frequency of a low-frequency alternator. Thus it is not possible to maintain a continuous high-frequency current in any circuit of the generator. Even if the spark rate be high it has no relation to the current frequency, hence successive sparks in general commence with a current out of phase with the tail end of the jig, which may exist in the circuit if the damping be low enough.

If, however, as in the Lepel system, the discharge rate be controlled by the high-frequency current itself the conditions are entirely different, with the result that a continuous high-frequency current of only slightly varying amplitude is produced in the transmitting circuit.

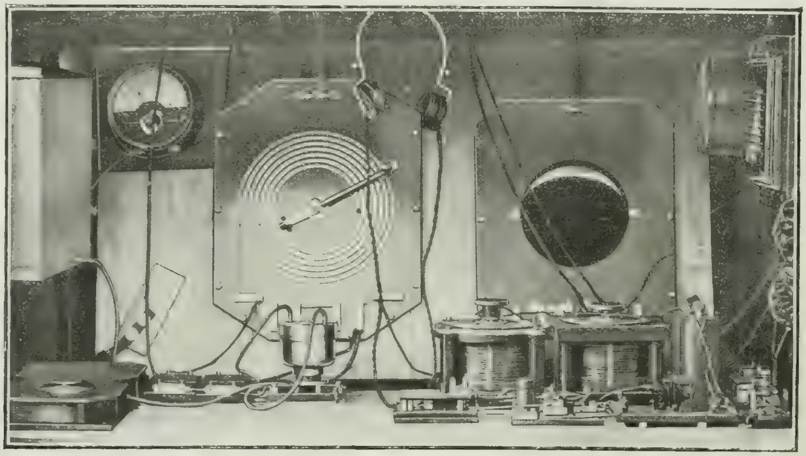


FIG. 1.—LEPEL PORTABLE WIRELESS STATION.

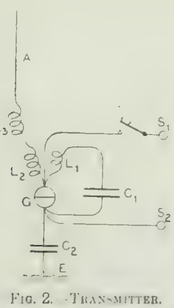


FIG. 2.—TRANSMITTER.

A, Aerial wire. G, Generator. C_1, C_2, Capacitances. L_1, L_2, Coupled inductances. L_3, Aerial inductance. S_1, S_2, Supply terminals. The current in C_1, L_1, G is of the same frequency as A, L_2, L_3, G, E.

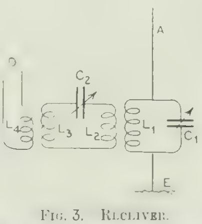


FIG. 3.—RECEIVER.

C_1, C_2, Variable capacities. L_1, L_2, L_3, Inductances in tuned circuits. L_4, Coupling of detector circuit D to intermediate circuit.

The apparatus is shown in Fig. 1 and diagrammatically in Figs. 2 and 3. The thing which strikes one on seeing the apparatus is the absence of any large piece—no induction coil, no enclosed arc, only a small metal box about the size and shape of a breakfast cup, a condenser about $3\frac{1}{2}$ in. × $2\frac{1}{2}$ in. × $\frac{1}{2}$ in., and a spiral coil of thick wire. The box is the generator and contains the flat metal plates, about 3 in. in diameter, which constitute the electrodes of the discharge gap. These are separated by one or two thicknesses of thin paper except at the centre, where a small hole is cut in the paper leaving only air between the plates. The paper burns very slowly as the discharge proceeds, one piece often sufficing for from two to three hours' continuous working. Fig. 4 shows one of the pieces of paper after three hours' use by the Territorials on May 2nd. The electrodes are usually water cooled, one or both of them being hollow, but air cooling is also practicable. There is a screw which gives a fine adjustment of the distance

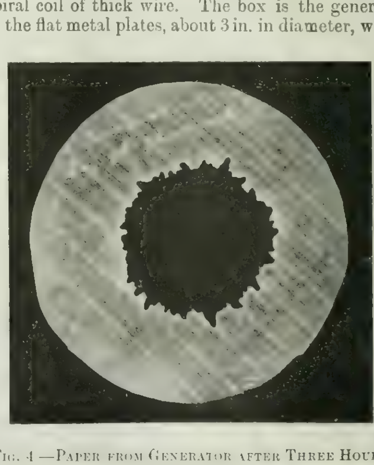


FIG. 4.—PAPER FROM GENERATOR AFTER THREE HOURS' CONTINUOUS USE.

between the electrodes, and a bayonet joint which allows of the upper electrode being removed in a moment should it be necessary to change the paper or clean the surface. The condenser, though of considerable capacity, is very small in bulk; it consists of mica and metal foil, the details of its construction being covered by one of the Lepel patents. The spirals which form the main inductances consist of thick copper wire or rod, and, being mounted on ebonite plates, take up but little more space than an ordinary blotting book. A sliding contact on the principal spiral L_1, Fig. 2, gives the wave-length adjustment, and the outer, or aerial spiral, is hinged so that its mutual induction with the other can be varied within wide limits. A supply voltage of from 400 to 500 volts, either direct current or alternating current, is used, the current being limited to a few amperes by the introduction of an iron wire resistance in series with the generator. Since the discharge gap is so small the current starts immediately on pressing the key in the supply circuit, and ceases on its release. Thus no energy is wasted, as the circuit is made only during the transmission of a signal.

The actual high-frequency energy in the generator circuit is surprisingly large, amounting, with a supply of 800 watts direct current, to as much as 250 or 300 watts, an efficiency not hitherto attained by any other high-frequency current generator which has come under the writer's notice. A hot arc can be drawn out from the lower part of the aerial to a length of nearly 2 cm., the energy being sufficient to melt the tang of a small file in the course of a few seconds.

During some recent experiments it has been found possible to cause a periodic variation of the high-frequency current of audible pitch, thus obviating the necessity for an interrupter in the receiving circuit and rendering the signals audible in any tuned receiver. The system thus complies with the condition of intercommunicability imposed by the Radio-telegraphic Convention.

The receiver, which is a patent of von Lepel and Dr. Burstyn, contains two tuned circuits—the aerial and intermediate—and an aperiodic circuit, in which is the detector. This last is of the thermo-electric type, and compares very favourably in sensibility with better known forms. At moderate ranges a recording instrument has been used, though this is naturally not as sensitive as a telephone. Signals from the experimental station situated between Slough and Windsor have been received strongly at Hunstanton in Norfolk, a distance of about 100 miles overland, and communication was established at a distance of over 300 miles during experimental tests in Germany some time ago.

Owing, no doubt, to the large high frequency energy produced by the generating circuit, it is possible to use comparatively small aerials. The whole system is thus one of great simplicity; the apparatus contains probably a smaller amount of wire than is used in any other "wireless" system, while at the same time the efficiency is high. There are at present two experimental stations in England, at Slough and Twickenham, and three in Germany, under the control of the Lepel Syndicate.

INTERNATIONAL ELECTROTECHNICAL COMMISSION.

The "Transactions" of the Council of the International Electrotechnical Commission, which met in October, 1908, have just been published, and contain full details of the business done and the various resolutions passed at the different sittings. In our issue of October 23, 1908, we gave a short description of the various subjects discussed and resolutions passed; and we are now able to amplify these to some extent. It will be remembered that the chair was taken by Sir John Gavey, C.B., and that an address of welcome was delivered to the delegates by the Rt. Hon. A. J. Balfour, M.P. Prof. Elihu Thomson was elected president in succession to the late Lord Kelvin, while Col. R. E. Crompton was re-elected Hon. Secretary, and the appointment of Mr. C. Le Maistre as first general secretary was confirmed.

The report, which we have before us of the Council meetings, is prefaced by two excellent photographs: one of the president, Prof. Elihu Thomson, and the other of a group, taken on the steps of the new building of the Institution of Electrical Engineers, where the meeting was held, showing the delegates from the various countries, as well as the officers and certain invited guests who attended the meeting. A list of the delegates present is then given.

It will be remembered that at the time of the meeting some difficulty had been experienced by the Italian electrical engineers in forming a committee in that country to deal with the work of the Commission. We are now able to state that owing to the efforts of Signor Guido Semenza, of Milan, the Italian Electrical Society has decided to join in the work of the Commission, and is forming an electrotechnical committee, the president of which will probably be Prof. Luigi Lombardi, of the Technical School in Naples. An electrotechnical committee has been formed in Belgium, with the assistance of the government of that country, the President of which will be Prof. Eric Gérard and the secretary M. S. Mittewie, the energetic secretary of the electrical section of the Chamber of Commerce. A Brazilian committee has also been formed in Rio by the Brazilian government, under the Presidency of Prof. Morize.

The report of the council meeting of the commission, which we now have under notice, begins by an account of the opening meeting held in the Examination Hall, Victoria Embankment, on October 19, 1908. The address of welcome to the delegates by Mr. Balfour is given in full, and the formal business proposals with regard to the election of officers, the ratification of the rules and the report on progress read by the secretary, Col. R. E. Crompton, are also set out at length. In this connection it is interesting to notice that at the time of the meeting there were ten electrotechnical committees in proper working order, while there were also six countries in which committees would be formed very shortly, and six other countries had the matter of the formation of a committee under consideration. In our notice in THE ELECTRICIAN, to which we referred above, the principal points in this report were detailed, and it is unnecessary to refer to them further here.

At the second meeting the delegates assembled as a committee and proceeded to discuss the various business laid before them. This included the alteration of the statutes so that each country should be entitled to one vote only, and that the decisions of the committee should be subject to a majority of at least four-fifths of the votes recorded. Any modification of this resolution is only to be decided by a unanimous vote of the delegates. The subject of nomenclature was then discussed, and various proposals carried. This subject had, it appeared, been already taken in hand by a firm of German publishers, and the question for the committee to decide was whether this work should not be done by the commission itself. It was finally decided that it was not the business of the commission to publish an extended dictionary, but rather to confine its energies to the explanation of a comparatively small number of electrotechnical terms. It was, therefore, decided to issue a glossary which should give short explanations of the various terms used in the electrical industry. It will be remembered that part of this has already been published, and has appeared in the columns of THE ELECTRICIAN.

The next subject dealt with was the provisional unit of light, but after some discussion on this matter the question was postponed to allow the various committees to consider the subject in such a manner as would give satisfaction to both the electrical and gas industries. The question of Fire Insurance rules was postponed for the time being, and that of symbols, after having been discussed, was referred to the committees in the various countries, in order that they might gather information with a view at some future date of being able to put forward a proposition for a consideration by the commission.

The Council met again on October 22, and the various subjects discussed and resolutions passed by the committee were reported to them. Reports by the delegates on the progress of their committees were submitted, and various resolutions, thanking the officers for the work they had undertaken, were passed. The Council then adjourned.

THE EFFECT OF AN AIR-BLAST UPON THE SPARK DISCHARGE OF A CONDENSER CHARGED BY AN INDUCTION COIL OR TRANSFORMER.*

BY J. A. FLEMING, D.SC., F.R.S., AND H. W. RICHARDSON, B.SC.

Summary.—The discharge current is shown to be more regular, and the resonance more accurately delineated, when the spark gap is subjected to an air-blast. Also it is shown that with the spark gap broken into a number of smaller gaps in series arcing is suppressed almost as effectively as by blowing upon a single gap, but greater steadiness is obtained in the latter case.

When the oscillatory discharge of a condenser is caused to take place across a spark-gap in the usual manner by charging the condenser by means of an induction coil or transformer, the resulting intermittent spark between the spark balls is a complex effect. It consists partly of the true oscillatory discharge of the condenser

* Abstract of a Paper read before the Physical Society, a short account of the discussion appeared in our issue of April 16, p. 26.

and partly of an electric arc, unidirectional or alternating, which is superimposed on the true condenser oscillatory spark. The discharge current will generally be found to be irregular, and if a radiative circuit is coupled to the condenser circuit as in radio-telegraphy, the radiation from it will be found to consist of trains of waves whose initial amplitude is also variable. This irregularity is a source of difficulty in making radio-telegraphic or laboratory measurements of current decrement, wave-length, &c., when originated by condenser discharges. To produce a uniform oscillatory discharge the true arc discharge must be either prevented or arrested at once, and the spark between the balls should arise wholly from energy which comes out of the condenser, and not from energy coming directly from the transformer or coil. When moderate power is being employed this arc discharge can be best annulled by a blast of air thrown on the spark-gap. This has the effect of blowing away the arc, but does not stop the condenser oscillatory discharge.

To determine the effect of air blast the following experiment was tried: A 10 in. induction coil had its secondary circuit connected to brass spark balls 3 cm. in diameter set with a gap of 1 mm., and the balls were also connected to a rectangular circuit of round copper wire, the diameter of the wire being 0·162 cm. and the sides of the rectangle respectively 142·1 cm. and 34·17 cm. The ordinary or steady resistance of this rectangle is 0·046 ohm, and its high frequency resistance to currents of a frequency of the order of $1{\cdot}25 \times 10^6$ is 0·31 ohm. The inductance of this circuit (calculated) is 5,012 cm. In series with this circuit was placed a condenser consisting of metal plates immersed in paraffin oil, the capacity of which was 0·002645 mfd. In contiguity to the long side of the above rectangle was placed the bar of a Fleming cymometer, two such instruments being used in the experiments, called respectively No. 2 and No. 3. The cymometer circuit can have two short fine wires of constantan, each about 5 cm. long, inserted in it at pleasure, against one of which a bismuth-iron thermo-junction is attached. By passing measured small continuous currents through this fine wire and connecting the ends of the thermo-junction to a low resistance single-pivot Paul galvanometer, the arrangement can be calibrated as a hot-wire ammeter to indicate directly the mean square value of the oscillations. The other fine wire can be inserted as an added resistance in the circuit of the cymometer. The cymometer consists of a circuit including a spiral wire having inductance L and a condenser of capacity C, which can be continuously varied in the same proportion, so that the oscillation constant ($\sqrt{CL}$) of the circuit can be given any value between certain limits. The cymometer was employed to take a resonance curve of the spark circuit by the usual Bjerknes-Drude method (i.) when the spark balls were not subjected to air blast, and (ii.) when the jet of air was thrown between them.

An extremely steady jet of air for this purpose can be obtained by the use of a small Lennox blower. The resonance curve is obtained by plotting the values of the R.M.S. current (a) expressed as a fraction of the maximum current (A) induced in the cymometer circuit by the damped oscillations in the spark-ball circuit corresponding to various values of the natural frequency n or oscillation constant for any setting of the inductance and capacity of the cymometer circuit.

If there is no air blast on the balls the deflection of the galvanometer hardly ever remains steady, and the points plotted for the resonance curve do not lie well on a smooth curve. This difficulty has been experienced by other observers—viz., Mr. R. A. Houstoun (*see* THE ELECTRICIAN, Vol. LXII., p. 636), and Messrs. J. E. Taylor and W. Duddell. If, however, a steady blast of air at a suitable pressure is thrown between the spark balls, this irregularity is greatly reduced provided the spark-gap is not long.

With the above described arrangements a resonance curve can be easily taken as follows: The jet of air from the Lennox blower conveyed by a rubber pipe ending on a glass nozzle is allowed to play between the spark balls and these are connected together by a condenser of known capacity in series with an inductance which has either been measured or predetermined. This inductance is preferably formed of round copper wire, and may be rectangular in form, and its high frequency resistance and inductance can then be calculated by known formulæ. The cymometer is then placed alongside this rectangle so as to have induced oscillations created in it, and by means of the hot-wire ammeter inserted in its circuit the mean square value a of the cymometer current is taken for various settings of the circuit, which give it various assigned natural frequencies n. If A and N are the maximum values obtained we then calculate the value of the sum of the decrements of the spark and cymometer circuits from the Bjerknes-Drude formula.* Since the resonance curve is not symmetrical with respect to its maximum ordinate, the best mode of procedure is as follows: Having taken a series of values of the cymometer current a without the extra damping resistance, and those of the current a_1 when the resistance is inserted in the cymometer circuit, and observed the maximum values A and A_1 of the quantities, for various values of n we plot two curves, each to abscissæ n/N, but one having ordinates a/A and the other ordinates a_1/A_1. The latter curve should lie outside the former, but should have the same value for its maximum ordinate—viz., unity. We then draw a number of horizontal lines across the hump of the resonance curves with such ordinates that the greatest length intercepted by the curves is not more than 0·06 on the same scale that N is taken as unity. Let the half length of any such horizontal intercept be called x and the corresponding ordinate a/A be denoted by y, we then calculate the value of $D = \pi x \sqrt{y^2/(1-y^2)}$, and this gives us the value of the sum of the decrements of the spark and cymometer circuits. It is well to calculate D from several, say four or five, measurements of x and y for intercepts of different lengths, and then take the mean value for D. In the same way from the outer resonance curve we can calculate the value of D_1. The difference between D and D_1 is the increment in the decrement due to the added resistance wire, and if R is its high-frequency resistance and if the frequency of resonance is N and the corresponding inductance of the cymometer is L, we should have $D_1 - D = R/4NL = \delta_2'$ as a check on the observations. Details of one set of experiments are given in the Paper to show the advantage gained by the use of the blower.

The observations also appear to show that the air blast has not much influence upon the primary decrement or upon the spark resistance, or at most tends to slightly increase the spark resistance for very short sparks. The good effect of the air blast is seen best when applied to short sparks, which tends to show that it is of assistance in destroying the arcing then occurring. This arc, however, is unable to persist with longer gaps; that is to say, it blows itself out, and accordingly for spark-lengths of 3 mm. or upwards, and when using an ordinary 10 in. induction coil with mercury break as interrupter, the blast is of no special advantage.

Another set of experiments was conducted, the object of which was to ascertain the effect of the air blast upon multiple and upon very short spark-gaps, since at one time some radio-telegraphists were of opinion that an advantage was gained by dividing up a spark-gap into smaller spark-gaps in series. In order to avoid misinterpreting the results, it was necessary to be sure that when using, say, one single spark of 0·5 mm. in length and comparing it with the effect of five spark-gaps of 0·1 mm. in series, any increase in the current at the discharge circuit was not due to an alteration in the number of discharges. As far as could be observed, this was not the case when sufficiently short spark-gaps were employed. The results of the measurements, of which particulars are given, show that up to a certain length of gap (about 2 mm. in the case of the experiments) the air blast had a very decided effect in increasing the mean square value of the discharge current, but beyond that point it seems to have the effect of diminishing it. On the other hand, if a single gap, say of 0·2 mm., is broken up into two gaps in series each of 0·1 mm. and so on for the other spark lengths, it is found that dividing the spark-gap into two parts also increases the discharge current up to about 0·8 mm., and after that the current diminishes. If the double air gap is blown upon, the current is increased as compared with the same two gaps not blown upon, but is not increased as compared with a single gap blown upon. The same is true when the spark-gap is broken up respectively into three, four, five and six gaps. The effect of dividing the gap up to a certain point is to increase the discharge current, but the effect of the air blast on the multiple gaps becomes less and less marked in proportion as the number of gaps increases, so that the effect of dividing up a gap, say 0·6 mm., into five gaps of 0·12 mm. each, is to increase the discharge current almost as much as by subjecting the single gap of 0·6 mm. to the air blast. This increase appears to be due to the suppression of the arc discharge, and hence the arcing is suppressed by the separation of the gap into multiple gaps, almost as effectively as by blowing upon the single gap. On the other hand, separating the spark-gap into more than five separate gaps seems to result in diminishing the total discharge current beyond a certain very short length of spark. The figures obtained, however, do not show what is observed in practice—namely, the greater steadiness of the discharge current under the operation of the air blast; and the conclusion, therefore, is that in any experiments in which great constancy is required in the discharge current in the condenser circuit, a great advantage is obtained by using a short spark-gap, and by subjecting the discharge spark to an air blast, as this both increases the charging voltage of the condenser and steadies the discharge current by abolishing the arc.

A similar set of experiments, of which particulars are given in the Paper, was tried with a larger alternating-current plant and a high-tension transformer.

* See "The Principles of Electric Wave Telegraphy," by J. A. Fleming

PHYSICAL SOCIETY.

At the meeting held on April 23, at the Imperial College of Science, Dr. C. Chree, F.R.S., president, in the Chair, a Paper by Prof. W. H. Bragg and Mr. J. L. Glasson,

"On a want of Symmetry shown by Secondary X-rays,"

was read by Prof. Bragg. When a primary X-ray strikes an atom, a secondary X-ray sometimes starts out from the place of impact. The experiments described in the Paper were made with the object of comparing the intensity of emission of the secondary X-ray in a direction making an angle of about 45 deg. with the primary with the intensity in a direction making an angle of 135 deg., and therefore turning back almost completely. It was found that in the case of atoms of platinum, tin or aluminium, or of such light atoms as are contained in celluloid, the former was larger than the latter, being sometimes three times as great. Madsen has obtained similar, but much greater inequalities in the case of the γ-rays. When atoms of copper or iron were tested, atoms which give rise to a very soft radiation, there was little inequality. A similar inequality effect also occurs in the case of β-rays. On the original pulse theory, calculation showed that there should be no inequality of the secondary X-radiation in any case. If that theory were abandoned, as most writers now agree to do, and the X-rays were supposed to be bundles of energy travelling through space, there did not appear to be sufficient definition of such entities as would enable any comparison to be made between theory and experiment. If the rays were supposed to be material, the facts were generally in agreement with expectation and afforded another instance of close parallelism between the phenomena of the X and the γ-rays.

Prof. C. H. Lees said that Prof. Bragg had given a lucid account of his theories of γ and X-rays. His researches would make physicists more careful in accepting the æther-pulse theory. He asked if it was likely that better means would be devised to discriminate between various forms of γ and X-rays than dividing them into "hard" and "soft" radiations. He thought many discrepancies could be attributed to this want of discrimination.

Mr. C. A. Sadler pointed out that whatever lack of symmetry might exist in the emergence and incidence secondary X-radiations from a plate of a substance which was a source of scattered primary radiations, Professor Bragg's results conclusively proved that such lack of symmetry did *not* exist when the plate was a source of homogeneous radiation. If then it was a necessary condition of Prof. Bragg's theory that such lack of symmetry should exist with secondary X-radiations, we must either conclude that the theory here broke down or that these homogeneous radiations were not X-radiations as usually understood. It was to be noted also that the measured lack of symmetry (ignoring the lack of symmetry in the case of homogeneous beams, which had been shown to be only apparent) in the most pronounced cases was small compared with those obtained with γ-rays.

Prof. Bragg, referring to the remarks of Prof. Lees, said that for precision the actual speed of all electrons ought to be measured. Instead of measuring the speed the penetrating power might be determined.

A Paper entitled

"Transformations of X-rays"

was read by Mr. C. A. Sadler. It has been shown that the members of the group of metals Chromium—Silver emit under suitable primary beams radiations which are homogeneous and which increase in penetrating power with increase of atomic weight of the radiator. Using these homogeneous beams, the tertiary radiation excited by them in other metals has been studied by the Author. It was found that the tertiary radiation excited in any member of the group Cr—Ag was homogeneous, and its penetrating power was that characteristic of the radiation from the substance when excited by a primary beam. With any given tertiary radiator it was found that the intensity of the homogeneous type of radiation emitted when the homogeneous radiations from the members of the group Cr—Ag successively fell upon the radiator was inappreciable unless the exciting radiation was more penetrating than that characteristic of the radiator. Defining a quantity k such that the fraction of the energy of the secondary beam passing normally through a thin layer δx of the tertiary radiator which was transformed in tertiary radiation $= k\delta x$, it was found that as long as the penetrating power of the secondary beam was less than that characteristic of the tertiary radiator, k was sensibly zero. When the secondary beam became more penetrating than that characteristic of the tertiary radiator, k increased rapidly to a maximum and then decreased over a considerable range, with increase of penetrating power of the secondary, as a linear function of the ionisation produced in a thin layer of air by the secondary beam. It has been shown that when the characteristic radiation is excited in a substance, a corresponding increase in the absorption of the exciting radiation by that substance takes place. If λ' denote the increase in the value of the absorption coefficient of the exciting beam by the material of the tertiary radiator consequent upon the emission of the tertiary radiation, k/λ' was found to decrease slowly at first and then more rapidly as the exciting beam became more penetrating.

Prof. Bragg congratulated the Author on his interesting experiments, and said he could not see any satisfactory explanation of them on the pulse theory.

A Paper on the

"Theory of the Alternate Current Generator,"

by Professor Lyle, was read by Dr. Russell. The Author points out that the theory of armature reaction as ordinarily discussed by electricians is unsatisfactory, as an important effect due to the mutual induction between the current in the field winding and the current in the armature circuit is neglected. To simplify the problem, the case of a simple ironless single-phase alternator is first discussed. The magnetic field, supposed uniform, is due to the current in a fixed coil connected with a source of constant E.M.F., and the armature is a coil of wire rotated in this field with constant angular velocity. In these circumstances, we may suppose that the mutual inductance between the two circuits varies in accordance with the harmonic law. The differential equations which determine the values of the two currents are easily written down, but their solution presents difficulty. The Author gives a method of getting the complete solution. He first assumes that both the currents can be expanded in Fourier Series. He then applies a novel vector method and obtains equations to determine the value of the harmonic of any order in terms of the constant term in the field current. The operators in these equations are infinite determinants, but he shows how these can be readily reduced to continued fractions. In practice, the resistance of the exciting circuit is small compared with its inductance, and thus the time constant is large. The continued fraction operators therefore rapidly become recurring, and so the equations giving the solution are simple.

The results prove that only odd harmonics appear in the expression for the armature current, and only even harmonics appear in the expression for the field current. The frequency of the induced ripple superposed on the exciting current is therefore double the fundamental frequency. The interesting fact is proved that this ripple is asymmetric, that is, the positive half of the wave is of a different shape from the negative half. A simple geometrical solution is also given.

The Author next takes into account the effects of hysteresis and eddy currents. This he does by means of the permeability operators, the use of which he explained in the "Phil. Mag." for January, 1905. The magnetic leakage of the armature is also taken into account. As a practical illustration of the method, the operation of a small two-pole alternator when supplying a non-inductive load is predetermined. A diagram is given showing the exact shape of the current wave in the armature, the ripple superposed on the exciting current, and their relative phase displacement. The action of "dampers" and the theory of the synchronous motor are also discussed.

Mr. W. Duddell expressed his interest in Prof. Lyle's Paper, and remarked that the results which he had obtained were in accord with experiments made by himself and Dr. Marchant some years ago.

Dr. Russell congratulated the Author on having obtained such instructive solutions of the differential equations which determine the value of the armature and field currents in a simple generator. The subject of armature reaction had been carefully studied by electrical engineers, and the literature of the subject was quite extensive. He referred in particular to the study made by Prof. Blondel in 1900 of the ripples in the exciting current of a two-phase and a three-phase alternator. It was well known that in a single-phase machine the frequency of the ripple superposed on the exciting current by the alternate magnetising and demagnetising effect of the armature current was double the frequency of the armature current. This ripple disappeared at no load, but in practice the ripples at no load were often very marked owing to pulsations of the reluctance due to slots in the armature. The latter ripples were much less pronounced at full load as the load circuit acted like a damping-coil; but new ripples due to the armature reaction appeared, causing a distortion of the wave-form. As a rule, electrical engineers assumed the existence of a sine wave of armature current and then investigated the ampere-turns to be added or subtracted from the field coils so as to neutralise the magnetising or demagnetising effect produced. In this connection Blondel's two-reaction method was extensively used as it enabled approximate values to be rapidly obtained. The effect of the reaction on the wave-form of the machine, however, had been practically neglected, and Prof. Lyle deserved great credit for his solution. In connection with the parallel running of turbo-alternators it was important, and the theory deserved careful study by engineers. The speaker thought that "dampers" were mainly used to prevent phase-swinging. He agreed with Prof. Hopkinson that a similar effect might often be more economically produced by putting more copper on the field windings. The difficulties that arose in connection with perfecting the theory of synchronous motors arose mainly from the difficulty of taking hysteresis into account in the mathematical equations. He thought that Prof. Lyle's work in this direction was most valuable.

Prof. L. R. Wilberforce exhibited a galvanometer of the Broca pattern suitable for general use in elementary laboratories.

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ANTIQUATION.

From time to time the subject of antiquation looms somewhat large on the engineering horizon, though it has never become so important in this country as in America. Here we do not take risks to any great extent; and it may be said that our progress would be more rapid if our financiers regarded engineering risks more favourably. In America less caution is exhibited, and, consequently, progress is often made there while we, on this side, look on to see what the outcome will be. Sometimes the result is unsatisfactory, and thus scrapping has been there a common occurrence at times. Such a course requires a considerable amount of courage, for the financial outlook certainly is not improved by this process for the time being, though it may ultimately be strengthened very materially. Scrapping is always a contingency where different systems of doing the same thing arise, and where the process of survival of the fittest has to be endured. There is no difficulty so long as any one system does not show a marked superiority or inferiority in comparison with the others, but the longer it takes to reach this stage the more serious may be the ultimate result.

A town where the question of depreciation is exercising the minds of the Council is that of Walsall. Here we have a town of something like 93,000 inhabitants, where the electricity undertaking is in its fourteenth year and the out-

put is about a million and a half units per annum. Considering the age of the undertaking and the character of the town one might expect financial success here as elsewhere. The undertaking, however, is still working at a loss, and this is attributed by the Council to the system in use. Walsall is one of those networks which is operated on what is known as the "Oxford" system, which, although taking its name from Oxford, is no longer in use in that town. As is well known, it consists of high-tension continuous-current generation with transformation to low-tension continuous current at sub-stations by means of motor-generators. Although £110,000 has been spent on the undertaking, the Council feel the system to be so far at fault that they are considering the question of reconstructing the whole concern and scrapping the present high-tension continuous-current plant.

Serious differences of opinion as to generation and distribution are scarcely likely to arise in the future, now that the limitations of continuous current and alternating current are so well known, though in matters of detail it may be otherwise. In detail there must be continual progress. The reciprocating steam engine is giving way to the steam turbine, and it may be that gas engines will yet prove their superiority over both. Such changes in engineering practice, however, do not introduce any very serious difficulties. The more modern plant is used in extensions, and the older plant can generally be utilised until it has served a fair lifetime. But with systems as a whole it is otherwise.

Although we do not suppose that any engineer would put down the Oxford system at the present time, it is questionable whether it is worth while to scrap such a system once it is in. It is working well at Hull, where the population is 250,000, and the undertaking is in its seventeenth year, with an output of about 5½ million units per annum. We described this interesting plant in THE ELECTRICIAN some time back. It appears to be successful, and it is being extended from time to time. There seems no particular reason, therefore, why the Oxford system, as a system, should not compete commercially with others, although very possibly it may be undesirable in certain respects. We would, therefore, suggest that the Council of Walsall would do well to consider very carefully whether there are not other reasons to account for the poor result achieved by the electricity undertaking, and to hesitate before such a drastic step is taken as to scrap the present plant and system.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

An Elementary Manual of Radiotelegraphy and Radiotelephony. By J. A. FLEMING, F.R.S. (London: Longmans, Green & Co.) Pp. xiv.—329. 7s. 6d. net.

Radiotelegraphy has developed at such a rapid rate during the past few years, and is now of such practical importance that, as the author says in his preface, "means are required for adequately teaching the subject to electrotechnical students, and to practical operators, and thus equipping them with the initial scientific information necessary to enable them to follow intelligently its practical development."

The present work has been written with this aim in view, and Prof. Fleming has earned the gratitude of all electrical students, for, in spite of several defects which are referred to below, he has produced a really valuable introductory text-book.

To the average electrical engineer there is something mysterious about electromagnetic waves, just as polyphase currents were mysterious not many years ago; the latter mystery has now largely disappeared, or rather, is ignored, owing to the fact that the engineer uses such currents daily, and can measure them and think numerically about them; the former mystery will vanish in exactly the same way. Thus to familiarise a student with the phenomena associated with electromagnetic waves, we must teach him how to make numerical calculations about them. This is exactly what Prof. Fleming has attempted, and from this point of view the only improvement one can suggest is the inclusion of a number of exercises for the student to work out for himself.

From a theoretical standpoint, however, the book is not quite so satisfactory; thus in the section on plane waves (p. 123), E and H being taken parallel to the axes of x and y respectively, and the direction of propagation along the axis of z, we find: "If at the origin the electric force has a value E along the axis of x, then the electric force in the plane xz in a direction parallel to the axis of x, but at a distance δz from it is $E - \frac{dE}{dz}\delta z$, being less the further we remove from the origin." This error is corrected by integrating round a small rectangle in the wrong direction; the same mistakes are made with H, and so the correct circuital equations are obtained, viz.:

$$-\mu\frac{dH}{dt} = \frac{dE}{dz}. \qquad K\frac{dE}{dt} = -\frac{dH}{dz}.$$

and from these follow the wave propagation equations

$$\frac{d^2H}{dt^2} = \frac{1}{\mu k}\frac{d^2H}{dz^2} \qquad \frac{d^2E}{dt^2} = \frac{1}{\mu k}\frac{d^2E}{dz^2}.$$

The author then goes on to say that these equations can be satisfied by solutions of the form

$$E = E_0 \sin 2\pi\left(\frac{z}{\lambda} - \frac{t}{T}\right).$$

$$H = H_0 \cos 2\pi\left(\frac{z}{\lambda} - \frac{t}{T}\right).$$

where $\frac{T}{\lambda} = \sqrt{\mu k}$

This is quite true, but these solutions do not satisfy the circuital equations; to do this, one must replace the sine by cosine, or the cosine by sine, *i.e.*, E and H are in the *same* phase and do not differ 90 deg. in phase, as the above expressions imply, and as the author repeatedly asserts.

Again, in dealing with the problem of two inductively coupled oscillation circuits which separately have the same frequency, it is stated (p. 35) that "if free oscillations are excited in one circuit, the result will be to create in both circuits a complex oscillation which is alternately of greater and of less frequency than the natural frequency of either circuit taken alone." From this, and a mechanical analogy which is given, we are led to believe that if one of the circuits is radiating we should obtain a train of waves consisting of a series of waves of one frequency then a series of the other frequency, followed by a series of the first frequency and so on; surely both frequencies will be radiated simultaneously.

The chapters dealing with radiating and receiving circuits, detectors, radiotelegraphic stations and radiotelegraphic measurements are very good indeed. One point may be noticed with regard to Marconi's disc discharger; the explanation given does not agree with that given by Marconi himself at the Royal Institution last year. The last chapter is devoted to radiotelephony, and contains a brief account of the results achieved, and the methods employed in this branch. J. L.

Die Elektrotechnik. By K. LAUDIEN. Vol. LXXXVIII. of "Bibliothek der gesamten Technik." (Hanover: Dr. Max Jaenecke.) Pp. 291. M. 3.60.

The present little book, Vol. LXXXVIII., of the "Bibliothek der gesamten Technik," is the outcome of a series of lectures delivered by the author in his capacity of teacher at the

Royal High School of Machine Construction at Hagen, Westphalia. Static electricity has been entirely omitted, and rightly so. As the author himself states in the preface, far too much time is spent in public schools in teaching the students frictional electricity, and showing them numberless experiments on the subject, but rarely one from the domain of electrical technology.

The fundamental principles of current electricity and the technical production and application of the electric current constitute the contents of the book, which may be said to maintain the standard of this German technical series. The subject has been concisely and well treated; the text is clear and profusely illustrated, and the book is well printed. A good many of the illustrations have apparently been specially prepared; they are not the old familiar ones almost invariably found in this class of book.

There are four main sections. The first one deals with the general fundamental laws of current electricity, magnetism and electromagnetism—necessarily in a brief manner—Ohm's law, Kirchhoff's law, &c. Section II. is on the electrical units—the ampere, volt, kilowatt, watt-hour—and also on electrical measuring instruments. Section III. is the largest in the volume, and gives a cursory but excellent account of the production of heat by the electric current, the transformation of heat into electricity, hot-wire instruments, electric lighting—carbon filament, metal filament, Nernst and different types of arc lamps—primary batteries, bells, telephones, telegraphy, electrolysis, accumulators, the conversion of mechanical into electrical energy and the converse, continuous-current and alternating-current dynamos and motors, transformers and converters, power transmission, tramways. The final section is on installation material.

Physikalische Wandtafeln. L. Pfaundler. (Brunswick: F. Vieweg & Sohn.) M. 12.

This series of lecture-room tables and diagrams deals with Heat, and the subjects are of the standard dealt with in the more advanced lectures of a first-year college course and in the ordinary lectures of a second-year course. They are 12 in number, each being on a sheet 100 cm. by 140 cm. They are very good, and it is to be hoped that their sale (individual diagrams cost m. 1½) will justify the production of succeeding series.

THE THEORY AND APPLICATION OF MOTOR CONVERTERS.

We give below an account of the discussion last week at the meeting of the Institution of Electrical Engineers, when Mr. H. S. Hallo read his Paper on this subject. An abstract of this Paper appeared in our last issue.

Dr. E. Rosenberg said that no doubt the author had given them the theory and application of a very interesting machine, but even the author would scarcely claim that the comparison with the rotary converter was impartial, and it was necessary to illuminate the other side of the question. In the first part of the Paper the author never mentioned the expression "rotary converter" for one part of his machine, but always called it a "direct-current machine." The only reason appeared to be that if he had said from the beginning it was a rotary converter then he could not have claimed the many advantages over the latter which were put in the Paper. Let them consider of what a motor converter really consisted. It was a rotary converter for full output and half frequency, but with higher losses and worse commutation than a plain rotary, combined with a motor for full output, but running at half speed and having additional iron losses. Therefore the efficiency was undoubtedly much inferior to the plain rotary. Lower frequency in the rotary part was no advantage. Even with high-speed direct-current machines we prefer a higher frequency than 25, and the motor converter necessitated a lower speed. A plain rotary converter for 50 cycles was an excellent and absolutely reliable machine. From the tables in the Paper it appeared that a motor converter would be practically as good as an ordinary converter for half the frequency. The comparison was hardly correct. In a motor converter the wattless current for the motor was to be provided. The author claimed 25 per cent. as magnetising current. This might be correct for no load, but due to the leakage in the primary and the secondary of the induction motor, the wattless current at full load would increase to something like 40 per cent. Therefore 33 per cent. was not even sufficient to make up for the lagging current of the motor, to say nothing of giving leading current to the supply, whereas the rotary converter supplied nearly 30 per cent. leading current. That would show that the converter part of the motor converter had to be about 20 or 25 per cent. larger than the ordinary rotary converter for half frequency for the same heating. While blaming the use of boosters in plain rotary converters, the author had advocated the use of a booster for motor converters which had to work on lighting and traction loads. For exactly the same voltage range, however, a plain rotary converter could be built and worked very satisfactorily without a booster, using two tappings on the transformer and regulating ± 5 per cent. by means of a shunt regulator, obtaining a good power factor throughout. The winding for a three-wire machine, mentioned by the author, was invented (by the speaker) in 1903 and described in the technical press in 1904 for compounding three-wire machines.

Mr. B. M. Jenkin mentioned that when motor converters were adopted for the Great Western Railway no machine of the kind had been built with the exception of a small experimental one at Messrs. Bruce Peebles' works. The machines, however, had worked very satisfactorily, and he was very satisfied with the results. One reason for adopting them was that they suited the conditions particularly well. The problem was to supply power for the Hammersmith and City Railway and also power for lighting Paddington station, goods sheds, &c. It was absolutely necessary to maintain a lighting supply under all conditions, and for that reason they put in at the sub-station some batteries of sufficient size to maintain for a short time the supply to the railway and for a long time the supply for lighting, should there be an interruption in the supply from the Park Royal power station. The system of lighting at Paddington was by alternating current, so that in the case of such interruption an alternating-current supply had to be maintained from the sub-stations by means of the batteries. They decided in order to do that, to put in reversible motor converters. In addition to doing the work better, the motor converter had other advantages—viz., smaller floor space as compared with the motor generator, they could be started up equally well from the alternating-current or the direct-current side, they were as reversible as direct-current machines, no exciters were required, unity power factor, and a high efficiency at both full and low load. On comparing the efficiency curve with that of a motor generator they found that a much better efficiency was obtained at light loads, and, in consequence, a higher overall efficiency was obtained at the sub-station. In dealing with widely fluctuating loads, as was the case in supplying power to a railway, the conditions were not the same as in the case of a steady load, because in the latter case one was able to select the number of machines necessary. But with a railway load machines had to be used that would work efficiently over a very wide range. The tests showed an efficiency of 90·5 per cent. at full load, and it must be remembered that at that time the machines were practically untried and were of the three-bearing type. With later types an efficiency of 92 per cent. could no doubt be obtained. As to reversibility, he varied and reversed the direct-current and alternating-current loads from a 30 per cent. overload as generator to an overload of 77 to 100 per cent. as motor with practically no sparking. That showed the reliability of the machines for that purpose. One objection advanced against the motor converter was its liability to run away. It was true that if the direct-current field was broken the machine would run up to the true synchronous speed of the induction motor—viz., about twice the normal speed of the converter. Machines intentionally allowed to run away in this way stood the test satisfactorily. There were one or two other peculiarities which might be emphasised. Regarding the arrangement of the switchgear one had to be careful in starting up from the alternating-current side that the field of the direct-current machine built up as the machine gained speed, or else it would be necessary to shut down and begin again. In effect the machine was a transformer, and that had to be borne in mind in adjusting the voltages. In starting from the direct-current side the machine was run up to speed exactly as a direct-current motor. The speed was regulated by a rheostat, so as to obtain synchronism. The simplest way to regulate the alternating-current voltage in synchronising was to vary the direct-current voltage. Tests were made to ascertain how the machines behaved under actual working conditions. One was to run under regular working conditions for 24 hours with the batteries, and then for 24 hours without the batteries at the sub-stations, in order to see what effect it had on the efficiency. In addition to the primary reason for putting in batteries—viz., to ensure continuity of supply and steadiness of high-tension voltage for lighting—it was also hoped that the load on the motor converters would be steadied, so that less plant would be required in the sub-stations and power house. Taking the results obtained at one of the sub-stations, when the battery was in use, they ran two motor converters, and without battery on the second day they had to run three. The fluctuation in load on the machines, with the battery, was from a minimum of 38 per cent. to a maximum of 116 per cent., *i.e.*, 16 per cent. overload. On the second day the load varied from zero to an overload of 32 per cent. The fluctuation of the high-tension volts on the first day was 2·7 per cent. and on the second day 6·8 per cent. The mean load on the direct-current generators of the motor converters on the first day was 75 per cent. and on the second day 43 per cent. The motor converter efficiency was 89 per cent. on the first day and 82 per cent. on the second. The greater variation in the load brought the efficiency down, but still 82 per cent. was very high for a varying load that constantly dropped to zero. The battery losses on the first day, of course, reduced the sub-station efficiency somewhat, and the overall efficiency on the first day with the battery was 78 per cent. and on the second day it was 82 per cent. The figure of 82 per cent., without batteries, compared directly with the sub-station efficiency of the

London County Council tramways, where, from Mr. Rider's Paper, it was 75 per cent. with ordinary motor generators.

Mr. ROGER T. SMITH had found that the property of the motor converter in giving leading currents above a certain load was most important, and, as a matter of fact, the current was always leading in the machinery at the Great Western sub-stations. On high peaks the power factor fell as low as 92 per cent., but when running with a battery under ordinary conditions it reached 98 per cent. The leading currents assisted the lagging currents of the generators at the power station, the result being that the inherent regulation was improved and the very difficult problem of keeping a steady voltage on the lighting 'bus bars was rendered easier. Another excellent feature of the converters was their overload capacity. During the Exhibition traffic last year it was not uncommon to have all the machines in a sub-station overloaded 60 per cent. The reason was that the reversible booster of the Highfield type did not reverse quickly enough to take up the load as it came on, so that the whole of the load at first had to be taken by the converters. As soon as the booster got properly reversed it took up the overload of the converters, and did exactly what was required. Without that instantaneous overload capacity of the converters they would not be nearly so successful as they actually were in working with batteries. He had made a supplementary test to the one referred to by Mr. Jenkin and would publish the results in the "Journal." The average daily input for 11 days, including Easter week, was 15,500 kw.-hours, the daily battery charge 1,730 kw.-hours, and the discharge 1,630 kw.-hours. That meant that 12 per cent. of the whole energy came through the batteries. The loss in the booster and battery was 5 per cent. The daily machine load factor was 51 per cent. and the daily efficiency of the machines was 83·5 per cent. That was considerably lower than the 89 per cent. mentioned by Mr. Jenkin, which was for another sub-station. An interesting point to note was that at the sub-station which had the efficiency of 89 per cent. the battery was of 1,000 kw. capacity, 36 per cent. of the output passing through the battery; and at the sub-station where the efficiency was 83 per cent. the battery was of only 500 kw. capacity, 12 per cent. of the output passing through the battery. The commercial efficiency of the whole station, *i.e.*, from the A.C. input to the D.C. output to the track, was 79 per cent. in both cases. It did not pay, therefore, so far as efficiency was concerned, to instal so large a battery. It had been put in so large to provide for breakdowns. If the Great Western work had to be done all over again there would be no hesitation in installing motor converters.

Mr. A. HUGH SEABROOK (West Ham) disagreed with the author as to the unsuitability of rotary converters on 50 period systems. At West Ham they had 12 sub-stations, in three of which 50 period rotary converters were used, one running day and night, and they had not experienced the slightest trouble. As to starting up there was also not the slightest trouble. He thought there was, perhaps, something in the liability of the polarity to become reversed at starting up, but he found that a two-pole switch was a perfectly simple way of getting over the difficulty. As to reversibility, he knew of rotary converters running on an inductive load day and night from the direct-current side and giving alternating-current output. Only a spare armature was kept, and there had not been the least trouble in running. He thought it was quite wrong to say that a motor-converter took up less floor space than rotary converters and their transformers. The efficiency, in connection with day and night continuous running, was an important point, and from his experience it would not pay to run motor-generators or motor-converters on day and night load, even if the machines were obtained free of cost. The efficiency of such machines was lower, greater attention was required, and high-tension current being used for the stator caused greater liability to breakdowns. By installing rotary converters capital was saved and efficiency gained, and if space was a consideration, the transformers could be put in the basement or on the roof, or, as they frequently did in West Ham, out of doors.

Mr. FRANK BAILEY (City of London Electric Lighting Co.) welcomed the Paper as giving a clear explanatory description of a most interesting apparatus. In testing rotary converters for use with frequencies above 50 he had found that they were not easy to handle in practice, and for that reason he had adopted motor generators in spite of the greater loss. At Bankside, during last year, they had put about 4,719,000 units into motor generators and obtained 3,635,000 units out of them, or an overall efficiency of 77 per cent. He thought the author was justified in calling attention to the remarkable results obtained, and particularly in referring to the ease of manipulation, which was an important feature. The question of efficiency required serious consideration as with large outputs at varying loads the average efficiency was of more importance than the full-load efficiency.

Mr. J. S. PECK remarked that the future success of the motor converter always seemed to him to be based on the fallacy that a high-frequency rotory converter could not be made to operate successfully, but in view of the number of high-frequency rotaries now operating satisfactorily, it had to be admitted that it was a satisfactory machine and that its efficiency was higher than that of the motor converter. As to the point that the rotary converter had made little progress in this country since 1904, the firm with which he was associated had installed over 160,000 kw. of rotary converters, a very fair proportion of which had been for high-frequency circuits. The author stated that the motor converter was patented by Messrs. J. L. La Cour and O. S. Bragstad in 1902, but he omitted to state that a fundamental patent was granted to M. Maurice Leblanc in 1899, and he believed that all companies manufacturing motor converters were paying royalties to the owners of it. He also thought that after what Mr. Jenkin had said, they would agree that the starting up of a motor converter was not quite so simple as would appear from the description in the Paper, whereas the starting of a rotary from the A.C. side, as described by Mr. Seabrook, was extremely simple. In regard to voltage regulation, it was quite possible, by putting reactance in the circuit of a rotary to obtain exactly, the same voltage range by field adjustment as it was possible to obtain on the motor converter. The reactance could be placed in transformers or in separate choke coils. He admitted that the transformers and the rotary converter would probably take up slightly more space if placed on the same floor level than would the motor converter, but if the station was built for rotary converters a gallery would be provided for the transformers, or they could be placed in the basement, since they required no attention whatever. The Charing Cross sub-station of the Underground Electric Railways was a good illustration of the amount of rotary capacity it was possible to squeeze into a small floor space. He did not believe that the same capacity of motor converters could possibly be placed in the same substation. He asked why Mr. Hallo, in comparing the copper losses of the rotary and motor converter had chosen an unusual combination of poles. If the author took $p_c/p_a+p_c=0{\cdot}5$ instead of 0·6, the comparison would be still more in favour of the rotary. He thought the efficiency curve given in the Paper was impossible, as one could not obtain with any ratio of losses a machine which could give 92 per cent. efficiency from $\frac{6}{10}$ths to $1\frac{1}{4}$ load and still meet the efficiencies given for the lower loads. He asked the author to give the separate losses. For the rotary converter there was no high voltage winding, the high voltage being confined to the transformer. An additional transformer could be kept as a spare in the event of breakdown, and even if this was not done, a transformer could be repaired in the course of a few days, while a breakdown in the high-tension stator winding would require several weeks to repair. The highest voltage for which an ordinary size motor converter could be safely wound was about 6,000. For 10,000 volts or higher, it would in general be necessary to instal transformers for the motor converter, which would put it entirely out of the running. The switchgear for a rotary converter was no more complicated than that required for a motor converter, provided the transformers were connected directly to the rotary. The fact that switches could be put in between transformers and rotary, while they could not be placed between the motor and D.C. machine of a motor converter set, was an advantage which the rotary had over the motor converter.

Mr. F. L. LA COUR (communicated) called attention to Fig. 5 in the Paper, showing a motor converter with mesh-connected rotor, which might lead to the impression that such a converter was as good as one with star-connected rotor. As far as he knew, the rotor connection shown in that figure had never been tried. Both the rotor and the armature windings were mesh connected and wound in 12 phases. Should the shape of the fields in the two machines differ materially from each other it was evident that idle currents would pass between the two windings. Those idle currents could be considered as made up of many harmonics of which the fifth in the case of a three-phase converter might be the most prominent. From one rotor phase to the next those fifth harmonics were displaced five times 30 deg., *i.e.*, 150 deg., which was a little more than the angle between the phases in an ordinary three-phase motor. For that reason and while each phase of the rotor and armature windings consisted of few turns and thus possessed a very small self-induction, a small fifth harmonic E.M.F. would produce a fairly strong fifth harmonic current with a considerable amount of power. If, on the other hand, the mesh-connected rotor was replaced by a star-connected one the fifth harmonic current from the armature winding would have to pass through two rotor phases with twice as many turns as on each of the mesh-connected phases, and as those rotor phases were displaced 150 deg. with regard to the fifth harmonic, the self-induction of the two rotor phases in series would be very large for the fifth harmonic current. In other words, the fifth harmonic E.M.F. induced in the armature winding would only produce very small currents in the rotor winding. As that was the same case with the seventh and eleventh harmonics the idle current passing between the armature winding and a star connected rotor winding would be so small that they could be connected in practical work. On account of the few poles on the D.C. side of the motor converter the commutator was not so crowded with brushes as rotaries for the same frequency, so that flash-overs and burning of brush gear did not occur so often. Another reason why the motor converters very seldom flashed over was on account of the large reactance and the revolving magnetic field of the induction motor. That feature led to the problem of parallel operation and that was where the motor converter stood at a great advantage over rotaries. On the D.C. side a good parallel operation was dependent on a fair voltage-drop from no load to full load, which was the case with the motor converter, so that no trouble had been experienced in that direction. On the A.C. side good parallel operation depended on the synchronising current as well as on the tendency to hunt and drop out of step. By designing the induction motor with a large reactance, the natural frequency for hunting of a motor converter was very low (from 75 to 150 oscillations per minute), so the resonance could not take place between a converter designed in that way and alternators driven either by reciprocating engines, which made 150 to 200 revs. per min., or steam turbines, which worked with more than 200 steam impulses per minute.

Prof. E. ARNOLD (communicated) thought that the installation recently put in by Messrs. Brown, Boveri & Co. for an electrochemical works in Saxony a remarkable one. The power was generated in two three-phase 50 cycle turbo-alternators of 1,000 kw. each, 2,000 revs. per min., 500 volts. The three-phase current was converted into direct current by means of two motor converters of 900 kw. each, 160-175

volts, 5,600-5,150 amperes, 214 revs. per min., the induction motor having 12 poles and the D.C. machine 16. With the heavy conditions of a continuous 24 hours' full load running, a difference of efficiency of 2 to 3 per cent. meant a reduction of cost of at least £300 to £450 a year. The extra winding referred to by the author for a three-wire supply could be dispensed with if the main excitation winding was divided into two equal portions and the one half supplied with the positive and the other with the negative ma'n wire current.

Mr. H. W. Gregory (communicated) said that the high efficiency of the motor converter at low loads, as compared with the rotary, might be understood when the iron losses were considered, or did the author attribute the efficiency solely to the absence of higher harmonics in the motor converter running light? The motor converter lent itself better to the adaptation of the synchronous booster than did the rotary converter, inasmuch as the booster armature in the former machine dealt only with a part of the current in the D.C. armature while the rotary converter booster dealt with the whole of the D.C. output. He thought the absence of slip-rings carrying heavy currents on the motor converter was a point insufficiently appreciated.

Mr. K. Faye-Hansen (communicated) said that the claim made by the author that the motor converter was at an advantage over the rotary converter, due to the higher reactance of the induction motor compared with the transformer, was a mistake, as the transformer, besides the advantage of high efficiency and increased safety for high voltages, also had the advantage that any reactance required could be obtained between very wide limits. His experience had shown that a transformer with a reactance of 20 to 30 per cent. was cheaper and had as good an efficiency as transformers with ½ to 1½ per cent. reactance. The transformer also had the further advantage that reactance could be easily and cheaply altered after the transformer had been built up. The ease with which any desired reactance could be obtained in a transformer was one which made the rotary converter suitable for many services for which the motor converter could not be used with advantage. If the rotary had to run from D.C. to A.C., the transformer would be designed with low reactance, which, compared with the high reactance of the induction motor, made the regulation of the rotary plant very much better than that of the motor converter, the voltage drop being about one-third or less. A further advantage of the transformer over the induction motor was that it could easily be provided with tappings on the H.T. side, so that the rotary could be used for the purpose of lighting and traction without a booster and still run at the best possible power factor in both cases. If the A.C. voltage was specially low, an auto-transformer could in many cases be used, thereby further increasing the superiority of the rotary plant regarding price and efficiency. There was one thing the induction motor could do which the transformer could not, and that was to alter the frequency of the supply; in all other respects the transformer could do the same work as the induction motor in a better and more efficient way.

Mr. H. S. Hallo gave only a brief summary of his reply. Those who had spoken from actual experience had, like himself, arrived at the conclusion that the motor converter had fulfilled the high expectations of its inventors and had become a very important factor in sub-station practice. He next considered those who had not spoken from experience, and recommended Dr. Rosenberg to read the Paper again. The 30 per cent. wattless current was the current which was actually in the stator and not the current in the rotor, and it referred to cases where the converter had to supply leading wattless current to compensate for wattless current taken up by induction motors. In regard to the slow speed of motor converters, he did not think the Great Western Railway slow-speed ones were a fair instance, as the standard motor converters of that output ran at a higher speed. As to tappings on transformers, he need only refer to the discussion on a previous Paper where the idea had been condemned. He thought Mr. Seabrook had been particularly lucky, as there were very few engineers who had pleasant experiences with 50 cycle rotaries. The only rational way of considering the comparison of the floor space required was to take the actual space occupied by the motor converter and its accessories as against the rotary and its accessories. The argument that transformers did not take up any space because they could be placed in the basement did not hold good at all; in fact, the whole motor converter could be placed in the basement. He admitted that there was a time when high-tension stator windings could not be manufactured satisfactorily, but that was a thing of the past. During the last three or four years Messrs. Bruce Peebles had not experienced such a thing as a breakdown in a high-tension winding. In fact, stationary high tension windings could be made just as safe or safer than revolving D.C. armature windings. He considered that the efficiency of a motor converter under actual working conditions was only 1 per cent. less than that of a rotary converter and its transformers. It had often been found, as had been repeatedly stated by leading engineers in the pages of the "Journal" of the Institution, that the high efficiencies claimed by the manufacturers of rotary converters were not realised in practice. The efficiency curves in the Paper were not calculated from the separate losses, but were actually obtained. He had before him some figures taken in the Manchester Corporation electricity works to ascertain the efficiency of motor converters and motor generators under actual running conditions. Although the machines were built for the extremely high voltage regulation of 30 per cent., the efficiencies were very high, in fact, at a quarter load considerably higher than given in the Paper. The efficiency of a 250 kw. motor converter at full load was found to be 89·2 per cent., and of the motor generators in the stations [illegible] and [illegible] per cent. At quarter load the efficiency of the motor converter was [illegible] per cent. and of the motor generator 74 per cent.

CORRESPONDENCE.

PARALLEL RUNNING WITH EARTHED NEUTRALS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: When writing my letter of the 26th ult. I was under the impression that the suggestion of using choking coils to connect the neutrals to earth was a novel one. The letters in your last issue make it clear that the idea has occurred to others. But the only important matter is to discuss how such choking coils would work, and this was the main object of my letter. Mr. Brazil is not quite correct in assuming that I recommend choking coils in preference to resistances for opposing the normal frequency earth currents. All I said was that it would be easy to design the choking coils for such a purpose. The arrangement I suggested involved the use of some form of resistance. The particular form of resistance recommended by him may have advantages over others, but when I wrote my letter I was quite unaware of Mr. Brazil's suggestions.

Prof. Marchant, while agreeing with me that the large circulating current around two machines is due to the comparatively small inductance of the local circuit, expresses some doubt about my statement that the star connected windings of the alternator form a practically non-inductive combination so far as the triple frequency currents are concerned. He alludes to the "slot leakage flux," and is quite correct in implying that this will cause some inductance in the coils. But the main coil flux is due to the action of the currents on the normal magnetic circuit of the machine, and my point was that when a current flows from the neutral point to the mains through the three windings the joint magnetising effect on the normal magnetic circuit is nil, or negligible, and that, except for small leakage effects, no reactive E.M.F.s are induced in the coils. When a machine is working under normal conditions the currents in the three windings are so directed that the sum of the currents flowing from the neutral point is zero at each instant—that is, if one of the currents flowing to neutral is 10 amperes and the other two currents are flowing from neutral, the sum of the two latter currents is also 10 amperes. Currents fulfilling this condition magnetise the iron strongly. If, however, one of the currents were reversed in phase, the other currents remaining as before, the joint magnetising effect of the currents would be zero, except for small secondary effects due to leakage. This can readily be seen by studying the distribution of currents in the stator windings of a three-phase motor with rotor on open circuit. When the triple frequency current flows between the neutral point and the mains it is in the same phase in each winding, and at every instant is similarly directed in each coil as regards the neutral point. The result is that very little magnetism is produced by such currents, and the coils are essentially non-inductive. In fact, if the distribution of currents is examined, it will be found that adjacent conductors are traversed by equal currents flowing in opposite directions. The armatures act almost like dead resistances for these triple frequency currents. When two machines are connected by their neutral points I think it probable that it is principally owing to this fact that these triple frequency currents are so noticeable.—I am, &c.,

May 10. W. E. Sumpner.

ACCUMULATORS FOR PEAK LOADS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The announcement as to Manchester, which you were able to make last week, is very satisfactory, and Mr. Pearce is entitled to much congratulation on his practical advocacy of views which coincide with my own.

I do not anticipate, however, that he will long be in the proud position of being sole exemplar of the Lighting Peak Battery policy.

As regards my personal efforts to further this cause (ably assisted by your paper), which you were good enough to touch upon, I feel I have only very clumsily put forward, as it has developed, what has been in my mind; but it is rather significant that the only two engineers to whom I have had an opportunity of putting forward what I consider the most impressive and up-to-date aspect of the case have *both* decided to put in large batteries.—I am, &c.,

King's Heath, May 11. A. M. Taylor.

SOME "ELECTRIC AND ORDNANCE" SPECIALITIES.

We are often told by those who ought to know that to succeed in electrical engineering work our attention should be confined to one particular branch of the subject—in fact, that we should specialise—and that to wander at our own sweet will over the whole range of the profession, even if it does not lead to disaster, will not bring us to the top of the tree. Like all generalisations, this statement is sometimes true; on the other hand, it is often false, for it is not at all difficult to point out both men and firms who, not confining themselves to one narrow groove, have achieved success in numerous directions. Among the firms of whom this is true may be placed the Electric & Ordnance Accessories Co., of Birmingham, who are well noted as general specialists.

First among their products may certainly be placed controllers of all kinds and sizes, suitable for both series, shunt and compound continuous-current motors, as well as for alternating-current slip-ring motors. The company's new catalogue shows that these controllers are listed for capacities between 7·5 H.P. and 125 H.P., and for standard voltages of from 110 to 125, 220 to 250 and 440 to 500 volts. These controllers are equipped with all the necessary fittings, including braking stops for tramway and crane work, if necessary. One type of crane controller is fitted on the hoisting side with two "dead-slow" contacts, in addition to the ordinary contacts, and is specially intended for foundry work. An interesting controller is that of the "D. V.," or double voltage, type. It is used when a wide range of speed is required, and is so arranged that the motor is first put across one outer and the neutral of a three-wire system, and is then put across the two outers. Shunt regulation is obtained on the low-voltage, as well as on the high-voltage, side, while it is claimed the change over from low to high voltage is effected quite sparklessly.

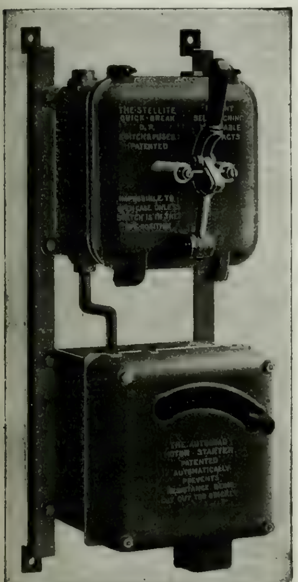

FIG. 1.—MOTOR PANEL, FITTED WITH "STELLITE" QUICK BREAK D.P. SWITCH AND FUSES AND "AUTOGRAD" STARTER.

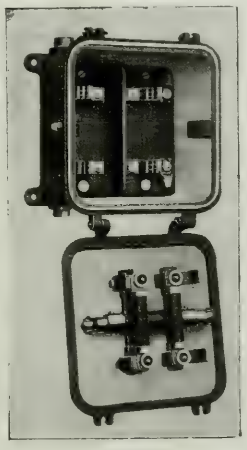

FIG. 2.—"STELLITE" QUICK BREAK SWITCH AND FUSE (Open).

FIG. 3.—GROUP OF "STELLITE" INSULATORS.

In these days, when the use of the electric drive is becoming more and more extended, and is finding its way into remote places where the attendance is far from skilled, it is very necessary that the starting equipment should be arranged to stand "the heartache and a thousand natural shocks" that motor starters are heir to without being itself damaged or damaging other people. These somewhat arduous conditions are, it is claimed, fulfilled by the "Autograd" starter of the Electric & Ordnance Accessories Co. The general construction of these starters is identical with that of the firm's well-known standard type, the only difference being that in the "Autograd" all responsibility is taken from the operator. The motor can only be started up gradually, and all the operator has to do is to push the handle to the starting position, the automatic accelerating gear doing the rest. A starting panel fitted with iron-clad quick-break combined switch and fuse of the double-pole type and an "Autograd" starter is shown in Fig. 1.

This starter works in the following way: The handle, which carries a small pot magnet, and which at its "off" position is on the right of the starter, is pushed over to the left and picks up the starting lever. This action compresses a steel spring, which draws the switch arm over the contact plates. This movement is controlled by a dash pot, so that the motor cannot start up too rapidly. The overload acts both during switching on and when the motor is running. It de-energises the pot magnet mentioned above and causes the switch arm to fly back. The controlling action of the dash pot renders it impossible, it is claimed, to accelerate the switch sufficiently to cause damage to the motor, and thus makes the starter practically fool-proof.

An iron-clad combined quick-break lever switch and fuse similar to that shown in Fig. 1 is illustrated open in Fig. 2. This switch has been specially designed for house service and motor work, its purpose being to replace the more or less unsatisfactory arrangements hitherto employed. It combines the three separate devices—viz., the double-pole switch, the two single-pole main fuses and the connecting cables, in one, and is at the same time claimed to be a much sounder piece of apparatus. The case is of cast iron, asbestos-lined and provided with inlet and outlet glands that can be adapted to take any kind of tubing. Separate slate bases are provided for each pole, on which are mounted self-aligning and renewable copper contacts, as well as sweating sockets and the other necessary switch fittings. These bases are well insulated from the iron cases, and the poles are also separated by an insulating fillet. The switch lever and all outside parts are insulated and an earthing terminal is provided. The switch is designed on generous lines, so that the resistance is low and heating is avoided. The mechanism is simple, the actual quick make and break being operated by inclined angle pieces which are cast solid with the bottom of the case. These work in conjunction with two special plungers, fitted with steel rollers, on the brass switch blade and fuse-carrying body. In closing the switch each plunger engages with one of the angle pieces, and is under compression until the top of the angle piece is reached. The compression is then released, and, owing to the inclined surface of the angle piece, the switch blades are rapidly driven home and a "quick make" thus effected. A "quick break" is similarly obtained. The switch lever works in a loose link.

Another speciality of the Electric & Ordnance Accessories Co. are insulators, a number of which are shown in Fig. 3. These are made at the firm's own factory, and merely illustrate what has been done in this direction. The examples are not intended to be exhaustive, and other porcelain ware, such as ceiling roses, counter counterweights, cut-outs and high-tension insulators for switchboard and external line work are also made.

Guessing is not a scientific operation; and it is, therefore, by no means surprising that it sometimes leads to curious results. In modern cutting processes, owing to keen competition and the higher speeds made possible by the use of high-speed steel, it is necessary to have some accurate method of arriving at the correct cutting speed of the

tool. Guessing can be employed, but this is not accurate even when done by experts, for one of these latter estimated in a special that the speed was four times greater than it really was. Tachometers also have certain objections owing to the vibration of the indicating finger and friction, so that some other method is really required. These disadvantages are, it is claimed, overcome by using a "Warner" cut-meter. This consists essentially of a permanent magnet fastened to a spindle, at one end of which is a driving wheel or disc fitted with a rubber tyre. When this tyre is placed against any revolving body the magnet actuates an aluminium dial calibrated in feet or metres per minute, as may be required. A portion of this dial is visible through a small glass window in the instrument case, and a line etched on it allows the exact speed of the tool to be accurately read off.

The apparatus described and illustrated forms only a part of those contained in a set of catalogues recently issued by the Electric & Ordnance Accessories Co. These, in their turn, only form a part of the equipment turned out by the firm. Other specialities include fans, which we dealt with in the last issue of our INDUSTRIAL SUPPLEMENT, telephones, switchgear and arc lamps.

PATENT OFFICE PROCEDURE.

In future the following procedure will apply in all cases of applications for revocation of patents under Secs. 27 and 78 to 81 of the Patents and Designs Act, 1907 :—

1. The applicant should simultaneously with his application on patents form 24 leave at the office evidence by way of statutory declaration, stating the particulars upon which he relies in support of the allegations contained in the application ; the copy of the application delivered to the patentee or his agent, in accordance with patents rule 78, should be accompanied with copies of such evidence.

2. The patentee should, within 14 days from the delivery of such copy or within such further time as the Comptroller may allow, leave at the office evidence by way of statutory declaration stating whether or not the allegations contained in the application are correct ; and, if they are incorrect, giving the particulars upon which he intends to rely in answer to the allegations made by the applicant. Copies of such evidence should at the same time be delivered to the applicant.

3. Should the applicant then decide to proceed with his application, he may then leave and deliver further statutory declarations in answer, in accordance with the provisions of the latter part of rule 79.

4. The Comptroller will then intimate to the parties whether, having regard to the circumstances of the case, he considers it desirable and intends to hold a preliminary hearing on the question whether a *prima facie* case has been made in support of the allegations in the application, or whether he intends in ordinary course to deal at one hearing with the whole case, including the further questions whether the patentee can prove that the patented article or process is manufactured or carried on to an adequate extent in the United Kingdom, or can give satisfactory reasons why the article or process is not so manufactured or carried on.

5. Should the Comptroller think fit to hold a preliminary hearing as aforesaid, and as a result of such hearing, decide that a *prima facie* case has been made in support of the allegations in the application, or should he determine to proceed in ordinary course to deal at one hearing with the whole case, including the further questions mentioned in head (4), then, and in either of the said cases, he will give to the patentee further time for leaving at the office and delivering to the applicant, pursuant to rule 79, evidence by way of statutory declaration with regard to such further questions or either of them, and will subsequently give to the applicant, under rule 79, and thereafter if necessary to the patentee under rule 80, further time for leaving further evidence by way of statutory declaration with regard to such questions or either of them in answer or reply as the case may be.

6. In the event of an application under sec. 27 being uncontested by the patentee, the Comptroller in deciding whether costs should be awarded to the applicant will consider whether proceedings under the section might have been avoided if reasonable notice had been given by the applicant to the patentee before the application was filed.

High Frequency Electric Oscillations.—A patent recently issued to Mr Otto Scheller of Steglitz describes a modification of the Poulsen system, in which he makes use of the heat of the arc to produce the hydrogen atmosphere required for these high frequency oscillations. He places a vessel containing a liquid hydrogen compound above the chamber enclosing the electrodes of the arc. The liquid is fed by drops upon the electrode near the arc, and is immediately evaporated by the heat, the hydrogen atmosphere thus being maintained. At the same time the electrode is cooled. In order to provide against an explosion when starting the apparatus, safety valves are fitted to the arc chambers.

LEGAL INTELLIGENCE.

Telegraph Construction & Maintenance Co. v. Merchant & Co. and A. Cohen & Co.

The hearing of this action was commenced by Mr. Justice Lawrance and a special jury last week, and arose out of thefts of large quantities of gutta-percha from plaintiffs.

Mr. Shearman, K.C., and Mr. Disturnal were for plaintiffs ; Mr. Rufus Isaacs, K.C., and Mr. J. R. Atkin, K.C., and Mr. R. B. Murphey for defendants Cohen & Co., and Mr. Spencer Bower, K.C., and Mr. P. T. Blackwell for Merchant & Co.

Mr. SHEARMAN said plaintiff company were the largest makers in the world of submarine telegraph cables in the manufacture of which they used a large quantity of gutta-percha. Plaintiffs' claim against both defendants arose out of large quantities of gutta-purcha which had been stolen from plaintiffs and had found its way first to Merchant & Co. and then to Cohen & Co., the latter being the substantial firm in the matter. Between 1905 and 1908 serious thefts of gutta-percha took place from plaintiffs' works, and upon inquiries the stuff was traced to a small shop kept by Merchant & Co., who sold some of it to Cohen & Co. A man named Boniface and several workmen of plaintiffs were prosecuted for the theft and Boniface received 18 months imprisonment. The main question was the value of the gutta percha, as Messrs. Cohen had admitted that a portion of the goods in question belonged to plaintiffs, but denied that the value was, as stated by plaintiffs, about 4s. per pound.

Mr. W. P. GRANVILLE, assistant manager of plaintiffs' works, said the police in January, 1908, brought to them a large quantity of gutta-percha stolen from them, and the result was the conviction of Boniface and others. They had received back from Messrs. Cohen a quantity of gutta and had credited them with the value in the claim. The gutta-percha which had been returned to plaintiffs by Cohen's had cost 3d. per lb. to finish.

In cross-examination Mr. Granville said Messrs. Cohen had given plaintiffs every information and submitted their books for plaintiffs' inspection. A parcel of 21 cwt. was identified by one of plaintiffs' men as belonging to them at Messrs. Cohen's and they allowed the police to remove that parcel. A parcel of 28 cwt. was recovered by Messrs. Cohen from Messrs. R. & J. Dick and handed to plaintiffs. The market in raw gutta percha was very limited and was only dealt in by brokers. There were no current prices, and it would not be possible to trace stolen gutta-percha to the brokers' sales. His company dealt with about 1,000 tons of gutta-percha yearly.

Mr. ISAACS remarked that the witness having admitted the bona-fides of Messrs. Cohen, the only question that remained was that of the value of the gutta-percha.

Mr. GRANVILLE said none of the stolen gutta was raw, but was all partly manufactured.

In re-examination he said that 21 cwt. were given up by Messrs. Cohen and a quantity was in blocks bearing the impress of parts of a man's body. No firm could buy such blocks as parts of an ordinary consignment of gutta. Witness valued the stuff at 4s. per lb. for the police court proceedings against the men who were convicted.

CHAS. BONIFACE said he was in the employ of plaintiffs for 19 years up to two years ago. From 1905 to 1908 several men used to bring witness soft gutta and he immediately disfigured it and sold it to Merchant & Co., who kept a private house. He did not know Merchant & Co. but saw a man named Jewell there (Jewell stood forward in Court, and witness identified him). Sometimes his wife took it in. Merchant's used to send a carman to witness's house for the stuff, for which he got 9d. per pound.

MR. CHAS. W. ALLER, chief clerk to plaintiffs, submitted figures as to the value of the gutta-percha, and said a sample was made up of the goods returned from Cohen's and Dick's and submitted to a German firm, the result being an order for 2 tons at 5s. 1d. per pound.

Mr. RUFUS ISAACS said he took the point that plaintiffs had not established, by any evidence against Cohen & Co., that they received 1 lb. more than they said they received and accounted for. The question of value was, of course, in dispute.

Mr. BOWER (for defendants Merchant & Co.) said Mr. Merchant was dead, and his widow represented the firm. It was very hard on her that buying gutta, as she believed honestly, she should have to pay again its value. But she ought not to be made to pay more than the actual value.

Mr. ISAACS (for Messrs. Cohen) said that the firm had been in business for over 100 years, and were highly respected in the trade. The question was, what was the real value of the gutta at the time it came into the possession of Messrs. Cohen.

Miss MCKNIGHT (daughter of Mrs. Merchant) said Merchant & Co. started buying from Boniface before she had anything to do with the books. She never asked who Boniface was. Jewell left Merchant's just before the trouble.

Mr. A. MCKNIGHT said that after Jewell was engaged by his mother the firm dealt in gutta-percha, &c. They bought from Boniface through Jewell, who then kept the books. He believed Boniface came to the firm. He had offered gutta-percha to other firms besides Cohen, but the price offered was too low. He did not know where Jewell was employed, before he came to Merchant's.

Mr. SIMON G. COHEN, partner in the firm of Cohen & Co., said that in March, 1905, his firm bought from Merchant & Co. waste rubber, and their first purchase of gutta was in August of that year. They bought

from Merchant & Co. 256 cwt. 2 lb. in all, and it was paid for in the usual way, all the transactions appearing in their ledgers. He had not the slightest idea that any of the stuff he bought was stolen from plaintiffs. The average price he paid for it was 11½d. per pound, and the sale price was under 1s. 2¼d. per pound. When it was found the gutta percha was stolen it was at once given up. Block gutta percha might be offered for sale in any shape. He looked on the gutta percha bought from Merchant's as waste.

Other evidence followed, which closed defendants' case.

Mr. Justice LAWRANCE, in summing up the case to the jury, said the only question they had to try was what was the fair and reasonable sum to be paid to plaintiffs for their loss. They need not trouble about the way the goods were stolen by Boniface and the other men in plaintiffs' employ, as that was not the question they were trying. The jury had to say what was the value of the gutta-percha which had not been returned to plaintiffs.

In the result the jury returned a verdict for plaintiff for 3s. 6d. a pound for all gutta-percha not returned to them, and judgment was accordingly entered for plaintiff for £4,057. 4s. and costs, and an order was made for payment out to them of £1,500 in court.

Consolidated Nickel, Tin & Copper Mines v. Crompton & Co.

The evidence in this case was resumed when

Mr. THOMAS TOMKIN said that before the installation of the electric plant in the mine he had had no experience of electric pumps or gas engines. He and his men had nothing to do with the setting up of the plant, except such help as they rendered under the supervision of Messrs. Crossley's or Messrs. Crompton's men. The Worthington pump was delivered on July 23, but it was not complete, and whilst negotiations were proceeding with regard to these missing parts a temporary pump was erected. He came to the conclusion that the motor was not strong enough for the work it had to do. He noticed that where they were using a long suction pipe and the pump was falling off in efficiency the motor seemed to drive it more easily, but when they used a shorter suction pipe and worked the pump up to its full capacity the motor did not seem equal to the task and the insulation burnt. Witness reported these observations to Mr. Williamson and his report was communicated to defendants. Before they had got the pump at work again after the last breakdown the water had again risen to the adit level, and all the mining operations had to be stopped. After several repairs the motor was returned, but even since they had had several short stoppages, owing to the overheating of the exciter, &c., but from that time onwards Mr. Garner, employed by plaintiffs, had had charge of the electrical part of the plant, and they had pumped out the water to a depth of 93 ft., and, acting on the instructions of Mr. Norbert, they had maintained the water at that level. He admitted that he had only had experience with Cornish pumps. He gathered his opinion that the motor was not strong enough from his observations of it whilst it was working.

By Mr. ABEL THOMAS: Was there ever in your reports any suggestion that the pump was incapable of pumping 1,000 gallons per minute ?—I do not think so.

Yet you tell us you have thought so all along.—I do not think the motor is sufficient to drive the pump so that it can give that output. He denied that he had any prejudice against electrically-driven pumps; in fact, he was rather in favour of them, as they were very convenient. Altogether, the plant broke down four times. Crompton's men had never suggested that the breakdowns were caused by the incompetence of witness's men in handling the plant.

Mr. S. R. TOMKIN, son of previous witness, and assistant to his father, said complaint had never been made as to the incompetence of the plaintiff's men working the plant.

WM. SANDON, who was engaged to help Crossley's men in the erection of the gas plant, said they were in the habit of starting the whole plant from the engine. He knew there was a triple pole switch at the mouth of the mine for starting the motor, but to his knowledge it was never used. They started by speeding up the engine and generator. They had always had trouble with the governors of the engine and they did not work properly now. Mr. Craig had never complained that witness did not run the engine properly, and he was still employed at the mine doing so. He had had no experience of gas engines until he was employed at the Wheal Busy mine. He found that if the engine worked irregularly the motor got hot. Sometimes the motor got out of step, but seldom. When that happened they had to switch off. During the last six months they found that the thing worked all right. He did not think that was because the engine drivers had learnt their business. The governor had been improved upon by Garner.

Mr. GILBERT ROSENBUSCH said that in January last he examined the various parts of the machinery and he also measured the water that was being pumped. He had no criticism to make about the producer plant. With regard to the engine, in his view that was not satisfactory and did not comply with the specification with regard to the flywheels, which should have been three times the weight. The running of the engine was affected by this want of weight and therefore the running would be very irregular. The degree of regularity would be affected by the variation of the load. There were two flywheels, and in addition the pulley carrying a heavy belt dividing the generator was fixed on an overhanging projection of the main shaft of the engine so that the centre —the driving pulley outside the flywheel—was some 2 ft. from the nearest support. The result of that was that the shaft became bent, and was the cause of hot bearings, which must involve the wearing of the brasses. He examined the governor and found that it had been set so that it did not govern the speed of the engine. The flywheel of the engine was so very light the governor was unable to prevent abnormal fluctuations in speed. The alternator was not of the modern type provided for in the specification. There was also an absence of anything to prevent the oil from splashing on to the field windings. The exciter was of extremely low voltage. In his opinion, 40 volts was extremely low, the usual voltage being 110. The switchboard was defective, the current reading ammeters being too large for the working current. There was no wattmeter or any means of telling what power was being taken. There was no starting switch for the motor. The fuses were so large that they did not give the desired protection. The main cable leading from the switchboard to the motor was hung unsatisfactorily. The cable was rubber covered. Bitumen would have been a far better insulation. If continuous running of the motor was necessary the heat generated must be dissipated. The motor was not totally enclosed. It had air pipes inserted to produce a passage of air through the motor and therefore was a ventilated motor. If air pipes had been added afterwards it would indicate that they found the motor was getting too hot. Increase of load on the motor would tend to increased heating. He had made a calculation for the purpose of testing theoretically whether the motor was powerful enough for the work to be done. They ought to have had an engine of from 115 to 120 H.P. The engine as supplied could not have kept the work going even if the pump had done the proper work. The plant could not do the duty which was required under the contract.

Cross-examined by Mr. ABEL THOMAS, witness said that until he came to England in 1898 his experience was entirely in America.

You say the Crossley engine is hopelessly wrong ?—Yes, for this kind of work.

What does this class of work require different to any other ?—It requires constant speed.

With a 71 H.P. gas engine driving an electric generator, would you want heavier flywheels than would be required for any other purpose ?—No; it would depend upon the variation of the speed at which you were working.

Have you ever known a gas engine such as the one at the mine with flywheels heavier than 9 tons, even for the production of electric light, where the running has to be particularly even ?—Yes.

The engine you require for electric light is very different from the engine you want for pumping ?—No. The object of the engine is to keep the speed constant, whatever the requirements, and the way to keep the speed constant is to have sufficiently heavy flywheels.

Do you think there was anything improper in supplying the alternator with revolving armature and stationary fields ?—The use of such machines is not advisable for mine work, &c. By supplying such a machine defendants did not fulfill the terms of the specification.

You would have to have brushes in any case ?—Yes, but they would be for very small current. The voltage of the exciter was too low, and they had constant trouble to excite the field. 110 would have been a suitable voltage.

Do you really mean that 110 would be any use on an engine like this ? —Certainly, I recommend it.

Have you ever known a machine like this, coupled to such an alternator, fitted with an 110 volt exciter ?—Yes, it is a very usual voltage. All the exciting machines at the Chelsea power house are 110 volts.

How many thousands of volts does that machinery run up to there ? —They use up to 125 volts for excitation and the machines are about 200 H.P.

Do you think that's a fair comparison ? In this case, you know, we have a 71 H.P. engine ?—There is no difference whatever.

With regard to the absence of a starting switch for the motor, witness said that to start the motor directly on the line was a very inadvisable method. As to the ammeter it would depend upon the amount of the starting current whether or no a smaller meter would indicate properly. The starting current ought to be 2½ times the normal running current, in this case 60 amperes, so that the starting current would be in the region of 150 amperes. He could not say the exact capacity of the fuses but at all events they were a great deal larger than was actually required. The motor was a "ventilated enclosed motor," to use the proper term. it was not sufficient for the work it had to do So far as he knew the pump was properly constructed. A 55 H.P. motor ought to raise water to a head of 120 ft. including friction, with a margin of about 2½ H.P. With a totally enclosed motor 35 per cent. rise was the standard rise—that is, 63°F. It was the standard for totally enclosed motors, railway motors, or power motors of any kind. The motor ran for nearly eight hours (with one stop of a few minutes) and it was loaded 27 per cent. during the first 6½ hours' run, and 56 per cent. during the last 1½ hours, and that was a strong test for any motor. Under such a test as that he should expect the temperature of the motor to rise to over 200°F. He should test a motor of that type at its rated brake horse-power for six or eight hours, and then give it an overload of 25 per cent. for two hours. After that he would have given it a heavy overload to see how much it would take to pull it out of step. If during the run at its brake horse-power the temperature rose to over 72°F. he would not let it go out of the shops. The standard specification was 40°C. For motors running continuously the standard specification varied between 35°F. and 40°F. There were accepted rules in the electrical industry in this country, but there were no Board of Trade rules corresponding to the Government rules in other countries.

Mr. THOMAS submitted a letter by Mr. Cragg which stated that he thought the real cause of the motor going wrong was that it was not quite large enough to drive the pump when it had a short-circuit. It was under similar circumstances that it went wrong just after the pump

had been lowered. The reason for his (Mr. Cragg) thinking that the motor was overloaded was that the cotton insulation of all the coils both good and bad was charred and the troughs in the slots appeared to have burnt so much that it was a job to get them out.

Witness said that when the stator device broke down the coils were burnt out and were re-wound at the mine. If they kept switching on the current and the motor did not start owing to trouble in the rotor and they got excessive current in the stator it would burn out the coils. As to the cause of the windings of the stator being burnt out, he thought that what caused that was that the shaft was not stiff enough, that the rotor mechanically rubbed the stator and produced heat there and burnt that out. Either the shaft really burnt or the bearings permitted it to go out of line. The shaft was not thick enough originally, because he was told the rotor did actually touch the stator. Either that or the air-gap was too small. If the air-gap was very small then the shaft must be extremely stiff. He thought 0·75 mm. would be a fair air-gap for a motor of that size. He would be surprised to hear that it was certainly $\frac{45}{1000}$ths. Witness admitted that the motor might pull out of step and cause short-circuiting and burning of the bars. If any of the bars of the motor were burnt out there would be more pull at one place than another. If such tension occurred by the burning out of the bars the rotor might well come against the stator if the shaft did not prevent it. That is a thing which is guarded against by making the shafts of that particular type of motor abnormally heavy. He did not know the details of the motor and he did not know the actual air-gap or how high they were working the machine.

When the rotor was perpendicular or upright what was to bring it against the stator unless you have a "burn out?"—A worn bearing or a bearing out of line.

What bearing was it in such a condition on that motor?—The one I saw—the ball bearing.

Did you see one?—I saw the drawing.

Have you ever heard that it did wear?—Yes, one letter stated so.

Witness said a ball bearing had only a line contact with the shaft, and, therefore, a shaft which was held in position by two ball bearings was a shaft which was only supported at two points and there was no tendency to prevent deflection. If, however, the shaft ran in solid bearings, then it was fixed at both ends and those bearings resisted deflection. It was true that in that particular machine there was a third bearing, but that he understood had been put in afterwards. This third bearing would enormously help the top end, but it would not affect the bottom end. The third bearing would help to stiffen the shaft, but he should not do it in that way. Solid bearings were the standard practice. He would lubricate it with oil from the top. The conclusion he came to was that where there were two ball bearings they did not tend to keep a rigid shaft and that a solid bearing kept it more rigid. Those ball bearings would cause the shaft to deflect sufficiently to allow the rotor to hit the stator. Whether it would be possible for the rotor to touch the stator when they had got in the other set of ball bearings would depend on the mechanical air-gap. If it were very small it might touch; on the other hand, if it were very large it would not touch. Sixty-thousandths was a large air-gap, and he would be surprised to hear that with that air-gap the rotor touched the stator. With regard to the suction of the pump affecting the running of the motor, witness said that with a proper motor, if the suction were kept within reasonable limits it should not affect the power required. To work a pump of the particular kind he had put the efficiency of the motor at 85. 92 was too high. It was usual to specify the nature of the water to be pumped; pump makers invariably requested information, because, not only the amount of material in the water affected the pumps but the nature of the water. Those pumps worked with a very small clearance, and dirt or metallic particles had a large effect upon them.

Continuing, witness said the acid in the water would have an effect on the delivery pipe, and more horse-power would be required to pump the same quantity. It was advisable to keep the exciter at a low voltage to ensure satisfactory operation. That is the tendency of modern practice. They did not need a high voltage on the field coils.

The Official Referee: What do you suggest, Mr. Thomas?

Mr. Thomas: I suggest 40, for instance, in a big machine like they use.

Witness said that that was not an extremely low voltage for large exciters, but it was for small ones. That exciter was a very small one. 40 volts was very low. With such an exciter, where they had large brushes the thing was entirely different. Then a low voltage was adopted. It might be 40 or 50 for large machines, but not with little ones like this, where it was most difficult to get sufficient carrying capacity on the brushes with 40 volts. The overall efficiency of machines of that sort, motor, pump, and so on, was not more than 30 or 40 per cent. Under ordinary working conditions it worked out at about 33⅓ per cent. As to rise of temperature the American rules were practically the same as the German. He would accept the German rules as being fairly accurate for the conditions with an enclosed motor of the type at the mine. According to the German specification the temperature might go up to 50°C. or 90°F. above the surrounding atmosphere. That would be for cotton wire insulation. Witness did not know the kind of insulation on the motor in this case. It was quite true if the insulation were paper in certain instances, 60°C. might be allowed, but it would depend on the position of the motor. If a motor were in a place where it is not likely to receive a tremendous amount of attention it was best to rate it very conservatively to avoid the dangers of overheating. If the insulation were paper it would be 60 per cent., which was equivalent to 108. There was not a rise of 10 per cent. above that figure for a stationary winding. He did not know the German specification. He was actually quoting the American.

Do you agree that the German rules are reasonable and proper to be used?—Yes, when they are taken in conjunction with the conditions imposed. Those are Government rules and may be varied for certain purposes. He would not specify any motor in a mine to be run up to 108°F. In a mine where a motor had to work continuously and could not receive the attention it would have in an engine house it was policy for engineers and contractors to rate such motors as conservatively as possible in order to keep the temperature down. For that reason, squirrel-cage induction motors were often rated at 40°C., and he could give instances where they were rated at 35°C. Of course, they could be run up to 50°C. and 60°C., but it was not advisable, nor was it good practice. With totally enclosed motors it was the practice to rate them a little higher because, being totally enclosed, the atmosphere did not affect the high temperature. He had not heard of thousands of motors running in this country at a temperature up to 220°F. He did not know what happened to the bars of the rotor when the three great breakdowns occurred. He had put the efficiency of the motor at 85.

Witness put in specifications from various electrical engineering firms and electrical undertakings in support of his evidence as to the rise of temperature allowed under certain working conditions, among them being the specification issued by the Underground Railway Co. for all their 20 sub-stations machinery. This specification was for motors and rotary converters and it allowed a rise of 35°C. or 63°F. Witness said this specification was prepared by Mr. James Chapman, chief engineer, and was for very small motors.

In answer to the Official Referee, witness said that he should call the pump installed at the mine a medium-sized pump, with a normal capacity under the best conditions of about 70 per cent. When such pumps were not worked under the best conditions the efficiency dropped very rapidly after a certain point. A turbine pump was designed for a given head, and if the head were increased above that amount, which was the same as decreasing the speed for its head, then the efficiency fell off rapidly, so much so, that if they decreased the speed of a Worthington pump from 15 to 20 per cent. below normal it would pump no water whatever. On the other hand, a decrease of the head tended to overload the machine, and that was why check valves were put in. The pump in this case was made for 120 ft. total head, but it had to work if dropped to that depth to a much larger head because of the friction. The friction was unusually high, because the 7 in. pipe which was being used was much too small for 1,000 gallons a minute, and it was for that reason that he calculated the efficiency of this particular pump at only 65 per cent.

Evidence of Mr. Garner, plaintiff's electrical engineer, which had been taken on commission was then put in, and counsel announced that that concluded plaintiff's case.

Mr. Abel Thomas, for the defence, said that, broadly speaking, his clients' case was that the plant supplied was in accordance with the specification. The trouble experienced was always ascribed by plaintiffs to the machinery itself, and not to the way the plant was worked. His submission was not that the machinery was over loaded or that it was too weak for the purpose, but that it was worked by people who were utterly ignorant of every point in connection with gas engines and electrical plant. The contract had been acted upon by plaintiffs as though it were a contract by which defendants had guaranteed that they would work the machinery for months with their own men. In reality it was nothing of the kind. If they had liked they could have sent Mr. Cragg away on September 7, 1907, when the machinery had been set to work, but unfortunately for defendants, and fortunately for plaintiffs, Messrs. Crompton & Co. had a habit—a habit which in this instance had led to very sore results—of leaving a man in charge when they sent machinery down to distant places, not because they were obliged to, but because they desired their machinery to run properly. It was in this way Cragg was left, and he could not help thinking that that was the secret of the whole mess they and plaintiffs had got into. With regard to the criticism on the gas engine, plaintiffs had only called one engineer expert, and for him to come forward and tell Messrs. Crossley that their ordinary design was bad, and ought to be altered was coming it pretty strong! All they guaranteed with regard to the electric generator was that it should be capable of producing a normal output of 55 kw., at 550 volts, 50 cycles, when running at a speed of 750 revs. per min. Nobody had denied that it did do that, nor had anyone suggested that it could not do it. It was for plaintiffs to prove that they did not supply it, and he hoped to prove beyond any doubt that the motor supplied to plaintiffs was like hundreds and probably thousands of other motors sent out by defendants, which were tested and were capable of doing the work which they were specified to do. As to the exciter, he thought his evidence would prove conclusively that that machine was ample for the purpose if used properly. If they proved that, then the fact that it was a 40 volt machine was to its advantage. The specification said the pump would be "of the turbine multi-stage vertical-spindle pattern, capable of delivering 1,000 gallons of water per minute, against a total head of 120 ft., including friction. The pump will be direct coupled to one of our standard vertical spindle totally-enclosed three-phase induction motors, 55 B.H.P., running at a speed of 1,450 revs. per min. on a 550 volt, 50 cycle circuit." A great deal of the case depended upon what meaning was going to be put upon that clause. His clients submitted that the meaning of the specification was that the 120 ft. was to include the friction. That was, they had to supply a pump capable of raising water where there was no friction 120 ft. high. That was what they asked Worthington's to give them, and that was what they promised to give plaintiffs. The whole of Mr. Rosenbusch's evidence was based upon the assumption that defendants were supplying a pump which would raise water ideally to a height of 130 ft., but every witness he would call would say that the pump would not do that. In a letter written to

Williamson by defendants on February 28, 1907, they stated that the pump motor would be forwarded to the pump builder's works where a complete sinking pump would be erected to see that everything was satisfactory, and they estimated that the complete pump would be delivered on the site in about 12 weeks from that date. That contended counsel, defendants did not in this case do. It was a thing they nearly always did, but in this instance Mr. Williamson succeeded in frightening them so much, that they were afraid not to deliver as soon as possible. The time passed for delivery, and what they did was not to wait to test the pump with the motor complete, in accordance with practice, but to send them separately and put them together at the mine. That, unfortunately, was the beginning of the way in which the minds of the agents who were working for Messrs. Crompton were misled, because they knew there ought to have been this test, and they were afraid, when things went wrong, that perhaps it was the fault of their machinery, and that for some reason or other something was wrong. Having set their minds, as it were, in that direction, the result was that they never saw what was really happening, viz., that unskilled men were trying to work a thing which really required skill, and they were always trying to do something to the motor. The motor as it went down in the mine was absolutely fitted in every way to carry out the duties required of it, but there was one thing which it could not meet, nor could it be protected against, that was unskilled workmen allowing an excess of electric power to run into the motor at a time when the irregularity created by bad gas in the suction plant had put the generator out of step with the motor. Immediately that happened, unless the pump were switched off, the results would be to burn out either the motor or the rotor, and that was what happened, not once but three times. Curiously enough on each occasion Mr. Cragg was nowhere near the mine, and the plant was in the hands of infants at the work. As to the question of the air-gap, it was an astonishing story that with a suspended motor as this one was, with a shaft on two bearings 29½ in. apart—he was taking Mr. Rosenbusch's figures—that that shaft could be moved over even the small space there was between the rotor and the stator. It would be very difficult for it to do, but it had, and there was only one way of accounting for it, viz., by burning some of the bars either of the stator or the rotor. Let the Court follow what happened. The rotor revolved with very great velocity, and if the machine were perfectly working the tension on every side was exactly equal. The object of the machine was that they should be equal and the rotor run perfectly straight and steady. Burn out some of the bars, however, and the result was that they had an enormous pulling at one side and a pushing at the other, where the electric force could not act, because the bars were burnt out. His clients, after long consideration, and after examining the inside of the machinery to have it repaired, had come to the conclusion that they had now reinstalled that motor in practically the same condition it was in when it was put up, and that it was working at the present time perfectly, and will, without burning out either the stator or rotor, because the people who were now in charge of the gas engine and motor knew their business, and were running the plant properly and regularly.

Mr. R. B. H. Cragg said that on June 3, 1907, he went down to take charge of the plant at the Wheal Busy mine for Messrs. Crompton. He saw there three of "Captain" Tomkins' men who were ultimately made engine drivers, although he did not know they were engine drivers at that time. None of them seemed to know anything about electricity. When they installed the temporary pump the water was lowered in the shaft some 17 ft. or 18 ft., and had they put the pump to a lower platform they could have gone down another 20 ft. Captain Tomkins, however, did not desire that, as he wanted to get the Worthington pump in and go right down with it when it arrived. The pump arrived on July 23, and, after delay over a foot valve and strainer, the first attempt to start it was made on Aug. 19. In order to do so the volts on the alternator were to go up to about 450 and the main switch put in. Then all the resistance in the shunt of the exciter was cut out, but the pump would not start. An engineer and fitter came down and the spindle of the motor was examined but found to be correct. Ultimately the stator was taken away and the air-gap increased by $\frac{2}{100}$ in. On Aug. 31 they got to work. It ran then but after a week the thrust bearing of the pump heated and Messrs. Worthington's representative came down. The installation was again started. During the week ends witness reported to his firm they had trouble in getting the plant to start, but that was due to bad gas, as the producer was cleaned out on Saturdays and the gas was generally bad for some time afterwards. In the same report, witness stated that the motor took about 50 amperes to drive, but it was doing more than 1,000 gallons at that time. The motor got very hot after six hours' run, and then it seemed to remain constant. He had reduced the periodicity to about 48 so that the pump did not do much duty. On Sept. 13 the main bearing of the motor seized whilst he was away at dinner, and when he arrived at the engine house he found the pump stopped. The engine man in charge at the time said he had tried once or twice but could not get it to go. He tightened the belt and tried to start the plant himself, but failing to do so he went down and examined the motor and found that the main shaft had seized and was sticking to the sleeve in the thrust bearing.

Mr. Muir Mackenzie: What caused it?—The rotor might have been pulled out of centre. I think that was the only thing that could have caused it. Excessive current going round the stator might cause that. I can think of no other reason.

On the 17th, said witness, the motor broke down again; the stator was burned out in two places and the bars of the motor had gone. He was not present when it happened, which was about 9 or 10 o'clock in the evening. When he got there the engine man told him that the fuse had gone whilst the motor had been running. One of the three fuses on the switchboard had blown, and it was that fact that made witness guess there was some trouble with the motor. An excessive current would cause the fuse to go, and that excessive current might be produced by an earth owing to one of the cables becoming damaged in the shaft or the gas engine running badly. They examined the cable, however, and found it intact. If the electric motor had got out of step with the alternator there was no method of remedying it. Excessive current going through the electric motor warmed it up, and if it was continued it would burn it out. At the time the burn out occurred the plant was in the hands of plaintiff's men. It was a bad burn out and the motor was sent away to Chelmsford, returning again on Sept. 30. By that time the water was back to the adit level. On Oct. 4 Mr. Miller came down, and from Oct. 9 to Nov. 13 the motor ran without any serious stoppage. In reporting to defendants, witness wrote that he thought all his time since Oct 14 ought to be charged to the Consolidated Company, as, with the exception of the burning of the leads on Oct. 17, nothing had been wrong with the plant which could fairly be ascribed to defendants. "While I am writing on this subject," witness continued in his report, "I must say that unless they get a good man to look after this job, they will continue to have trouble, as the men do not know their work, and apparently do not intend to endeavour to make themselves competent. There is, unfortunately, a strong prejudice against gas engines, and if there is any trouble their tendency is to sit down and send for somebody to put it right. They are used to Cornish pumps, which want little or no attention, and resent having to look after things." On Nov. 13, there was another breakdown, but again witness was not present when it happened. He denied that on this occasion, when he was leaving the mine to go to Truro, Martin reported to him that the temperature of the motor was high, and that he laughed at the suggestion. He got back from Truro at about 5:30 that afternoon, and found the plant was shut down because, they told him, the temperature of the motor had run up to 220. He stayed in the engine house until it was re-started, about 7 o'clock, but at 10 o'clock they sent for him saying a fuse had gone. He had the motor up to the surface and found that there was a burn-out in the stator; one of the end windings had gone and there were two bad coils on the stator. When they knocked out the bars a few days later they found there was no solder in the rotor. Before it could have done that the solder must have melted, which, of course, indicated great heat. Both stator and rotor were re-wound, new insulation was put on the rotor and seven new bars were put in and re-soldered. Between Dec. 7 and 20 the motor was again up out of the mine because she had developed a "knock," which was found to be due to the top ball race, and it was during this interval the ball races were being altered. Among other alterations, witness said that the top rings of the rotor were grooved and some steel wire wound round the top. The motor was installed on Saturday, the 20th, and after some trouble owing to bad gas for the engine, they started the plant running again at about 9:30 a.m. In the early hours of Sunday morning the earth lamps showed an earth, indicating a defect in one of the windings, and the whole plant was once more shut down. Examination of the motor showed that the solder had again been melted out of the rotor, and witness sent it back to Chelmsford. During the first week in March, when the motor again came out of the repairing shops, the plant started running again.

Cross-examined by Mr. Russell, K.C.: It was on May 24 that he came to the conclusion that it would be better to send the motor back to the works. He tried several ways of getting the motor to start easier, and on one or two occasion he held up the governors of the engine in order to get the engine to fire more frequently, as, with the governors as they were, he could not speed up the motor properly. He did not agree with the view that the method of starting up had alone been responsible for the trouble, because 10 H.P. induction motors were very often switched direct on. He was unable to say how long it took for a 55 H.P. motor of that type to get its normal heat. At the time referred to in his report the motor was taking about 58 to 62 amperes. It was an exceedingly heavy load, and it was developing more energy than necessary to lift the water.

Can you conceive anything except bad workmanship—very bad workmanship—which would allow the stator of the motor to move?—Yes. Supposing the motor had been dropped or anything like that, it might move the stator. That would not be bad workmanship. He found evidence that all the coils had been affected by overheating, because the cotton insulation, even on the coils which were good, was charred.

With the exception of the leakage trouble, and the governor once wanting a spring, had there been anything in the least to indicate that they were not running the engine properly?—There were a good many times when it stopped and was started again.

Do you mean that the charge mis-fired?—Yes, that might be it. They would let her drop out of step. In December he had personally looked into the matter of the running of the engine. On December 9 Messrs. Crompton wrote him: "Mr. McFarland told us that at certain intervals the pump appears to lose its water partially when the ammeter goes up to anything between 150 and 200 amperes." On the 11th he replied that it was incorrect that the motor took up to 200 amperes, as it did not take more than 150 at any time. His letter also ran: "Unfortunately, the governor of the engine was working badly for the two days on which we tried it last week. I have found that the engineer had the governor to pieces when it was idle, and has used the wrong spring when putting it together again, which will probably account for the bad running on the two nights in question."

Who do you say had the governor to pieces?—Jenkins, I understand.

We have had Jenkins and he said he did not do anything of the kind?—I have seen the governor to pieces on the bench in the engine room, when Jenkins was in the engine room, anyhow.

The defendants' case had not concluded when we went to press.

Seebold v. Page and Miles.

The hearing of this action was concluded by Mr. Justice Bucknill on Tuesday.

For the defence, Mr. Geo. Clements (of Messrs. Crompton & Co.) said he remembered the armature of the dynamo being returned to his firm in July. The cause of the breakdown was the filth and dirt. In his opinion the machine had not been properly attended to.

Mr. John Winder, foreman of defendant firm, said that after the trouble arose he inspected the plant and formed the opinion that the breakdown was caused through neglect on the part of the man in charge.

Mr. Edward Anderton, London manager of the National Gas Engine Co., said that the way the engine was placed was his suggestion and the pit was also his original suggestion. In his opinion the plant was properly installed.

Mr. Samuel Wilbers, working foreman of the National Gas Engine Co., gave evidence as to the erection of the gas engine.

Mr. E. J. Page, director of defendant company, said the plant was certainly properly installed and there was no trouble in running or starting it when he was there. It was a self-starting engine. The only difference in lighting a theatre and a large mansion was that they had to provide for changing the load. This was done by providing a dynamo compound wound and a shunt regulator. The outer bearing was on the concrete bed, but if the bearings had not been true the engine would not have run an hour.

Mr. A. Hughes was recalled on behalf of plaintiffs, and at the conclusion of the evidence counsel agreed not to address his Lordship on behalf of their respective clients, and his Lordship intimated that he would consider his decision.

"Z" Electric Lamp Mfg. Co. (Ltd.) v. Zossenheim.—On Saturday Mr, Justice Warrington ordered judgment to be entered for plaintiffs in default of defence, defendant not appearing.

Re Amalgamated Radio-Telegraph Co. (Ltd.)—On Saturday the Court of Appeal (before the Master of the Rolls and Lords Justices Buckly and Kennedy) heard the appeal of the liquidators of this company from a decision of Mr. Justice Neville confirming a contract for the sale of the assets of the company to Mr. Hage for £33,000. The facts were given in The Electrician for April 30 (p. 104).

At the conclusion of legal arguments the Master of the Rolls, in giving judgment, said he thought the decision of Mr. Justice Neville was right and his order should be affirmed, with this variation, that the liquidators should be entitled to raise any defence they might have under the Statute of Frauds.

Lord Justice Buckley that appeal ought to be allowed.

Lord Justice Kennedy agreed with the judgment of the Master of the Rolls, and, by a majority, the appeal was, subject to the variation stated, dismissed.

PARLIAMENTARY INTELLIGENCE.

ELECTRIC LIGHTING ACTS (AMENDMENT) BILL.

On the report stage of this bill in the House of Lords on Thursday last week, on the motion of the Earl of Onslow, an amendment was accepted to clause 7 (relating to the audit of companies' accounts) "further safeguarding the interests of the authority empowered to purchase an undertaking or of the consumers."

Lord Avebury moved to insert a new sub-section to make the provision applying to the accounts of a company apply also to the accounts of municipal undertakers.

Lord Zouche supported the amendment, and expressed the view that municipal audits were in many cases very unsatisfactory.

Lord Hamilton of Dalzell opposed the amendment, which he submitted was hardly relevant to the present bill, although he did not deny that the audit of municipal accounts might be capable of improvement in certain instances.

The Earl of Onslow sympathised with the object of the amendment, but he doubted whether that bill was the proper opportunity to raise the question. It would be better to deal with the subject in its broadest aspect in a separate measure.

The amendment was withdrawn.

Lord Avebury then moved the following amendment to clause 15:—

"1. Where the undertakers are a local authority they may (through a contractor, but not otherwise) provide, let for hire and fix, repair and remove, but shall not manufacture, lamps, meters, electric lines, fuses, switches, fittings, lamp-holders, motors and other fittings for lighting and motive power.

The clause to run on as drawn to the end of proviso (c), and then add:

"(d) Nothing in this section shall, in cases where, within three months after the undertakers have obtained any loan necessary for the purpose of the undertaking, there is or are no firm or firms carrying on the business of electrical contractors within the area of supply, prevent the undertakers themselves from exercising the powers given by this section without the employment of a contractor.

"(e) If the undertakers fail to comply with the provisoes (a), (b) or (c) of this section they shall, on conviction under the Summary Jurisdiction Acts, be liable to a fine not exceeding £10, and to a further fine not exceeding £5 for each day on which the offence is continued after conviction therefor."

His lordship said that the amendment in reality raised the question of municipal trading.

The Earl of Onslow said they had to consider the interests of consumers, and it was extremely convenient to be able to hire fittings from the persons who supplied either electricity or gas. To a large extent, however, the object sought to be attained by the amendment of the noble lord was already provided for in the bill.

Lord Faber thought it inadvisable to give local authorities the powers proposed in the bill, because they were under statutory obligation to inspect wires and lamps, and it would be unreasonable to ask them to inspect fittings they had themselves put into a house.

Lord Monkswell, in defending London County Council for establishing a works department, said that department was established because the Council had evidence that there were rings of contractors, which they considered could only be successfully fought by the Council doing the work themselves.

Lord Hamilton of Dalzell said the object the Board of Trade had in putting in this clause was to bring the bill into conformity with the model clause adopted in individual cases.

The amendment was agreed to.

An amendment by Lord Balfour was accepted so as to provide that where a main road is carried over a railway by a bridge maintained by the railway company, the rights, privileges and exemptions conferred on county councils shall, for the purposes of rebuilding, widening or repairing the bridge, be extended to the railway company.

In moving the third reading of this Bill on Tuesday, Lord Hamilton of Dalzell said he was authorised to state that in the case of any application being made under sub-sec. 1 of clause 5, which provided for the supply of electricity to railways, tramways and canals partly outside the area of supply, the Board of Trade would carefully consider all the circumstances before giving their consent, and in particular would endeavour to prevent any extravagant speculation by local authorities which might injuriously affect the interests of ratepayers or consumers of electricity within their area.

The Bill was read a third time and passed.

LONDON UNITED TRAMWAYS BILL.

On Tuesday a Select Committee of the House of Lords (presided over by Lord Ludlow) commenced the consideration of this bill.

Mr. Balfour Browne, K.C. (with Mr. Fitzgerald, K.C., and Mr. Macassey), for the promoters, said it was a bill to confer powers upon the London United Tramways (Ltd.) to run over certain parts of the London County Council's undertaking, and to postpone the period at which the London County Council could take over the lines belonging to the company at Hammersmith. The company had 55 miles in operation and had another 19 miles of tramways authorised. At Hammersmith there were short pieces of lines which the London County Council had powers to acquire in July next, and the promoters wanted those powers to be postponed till 1919 in the case of the line running from Young's Corner to Brentwoed, and till 1924 for the tramway from Askew-road to Acton. They also asked the Committee to allow them to have authority to run their trams over the London County Council lines to the bridges. The company would fit their cars so that they could be worked on the conduit system as required. The cars of the County Council would be able to run right through from the bridges to Hampton Court and vice versa, and the company would have the same facilities.

On Wednesday Sir J. Clifton Robinson, managing director of the London United Tramways, gave evidence in support of the bill, and expressed the opinion that the proposals were in the public interest.

A number of witnesses, including Sir F. Dixon-Hartland, M.P., stated that the present facilities for through travel from Uxbridge, Chiswick, and other outside places to Shepherd's-bush and Hammersmith were a great public convenience, and they feared that, if the London County Council purchased the lines in the county there would be an interruption of those facilities.

The hearing had not concluded when we went to press.

NORTH-WEST LONDON RAILWAY BILL.

A Committee of the House of Commons (presided over by Sir J. Compton Rickett) commenced the consideration of this bill last week. The bill proposes to authorise a tube railway between Cricklewood and Edgware-road railway station. The remainder of the line from Edgeware-road to Victoria, which was previously authorised, has been abandoned.

Mr. Balfour Browne, K.C., said the promoters wanted a junction at Edgware-road with the Bakerloo Tube, so that passengers could complete the journey to Victoria by connecting with the District Railway at Charing Cross. Originally the capital to be raised was £3,000,000, but under the new proposal only £1,200,000 would be required.

The Chairman said he did not think Parliament was very favourable to extension schemes, which were hung up for years and then modified or abandoned. Such action prevented other schemes being started.

Mr. Balfour Browne stated that the undertaking had been taken over by the British Electric Traction Co. and the change of plan was supported by local opinion.

Mr. E. Garcke said that about a year ago the Brush Co., the original promoters, approached his company with a view to raising the necessary capital. In the new circumstances, it would be impossible to raise money for the old scheme, or for a scheme which was wholly and solely a tube railway. In the case before the Committee there was to be a working agreement between witness's undertaking and the Bakerloo Railway. The British Electric Traction Co. would find the money required for the construction and also take the deferred ordinary shares. There would be no difficulty in raising the preferred ordinary and the debentures. In cross-examination he admitted that the tramway undertakings with which he was connected had not been so profitable as was anticipated, but he argued that the company was in the position, so far

as raising money was concerned, of a millionaire who was earning small profits.

Sir Charles Rivers Wilson and Mr. Cecil Braithwaite also gave evidence as to the financial proposals.

Mr. R. W. Howley, inspecting officer of the British Electric Traction Co., gave particulars of the estimated receipts from the proposed line.

Mr. W. Barclay Parsons, C.E., said he had designed and constructed the New York underground system and he declared the scheme to be a great improvement on the original proposal to run to Victoria.

Sir George Gibb gave evidence as to the merits of confluent junctions, exchange stations and shuttle services. In his view a junction at Paddington would be a serious injury to the North-West London and Bakerloo Railways.

Mr. W. Forbes and Mr. A. H. Stanley also gave evidence in support of the bill.

Mr. E. Garcke was recalled, and stated that his company were prepared to finance the new scheme to the extent of half the capital. They promoted the Bill in the hope to make a moderate profit, and of that profit had agreed to allow the Brush Co. 32 per cent. The Brush Co. had spent £75,000 in the promotion of the original scheme.

On Wednesday Mr. C. Aldington, assistant traffic superintendent of the G.W. Railway Co., gave evidence in support of that company's petition against the bill. A shuttle service to Edgware-road would not be satisfactory. The change of trains meant loss of time, and he did not believe that the platforms could be cleared by such a service.

Mr. J. C. Inglis, general manager of the G.W. Railway Co., and Sir C. McLaren, chairman of the Metropolitan Railway Co., also gave evidence in opposition to the bill.

Evidence in favour of a direct service through Paddington station to parts of London served by the "Bakerloo" line was given by witnesses from Windsor, Ealing, Reading, &c.

Folkestone, Sandgate & Hythe Tramways Bill.—On Tuesday a Select Committee of the House of Commons, presided over by Mr. Stuart Samuel, commenced consideration of this Bill, which is promoted by the Folkestone, Sandgate & Hythe Tramways Co. Mr. Coward, K.C., explained the objects of the bill, one of the principal being the recission of such portions of the company's agreements with the local authorities as provided for the equipment of tramways in their areas on the Dolter surface-contact system of electric traction. Mr. Coward said the Board of Trade had written to the company suggesting that they would be well advised to adopt some form of traction other than the Dolter system. In July or August last the promoters had to reluctantly recognise the fact that the Dolter system, as it then existed, would not do for tramway traction in this country. The company would not venture to propose the Lorain or the G.B. systems, and, as the result of correspondence with the company, Sandgate Council stated that they would not object to the substitution of the overhead system but they wished to impose terms as to street widenings, &c., which the company could not accept. Folkestone had already agreed with Lord Radnor that the overhead system would not be installed, otherwise the company would have taken up a different position there. The company had had to expend £32,659, of which £23,000 had been paid to the Councils in solid cash. Hythe and Sandgate had on more than one occasion approved the overhead system, which they opposed in this case. Folkestone Council had resolved that the system to be adopted on the Folkestone tramways should be determined by arbitration in accordance with the Act of 1906, but there was nothing to arbitrate about. The Council ought to be satisfied with the present proposal, which would give them the conduit system on all the main lines, and if they did not want any overhead lines in their district the company would comply, provided the overhead lines in Folkestone were not made obligatory under the Bill.

The consideration of the Bill had not been completed when we went to press.

North Metropolitan Electric Power Supply Bill.—A Committee of the House of Lords (presided over by Lord Ludlow) on Friday passed the preamble of this Bill, which has already been through the House of Commons.

Mr. Balfour Browne, K.C., for the promoters, said the authorised area of supply extended over 325 square miles. The company were under the restriction to supply to authorised users for haulage and traction purposes and for lighting the vehicles propelled by such power. They now sought power to supply to authorised users for lighting railway stations and workshops. The powers of the company extended into the areas of 50 different authorities, but only West Ham opposed.

Telegraph and Electric Light Wires.—In the House of Commons last week Mr. Brace asked the Postmaster-General a question in regard to a dispute between Llanharan District Council and the Postal Telegraph Department as to the cost of altering their system of electricity supply in consequence of the erection of Post Office wires in the village of Llanharan.

Mr. Buxton said that the liability to protect the Postmaster-General's wires, as well as the persons of the general public, was thrown upon electric light undertakers by Board of Trade Regulation under sec. 4 of the Electric Lighting Act, 1888. In the present case there was some question as to the best means of affording the required protection, and there were circumstances which led him to think that he might properly charge the public funds with most of the cost. The chairman of the Parish Council had undertaken that the small proportion charged to the Council would be paid. All difficulties, therefore, were, he hoped, at an end. He could not undertake to accept responsibilities which by law were thrown upon local authorities or private persons.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

West Ham Corporation invite applications for the position of electrical engineer and manager of their electricity undertaking. Candidates must have had considerable experience in important electricity undertakings, and have a sound knowledge of the commercial management of electricity supply. Application forms, &c., from the town clerk, Mr. Fred. E. Hilleary, Town Hall, West Ham, to whom applications must be sent by 5 p.m. Tuesday, June 1. See also an advertisement.

Sheffield Electric Light committee invite applications for the position of deputy manager and chief assistant of the electric supply department. The commencing salary will be in accordance with the qualifications of the candidate selected, the maximum being £300, rising by biennial increments of £25 to £400 per annum. Candidates must have had workshop training, practical experience in the working of electricity undertakings, &c. Applications to the general manager (Mr. S. E. Fedden), electric supply department, Commercial-street, Sheffield, by May 29. See also an advertisement.

An assistant engineer is wanted by Liverpool Corporation to take charge of erection and maintenance of overhead equipment of electric tramway. Salary, £250 per annum. Applications to the resident electrical engineer, 24, Hatton-garden, Liverpool.

The managers of the Technical College, Dundee, invite applications for the position of lecturer in electrical and mechanical engineering. The person appointed will have full charge of the electrical department, and must be competent to take the senior branches of mechanical engineering. Salary £350. Applications to the Director of Studies, Technical Institute, Dundee, by June 15. See also an advertisement.

The appointment of lecturer in the physics and electrical engineering departments at the Sunderland Technical College is now vacant. Salary £150 per annum. Applications to the Secretary, Mr. T. W. Bryers, 15, John-street, Sunderland, before Monday, May 31. See also an advertisement.

Blackburn Council have appointed Mr. E. Moxon, chief assistant electrical engineer at £225 per annum, as from June 7, rising by annual increments of £12. 10s. to £250 per year; and Mr. G. Turner, station superintendent at £175 per year, rising by annual increments of £10. 8s. to £206 per annum.

Mr. C. A. Thorpe, junior engineer of Hammersmith (London) electricity works, has been promoted to the position of fourth engineer-in-charge.

Mr. G. Wheeler has been appointed junior shift engineer at Southport.

Mr. T. H. Laby has been appointed professor of physics at the Victoria University College, Wellington, N.Z.

EDUCATIONAL NOTICES.

Motor Car Engineering.—The new department for this subject in the Merchant Venturers' Technical College, Bristol, was opened on May 3, when the first professor of motor car engineering in this country (Mr. Wm. Morgan, B.Sc.), began his courses of lectures, and the demonstrations of practical work in the recently equipped motor car engineering shop. We are informed that the new department has proved distinctly successful, as during the first week nine students have presented themselves, five of whom are taking the complete courses in motor car engineering (30 hours a week), and the remaining four are motor car users who have entered for the short summer course of lectures and practical work.

Scholarships.—West Riding (of Yorks.) County Council offer four technical scholarships (of the value of £60 per annum) to residents within the administrative area of the West Riding, and available for courses of instruction in connection with engineering (mechanical or electrical), metallurgy, dyeing or other approved industry. The scholarships are intended for young artisans who already have a suitable amount of mill or workshop experience, and the awards will be mainly based on the results obtained at examinations of the Board of Education and of the City and Guilds of London Institute. Particulars may be obtained from the Education Department (Technical Branch), County Hall, Wakefield.

Bristol Merchant Venturers' Technical College.—The new buildings of this college will be opened by Lord Reay on June 24.

Australasia.—The Victorian Railway Commissioners have decided not to proceed with the electrification of the Melbourne suburban steam railways, upon which Mr. C. H. Merz prepared and submitted a report in favour of converting the Port Melbourne–St. Kilda and the Brighton–Essendon branches to electric traction at a cost of nearly £900,000, the length of track being about 29 miles. Then, by stages, the whole of the lines, aggregating some 129 miles, were to have been changed to electric working, the cost of the entire scheme being £2,227,000. The Railway Commissioners are reported to be in disagreement with Mr. Merz's estimates of increased traffic to follow electrification, and are of opinion that for several years to come equally good or better financial results can be obtained by overhauling the steam rolling stock and running an accelerated service.

Barnsley.—The Market committee have applied for sanction to borrow £308 for the electric lighting of the stalls in May Day green market.

On Tuesday the chairman of the Electricity committee (Ald. Brady) reported to the Council that, after granting £1,000 in aid of the rates out of the past year's profit on the electricity undertaking, £429 was carried forward. He was pleased to say that their experience, contrary to that of other towns, was that the introduction of metallic filament lamps had not reduced their turnover.

Bath.—The City Council have decided to return the whole of the deposit made by Mr. Schenk on the execution of the abortive agreement for the purchase of the electricity works (with interest at 3 per cent. per annum), deducting only £2,500 paid in July, 1907, as consideration for the extension of time.

Bexhill.—After paying all expenses, including interest and sinking fund, there was a net profit of £536. 6s. 10d. on the past year's working of the electricity undertaking. £220. 9s. 1d. was allowed for depreciation.

Birmingham.—The Tramway committee propose to hand over £30,000 out of the past year's profits of the tramways undertaking to the relief of rates.

The committee have decided not to entertain the proposal to manufacture their own tramcars.

Bolton.—The Electricity committee have decided to allocate £6,500 out of the net profits on the past year's working of the electricity department to the relief of rates.

Bournemouth.—There will be a deficit of about £6,000 on the past year's working of the municipal tramways.

Brighouse.—There is a deficiency of £483 on the past year's working of the electricity undertaking. The Council are now taking electricity in bulk from the Yorkshire Electric Power Co.

Burnley.—The profit on the past year's working of the municipal tramways was £8,381, of which £2,380. 16s. 8d. has been devoted to relief of rates and £6,000 added to reserve. 12,176,782 passengers were carried and 1,229,224 car-miles run. The total revenue was £62,669 and the expenses £40,950.

Bury (Lancs.)—The profit on the past year's working of the tramways was £3,272, of which £2,500 has been placed to reserve, and the balance (£772) has been voted to the relief of the rates. Over 11,500,000 passengers were carried, an increase of 500,000.

The profit on the electricity undertaking was £2,914, against £4,026. The decrease is attributed to the reduction in the price of current, to the extended use of metallic filament lamps, &c.

Cable Makers' Association.—We are informed by the secretary (Mr. A. H. Howard) that, in accordance with a resolution of the Association passed at a meeting on the 5th inst., Messrs. Charles Macintosh & Co., Ltd. (William Rickard, Ltd.) have ceased to be members of the Association.

Carlisle.—A new feeder cable is to be laid to Caldewgate and Newtown at a cost of £1,550.

The electrical engineer and manager (Mr. S. T. Allen) has prepared a report on the extensions of plant necessary to meet next winter's demand for current, and he recommends the Council to put down additional plant at an estimated cost of £5,650.

Owing to the resignation of Mr. Moberley, mains superintendent at Carlisle, Mr. Thompson, the present station superintendent, has been promoted to the position of principal assistant.

Cleethorpes.—An inquiry was held here on Tuesday into the application of the Council for permission to borrow £4,000 for electricity supply.

Customs Decisions.—According to recent decisions, no import duty is leviable under the Netherlands tariff on wire clamps used in stretching telegraph and telephone wires or on wolfram metal wire used for incandescent lamps, even if cut in lengths. Electric transformers are dutiable according to their chief component parts or as instruments

Darwen.—There was a profit of £627 on the past year's working of the electricity department.

Dudley.—Electrical energy is to be supplied by the Corporation to Messrs. Bingleys' marine works at Cradley-road by means of an overhead cable.

East Grinstead.—The Finance committee have been asked to report upon a proposal of the Sussex Electricity Co. for the supply of electricity in the district, and as to the advisability of allowing overhead cables.

Electric Lighting Accounts.—The Board of Trade have just issued a form of accounts for electricity supply companies. The prescribed form differs in no respect from the form given in the Digest of the Law of Electric Lighting and Traction in the 1909 edition of " The

Finchley.—An inquiry was held last week into the application of the Council for permission to borrow £2,000 for the supply and erection of 50 3,000 c.p. arc lamps in certain thoroughfares in the district.

Evidence in support of the scheme was given by the electrical engineer (Mr. E. Calvert), and there were two or three petitions from ratepayers also supporting it, but some opposition was offered by the North Middlesex Gas Co.

Fire.—We are asked by the Hart Accumulator Co. (Ltd.), Marshgate-lane, Stratford, London, E., to contradict the reports that have appeared in Wednesday's daily papers in regard to the fire which occurred at their works on Tuesday. The damage is not so extensive as has been stated, and the fire was entirely confined to a portion of the works that was at the time unoccupied, so that deliveries will not be affected in the slightest degree.

Fulham (London).—Tde lamps on Eelbrook Common are to be adapted for Osram lamps at a cost of £21.

Hammersmith (London).—The Board of Trade have agreed to appoint a referee to settle the difference between the Council and the London United Tramways (Ltd.) as to the repair of the tramway track in the borough. Mains are to be extended to supply current to the Metropolitan Water Board's new pumping station at a cost of £234.

Leith.—The Granton tramway extension was opened for traffic on Tuesday.

Light Railways.—Southend Corporation intend to apply to the Light Railway Commissioners for an order to revive the powers granted by Southend-on-Sea Light Railways Extensions Order, 1904, except that it is proposed to abandon a portion of railway No. 1.
Electrician " Electrical Trades' Directory and Handbook.

Llandudno.—An unopposed inquiry was held last week into the application of the Council for permission to borrow £2,450 for additional plant for the electricity works.

London County Council.—On Tuesday the recommendation of the Highways committee to expend £61,710 on the construction of tramways from Brockley-road to Forest Hill, S.E., was agreed to.

Labour Conditions.—A long report was submitted by the same committee with regard to the conditions of labour of drivers and conductors, which had been raised by the Amalgamated Association of Tramway and Vehicle Workers. The committee pointed out that there had been a steady and continuous improvement in these conditions, and they were not prepared to advise the Council to go further. In a further report the committee recommended that they be authorised, after conference with the Board of Trade, to submit to the Council the details of a scheme for the establishment of Conciliation Boards for the Council's tramways on the lines of those agreed to in the case of railway companies. The report was adopted.

London County Council and Metropolitan Boroughs.—Battersea, Camberwell, Chelsea, Fulham, Kensington, Shoreditch, Southwark, Wandsworth and Woolwich Borough Councils have approved of the action taken by Westminster City Council in protesting against the policy of the L.C.C. in encroaching on the jurisdiction of the Metropolitan Borough Councils in electric supply and other private bills.

Lowestoft.—The Council have decided that for the present electrical engineers canvassing and obtaining new consumers for " free " wiring shall be allowed to execute the wiring at the current contract price, subject to the satisfaction of the borough engineer.

Market Harborough.—A circular is to be sent out to all ratepayers in the compulsory area of the provisional electric lighting order to ascertain the probable demand for electric current.

Middlesbrough.—An inquiry was held yesterday (Thursday) into the application of the Council for sanction to borrow £10,000 for electric lighting extensions.

Nelson.—The net profit on the past year's working of the electricity department was £36. 889,572 units were sold, including 267,464 for lighting, 534,932 for traction, 65,188 for power, and 21,988 sold by contract.

Personal.—The salary of the Fulham (London) borough electrical engineer (Mr. A. J. Fuller) has been increased to £525 per annum.

Plymouth.—The Electricity committee have been authorised to put down additional plant at the electricity works at an estimated cost of £2,500.

Current for illuminated sky signs is to be supplied at ¾d. per unit less than the ordinary lighting rate, provided 750 units per annum are consumed.

Portadown (Ireland).—A plebiscite of the ratepayers is to be taken on a proposal to establish electricity supply.

Presentations.—Bradford Electricity staff have presented a dining room clock to the city electrical engineer (Mr. Thos. Roles), on his marriage.

Norwich tramway staff have presented a silver salver and cake basket to Mr. A. N. Banister on his retirement from the position of manager.

Brighton tramway staff have made a presentation of a travelling bag, &c., to Mr. F. J. Gosden, who has entered the service of the London County Council.

On his departure for Australia, Mr. Orr, late assistant engineer at the Summer-lane station, Birmingham, has been presented by the staff with a gold chronograph and Mrs. Orr with a silver vase.

On the 9th inst. the Bournemouth tramways staff presented the late manager (Mr. Cecil Barber) with a bronze electric light group ("L'Orage") and a leather suit case, and Mrs. Barber with a fitted luncheon and tea basket and an Indian lizard purse with silver fittings.

Mr. F. T. Olding, chief assistant in the traffic department, made the presentation, and, in reply, Mr. BARBER said he was very pleased and gratified with the great kindness which had been shown him by the staff, and he thanked them most heartily for their splendid presents to himself and Mrs. Barber. He was very proud of the staff, and his greatest regret in leaving Bournemouth was that it would sever his connection with them.

Rhine Water Power Scheme.—A French consular report states that it is proposed to form a company in Mulhausen, with a capital of about £2,114,000, for the construction of reservoirs in the Vosges district and the generation by water power of electrical energy for industrial purposes in Mulhausen. It is calculated that 200,000 H.P. could be generated by the Rhine waterfalls between Schaffhausen and Bâle.

Roumania.—The German Consul at Bucharest states that the demand for all kinds of electrical machinery is steadily increasing year by year. Electrical machinery is largely used in the oil fields and in the timber producing areas.

Sheffield.—The Electric Light committee propose to apply for sanction to borrow £50,000 additional for laying feeders and for general main extensions and sub-stations, and £6,000 for house services, &c.

South Africa.—Tables have been prepared by Mr. R. N. Kotze (the Transvaal Government mining engineer) showing the imports of machinery, &c., into the Transvaal during the year ended June 30 last, for the use of gold, coal and diamond mines and metallurgical, chemical and lime works, and which include electrical fittings to the value of £140,179, electrical generators, engines, &c., £38,868, electric hoists and motors £17,169, electric locomotives £1,001, other electric motors £21,556, electric pumps £27,126.

The "British and South African Export Gazette" says:—

The Transvaal Government are about to establish iron smelting works at Pretoria and it is understood that the Agent-General in London will shortly invite tenders for the supply of an electric furnace to turn out 6 tons of steel per day.

The Crown Deep (Ltd.) have ordered four 125 H.P. and two 150 H.P. motors. The West Rand Consolidated Mines have also ordered a number of motors.

Johannesburg Corporation will shortly want tenders for electricity meters. The Municipality have ordered a 10 H.P. and a 5 H.P. motor and lamps, switches, &c., for the abattoirs and cattle markets.

Oudtshoorn Electric Lighting Co. are in the market for complete electric lighting plant. Particulars from Mr. G. Koelewijn, P.O. Box 47, Oudtshoorn.

Southwark (London).—We are asked to state that, in regard to the advertisement of the Borough Council which appeared in the issue of THE ELECTRICIAN for March 19, the Council have deferred the appointment of a chief engineer and manager of their electric light undertaking for three months.

Telephony in Saskatchewan.—The Saskatchewan Government took over all the long-distance lines, local exchanges and equipment of the Bell Telephone Co. in the province on May 1.

Tramcars for Military Purposes.—The possibility of employing tramcars for the mobilisation of troops has been discussed at a conference held in Manchester between officers of the E. Lancashire Territorial Force and representatives of the tramway undertakings in the district. Between 12,000 and 13,000 troops of the division will assemble at Worsley in July for review by the King. Of these some 3,000 will be transported by tramcar from the various East Lancashire towns. Others will journey by train, but the Manchester and Salford contingents, which form by far the greatest number, will march to the parade ground.

Turkey.—The imports at Constantinople during the year ended February, 1908, comprised electric bells, &c., to the value of £4,000, including £340 from the United Kingdom.

Utilisation of Waste Heat from Coke Ovens.—At Messrs. Pease & Partners' collieries at Bankfoot (Durham), an installation of 90 patent coke ovens has been in operation for some time, and recently it was decided to lay down 30 additional ovens. Wherever possible electric power has been adopted. The waste heat from the 90 coke ovens at Crook is being utilised at a power station which has been provided in the immediate vicinity by the Bankfoot Power Co., in which Messrs. Pease & Partners have subscribed one-half of the share capital, and the Waste Heat & Gas Electric Generating Stations (Ltd.) the other half. At this station, which was put into commercial service a few weeks ago, there is plant of 3,300 H.P. generating three-phase current at 3,000 volts 40 cycles.

Venezuela.—Reuter's Agency announces that all outstanding differences between the Venezuelan Government and the Compagnie Française des Cables Télegraphiques have been settled, and an agreement between the parties has just been signed which will enable the company to re-open its regular service with Venezuela forthwith.

Watford.—The chairman of the Electricity committee (Mr. Goodrich) has stated that metallic filament lamps are not having any serious effect on the actual number of units sold. Where these lamps had had a disastrous effect was usually where the bulk of the current was for lighting, but in Watford they were fortunate in having a number of power consumers.

An unopposed inquiry was held here last week into the application of the Council, for sanction to borrow £4,952 for electric lighting extensions.

West Ham.—The electrical engineer (Mr. A. H. Seabrook) and the tramways manager (Mr. H. E. Blain) have decided, in order to improve the traction supply in Stratford district, to lay a 0·15 6,000 volt two-phase twin concentric cable from the generating station to the Town Hall, to install rotary converters and transformers and the necessary switchgear at a cost of £6,258.

The value of the tramways cable recovered will be about £9,000. Under this arrangement the tramways department cut out the transmission losses between Canning Town and Stratford, valued at approximately £1,000 per annum. The electricity department gains the advantage of having rotary converters running in the middle of Stratford, which will have the effect of increasing the current-carrying capacity of the cables by improving the power factor of the system.

In conjunction with the above scheme the ordinary supply arrangements from Canning Town to Stratford will be rearranged by laying one 0·15 6,000 volt two-phase cable from the generating station to the Town Hall (duplicate of the proposed tramway cable), costing, with the step-down transformers and switchgear, £3,200, and removing the existing cables to stock, value £3,400. The capital cost will be nil, as the cables to be removed are perfectly good and can be removed to other parts of the borough. A final improvement to consolidate the supply to Stratford is to be the linking up of the 6,000 volt two-phase cable from the corner of Abbey-lane to High-street, where the present 6,000 volt two-phase cable from Canning Town to that point ends, and along High-street and Broadway to Town Hall, connecting up with the proposed new cable. The cost of this will be £1,000, which is the net cost of the three schemes on capital account. The Electricity committee have decided to carry out the work.

The Electricity committee have unanimously passed a resolution recording the fact that, while they heartily congratulate Mr. Seabrook on his success in obtaining the important appointment of general manager of the Marylebone electricity undertaking, they deeply regret the loss of his valuable services to the Borough, and recommend that, in order to place on permanent record the Council's high appreciation of the value of Mr. Seabrook's work in developing the West Ham electricity undertaking, a testimonial on vellum under the Corporate seal be presented to him.

As several important matters relating to electricity are pending, the Electricity committee have decided, subject to the consent of Marylebone Council being obtained, that the services of Mr. A. Hugh Seabrook be retained as consulting electrical engineer at a fee of 100 guineas for a period of one year, or such time as may be necessary to finally dispose of the several pending matters.

Wireless Telegraph Notes.—The wonders of wireless telegraphy form the theme for much newspaper writing, and some of the more recent developments have appealed to the public imagination. It is now announced that the arrangements taken by the French authorities to circumvent the postal telephone and telegraph strikers include an arrangement with the French Ministry of Marine to hold

all warships in port in readiness to take up positions along the coast, in order that their wireless telegraph equipments may be utilised to secure and maintain telegraphic communication, which may other-interrupted by the strike and the strikers.

It is announced that Capt. Hovland, of the Norwegian Navy, has invented a system of automatically recording wireless telegraph messages in print. Messages are said to have been exchanged between a station erected after the inventor's own designs and a Norwegian naval wireless station 12½ miles distant (Töjmö), when Capt. Hovland demonstrated how by his system absolute secrecy of wireless telegrams could be preserved and the ordinary signals could be automatically transformed into secret written characters. With the aid of a "tabulator," constructed somewhat on the plan of a typewriter, the signals are despatched and the wireless message arrives at the receiving station printed, either in ordinary or in secret characters, as desired. It is further stated that the Norwegian naval authorities have decided to give financial support to the exploitation of the system.

The Paris "Matin" recently gave some particulars of a claim made by two army telegraphists (MM. Mailly-Chalon and L. Chantelot) to have invented a method of transmitting handwriting over wireless telegraph systems. The invention consists of adapting the ordinary Hilautograph to the influence of Hertzian waves in such manner as to render the communication perfectly intelligible and secret. This is said to be effected by means of a sensitive drum on the receiving instrument, the "impressions" being meaningless to everybody until they are recorded on this drum, with the result that only the receiver can read the message. The inventors claim that experiments extending over several months lead them to the conclusion that the invention is of practical utility.

At an exhibition of recent inventions which is being held at St. Petersburg an exhibit is shown of wireless telegraph apparatus connecting St. Petersburg with Viborg (Finland) and with Sebastopol (Crimea). The latter city is 1,000 miles from St. Petersburg.

At Punta del Este a wireless telegraph service was opened on April 15. Another station is to be erected at Rio Grande, and these stations, when ready, will enable communication to be maintained with vessels between Rio de Janeiro and Buenos Ayres, the Argentine station being located at Bernal.

Electrical Contractors' Dinner.—The eighth annual dinner of the Electrical Contractors' Association will be held at the Holborn Restaurant, London, on June 14.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited for the supply, alternatively, of one 1,000 kw., 1,250 kw. or 1,500 kw. d.c. dynamo and engine to the City of Melbourne. Tender form, conditions, specification, &c., can be obtained from the agents of the Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter Square-buildings, London, E.C. Tenders, addressed to the chairman of the Electric Supply committee, Town Hall, Melbourne, by 2 p.m. Wednesday, July 14. Further particulars are given in an advertisement.

Tenders are invited for the supply of 69,750 incandescent lamps to the City of Melbourne. Specification and forms from the agents of the Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by noon Tuesday, June 1. See also an advertisement.

Tenders are also invited for supply of 1,125,000 flame and 70,000 ordinary arc lamp carbons for Melbourne Corporation. Tender form, specification, conditions, &c., from the agents for Melbourne City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon Tuesday, May 25.

Tenders are invited for supply of 50 coin attachments (suitable for coins of different values) to the Postmaster-General's Department in Victoria. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for eight sections of common battery switchboard and subscribers' apparatus for Hawthorn Exchange for the Postmaster-General's Department, Victoria. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are also invited for supply of telephone material to the Postmaster-General's Department in Queensland. Tender forms and specifications may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of a branching multiple magneto switchboard to the Postmaster-General's Department in New South Wales. Tender forms and specification may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of one photometer, &c., to the Postmaster-General's Department in New South Wales. Tender forms and specification from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Wigan Corporation invite tenders for the supply and erection of 750 kw. engine and generator, two water-tube boilers, steam and water piping, motor-driven feed pumps, economiser, separators, feed water filter and meter, exhaust steam and water piping, motor-driven pumps and condenser, coal-handling plant and bunkers, h. and l.-t. cables, h. and l.-t. switchboard, removal of plant from Pemberton generating station to Wigan, constructional steelwork for the boiler house extension and switchboard gallery. Tenders to the town clerk, Mr. Harold Jevons, by May 17.

Manchester Tramways committee invite tenders for the supply and delivery of main switchboard and auxiliary distribution boards, steel girder tramway rails, steel tiebars for tramway rails, copper trolley wire, and tramway rail bonds. Tenders to the Chairman of the Committee, 55, Piccadilly, Manchester, 10 a.m. of Tuesday, May 18.

St. Pancras (London) Borough Council invite tenders for supply of arc lamp carbons. Copies of specification, &c., from the Electricity Department offices, 57, Pratt-street, Camden Town, N.W. Tenders by noon July 10 to the town clerk, Mr. C. H. F. Barrett, Town Hall, Pancras-road, London, N.W.

St. Pancras (London) Council want tenders by noon May 17 for 12 months' coal for the electricity works. Specification, &c., from the electricity department.

London County Council want tenders by 11 a.m., June 15, for 200 double-deck, roof covered tram car bodies, 200 car sets of maximum traction swing bolster trucks, and 200 electrical equipments. Forms of tender, &c., from the County Hall, Spring Gardens, S.W.

Farnworth Council want tenders by May 24 for the supply, laying, &c., of e.h.t. and l.t. cables, and 10 circuit breakers. Specifications, &c., from the electrical engineer.

Dartford Council want tenders by noon May 19 for 12 months' supply of house service cable, jointing material, &c. Forms from the Clerk.

Whitehaven Corporation want tenders by noon May 25 for supply and erection of a balancing set. Specification, &c., from the Borough Electrical Engineer.

Hornsey Council require tenders by noon May 28 for supply of cables. Forms of tender, &c., from the Borough Electrical Engineer.

Woolwich Council want tenders by noon May 17 for coal for the electricity department. Forms from the Town Clerk.

The Direction of Public Works, Madrid, invite offers (until May 21) for a concession for an electric tramway from Catarroga to Silla, in competition with an offer received from the Cia General de Tranvias de Valencia.

TENDERS RECEIVED AND ACCEPTED.

London County Council have received the following tenders : —

Construction of tramways from the " Plough," Clapham, to Cedars-road, near Lavender Hill, &c.

Dick, Kerr & Co. (*accepted*)	£28.703	Fry Bros.	£31,206
A. M. Coles	29,361	R. C. Brebner	33,669
W. Manders	29,619	H. M Nowell	43,617
J. Mowlem & Co.	30,274		

The undermentioned portions of the work may be sublet : The yokes to the Anderston Foundry Co., or Wilsons, Pease & Co ; the insulators to Doulton & Co., or Bullers (Ltd.) ; and the tiebars, bolts, &c., to Bayliss, Jones & Bayliss, or Guest, Keen & Nettlefolds.

For Track Rails and Fastenings.

Bolckow, Vaughan & Co. (*accepted*)	£24,958	19	8
Stahlwerks-Verband, Düsseldorf	*21,057	5	0
Société Anonyme d'Ougrée Marihaye	22,511	16	2
Société Anonyme des Aciéries d'Angleur	22,656	14	0
Lorain Steel Co.	26,062	19	0
P. & W. MacLellan (North-Eastern Steel Co.)	26,465	1	0
Walter Scott (Ltd.)	26,865	5	0
Barrow Hæmatite Steel Co	27,399	6	6

Slot Rails and Conductor Tees.

Frodingham Iron & Steel Co. (*accepted*)	£21,197	15	0
Walter Scott (Ltd.)	21,784	5	0
P. & W. MacLellan (North Eastern Steel Co.)	22,012	10	0
Barrow Hæmatite Steel Co.	33,650	0	0
Société Anonyme des Aciéries d'Angleur	*14,869	0	0

* Incomplete tenders.

The contract for the manufacture of bolts and nuts may be sub-let to Guest, Keen & Nettlefolds.

The offer has been accepted by the L.C.C. of W. T. Henley's Telegraph Works Co., to extend the existing l.t. cables on the Aldgate–Bow tramway route at a reduction of 1½ per cent. on the rates under their contract for l.t. cables, entered into on March 31, 1908.

For withdrawing and relaying l.t. cables at Elephant and Castle sub-station.

R. W. Blackwell & Co. (*accepted*)	£29,44	16	2
Western Electric Co.	3,147	17	4
Johnson & Phillips	3,191	2	2
British Insulated & Helsby Cables	3,198	17	6
W. T. Henley's Telegraph Works Co.	3,245	0	3
W. T. Glover & Co.	3,324	17	7
Callender's Cable and Construction Co.	3,435	16	6
Siemens Bros. & Co.	3,438	7	9

Marylebone (London) Council have accepted the following tenders .

W. T. Glover & Co., binding wire and tinned copper fuse wire ; London Electric Wire Co., tinned fuse wire and tinned copper sheet ; Siemens Bros. & Co., Para strip and black adhesive tape ; Le Carbone and Wm. Patterson, dynamo brushes ; British Electric Mfg. Co., ceiling roses and lampholders, J. H. Tucker & Co., switches ; Edison & Swan Co., switch-blocks ; W. McGeoch & Co., sockets ; General Electric Co., switchblocks, distribution boards and pear switches ; Davis Electrical Co., distribution boards and fuse bridges ; Union Electric Co. and Sloan Electrical Co., arc lamp carbons ; Jennings & Co., meter boards and creosoted troughing ; British Electrical Trades Supply Co., pitch ; Armorduct Mfg. Co., cut-outs.

Hammersmith (London) Council have accepted the tenders of the British Electric Transformer Co. for a 200 kw. transformer at £175, and Spagnoletti Limited for a 100 kw. transformer at £89. An order has been placed with the Western Electric Co. for the supply of cable at £1,710; and the tender of Brown, Duncan & Co. has also been accepted for supplying and fitting a furnace for a boiler at £105. 10s.

The Metropolitan Asylums Board received the following tenders for two large ambulance tramcars and two smaller ones :—

United Electric Car Co. (*accepted*) **£838**, Dick, Kerr & Co. £846. 7s. 6d., Gloucester Railway Carriage & Wagon Co. £860, Brush Co. £875, Hurst, Nelson & Co. £1,000, G. C. Milnes, Voss & Co. £1,200, Mountain & Gibson £1,930.

Wrexham Council have accepted the following tenders :—

British Insulated & Helsby Cables for pillar box, £70; Willans & Robinson, automatic expansion gear, £105 ; and E. Green & Sons, economisers, £162. 15s.

Darlington Corporation have accepted the tender of Belliss & Morcom for supply of a 500 kw. electric generator and exhaust steam turbine. The full list of tenders was given in our issue for April 23 (p. 71).

Merthyr Tydfil Guardians have accepted the offer of the local Electric Traction & Lighting Co. for wiring the workhouse and infirmary at £521. 2s., and for supply of electric current at £200 for a minimum of 15,000 units and 2½d. per unit beyond.

Hastings Corporation have accepted the following tenders :—

Tudor Accumulator Co., for overhauling the storage battery and also for maintaining same for 10 years at £41. 5s. per annum; H. G. Mayer & Co., for the supply of 200,000 carbons for Oriflamme arc lamps.

The Lancashire Dynamo and Motor Co. have obtained the contract for the supply of motors (5 to 30 H.P.) to Govan Council for the ensuing year. This is the sixth year the Company has secured the motor contract at Govan.

Fareham Urban Council have accepted the following tenders : —

British Insulated & Helsby Cables, electric supply mains, £238 ; Spagnoletti Limited, transformers, £172 ; and W. Lucy & Co., lamp pillars, brackets and fittings, £24. 14s. 8d.

Hammersmith (London) Council received 11 tenders for the conversion of the lift in the Town Hall from hydraulic to electric power, the amounts varying from £116 to £290, and that of Medway's Safety Lift Co., at £167, was accepted.

Bury (Lancs.) Council have accepted the tender of the General Electric Co. for supply of two 500 kw. sets of motor generators, that of Le Carbone (Ltd.) for six gross of carbon brushes, and that of Carr Bros. for 500 insulation bolts.

Bradford Electricity committee have placed an order with the Crosthwaite Fire Bar Synd. for two cooling at the Valley-road works at £3,475.

Maidenhead Council have accepted the tender of W. Geipel & Co. for carbons for Crompton lamps, that of Chamberlain & Hookham for meters, and that of the Western Electric Co. for cables.

For the supply and erection of the second portion of the e.h.t. switchgear at West Ham generating station the tender of the British Westinghouse Co. at £345 has been accepted.

York Tramways committee recommend the acceptance of the tender of Dick, Kerr & Co. for the construction of the permanent way and equipment of about 10 miles of tramway track at £78,827.

West Sussex Education committee have accepted the tender of Mr. Privett for wiring the secondary school, Chichester.

The General Electric Co. have secured the contract for the supply and erection of plant for the proposed electricity works at Uitenhage, South Africa.

Walmer Council have placed an order with Stuart & Moore for installing electric fire-alarms at £61.

Aldershot Council have accepted the tender of Burch & Vertue for installing electric fire-alarms.

The Mirrlees-Watson Co. send us a list of recent contracts for condensing plant secured by them.

Ravensthorpe Council have accepted the tender of Ferranti Limited for 50 metallic lamps for street lighting.

Wandsworth (London) Guardians have accepted the tender of G. E. Taylor & Co., for wiring the new infirmary at £1,855.

Clacton-on-Sea Council have accepted the tender of Johnson & Phillips for supply of cable at £56.

Battersea (London) Council have accepted the tender of Mackenzie & Moncur for supply of six arc lamp columns at £12. 15s. each

Bristol Docks committee have accepted the tender of W. T Henley's Telegraph Works Co. for cables, &c.

The A.E.G. Electrical Co. of South Africa have received orders for a 300 H.P. and a 160 H.P. motor for Geldenhuis Deep (Ltd.), eight 50 H.P. and two 60 H.P. motors for Nourse Mines (Ltd.), four 125 H.P. motors for the Crown Deep and five electric winding hoists and a 1,000 kw. generator for the Randfontein Estates Gold Mining Co.

C. J. Thursfield & Co. have a contract for electric light fittings for Durban Town Hall.

BUSINESS NOTICE.

A new company is being formed to take over the British business of the well-known firm, Pirelli & Co., cable manufacturers, of Milan, and Mr. H. Bevis has resigned from the board of the General Electric Co. in order to take up the position of managing director of the company. The address of the new company, Pirelli (Ltd.), is 45, Basinghall-street, London, E.C.

Patent Development.—The proprietors of the following patents are desirous of entering into arrangements by way of licence and otherwise for exploiting same in this country :—

No. 15,243/1903 for "Improvements in Means for Automatically Regulating Electric Currents generated by Dynamos."

No. 17,314/1905, for "Improvements in Automatic Regulators or Rheostats for Electric Currents."

No. 28,159/1897, for "Means for use in Lighting Railway Cars or Carriages by Electricity and for regulating the Current for same."

No. 17,601/1901, for "Improvements in Apparatus and Devices for controlling Electric Currents."

No. 16,962/1902, for "Improvements in Electric Switches or Cut-offs."

Communications in regard to the above to Messrs. Haseltine, Lake & Co., chartered patent agents and consulting engineers, 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane, Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

Two alternator-gas engine sets (250 kw. each), direct coupled, are advertised for sale.

A second-hand Kc Peache high-speed engine, 340-365 B.H.P., made by Davey, Paxman & Co., is offered for sale in another column.

CATALOGUES, &c.

Line Material for Electric Railways.—Some weeks ago we called attention to a catalogue sent to us by Messrs. Siemens Bros. Dynamo Works, in which the various apparatus necessary for electric railway work were dealt with in an artistic and complete manner. These lists have now received two additions. The first contains details of rosettes and fork bolts, straps for the various types of poles used in railway work, hangers, sound dampers, strain insulators and the various other apparatus which are required in this important branch of electrical engineering.

We have also received a supplement to one of the price lists already noticed. This contains details of hand switches with magnetic blow-outs arranged for pressures up to 650 volts and currents up to 3,000 amperes.

Prescot Joint Boxes.—The British Insulated & Helsby Cables send us a number of pamphlets illustrating and describing their well-known Prescot joint boxes. These are made in a number of patterns, but those now under notice are specially intended for three-phase work. They are made suitable for working voltages up to 6,000 volts, and are intended for colliery work as well as for general use. An interesting pamphlet gives a list of the various undertakings where Helsby tramway materials and cable have been supplied.

Electrical Plant and Supplies.—We have to acknowledge from the Electric & Ordnance Accessories Co. a binder containing a number of catalogues dealing with the various activities of this firm. These catalogues contain details of controllers, starting gear and switches, fans, insulators and telephones. We take the opportunity of noting these here, the apparatus is dealt with at greater length on another page of this issue.

Leitner System of Train Lighting.—Practically everybody at the present day is agreed that electric lighting is the best and safest method of illuminating railway carriages. This being granted, the difficulty is to design an equipment which shall fulfil the many and arduous conditions met with in railway working. Numerous systems have been proposed for this purpose, and one of the most successful is that invented by Mr. H. Leitner. The system, which, it will be remembered, is in use on the Great Western Railway, has been fully described in The Electrician, and we have now received from Mr. Leitner an excellently illustrated pamphlet giving various details of his system, and the results of numerous tests that have been carried out by independent persons, and which show the general efficiency of the apparatus and its suitability for the work it has to do.

Adaptors for Metal Filament Lamps.—Messrs. Julius Sax & Co. forward a pamphlet dealing with this subject. The adaptors illustrated in the catalogue are intended for fitting to lamp-holders when it is desired to burn two metallic filament lamps in series on high voltage. They can, however, also be used as fittings when supplied with cord grips. These fittings are made in numerous types and are specially adapted for use with "Holophane" reflector globes.

Fan Advertising Literature.—The Union Electric Co. have issued two pamphlets dealing with "Fortiter" fans. The first indicates several methods in which the "Fortiter" fan may be useful to the ordinary consumer, while the second gives concise details, both electrical and financial, of these well-known apparatus.

"Facile" Twin Lead Wiring System.—A system of wiring which is known as the "Facile" has lately been put on the market by Julius Sax & Co., who in a new catalogue describe the fittings and accessories which make this arrangement, it is claimed, absolutely watertight. The system is said to be easy to erect and to adapt itself to future extensions.

Shot Firing.—The Sterling Telephone & Electric Co. have issued a catalogue containing details of various methods of shot firing.

"Gral" Lamps.—The Armorduct Mfg. Co. have issued a leaflet giving revised prices for "Gral" lamps.

Easy Replacement Automatic Distribution Boards.—A pamphlet received from Messrs. Spagnoletti deals with a new type of easy replacement automatic distribution board. This apparatus is intended to be used in house lighting instead of fuses, and forms what is practically a small circuit-breaker. A fuse is also carried on this arrangement, which operates in the case of the cut-out failing.

Electric Fans.—Mr. G. Braulik has issued a pamphlet dealing with small electric fans and power motors. The fittings are artistic, and take only 16 to 18 watts.

Engineers' Stores.—From Messrs. Watts, Fincham & Co., Billiter-buildings, London, E.C., we have received price lists of engineers' stores (including belting, asbestos goods, oils, tools, &c.), of iron and steel joists, building and railway material, castings, &c., and of bolts and nuts. The firm make a speciality of studs and screws for electrical work.

Imports.—The following are official values of electrical machinery, material, and apparatus imported into this country (a) during April, 1909, and (b) during the current year from Jan. 1 to April 30, with the increases or decreases compared with the corresponding periods of 1908:—

Electrical machinery (a) £34,591 (decrease £10,521); (b) £153,928 (decrease £72,192); telegraph and telephone cables (a) £7,553 (decrease £5,442), (b) £32,358 (decrease £15,336); telegraph and telephone apparatus (a) £16,205 (increase £1,452), (b) £60,527 (decrease £14,222); other electrical wires and cables, rubber insulated (a) £4,073 (decrease £3,893), (b) £18,022 (decrease £8,773); with other insulations (a) £7,973 (decrease £6,791), (b) £37,861 (decrease £4,616); carbons (a) £9,887 (decrease £2,908), (b) £46,065 (decrease £14,763); glow lamps (a) £45,068 (increase £26,198), (b) £161,671 (increase £84,844); arc lamps and electric searchlights (a) £268 (increase £203), (b) £7,630 (increase £6,429; parts of arc lamps and searchlights (other than carbons) (a) £3,759 (decrease £978), (b) £16,122 (decrease £2,982); primary and secondary batteries (a) £4,074 (decrease £2,321), (b) £18,281 (increase £1,512). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (a) £104,171 (increase £1,491), (b) £432,500 (increase £27,755).

Exports.—The exports of electrical machinery, material, &c. (a) during April, 1909, and (b) during the current year from Jan. 1 to April 30, and the increases and decreases compared with the corresponding periods of 1908, are as follows:—

Electrical machinery (a) £139,567 (increase £34,805), (b) £474,165 (increase £13,432); telegraph and telephone cables (a) £47,490 (increase £22,865), (b) £145,734 (decrease £44,741); telegraph and telephone apparatus (a) £15,675 (increase £5,060), (b) £65,625 (increase £14,877); other electrical wires and cables, rubber insulated (a) £26,199 (increase £8,558), (b) £88,814 (decrease £4,174); with other insulations (a) £20,017 (decrease £8,096), (b) £79,923 (decrease £7,815); carbons (a) £404 (decrease £140), (b) £2,471 (increase £206); glow lamps (a) £5,122 (increase £404), (b) £22,531 (increase £7,940); arc lamps and searchlights (a) £975 (decrease £814), (b) £7,064 (increase £1,745); parts of arc lamps and searchlights (other than carbons) (a) £1,225 (decrease £356), (b) £6,294 (increase £1,011); primary and secondary batteries (a) £7,968 (decrease £819), (b) £38,401 (increase £21,013). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (a) £152,825 (increase £28,649), (b) £576,309 (decrease £7,473).

BANKRUPTCIES, LIQUIDATIONS, &c.

In the London Bankruptcy Court, on Wednesday, the public examination was held of Chas. H. W. Biggs, of Salisbury-court, Fleet-street, London, printer and publisher, trading as Biggs & Sons. Gross liabilities £10,418. 5s. 1d., of which £9,270. 16s. 5d. was expected to rank, and assets £3,406. 12s. 3d.

Bankrupt stated that since 1884 he had carried on business as a printer and publisher. He began trading under the style of Biggs & Sons about two years ago, but his sons were not partners in the business, being merely employed by him at a weekly salary. From 1879 to June, 1908, he was a director of the "Contract Journal" Co. (Ltd.). Up to September last he had been employed by that company to edit, and since 1899, to print and publish the paper. He resigned his directorship of the company in the early part of last year. Since 1884 he had also published the "Electrical Engineer," and in October, 1908, he started "Biggs & Sons' Contractors' Record and Municipal Engineering." Soon after starting that paper he sold it to his daughter-in-law, who in turn sold it to the Salisbury Publications Co. (Ltd.) that had been formed to acquire it. The consideration for the sale of the paper was £250 in cash and £250 in shares of the company. The shares were placed in the names of his two sons because they had found money for the paper. He sold no other paper to the Salisbury Publications Co. He was employed by that company down to the time of his bankruptcy to edit and publish the paper on a profit-sharing system, but he had not yet received any profits. He attributed his insolvency principally to his liability to the representatives of a relative of a partner, who had joined him for a short time in 1888, for money advanced and interest claimed, and also to his household and personal expenses having exceeded his income during the last year.—The examination was concluded.

John R. W. Middleton and Alfd. E. E. Daniels (trading as Middleton & Co.), electricians, 11a, King-street, Dover, have been adjudicated bankrupt.

A supplemental dividend of 4⅝d. is payable at the O.R.'s, Byrom-street, Manchester, to the creditors of Walter Wardle, electrician, 14, Osborn-road, Levenshulme, Manchester.

Messrs. E. A. Lazarus and Fortescue Thursby have been appointed liquidators of La Capital Traction & Electric Co., Buenos Ayres, Ltd. (in liquidation), La Capital Tramways Co., Ltd. (in liquidation), and the Buenos Ayres New Tramways Co., Ltd. (in liquidation). Meetings of creditors will be held on May 20, at 62, London Wall, London, E.C. Claims to Mr. Thursby by June 1.

Generators Limited is being wound up voluntarily, and Mr. M. G. B. Murgatroyd (Murgatroyd, Shuttleworth & Haworth), Manchester, has been appointed liquidator.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are n o open to public inspection until after acceptance of Complete Specifications Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

January 22, 1909.

1,614 MUNRO & RAILLESS ELECTRIC TRACTION CO. Electric traction systems.
1,626 ROSE. Exhaustion of metal filament electric lamps and other apparatus requiring a high vacuum.
1,641 SIMMS & SIMMS MFG. CO. Contact breakers for use with magneto-electric machines.
1,642 LEITNER. Electrodes for electric accumulators.

January 23, 1909.

1,651 B.T.-H. CO. (G.E. Co., U.S.) Balancing end-thrusts in dynamo-electric machines. (Date applied for, 18/8/08. Comprised in No. 17,380, 18/8/08.)
1,652 BIRNBAUM. Electrical game apparatus.
1,662 SELBY, SANDERS & PRESTON. Electric switches.
1,673 BIRCHALL. Lamp-holders for electric incandescent lamps.
1,675 BIRCHALL. Electric iron-clad switches.
1,679 SIEMENS BROS. DYNAMO WORKS & KLOSS. (Siemens-Schuckert-werke, G.m.b.H., Germany.) Cooling of the windings of dynamo-electric machines.*
1,696 ELLISON. Circuit-breakers. (Addition to No. 13,285/07.)
1,705 ALLGEMEINE ELEKTRICITATS GES. Alternating-current electric machines of the commutator type. (Dat eapplied for, 24/1/08.)*
1,706 AUDIBERT. Dividing electric current.*

January 25, 1909.

1,741 HEWITT. Switches for electric lamp-holders and other purposes.
1,758 HERWIG. Arc lamps.
1,760 GRIBBLE. Electric traction.
1,761 OATWAY. Electric signal transmitter.
1,788 TAYLOR. Electric signalling systems. (Date applied for, 30/1/08.)*†
1,800 W. T. HENLEY'S TELEGRAPH WORKS CO. & NICHOLS. Disconnecting boxes and the like for electric cables.
1,805 TAMKIN. Combined current meter and insulation tester.
1,813 HANISCH & REGINA BOGENLAMPENFABRIK G.M.B.H. Arc lamps.*
1,820 FRASER & TUDOR ACCUMULATOR CO. Supply and regulation of electrical energy for train lighting and the like.

January 26, 1909.

1,875 S. P. SYNDICATE & SAYER. Electric traction on the surface-contact system.
1,878 BOWMAN. Electrical signalling at high speeds.
1,879 WALTER. Electrolytic cells.
1,927 LOWNE & LOWNE ELECTRIC CLOCK & APPLIANCES CO. Mechanism for electrically recording recurring movement or impulses.
1,928 B.T.-H. CO. (G.E. Co., U.S.) Electric lamp filaments.

January 27, 1909.

1,959 TAYLOR. Charging and discharging accumulators.
1,978 BELL. Electrical ignition for internal combustion engines. (Addition to No. 195/09.)
1,985 JULIUS SAX & CO. & WHEAT. Electric indicators.
1,998 BRULL. Electric resistances. (Date applied for, 1/2/08.)*†
2,004 CHAUDOIR. Electric fuse boxes, cut-outs, switch fuses or the like.*
2,016 HARDINGHAM. (Hartmann & Braun Akt.-Ges., Germany.) Alternating-current magnets for resonance apparatus.*
2,027 B.T.-H. CO. (G.E. Co., U.S.) Electric arc electrodes and in processes of making them.
2,028 & 2,029 B.T.-H. CO. (G.E., Co., U.S.) Electric lamp filaments.

January 28, 1909.

2,071 CLACHER. Purifying carbon for electrical and other purposes.
2,076 BEAVER & CLAREMONT. Apparatus for use with electric cables. (Date applied for, 23/3/08. Comprised in No. 6,477 23/3/08.)
2,106 GREEN. Holders for electric lamps.*
2,127 & 2,128 B.T.-H. CO. (G.E. Co., U.S.) Electrical insulating material. (Addition to No. 19,035/05.)*
2,130 WRIGHT. Electric accumulators.

January 29, 1909.

2,144 TERREY, PEATEY & HUNT. Controlling switch for electric transformers.
2,147 TAYLOR. Electric accumulator sub-stations.
2,167 RAYBURN. Incandescent lamps.
2,169 SHARMAN. Telegraphy and telephony by earth conduction.
2,176 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke, G.m.b.H., Germany.) Dynamoelectric machines for speed regulation.
2,177 SIEMENS BROS. DYNAMO WORKS, KLOSS & WILSON. Dynamo-electric machines.
2,213 MAIBEN. Construction of tangent galvanometers.
2,217 CURTIS, MACKLEY & ADAMS MFG. CO. Electro-magnetically controlled electric switches.

January 30, 1909.

2,252 LAMKIN & WETJEN. Electrical contact devices.
2,268 LANTOUR. Continuous-current commutatorless dynamo-electric machine.
2,286 MASCORD. Generation and transmission of electromotive power.
2,287 WEEKES. Fuse switches.
2,311 DAWBARN. Contact making devices for use with trolley wires.

February 1, 1909.

2,330 CHAMBERS. Telegraphy and telephony by means of Hertzian waves.
2,335 TAYLOR. Electric accumulator sub-stations.
2,353 HATRY. Indicating fuse containing indicator.
2,379 COWDEROY & REASON MFG. CO. Vents for use with electric accumulators, batteries and the like.*
2,389 B.T.-H. CO. (G.E. Co., U.S.) Treatment of electric lamp filaments.

February 2, 1909.

2,420 DICKINSON & LINZELL. Electric distributing systems.
2,464 SIEMENS BROS. DYNAMO WORKS & SCHUPP. Motor starting switches.
2,520 HEYLAND. Regulating system for alternate-current installations. (Date applied for, 3/2/08.)*†
2,526 HEYS. Discharging accumulators or primary batteries into an alternating-current circuit and charging accumulators by an alternating current.*
2,529 B.T.-H. CO. (G.E. Co., U.S.) Electric protective devices.

February 3, 1909.

2,550 BAKER. Switch for closing and opening an electric circuit.
2,552 & 2,553 HILL & ROWLAND. Arc lamps of the flame arc type.
2,568 TUCKER. Electrical switches.
2,595 FRY. Wireless telegraph circuits.
2,611 BRITISH ALUMINIUM CO. & HORN. Joints for electrical conductors.
2,612 HADEN, HADEN & BLACKMAN. Damp-proof box for electric switches and wall plugs.
2,642 AKT.-GES. STAHLWERKE WEISSENFELS VORMALS GÖPPINGER & CO. Electrically welding chains. (Date applied for, 3/2/08.)*†

February 4, 1909.

2,667 BEEVERS, CARNEGIE & CROWCROFT. Trolley heads.
2,683 MARINO. Secondary or storage batteries.*
2,686 SIEMENS BROS. DYNAMO WORKS, KLOSS & WALL. Dynamo-electric machines.
2,715 BAERLOCKER. Controllers for electric motors.
2,733 SPAGNOLETTI. Circuit interrupters to take the place of a fuse in electric lighting and power installations.
2,749 GARDE & ADAMS. Electrodes of secondary batteries (accumulators). (Date applied for, 2/4/08.)*†
2,754 RORKE & RORKE. Switches for electrical purposes.*

February 5, 1909.

2,767 PEAKE. Electrical thermometers and pyrometers.
2,851 SIEMENS BROS. & CO. (Siemens & Halske A.-G., Germany.) Telephone exchanges.*
2,853 SIEMENS & HALSKE AKT.-GES. Incandescence filaments from tungsten or other difficult ductile metals. (Date applied for, 11/2/08. Addition to No. 4,814/08.)*†

February 6, 1909.

2,900 MARTIN & JACKSON. Governing the speed of marine engines and turbines electrolytically and electrically.
2,933 FOX & RAILLESS ELECTRIC TRACTION CO. Electric traction systems.
4,932 THOMAS. Electrical controllers.

February 8, 1909.

2,959 TURNER. Dynamos and motors.*
3,002 THOMPSON. Electric tramways or railways.
3,004 ELECTRIC IGNITION CO. & HA L. Electric switches.
3.046 PECK, FAYE-HANSEN & LUSTGARTEN. Alternating-electric current distribution systems.

February 9, 1909.

3,105 SIMPLEX CONDUITS & ELLIOTT. Switches, adapters and wiring connections for controlling two lamps.
3,130 BELCHER. Earthing of all non-conducting parts of electrical tumbler switches.
3,160 HAWKER. Electric switches.
3,174 ODMAN. Starting devices for electric motors.
3,176 DUNNATT. Automatic electric switches.
3,191 CURTIS & ADAMS MFG. CO. Electrical resistances.
3,199 THOMPSON. (Meafabrik Magnet-Elektrischer Apparate G.m.b.H., Germany.) Magneto-ignition apparatus.*

SPECIFICATIONS PUBLISHED.

1907 SPECIFICATIONS.

24,197 LEMOINE. Automatic distribution of telegraphic messages.
27,849 B.T.-H. Co. (G.E. Co., U.S.) Single-phase motor control.
28,652 HOBART, CRAMER & COAD. Electrical distribution systems.

1908 SPECIFICATIONS.

1,450 MAVOR & MAVOR & COULSON. Electrical operation of haulage and winding gear.
2,163 ARCHER. Hauling gear for electric hauling machines.
2,411 STILL. Electric current generators.
2,581 NORTH & ORCHARD. Relay devices for electric circuits.
2,838 AMPHLETT & AMPHLETT. Dynamo-electric machines.
3,154 MUND. Signal apparatus with wireless transmission.
3,248 HOGE & "Z" ELECTRIC LAMP MFG. CO. Supports for filaments in electric incandescent lamps.
3,284 B.T.-H. CO., ROBERTSON & HOLDEN. Electrical power transmission systems.
3,388 HOWELL. Incandescent electric lamps. (Date applied for, 7/8/07.)
3,494 MARCHAL. Charging accumulators.
3,592 GRAMMONT & ROUTIN. Electric servo-motor systems. (Date applied for, 21/2/07.)
3,646 ROBINSON. Prepayment mechanism for electric meters.
4,113 FAIRWEATHER. (Allmänna Svenska Elektriska Aktiebolaget.) Electric polyphase induction machines.
4,246 BRADBURN. Telephone systems.
4,361 MORCOM & MORRIS. Choking coils.
4,637 WAGNER. Electrically-driven trackless train. (Date applied for, 16/3/07.)
4,977 JONES. Arc lamps.
5,042 BEECH. Printing and sight-reading telegraph apparatus.
5,502 GOODWIN & BURGESS. Generation of ozone.
6,370 HARRISON. Electric starting switches.
6,501 CHARLES. Electric switch boxes.
6,765 ENGEL. Electrical contact device. (Date applied for, 27/3/07.)
7,382 ELECTRIC & ORDNANCE ACCESSORIES CO., HALL & MUELLER. Electromagnetic circuit-breakers.
8,467 JACK. Driving and breaking gear for overhead electric cranes.
9,042 HOUGHTON. Electrodes for the application of high-frequency electric currents.
9,851 BOULT. (Union Switch & Signal Co.) Electric signalling systems for railways.
9,859 KALLMANN. Starting devices for electric motors. (Date applied for, 28/10/07.)
10,019 EISENSTEIN. Electrical impulse charges for use in wireless telegraphy.
10,590 B.T.-H. Co. (G.E. Co., U.S.) Electric incandescent lamp filaments.
10,918 BEVIS & COATES. Electrical ignition apparatus for internal-combustion engines.
11,575 WARD. Trolleys for electric tramcars. (Cognate application, 24,099/08.)
11,806 LINDQUIST. Alternating-current electromagnet.
12,009 HOOKHAM. Electricity meters.
12,302 WILKINS & MUIRHEAD & Co. Magneto-electric ignition apparatus.
12,592 IDE. Push-switch lamp-holder for electric light fittings.
12,683 B.T.-H. Co. (G.E. Co., U.S.) Controlling means for air brakes.
13,378 STEPHENS. Electric ignition apparatus for internal-combustion engines.
13,875 STOLZ & VIGGARS. Telephone apparatus. (Date applied for, 13/1/08.)
14,411 BOULT. (Benjamin Electric Mfg. Co.) Terminals or contact-pieces.
16,535 GAIFFE. Electrical condensers. (Date applied for, 8/2/08.)
16,621 B.T.-H. Co. (A.E.G.) Control of electric motors.
17,281 IMBERT. Electric furnaces.
17,331 HUBBELL & FULLER. Reversible galvanic batteries.
17,421 KÖRTING & MATHIESON AKT.-GES. Arc lamps. (Date applied for, 20/8/07.)
17,530 LAND-UND SEEKABELWERKE AKT.-GES. Electric cables. (Date applied for, 7/9/07.)
17,752 LULING. Electric switches. (Date applied for, 31/8/07.)
17,852 DUPONT & HARLE ET CIE. Continuous-current motors. (Date applied for, 27/8/07.)
17,886 FALK. Electric battery.
18,238 KOEPSEL. Electrical method of transmitting movements due to a small expenditure of energy. (Date applied for, 3/9/07.)
18,275 COOPER. Regenerative systems of control for electric motors. (Date applied for, 3/9/07.)
18,460 B,-T.H. Co. (A.E.G.) Commutating devices for dynamo-electric machines.
18,756 ZAHRINGER. Rotary interrupters for magneto-electric ignition devices. (Date applied for, 30/3/09.)
19,052 POPE & O'CONNELL. Supports for filaments of incandescent electric lamps.
19,054 BEACH. Current collectors and control systems of electrically-propelled vehicles. (Date applied for, 26/9/07.)
19,357 BAILEY. Trolley heads for electric traction.
19,720 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke Ges.) Securing the end connections of rotors of dynamo-electric machines.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Co. (Ltd.)

The seventy-fourth ordinary general meeting of this Company was held on Wednesday, under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The SECRETARY (Mr. A. R. Hardie) read the notice convening the meeting and the auditors' certificate.

The CHAIRMAN said: The gross revenue for the half year under review amounted, in round figures, to £566,100, against for the corresponding period of 1907, £595,400, or a reduction of £29,300. This falling off in our receipts extends over nearly every branch of the traffic. The principal reduction, however, is in our Egyptian traffic, which alone shows a decline of £11,000 when compared with the half-year to December, 1907, and is largely due to the cotton strike in Lancashire, this factor also being the principal cause of the falling off of £5,000 in our receipts from traffic with India. On the other hand, I am pleased to record an increase of about £5,000 in our receipts from messages exchanged with South Africa and Turkey. We hope that the improvement in South African traffic is an indication of the revival of trade in that country which has been so anxiously expected ever since the termination of the war, and we trust that the gradual development which is evidently taking place at the present time will prove to be of a permanent nature, and that our revenue from this source will again be maintained at a figure approaching the "Standard Revenue" of £300,000. The total amount of this revenue for the year 1908 was only £235,000. The increase in the Turkish traffic is due to the political changes which have lately been taking place in that country. I am pleased to say that the current year, so far as we have gone, shows an improvement in revenue over 1908. We trust that we have now turned the corner and that the improvement will continue.

Turning now to the expenditure side of the revenue account, it will be seen that the working expenses amounted in round figures to £253,600, against for the half-year ended December, 1907, £251,700, or a decrease of £8,100. The general expenses in London show an increase of £400, and the working expenses at stations are £3,600 more than they were for the corresponding half-year. Of the last-mentioned amount, £800 is due to automatic increases in the salaries of the staff, while maintenance of instruments shows an increase of £1,200, largely due to the introduction of improved apparatus at some of the more important stations. Our contributions towards the expenses of joint stations worked by other companies are also increased to the extent of £600 this half-year. Various other items of expenditure at stations show minor increases, while others show a decrease, the nett increase being, as stated, £3,600. As a set-off to the above-mentioned increases, the expenditure in respect of maintenance of cables, shows a satisfactory decrease of £11,400. As I have repeatedly pointed out at these meetings, this is an item of expenditure which is very difficult to control, and is of necessity of an extremely variable nature, the decrease in the present instance being due to the fact that it has not been necessary to lay in so much new cable when carrying out repairs. In view of the importance of continuing to make substantial contributions to the general reserve fund, we have not on this occasion added to the maintenance ships' fund, especially as this last-mentioned fund has now reached a considerable sum. We are, therefore, able to carry the same amount to general reserve fund as we did in the corresponding half-year of 1907. It was only to be expected that the general depression which has existed for some time past in the trade of the world would, to some considerable extent, reflect upon the traffic receipts of this Company. Our experience in the past has shown that no surer signs of the rise and fall of the commercial barometer can be found than in the study of the variations of the traffic receipts of submarine cable companies, and perhaps this is more marked in the case of this Company, whose revenues are derived from so many of the trade centres of the world. Although we have suffered in common with almost every other commercial undertaking, I am glad to say that we have been able to maintain the payment of the usual dividend and bonus on the ordinary stock, and make a substantial contribution to our general reserve fund, but the result of the working for the whole year ended Dec. 31, 1908, shows that we have carried £20,000 less to that fund and £7,000 less to the maintenance ships' fund than we did in the year ended Dec. 31, 1907. Had we not anticipated the loss of revenue which we foresaw was likely to occur during the year 1908, and provided for it by carrying forward from the 1907 accounts a balance of nearly £35,000 more than usual, the total contribution to the general reserve fund for the year 1908 would have compared still more unfavourably with the preceding year.

On July 1st next the alterations in the rules and regulations of the International Telegraph Convention, approved by the Lisbon conference of 1908, come into operation. There is very little in the alterations that affects this Company, but I may perhaps call attention to an existing anomaly in counting official code words which this Company was anxious to abolish. The regulations allow any pronounceable combination up to 10 letters to be accepted, but combinations composed of bona fide words are excepted. "Abobarbate" is accepted as a legitimate combination, but "Canyoucome," whether used as plain language or joined together as a code word, is charged as three words. This regulation has given rise to many disputes between our customers and ourselves, and the Companies expressed their willingness to accept any combination in artificial language that could be pronounced, whether composed of groups of plain language words or purely artificial combination. The Companies' proposition, which, no doubt, would have been a convenience and saving to the public, was fully

discussed at the Conference, and although the Governments recognised that the Companies were right in principle, they were, owing to financial reasons, forced to refuse the suggested alteration. A large proportion of European correspondence passing over the landlines or cables owned by the European Governments consists of plain language messages, and if the alteration in the rule had been passed the public would have been able to join any plain language message together and divide the total number of letters by 10 and so arrive at the number of paying words, but the estimated loss of revenue to the European Governments would, in consequence, have been so large that their representatives felt that the Companies' proposition could not be accepted. It is right for me to observe in this connection that, owing to the Companies' ordinary traffic being composed almost entirely of code language of about 10 letters, their revenues would not have been materially affected by the alterations we proposed. I now move the adoption of the report and accounts and the declaration of the dividends and bonus therein set out.

The VICE-CHAIRMAN AND MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the resolution, which was carried unanimously.

A cordial vote of thanks to the chairman, directors and staff (to whom the proposer, Mr. Agius, paid a warm tribute) was adopted, and the proceedings terminated.

Eastern Extension Australasia & China Telegraph Co. (Ltd.)

The seventy-first half-yearly ordinary general meeting of this Company was held on Tuesday, Sir John Wolfe Barry, K.C.B., presided.

The GENERAL MANAGER and SECRETARY (Mr. F. E. Hesse) read the notice calling the meeting, the minutes of the last meeting and the report of the auditors.

The CHAIRMAN said: Gentlemen, the gross revenue for the half-year under review amounted to £306,889, against £304,416 for the corresponding period of 1907, showing an increase of £2,473. Unfortunately this increase is more apparent than real, seeing that the revenue for the past half-year includes £10,000 which the Company earned over the Tasmanian cables in previous years, but for which the Australian Federal Government refused to account until they were compelled to do so by the decision of the High Court, as I explained when I last had the pleasure of addressing you six months ago. If this exceptional revenue be deducted, the figures show an actnal decrease for the half-year of nearly £8,000, which is due to the commercial depression that has prevailed for some time past in all parts of the Far East. I am, however, inclined to think from slight indications of improvement recently noticeable in the Straits Settlements and elsewhere, that we have seen the worst of this commercial depression, and, I venture to hope, that before very long the financial situation in the countries served by our cables will improve.

Passing to expenditure, it is to be noticed that the working expenses during the last half-year, amounted to £151,507, against £154,203 for the corresponding period of 1907, showing a decrease of £2,696. The net profit for the half-year was roundly £137,000, and after adding nearly £66,000 brought forward from the previous half-year, there remained an available balance of £203,000 (applause). The usual quarterly interim dividends of 2s. 6d. per share were paid during the past year, and it is now proposed to distribute a final dividend for the year of like amount, making a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution for the year 1908 of 7 per cent. on the share capital. The usual additions have been made during the past year to the maintenance ships', insurance, and depreciation Funds, and after applying £50,000 of the revenue balance to the general reserve fund, the sum of £18,005 is carried forward. The balance of cost of the Java-Cocos cable, amounting to £8,710, has been debited during the past half-year to the general reserve fund, together with £1,519 for the partial renewal of the Singapore-Banjoewangie cable, leaving to the credit of this fund £1,034,345. It will have been seen from newspaper references on the subject that the Company's cable steamer "Patrol" was unfortunate enough to run on to a shoal when proceeding last autumn to a cable repair in the Netherlands Indian Archipelago. Thanks, however, to the valuable help rendered by the Netherlands Indian Government in promptly sending one of their warships to the assistance of the "Patrol," and to the other facilities available at the time, the cable steamer was got off the shoal in a comparatively short time, without sustaining any material damage and at a very small cost to the underwriters. We desire to record our acknowledgments to the Netherlands Indian Government for their assistance, as also for several other instances of their goodwill towards the Company, which we greatly appreciate. (Cheers.)

When addressing you six months ago, I referred to the Company's unsatisfactory relations with the Australian Federal Government, and to the necessity for closing our Tasmanian stations when the concession giving us exclusive rights of cable communication between Australia and Tasmania expired, unless some arrangements were previously made with the Government on the subject. Unfortunately, the latter event has not taken place, and our Tasmanian stations were therefore closed on the 30th ultimo, when the concession expired, and the two cables recently laid by the Government between Australia and Tasmania were opened for traffic. The cable communication between those countries is consequently now carried on by the Government, and our cables will be picked up when a suitable opportunity occurs in order that we may utilise them elsewhere. I now move the adoption of the report and accounts, and the payments of the dividend and bonuses therein recommended.

The Marquis of TWEEDDALE, K.T., seconded the resolution, which was unanimously carried.

The retiring Directors, Sir John Denison-Pender, K.C.M.G., and the Hon. George Peel, and the retiring auditors, were then re-elected.

Mr. LYTH stated that at the last meeting he referred to the question of the division of the dividend. The dividend of 7 per cent. had now been paid for many years, and he was sure that his brother shearholders and himself were very grateful to the management that they had been able to maintain the dividend at that rate for so long; but he ventured to suggest that the division of the dividend which was paid quarterly might be arranged in a different manner. It had been the custom to pay 2s. 6d. per share for three quarterly periods, and in the fourth period to pay 6s. 6d. No doubt the word "bonus" sounded very nicely, but when a bonus was declared year after year it came to be regarded as part of the dividend, and he ventured to suggest to the Chairman and the Directors that it would be a convenience to the shareholders—and especially to the larger shareholders—if the dividend were divided in such a manner that a larger proportion of it might be paid in the first three quarterly periods and a smaller proportion in the final quarter—an arrangement similar to that carried out in the case of the Western Telegraph Co.

The CHAIRMAN: The matter shall be considered by the Directors before the next meeting. I am not at all clear whether we shall be able to meet Mr. Lyth in the way he wishes, but we will consider the point.

Mr. JOHN NEWTON in proposing a vote of thanks to the Chairman, Directors and staff, said it might not be strictly relevant to refer to the question of dividend, but he would like to say that it would be of great benefit to the property as an investment if the dividends were apportioned as was done by the Western Telegraph Co. He thought it likely that the shares would stand firmer and at a higher level, without fluctuation, if the dividends were more equally divided. He did not think there was any chance of the bonus being reduced, although, of course, the Directors knew the position better than he did; but the Chairman stated on a previous occasion that he would have the courage to utilise the reserve fund in case of a temporary necessity. He had great pleasure in proposing a vote of thanks to the Chairman and his colleagues for their continuous successful administration of the Company's affairs.

Mr. LYTH seconded the motion, which was carried unanimously.

The Chairman having returned thanks, the proceedings terminated.

Western Telegraph Co. (Ltd.)

The seventy-first ordinary general meeting was held on Wednesday, under the presidency of Sir John Wolfe Barry, K.C.B.

The SECRETARY (Mr. E. Steer Hodson) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, the remarks which I made when I had the pleasure of addressing you in November last perhaps prepared you for a decrease in our traffic revenue for the six months ended Dec. 31. The reduction is not so great as was at one time expected, some improvement being manifested during the last few weeks of the year. The message receipts, however, show a falling off of £13,624, and rents, interest on deposits, &c., were less by £383, together £14,007. This is reducible by an increase in the interest received on investments, amounting to £3,860, making a net decrease of £10,147. On the other side of the account, the general expenses, maintenance of cables, and income tax were more by £8,007, the result being that our net earnings were less by a little over £18,000. The decrease in message receipts occurred in Brazil, the River Plate and on the West Coast of South America, but more especially in the last-named district. The general expenses in London show an increase of £295, and those at the stations a net increase of £3,994. The other expenses call for no special remark with the exception of those in connection with improved apparatus, as the further installation of automatic and relay instruments caused an additional cost of over £1,500. The cable used in the maintenance of our submarine lines accounts for an increase of nearly £1,000. The result of the account is this—that after providing £16,000 for debenture stock interest and £5,661 for income tax there remains a balance of £188,333; to this is added the sum of £4,259 brought forward from June 30 last, making a total of £192,593. First and second interim dividends, amounting to £62,379, have been paid, and after transferring £100,000 to the general reserve fund, £5,000 to the maintenance ships' reserve fund, £10,000 to the marine insurance fund and £10,000 to the land and buildings depreciation fund, there remains a balance of £5,214, which is carried forward to the next account. A reduction of the tariff with the west coast of South America was made on the 1st inst. Negotiations are at present proceeding on our behalf with the Brazilian and Argentine Governments with regard to improved submarine telegraphic communication, but I am not yet in a position to enter into details on the matters. The tendency to growth in the cost of conducting the business of submarine telegraphy is noticeable, and this is in spite of our efforts in the direction of economy. The facts are that to obtain a really efficient service, which ours admittedly is, we must keep abreast of the time—both in improved apparatus, constant repairs and additions to our cables, and also in maintaining a highly trained and skilled staff. By these means we maintain our position in the face of competition at some of our most important centres, and we venture to think that we have secured the confidence of our clients and of the Governments of the countries with which we are connected. I now move the adoption of the report and accounts.

The DEPUTY CHAIRMAN (Sir J. Denison-Pender, K.C.M.G., seconded the motion, which was carried unanimously.

There being no other business, a vote of thanks to the Chairman and Directors terminated the proceedings.

West African Telegraph Co. (Ltd.)

The twenty-fourth ordinary general meeting was held on Wednesday, under the presidency of the Most Hon. the MARQUESS OF TWEEDDALE, K.T.

The SECRETARY (Mr. John Cambrook) read the notice convening the meeting and the auditors' report

The CHAIRMAN said: Gentlemen, the gross revenue for the year under review amounted, in round figures, to £56,300, against, for the year 1907, £59,200, or a decrease of £2,900. Our proportion of the receipts from the South African joint purse continues to decline, and is this year £990 less than the preceding year. I am, however, pleased to be able to state that the current year, so far as we have gone, shows indications of an improvement in this branch of our revenue. The Portuguese traffic shows an increase of £1,160 over 1907, and interest on reserve fund investments for 1908 amount to £1,000 more than in 1907. The diminution in our receipts is, in the main due to exchange, which has adversely affected our revenue to the extent of £3,900. Fluctuations, as you are aware, in the rate of exchange have marked the progress of the Company from the beginning. It was only two years ago, you may remember, when I reported to you a profit on exchange of £1,000. We hope soon to return to those better times. As regards the expenditure side of the account, there is little to which it is necessary for me to draw special attention. I may, however, point out that, although the working expenses of stations show an increase over last year of £700, the total working expenses were £945 less, owing to a reduction of £1,700 in the expenses attending maintenance of cables, which may be considered very satisfactory. I mentioned at our last meeting that the total cost of the renewal of the St. Thomé-Loanda section of our cables had not then been ascertained, but I am now able to inform you that the actual sum expended was £10,899. The final figure of £2,274 appears this year as a charge against the general reserve fund.

The MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the motion, which was carried unanimously.

The retiring director and auditors were re-elected, and the proceedings closed with a vote of thanks to the chairman, directors and staff.

West Coast of America Telegraph Co. (Ltd.)

The twelfth ordinary general meeting was held on Tuesday, under the presidency of Sir JOHN DENISON-PENDER, K.C.M.G.

The SECRETARY (Mr. Fred. L. Robinson) having read the notice calling the meeting and the auditors' certificate,

The CHAIRMAN said: There is nothing very important for me to bring to your notice to-day, either in favour of or against the working of the Company during the last 12 months. With regard to the gross receipts, you will see that there is a decrease of £9,242. This falling off is on account of the international traffic, and this is owing, to a great extent, to the stagnation of trade, and also to the reduced local traffic—chiefly, I think, due to the earthquake at Valparaiso and the effect it has had on the general business of that country. With reference to the working expenses, there is a reduction of £1,426. Salaries and wages show an increase of £270, but travelling expenses are less by £313, electrical expenses by £303, and stationery by £487. The material item which has caused the reduction in the expenses is owing to our having been fortunate enough during the year under review to get a charter for our repairing steamer; that gave us £1,500. The interruptions that have taken place during the year were six in number, which lasted for 57 days. That is a considerable time, but it was owing to two or three of the interruptions—three certainly—having taken place in the month of February. The steamer, therefore, had of course to effect the repairs one at a time. At the last meeting I referred to the new steamer we were about to build, our old steamer being about 30 years old, and practically beyond the work of a cable-repairing steamer, although she might still be a good vessel for cargo work or work of that description. Within the last four months the Directors have accepted a contract from the Goole Shipbuilding Co. to build a steamer, which will be engined under the same contract by Richardson, Westgarth & Co., and we hope within six months to have that steamer on the station at a cost of under £20,000, which, I think, is a very moderate price for the ship we are getting. With reference to the future, I can only say that notice has been given within the last month by our adversary of a reduction of the rates to Chile, Peru and Bolivia, and the reduction came into force on the 1st inst. I cannot say yet—it being early days—how that will affect our receipts. I now move the adoption of the report and accounts.

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E., seconded the motion.

Mr. LYTH said that he had been a shareholder for many years, and was a holder at the original price of the shares—£10. He was also a holder of debentures, which originally bore 8 per cent., but which was reduced to 4 per cent. The Chairman at the time gave him reason to think that the result of the change would be that good dividends would be paid, but he did not think that 2½ per cent. could be regarded as a good return. 5 per cent. would be only a moderate return. He might be told that the debentures would in due time have to be met or partially renewed, but he thought that the existing generation of shareholders ought to derive some benefit during their lifetime from the traffics which were now being obtained. He hoped that the Directors would sympathise with that view.

The CHAIRMAN: With respect to your remarks, I can assure you that we sympathise with you and ourselves, and we are doing the very best we can to improve matters. You must remember that a good many years ago we worked in conjunction with a company which, when they got on their legs—owing greatly to their association with this Company—threw us over, and our working expenses were thus very materially increased—in one case, certainly, by each of us having to put a ship on to the station instead of our having only one to do the work of the two companies. Competing cables were also laid alongside ours. In 12 months that reduced the Company from a prosperous one to one not paying a dividend. This was before my time, and also before any of the present members of the board were associated with the Company. But the Western Telegraph Co. then came forward, and materially strengthened the position of the West Coast of America Co. If it had not been for that assistance I do not think we should have been in existence to-day; our undertaking would very likely have been sold for an old song to the competing company. Our condition is quite different to-day. It may be said that we have reserves amounting to about £80,000, but the actual amount is £66,000 plus £12,000 for the ship's reserve. We have to find this year about £20,000 to pay for the new ship and put her on the station. Of course, that amount will be reduced by any credit we may obtain from the sale of the old ship. We are, however, gradually bringing up the reserve, which now amounts to £66,000; I put the ship's reserve aside, as that has practically gone, and more. I think you must allow the Directors to go on strengthening the position of the Company before we increase the dividend. You have your debenture interest to meet as well as the interest on your income bonds, but our position is certainly getting better, although our progress is very slow, I admit. If we could increase our dividend no one would be more pleased to do so than ourselves; but we shall always err on the side of caution, and work the Company into such a financial position that it will have considerable strength. That must be done at a certain sacrifice with respect to the dividend. Our capital is £280,000, and £60,000 reserve is a very poor amount when you come to think that a great part of that capital is in income bonds and debentures which have to be met in 1917. We shall be able, no doubt, to renew some of the debentures, but you must have a backing to balance the amount. It is not likely that we shall be able to renew the whole, because the cable is very much older now than when the debentures were originally issued. You must also remember that the reason we have had to put so much to reserve is that we started without any reserve at all. We shall, however, do the best we can, and, naturally, the Directors would be very pleased to add another 1 per cent. on to the dividend if they could possibly see their way to do it.

The resolution was then carried unanimously.

Resolutions sanctioning the dividend and re-electing the retiring director and auditors were then passed, and a vote of thanks to the chairman and directors brought the proceedings to a close.

Submarine Cables Trust.

The thirty-eighth ordinary annual meeting was held yesterday under the presidency of the MARQUIS OF TWEEDDALE, K.C.

The SECRETARY (Mr. Sidney Collett) read the notice convening the meeting and the report of the auditors.

The CHAIRMAN then said: Gentlemen, the receipts for 1908-9 amounted to £25,433, leaving, after deducting expenses, £24,266, as against £22,784 in the previous year. The net result is that after adding £49 brought forward from last year to our receipts, we have an available balance of £24,315. We have paid the two half-yearly coupons, amounting in all to £18,105, leaving a surplus of £6,210. This surplus has enabled us to purchase 50 certificates (the largest number ever acquired in any year out of the surplus funds of the Trust). This absorbed £5,982. 1s. 6d., leaving £228. 8s. 4d. to be carried forward. Up to the present time we have acquired 1,208 certificates, out of the original 4,200, leaving 2,992 still outstanding. I may add that the market values of the securities we hold show an appreciation over original cost of nearly £185,000, or an increase of more than £5,000 over last year. I now move the adoption of the report and accounts.

Sir JOHN DENISON-PENDER, K.C.M.G., seconded the motion.

Mr. E. W. GREENE referred with satisfaction to the improvement in the position of the West India & Panama Telegraph Co., one of the Trust's investments, and remarked that, although the amount involved was not large, it would be very satisfactory to receive a dividend on the ordinary shares held in that company. In other respects, the dividends received and the position of the Trust appeared to be stable. He afterwards inquired how the position stood with reference to the winding-up of the Trust.

The CHAIRMAN: With regard to the termination of the Trust, should our income remain the same as it is now, the last certificate will be acquired in 1936, when the securities will be sold and the proceeds be distributed among the holders of the coupons of reversion, and the Trust will then come to an end. With reference to the West India & Panama Co., their affairs are improving. Everything otherwise in connection with the Trust is in a perfectly satisfactory condition. He then put the motion, and it was carried unanimously.

The retiring auditors having been re-elected, a vote of thanks to the chairman and trustees brought the meeting to a close.

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—Mr. C. S. Hilton stated at the meeting last week that the traffic receipts were less by £2,262, mainly due to competition of the Corporation tramways. The electric lines had maintained their position fairly well. The expenses showed a decrease of £5,594, due to the lesser amount paid for insurance, &c. The net result was an improvement of £1,200. They were unable to come to a friendly agreement with Handsworth Council for the sale of the lines to them, and the matter would now go to arbitration.

ALDERLEY & WILMSLOW ELECTRIC SUPPLY (LTD.)—At the recent meeting the directors' report for the year ended Dec. 31 stated that the total connections had increased from an equivalent of 16,269 to 17,725 8 c.p. lamps. The profit of the year was £1,745. 6s. 8d.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—For the year ended Dec. 31, 1908, the gross profit was £28,213. 6s. 8d. Debiting general charges and maintenance, the net profit is £2,614. 6s. 2d. Debenture and other interest charges absorbed £17,798. 3s. 2d., and £24,173. 13s. 3d. has been added to meet bad and doubtful debts and depreciation of stocks. The directors propose to apply £10,229. 9s. 6d. standing to credit of general reserve towards writing off the loss on the year's working, and to carry forward the debit balance of £29,128. 0s. 9d. The report states that the year under review has been one of exceptional trade depression in which the engineering industries have been especially affected. The aggregate of orders secured during the first part of the year was below the average, but it was expected that, in accordance with previous experience, the results for the latter part of the year would help to counteract this shortage. Unfortunately this was not realised, and the concluding months showed a further marked falling off in the volume of business. The working expenses and establishment charges have, in spite of the abruptness with which trade declined, been substantially reduced and important economies have been effected. The shortage of orders has aggravated the already keen rivalry amongst home manufacturers, and with powerful competition from abroad to contend with, prices have ruled low. On the electrical engineering side, the company's business has been adversely affected by the general adoption of metal filament lamps. By the use of this new type of lamp a great economy in current is effected. While its advent should, therefore, be highly beneficial to the electrical industry in the long run, the immediate effect has been to leave many electricity undertakings with a surplus of power, thus temporarily checking the orders for additional plant. Negotiations are in progress to acquire selling rights of a well-tried and highly successful metallic filament lamp. The demand for tramcars was small during the year, and there has been a noticeable lapse in the promotion of tramways and light railways in the United Kingdom. Orders for main line rolling stock have also been scarce. The reduced demand for the company's staple manufactures has led the directors to investigate other openings for activity in the industrial applications of electricity, and the company's experts are engaged on developments in special branches which hold out encouraging prospects. The business so far secured in the present year shows a marked advance in comparison with a similar period in 1908.

DOULTON & CO. (LTD.)—At the meeting on Tuesday it was reported that, after including £7,999 contributed by the chairman towards providing for the preference dividend, and writing £500 off goodwill, the credit balance was £1,506.

ELMORE'S GERMAN & AUSTRO-HUNGARIAN METAL CO. (LTD.)—The directors' report for 1908 states that the only alteration in the accounts is that the amount of 8 per cent. debenture stock has been reduced by the redemption of £5,778. 10s. and the loan to the Metall Co. has been reduced by a like amount. The directors report an unsatisfactory year owing to the continued decrease in trade and increase in competition, resulting in a reduction in the selling price. The sales have increased and the cost of production reduced to a considerable extent, the sales to date showing an increase of 15¼ per cent. in weight. The amount standing to credit of profit and loss in the Austrian Co.'s balance sheet being only £389. 8s. 10d., the directors regret their inability to declare a dividend.

FALKIRK & DISTRICT TRAMWAYS CO.—At the meeting last week, the directors reported that the profit was £723, after placing £1,750 to depreciation. The directors recommended that no dividend should be paid, as the district had been very much affected by trade depression.

GENERAL ELECTRIC CO. (U.S.A.)—The annual report for the year ended Jan. 31 states that the profits (including $35,918 for securities sold and $1,453,942 from royalties, dividends, &c., and after deducting all patents, general and miscellaneous expenses, fixed charges, allowances for depreciation and losses, and writing off $1,524,295 from factory plants) were $4,802,250. After meeting dividend payments there was a deficit of $411,773, which was charged to surplus account. The year was marked by severe and continued depression in the business of the company. The value of orders received during the year was only 70 per cent. of that for each of the two previous years, and shipments to customers only 63 per cent. of the shipments for 1907. The great and sudden shrinkage in business had, because of the difficulty in reducing expenses, resulted in great increases in the ratio cost of selling prices, with a corresponding decrease in the percentage of profits. Since the close of the year these conditions have improved, and the outlook for the ensuing year is said to be encouraging. The total number of separate orders and contracts received was 248,384, compared with 236,864, an increase of 11,520, but the average value per order was 30 per cent. less. During the year there was expended in acquiring patents, for licences under patents and in patent litigation $929,109. The plan of decentralisation has been continued with satisfactory results. Each line of apparatus, such as switchboards, induction motors, steam turbines, meters and transformers, has been placed in its respective building or factory. Each group is supplied with a special set of engineers, manufacturing staff and clerical force, with a separate factory accounting system. The total floor space of factories on Jan. 31 was 7,000,000 sq. ft., and the number of employés 23,300. Among the buildings completed during the year was one with 142,000 sq. ft. floor space at Schenectady for the manufacture of wiring devices; a building of 99,000 sq. ft. floor space at Lynn, for meters and instruments; an iron foundry of 59,000 sq. ft. floor space at Pittsfield, and buildings of 92,870 sq. ft. for lamp works. Work has been resumed on a building of 71,000 sq. ft. at Pittsfield, to be used as carpenter and pattern shops and for pattern storage.

Vice-President E. W. Rice, jun., in his report, states that experience in the use of the high electric pressures of from 60,000 to 100,000 volts, needed for the economical distribution of electricity over very long distances, has been so satisfactory that higher pressures up to 150,000 volts are being considered in pending propositions. In this connection, it is stated that the sales of transformers of 60,000 volts and over in 1908 were nearly double those in 1907. Many improvements have been made in switches for the control of high-tension circuits, and there have been designed and placed in commercial operation switches capable of controlling 110,000 volts, which is the highest voltage now in practical operation. Two 14,000 kw. turbines, placed in operation in Chicago, and two in New York, have proved satisfactory in every respect, and orders for additional units of the same size have been received. The company engineers have completed the design of a number of turbine generators for operation by low pressure or exhaust steam. The economic value of these machines is based upon the fact that steam turbines are much more efficient than steam engines in the lower range of steam pressures between atmospheric pressure and a good vacuum. Turbines of this character have been designed up to 500 kw. capacity, and it is expected that they will, by utilising the exhaust steam from one of the existing engines, increase the capacity of the combined unit more than 40 per cent., with a substantial reduction in coal consumption. The Curtis steam turbine has been adapted to the driving of centrifugal pumps, and the city of San Francisco has purchased eight 750 H.P. and four 600 H.P. turbine pumps for a high-pressure water system. This is stated to be the first important application of steam turbines to this class of service. The new type of commutating pole railway motor has proved most satisfactory in practical operation, and large numbers have been sold. Several new sizes have been developed. The 1,200 volt railway system has been further perfected, and the installations already made have proved an unqualified success. The vertical type of rotary converters of the company's design has continued to give satisfaction, and many additional installations have been made during the year. A number of these vertical rotaries are being built of 2,500 kw. capacity, which are claimed to be the largest rotaries constructed. An especially interesting application of electricity is exemplified in an order received during the past year for the complete electrical equipment of two power stations and an electric transmission plant furnishing power and light for the construction of the dam at Gatun, Isthmus of Panama. The order includes 12 special electric locomotives and a number of special motors.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—For the year 1908 the profit was £21,644. 10s. 7d. Including amount brought forward the total balance was £6,556. 18s. 8d. A dividend has been declared and paid at the rate of 6 per cent. per annum on the preference shares for the six months ended March 31, and the directors recommend that a dividend be paid at the rate of 3 per cent. per annum for the six months ended Dec. 31 on the ordinary shares, making 4 per cent. for the year. There was an increase in the amount of power sold, and although the profit is not so large as last year, the directors consider the results satisfactory in view of the lower average price obtainable for power, the increased cost of fuel, &c.

LISBON ELECTRIC TRAMWAYS (LTD.)—At the meeting on Wednesday Col. Sir C. Euan-Smith stated that notwithstanding the political unrest during the year their traffic had shown a slight increase. The serious depreciation in the rate of exchange had, however, made a difference of £12,000 to them. They were only able to carry forward, after the declaration of the dividend, £4,640. 4s. 2d., against £13,271. 9s. 1d.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—The receipts for 1908 amounted to £108,722. 7s. 3d. The traffic receipts (£92,330. 7s. 9d.) show a decrease of £3,223. 10s. 4d. Deducting all expenses chargeable to revenue, the directors recommend that £5,409. 14s. 7d. be applied to permanent way renewals account, £1,000 to depreciation and £2,000 to general renewals account, and after paying the preference dividend (£12,250) the balance (£1,121. 3s. 11d.) is carried forward. Capital expenditure during the year amounted to £4,930. 1s. 1d.

RANGOON ELECTRIC TRAMWAY & SUPPLY CO. (LTD.)—The directors report to Nov. 30, in Rangoon, and Dec. 31, in Liverpool, states that during the year an additional 1,500 kw. turbine has been installed. Traffic receipts give fair satisfaction. Municipal street lighting was finally completed on July 1, and the company has just been granted a licence by the Government of Burma to light the military cantonments of Rangoon. During the year some progress has been made in the private lighting department, and the directors look for a substantial increase of consumption during the present year. The company is also to supply electrical energy to the Government buildings in Rangoon. The gross profit was £26,059. 0s. 4d. Deducting Liverpool expenses, interest, &c., the balance is £13,396. 2s. 8d., added to £439. 19s. 6d. brought forward. Preference dividend absorbed £12,278. 13s. 1d., and, after writing £1,174. 6s. 8d. off preliminary expenses, the balance has been carried forward.

SWANSEA IMPROVEMENTS & TRAMWAYS CO.—The gross receipts of the tramways undertaking for the half-year to Dec. 31 were £27,362. 2s. 8d., a decrease of £454. 16s. 9d. on the corresponding period last year. The available balance is £8,760. 19s. 3d., and the directors recommended that £2,000 be placed to depreciation and reserve, and, after payment of the preference dividends, a dividend at the rate of 3 per cent. on the ordinary shares was declared.

THAMES IRONWORKS, SHIPBUILDING & ENGINEERING CO. (LTD.)—The report for 1908 states that, after adding debenture interest, writing down investments, &c., there was a loss of £36,279. Deducting £19,539 brought forward, there remained an adverse balance of £16,740. It was proposed to transfer £20,000 from reserve, and to carry forward £3,260.

TYNEMOUTH & DISTRICT ELECTRIC TRACTION CO. (LTD.)—At the recent meeting the directors reported that the past year's revenue was £12,151. 7s. 3d., and after deducting expenses (including repairs and maintenance, interest and renewals) the balance was £3 542. 1s. 11d., added to £226. 9s. 4d. brought forward. £500 was placed to depreciation and reserve and £500 to sinking fund for debenture redemption. Preference dividend absorbed £1,525, and a dividend of 2 per cent. was declared on the ordinary shares (£928. 4s.). The balance forward is £315. 7s. 3d.

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The directors' report for the six months ended Dec. 31 states that the amount to credit of revenue (including £2,000 transferred from income tax account) is £34,871. 14s. 5d., against £37,252. 7s. 11d. for the corresponding half-year of 1907. Expenses have been £22,160. 3s. 3d., against £25,028. 3s. 5d. The balance is £12,711. 11s. 2d., added to £1,466. 16s.4d. interest on investment and £1,132. 1s. 8d. brought forward, making £15,310. 9s. 2d. The directors propose that this amount be dealt with by paying on the first preference shares a dividend of 6s. per share for the six months to Dec. 31 (£10,368. 18s.) and on the second preference shares 18s. per share on account of dividends accrued to Dec. 31 (£4,202. 2s.), the balance (£739. 9s. 2d.) being carried forward. The traffic receipts for the six months show a decrease of £3,231, compared with those for the corresponding period of 1907. The company's cables continue to be maintained in good working order.

NEW COMPANIES, STATUTORY RETURNS, &c.

NEW COMPANIES.

DAVEY ELECTRIC CO. (LTD.) (102,814.)—Reg. May 3, capital £2,000 in £1 shares, to carry on the business of electrical, mechanical and general engineers, manufacturers of and dealers in electric lamps, electricity meters, switches, cut-outs, &c. Private company.

DUAL IGNITION CO. (LTD.) (102,902.)—Reg. May 8, capital £100 in £1 shares, to carry on the business of manufacturers of appliances for the electrical ignition of internal combustion engines, electricians, manufacturers and warehousers of motors, automobiles, &c. Private company. Reg. office, 23, Colmore-row, Birmingham.

MOUNTAIN & GIBSON & THORNEWILL (LTD.) (102,873)—Reg. May 6, capital £150,000 in £1 shares, to acquire the business carried on by Mountain & Gibson (Ltd.) at Elton Fold Works, Bury, and to carry on the business of civil, mechanical, electrical, railway, tramway, marine, lighting, ventilating, consulting and general engineers, founders, machinists, suppliers of electricity, manufacturers of and dealers in railway, tramway and road locomotives, carriages, cars, motor cars, trucks, &c. First directors, R. Thornewill, J.P., M.I.M.E., E. D. Simon, B.A., A.M.I.C.E., M. B. Mountain, C. Spalding, G. M. Gibson, B.A., A.M.I.C.E., and N. M. Lawrence. Reg. office, 49, Queen Victoria-street, London, E.C.

NATIONAL TELEWRITER CO. (LTD.) (102,859.)—Reg. May 5, capital £300,000 in 210,000 preferred ordinary shares of £1 each and 90,000 deferred shares of £1 each, to acquire upon terms of an agreement with the Telewriter Synd. the patents and licences and the benefit of certain agreements in connection with the use of the telewriter and other property and rights, and to carry on the business of manufacturers of and dealers in dynamos, wire, cables, insulating materials, accumulators, telephones, telewriters, telautographs and other apparatus, electricians, &c. First directors, Sir William P. Treloar, Bart., A. R. Prideaux, Sir John G. Craggs, Kt., M.V.O., E. B. Ellice-Clark, E. W. W. Edwards, J. Liddell and Sir Albert K. Rollitt. Reg. office, 4, London Wall-buildings, London, E.C.

POLLAK VIRAG RAPID TELEGRAPH CO. (LTD.) (102,910.)—Reg. May 8, capital £100,500 in 100,000 preferred ordinary shares of £1 each, and 10,000 deferred shares of 1s. each, to adopt an agreement with P.-V. Synd., to carry on the business of a telegraph, telephone and electricity supply company, to establish, control and regulate telephone and telegraph exchanges, to transmit and facilitate the transmission of telephonic and telegraphic commmunications, &c. Three of the first directors shall be nominated by the Société Générale de Télégraphie Rapide (Pollak Virag) and two of the first are H. F. Bouillon and Bela Steiner, managing director and director respectively of the said society. Registered by Slaughter & May, 12, Austin Friars, London, E.C.

PROCKTER & KENYON (LTD.) (102,894.)—Reg. May 7, capital £1,000 in £1 shares, to carry on the business of mechanical, electrical and general engineers, &c. Private company. First directors, C. Kenyon and F. M. Prockter. Reg. office, Sun Life Buildings, 30, Cross-street, Manchester.

ROBINSON & CARTER (LTD.) (102,864)—Reg. May 5, capital £1,000 in £1 shares, to carry on the business of electricians, engineers, manufacturers of electricity, &c. Private company. C. A. Robinson is permanent governing director.

STRATHPEFFER & DINGWALL ELECTRIC CO. (LTD.) (7,111.)—Reg. in Edinburgh May 5, capital £100 in £1 shares, to carry on at Strathpeffer and Dingwall the business of electricians, electrical and gas engineers, suppliers of electricity, &c. Major E. W. B. Mackenzie is one of the first directors. Reg. office, Kildary, Ross-shire.

STATUTORY RETURNS.

NORTHALLERTON ELECTRIC LIGHT & POWER CO. (LTD.)—Return to March 10 gives capital as £6,500 in 2,900 preference shares of £1 each and 12,000 ordinary shares of 6s. each, of which 1,151 preference and 4,561 ordinary have been taken up. £2,519. 6s. has been received. Mortgages and charges at date of return, £5,400. Issued April 7, 1909, £260.

POWER PLANT CO. (LTD.)—In return to March 22 capital is £5,000 in £1 shares, all of which have been taken up. £4,992 has been received, leaving £8 in arrears. Mortgages and charges, £5,000.

SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)—Return to March 15 gives capital as £500,000 in 250,000 ordinary, 100,000 second preference and 150,000 first preference shares of £1 each, of which 123,000 ordinary, 50,000 second preference and 142,968 first preference have been taken up. £1 per share has been called up on 120,500 ordinary and 137,600 first preference and 5s. per share on 50,000 second preference shares, and £270,600 has been received. £7,868 is considered as paid on 2,500 ordinary and 5,368 first preference. Mortgages and charges, £254,175.

YORKSHIRE (WEST RIDING) ELECTRIC TRAMWAYS CO. (LTD.)—According to return to March 19 capital is £600,000 in 70,000 preference and 50,000 ordinary shares of £5 each, of which 46,261 preference and 40,000 ordinary have been taken up. £431,305 is considered as paid. Mortgages and charges, £299,000.

MORTGAGES AND CHARGES.

ENGINEERING INSTRUMENTS (LTD.)—Particulars of £5,000 debentures created Nov. 30, 1906, filed pursuant to sec. 93 (3) of Companies (Consolidation) Act, 1908, amount of present issue being £380. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

HARPER ELECTRIC PIANO CO. (LTD.)—Issue on April 27 of £500 debentures, part of series to secure £5,000.

LEICESTERSHIRE & WARWICKSHIRE ELECTRIC POWER SYND. (LTD.)—Issue on April 19 of £550 debentures, part of series created July 9, 1907, to secure £5,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees.

POPE'S ELECTRIC LAMP CO. (LTD.)—Land registry charge on freehold land and premises at Hammersmith, dated April 16, 1909, to secure all moneys due or to become due from company to London, City and Midland Bank.

RECEIVERSHIP.

AUTO CLAW CO. (LTD.)—A notice of the appointment of Mr. J. Todd, of 135, Wool Exchange, E.C., as receiver and manager, by order of Court dated April 30, 1909, has been filed.

CITY NOTES.

MEMORANDA (May 13).—**Bank rate** $2\frac{1}{2}$ **per cent.** (since April 1, 1909). **Price of silver,** $24\frac{3}{16}$**d. per oz. Consols** $84\frac{15}{16}$—$85\frac{1}{16}$ **for money and** 85—$85\frac{1}{8}$ **for account. Consols Pay Day,** June 1; **Stock and Shares Continuation Days,** May 25 and June 9; **Ticket Days,** May 26 and June 10; **Pay Days,** May 27 and June 11; **Mining Shares Carry Over Day,** May 24.

PRICES OF METALS (London).—*Copper*, cash, $59\frac{1}{16}$; three months $59\frac{3}{4}$. *Lead*, English, $13\frac{1}{2}$—$13\frac{3}{4}$; foreign, cash, $13\frac{1}{4}$; three months, $13\frac{9}{16}$. *Spelter*, cash, $21\frac{7}{8}$—$21\frac{15}{16}$; three months, $22\frac{1}{4}$. *Tin*, English, $132\frac{1}{2}$—$134\frac{1}{2}$; foreign, cash, $132\frac{5}{8}$, three months, $132\frac{7}{8}$—$133\frac{5}{8}$. *Iron*, Cleveland, cash, 48/5, and three months, 48/11. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BRITISH ELECTRIC TRACTION CO. (LTD.)—The Hon. Arthur Stanley, M.P., who recently joined the board, has retired pending the determination of a business in which he has conflicting interests.

CASCADE (1906) POWER CO. (LTD.)—The balance profit at the end of 1908 has been carried forward. Endeavours have been made to close up the sale of the undertaking of the Cascade Water Power & Light Co.

CENTRAL ELECTRIC SUPPLY CO. (LTD.)—The 4 per cent. debenture stock transfer books of this company will be closed from the 18th to the 31st inst. inclusive.

MELBOURNE ELECTRIC SUPPLY CO. (LTD.)—During the week this company invited applications for an issue of £100,000 5 per cent. first mortgage debenture stock and 20,000 7 per cent. first cumulative preference shares of £5 each, the latter at par and the stock at 93 per cent.

NATIONAL TELEWRITER CO. (LTD.)—During the week this company invited applications for 180,000 £1 preferred ordinary shares.

STOCK EXCHARGE NOTICES.—The Stock Exchange Committee have granted a quotation to 35,704 £10 fully paid 4 per cent. guaranteed preference shares of the *Gt. Northern, Piccadilly & Brompton Railway Co.* (in lieu of shares now quoted). The Committee have been asked to appoint a special settling day in, and grant a quotation to scrip fully and partly paid for £300,000 4½ per cent. perpetual consolidated debenture stock of the *Winnipeg Electric Railway Co.*, and to allow a further issue of $4,823,200 common stock (in $100 shares) of the *Mexico Tramways Co.* to be quoted.

TRAMWAYS & LIGHT RAILWAYS ESTATES CO. (LTD.)—The revenue for 1908 (including £186 brought forward) was £1,196, and the expenses were £749, leaving £446. After applying £100 to reduction of goodwill account and paying a dividend at the rate of 2 per cent. per annum, the balance (£146) was carried forward.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Amount.	Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 5	1,305	− 35	19	65,977	− 33
Airdrie	April 30	215	− 4	17	3 642	− 73
Anglo-Argentine	May 6	31,320	− 4,167	18	712,748	+ 43,563
Ayr Corporation	" 8	232	− 1	51	14,194	− 365
Baker St. & Waterloo Ry.	" 8	3,155	+ 115	18	60,600	+ 5,270
Barnsley	April 30	163	+ 16	17	2,793	− 6
Barrow	" 30	209	− 4	17	3,507	− 267
Bath Electric Trams, Ltd.	May 5	726	− 16	18	11,486	+ 415
Birmingham Corporation	" 8	6,394	+ 138	6	36,147	+ 435
Birmingham & Mid.	April 23	783	− 235	16	12,793	− 22
Blackburn Corporation	May 5	1,010	+ 41	6	6,996	+ 165
Blackpool and Fleetwood	" 8	380	+ 26	18	2,001	− 149
Bolton Corporation	" 9	2,378	+ 60	6	13,823	+ 11
Bombay	April 8	R41,099	+ R4,012	14	R511,816	+ R11,451
Bournemouth Corporation	May 5	1,522	− 44	5	8,817	− 22
Bradford Corporation	" 8	4,733	+ 243	6	26,891	+ 741
Brighton Corporation	" 9	878	+ 103	6	5,181	+ 510
Bristol Trams & Carriage	" 7	5,227	+ 318	24	118,793	+ 10,247
Burnley Corporation	" 8	1,262	+ 61	6	7,868	+ 319
Burton Corporation	" 9	256	− 10	6	1,481	+ 7
Bury Corporation	" 9	1,203	− 19	†6	6,875	− 53
Calcutta Tramways Co.	" 8	R50,238	+ R4,978	13	R859,690	+ R31,140
Camborne-Redruth	" 8	121	+ 6	19	2,153	− 93
Cardiff Corporation	" 8	2,098	+ 2	6	11,810	− 13
Cavehill	April 30	61	− 4	17	1,100	− 171
Central London Railway	May 8	5,352	− 647	18	98,646	− 8,783
Charing C., Euston & H'stead	" 8	3,600	+ 660	18	69,309	+ 11,935
Chatham & Dist. Lt. Rys.	" 6	789	− 19	18	13,152	+ 1,299
City & South London Rly.	" 9	2,952	− 46	13	59,313	+ 398
City of Birmingham	April 30	2,778	+ 13	17	45,503	− 493
Colchester Corporation	May 5	156	− 25	...	...	...
Cork Electric Trams Co.	...	...		...	...	...
Croydon Corporation	" 7	1,401	+ 6	§5	8,001	+ 500
Devonport & Dist. Trams	April 30	386	− 50	17	6,251	− 204
Dover Corporation	May 8	180	+ 1	6	1,034	+ 4
Dublin & Lucan Railway	" 7	131	+ 11	18	2,972	+ 155
Dublin United	" 7	5,249	− 114	18	89,282	+ 953
Dudley-Stourbridge	April 30	776	+ 59	17	12,456	− 236
Dundee Corporation	May 6	1,158	− 9	‡51	60,136	+ 2,105
East Ham Council	" 8	1,012	+ 213	§5	5,513	+ 1,046
Exeter Corporation	" 7	295	...	6	1,709	...
Gateshead & Dist. Trams	April 30	973	+ 75	17	16,597	− 89
Glasgow Corporation	May 9	17,979	+ 516	49	830,855	− 16,201
Glossop Trams	...	...		...	...	...
Gravesend—Northfleet	April 30	135	+ 11	17	3,107	− 119
Great Northern & City Rly.	May 8	1,415	− 181	18	27,731	− 3,398
Gt. Northern, Piccadilly, &c.	" 8	5,710	+ 115	18	101,475	+ 6,970
Greenock & Port Glasgow	April 30	513	+ 29	17	7,957	− 116
Hartlepool Tramways	" 30	203	+ 22	17	3,420	− 133
Hastings Elec. Trams Co.	May 6	893	− 59	18	14,556	− 438
Hong Kong	" 8	$8,581	+ $468	18	$147,819	+ $10,333
Huddersfield Corpn.	" 8	1,636	+ 142	5	9,271	+ 498
Hull Corporation	" 8	2,381	− 20	5	13,783	+ 92
Ilford District Council	...	...		...	...	...
Ilkeston District Council	" 5	118	− 23	5	660	− 16
Ipswich Corporation	" 8	333	− 15	6	2,011	+ 151
Isle of Thanet Co.	" 8	378	− 39	§23	9,348	+ 293
Jarrow	April 30	103	+ 26	17	1,802	+ 160
Keighley Corporation	May 6	152	+ 5	5	859	+ 34
Kidderminster & District	April 30	83	− 2	17	1,435	− 69
Kilmarnock Corporation	May 8	153	+ 3	5	7,381	− 351
Lanarkshire Trams Co.	" 6	1,211	− 24	18	21,457	− 1,314
Lancashire United	" 5	1,275	+ 28	18	22,210	+ 350
Leamington	April 30	153	+ 10	17	2,606	+ 175
Leeds Corporation	May 8	6,547	+ 319	6	36,657	+ 2,403
Leicester Corporation	" 8	2,205	+ 40	...	...	...
Leith Corporation	" 8	528	+ 24	51	26,412	+ 99
Lincoln Corporation	" 8	112	+ 4	6	754	+ 40
Liverpool Corporation	" 1	10,541	− 331	‖17	179,657	− 881
Liverpool Overhead Rly.	" 9	1,344	− 65	19	24,615	− 1,633
London County Council	" 1	35,598	+ 2,791	§4	159,342	+ 16,910
London United	" 8	6,149	− 215	‖21	96,183	− 4,730
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	" 8	174	− 10	5	978	− 37
Manchester Corporation	" 8	14,927	+ 458	6	82,730	+ 2,748
Mersey Railway	" 8	1,945	+ 106	18	35,269	+ 893
Merthyr	April 30	187	− 12	17	3,456	− 3
Metropolitan Dist. Railway	May 8	9,853	+ 879	18	175,103	+ 15,510
Metropolitan Elec. Trams	April 30	6 246	+ 1,196	17	94,473	+ 11,026
Middleton	" 30	306	+ 14	17	5,200	− 229
Nelson Corporation	May 8	142	+ 6	†5	797	− 17
Newcastle-on-Tyne Corp.	" 8	3,756	− 49	6	21,569	− 26
Newport (Mon.)	" 8	623		6	3,938	+ 32
Northampton Corporation	" 7	494	+ 18	§6	4,543	+ 214
Oldham, Ashton & Hyde	April 30	529	+ 4	17	9 166	− 631
Oldham Corporation	May 9	1,915	− 35	6	12,824	− 455
Perth (N.B.) Corporation	" 5	139	− 1	51	7,745	− 99
Perth (W.A.) Elec. Trams	" 7	1,377	− 2	18	26,577	+ 74
Peterborough	April 30	110	+ 1	17	1,734	− 100
Portsmouth Corporation	...	...	...	...	...	...
Potteries	" 30	1,778	+ 109	17	29,606	− 1,026
Preston Corporation	May 5	717	− 13	5	3,716	+ 123
Rotherham Corporation	" 6	678	+ 11	5	3,146	− 19
Rothesay	April 30	109	− 8	17	1,283	− 25
Salford Corporation	May 10	4,542	− 97	‡3	26,318	+ 53
Sheerness	April 30	47	− 6	17	741	− 98
Sheffield Corporation	May 9	5,623	− 118	§6	33,051	− 167
Singapore Trams	" 8	$9,817	+ $272	18	$173,372	+ $1,260
South Metropolitan	April 30	776	+ 51	17	11,817	+ 369
South Staffs	" 30	790	+ 6	17	13,831	− 791
Southend Corporation	May 5	393	+ 51	5	2,236	+ 469
Southport Tramways	April 30	252	+ 12	17	4,031	+ 135
Stalyb'dge, Hyde, &c., Jt. Bd.	May 8	759	+ 37	§5	4,403	+ 12
Sunderland Corporation	" 9	1,042	− 84	6	6,187	− 188
Sunderland District	" 5	409	+ 1	27	11,940	− 292
Swansea Trams	April 30	881	+ 9	17	14,961	+ 358
Swindon Corporation	May 5	111	− 37	...	...	...
*Taunton	April 30	36	− 1	17	530	− 51
Tynemouth and District	" 30	158	+ 12	17	2 412	− 95
Tyneside Trams Co.	May 5	316	+ 63	18	7,173	+ 556
Wallasey District Council	" 8	927	+ 99	§5	5,098	+ 383
Walsall Corpn.	" 8	497	− 33	18	9,011	− 742
Warrington Corpn.	" 6	390	− 17	5	1,943	− 35
West Ham Corporation	April 29	2,294	+ 370	4	9,853	+ 1,167
Weston-super-Mare	" 30	77	+ 4	17	715	+ 99
Wolverhampton Co.	" 30	397	− 32	17	6,715	− 744
Wolverhampton Corpn.	May 5	757	− 139	13	13,272	− 915
*Worcester	April 30	282	+ 3	17	4,091	− 1
Wrexham	" 30	93	+ 4	17	1,579	− 41
Yorkshire W.R. Trams	May 9	1,153	− 216	19	21,344	− ...
Yorkshire Woollen District	April 30	839	− 22	17	14,101	− 472

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed. May 12.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to May 12: Highest	Lowest
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½ −10	6 0 0	Mar, Sept	9¾	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞ −10⅛	4 9 0	Feb, Aug	10⅛	—
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼ −10⅝	5 11 6	Feb, Aug	10⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 −105	4 5 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅛ −4⅝	5 15 9	April, Oct	..	..
St.	4½%	†Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½ −9	5 11 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	8 −8½	4 2 6	Mar, Sept	..	..
St.	4%	Cent l Elec. Sup. Co. 4% Guar. Db. Stock	99 −102	3 18 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜ −3⅝	5 19 0	Feb, Aug	3⅜	—
5	2/8	Do. 4½ per Cent. Pref.	4¼ −4⅝	4 15 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98 −101	3 19 0	Jan, July	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	99 −101	4 9 0	..	100½	100
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅞ −4⅛	5 8 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜ −3⅝	4 9 3	March	3½	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 −105	4 7 6	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10¾ −11	5 19 0	Feb, Aug	10¾	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾ −12¼	4 13 0	Jan, July	12⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 −104	4 6 6	Jan, July	..	..
5	..	County of Durham Elec. P.D. Ord.	1⅛ −2⅛	—	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3⅝ −3⅞	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅜ −8⅞	5 12 6	Feb, Aug	8½	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞ −11⅛	5 6 6	Mar, Sept	11	10⅞
St.	4½%	Do. 4½% Deb. Stock (red.)	105 −108	4 3 6	Jan, July	..	..
St.	4½%	†Do. Second Deb. Stock	99 −102	4 8 0	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ −5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 −5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 −100	4 10 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7⅛ −7⅝	5 11 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7⅛ −7⅜	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝ −6⅞	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94 −97	4 3 0	..	—	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	—
St.	4½%	Kent Elec. Power Co.	85 −89	5 1 0	Jan, July	..	—
3	1/9⅝	London Electric Supply Ord.	1⅞ −2⅛	3 6 8	Mar, Sept	..	—
5	3/0	Do. 6 per Cent. Pref.	5 −5¼	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92 −96	4 3 6	Jan, July	95	91½
5	3/0	Metropolitan Electric Sup. Ord.	4⅝ −5	6 0 0	April, Oct	4¾	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾ −5⅛	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107 −110	4 2 0	June, Dec	—	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85 −88	3 19 6	Jan, July	..	—
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 −98	4 12 0	June, Dec	96⅝	..
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4¾ −5	4 2 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	84 −85	5 6 11	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅞ −5	2 10 7	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 −5¼	4 17 6	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	98 −100	4 0 10	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 19 0	..	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91 −93	4 17 10	Jan, July	..	..
10	8/0	Notting Hill Electric Ord	11¾ −12¼	5 14 0	March	—	..
5	4/6	Oxford Electric Ord.	6 −6½	5 8 0	March	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 −97	4 2 6	Jan, July	..	—
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅞ −9⅜	5 7 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	83 −90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	⅝ −⅞	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¾ −3⅛	6 8 0	April	2⅞	..
St.	..	Do. 5% 1st Mort. Stk. Red.	102 −104	..	—	103¾	102½
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	..
1	0/8⅖	Do. 7 per Cent. Cum. Pref.	[illegible]	5 7 0	Feb, Aug	1⅛	—
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −103	4 7 6	April, Oct	102¾	—
5	2/6	Urban Electric Supply Ord.	⅞ −1	—	April, Oct	[illegible]	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 −2½	10 0 0	April, Oct	[illegible]	2
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 −84	5 7 3	April, Oct	82¼	..
5	5/0	Westminster Elec. Sup. Ord.	9⅛ −9⅝	5 4 0	Mar, Sept	9½	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5¼ −5⅝	4 0 0	Jan, July	5¼	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	97 −99	4 1 0	Jan, July	98½	..
1	..	Bath Elec. Trams Pref. Ord.	⅛ −¼	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ −½	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88 −92	4 18 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 −92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	9 −9½	6 6 0	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ −9	4 9 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99 −100	4 1 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅝ −⅞	..	June, Dec	¾	[illegible]
10	8/0	Do. 6 per Cent. Cum. Pref.	2¼ −3¼	9 4 9	Feb, Aug	2⅞	2½
St.	5%	Do. 5 per Cent. Perpetual Debs.	84 −85	5 11 0	April, Oct	85	85¾
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 −70	6 8 6	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	69 −71	4 18 6	Feb, Aug	70½	69¼
St.	4%	Do. 4 per Cent. Pref. Stock	85 −87	4 12 0	Feb, Aug	85½	..
St.	2½%	Do. Deferred Stock	52 −54	4 11 6	Feb	54	52½
100	4%	Do. 4 per Cent. Debs.	102 −104	3 16 6	Jan, July	103⅝	—
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	92 −94	4 5 0	Jan, July	93¾	93
5	2/6	City of Birmingham Trams. 6% Cm. Pref.	4⅜ −5¼	4 15 0	April, Oct	..	—
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31 −32	4 14 0	Feb, Aug	31	30½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 −112	4 9 0	Feb, Aug	111	—
St.	5%	Do. (1896)	103 −109	4 11 0	Feb, Aug	—	..
St.	5%	Do. (1901)	102 −105	4 15 0	Feb, Aug	..	—
St.	5%	Do. (1903)	93 −94	5 4 0	Feb, Aug	..	..
St.	4%	†Do. 4 per Cent. Perpetual Debs.	99 −101	3 19 0	May, Nov	101	—
10	6/0	Dublin United Trams. Ord	—	4 15 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	12½ −13½	4 9 0	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¼ −⅜	..	Feb, Aug	..	—
10	..	G. Northern, Picc. & Brompton 4% G. Pf.	8½ −[illegible]	—	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 −95	4 3 6	Jan, July	95½	94
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2 −2½	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	82 −87	5 3 6	April, Oct	..	—
10	6%	Imperial Tramways Ord.	6½ −7	8 0 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	7 −7½	8 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	83 −90	5 0 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	54 −59	6 13 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9⅞ −10⅛	5 17 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 −93	5 7 6	Jan, July	91	..
10	..	Liverpool Overhead Railway Ord.	1 −1 1/16	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	4½ −5½	9 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	..	..
10	2/6	London United Trams. 5% Cum. Pref.	3 −4	12 10 0	Jan, July	3½	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	71 −75	5 5 0	Jan, July	73	..
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	—	—
St.	..	Do. 3 per Cent. Perp. Pref.	2 −3	—	..	..	..
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1		Do. Deferred	[illegible]	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95½ −97½	4 12 6	Jan, July	97	95¾
St.	½%	Metropolitan Railway Consolidated	38½ −39½	1 5 3	Feb, Aug	39¼	38⅝
St.	3%	Do. Surplus Lands Stocks	69 −71	4 4 6	Feb, Aug	69½	69
St.	3½%	Do. 3½ per Cent. Preference	83 −90	3 15 0	Feb, Aug	89½	88½
St.	3½%	Do. 3½ per Cent. "A" Preference	79 −81	4 6 6	Feb, Aug	80½	79⅜
St.	3½%	Do. 3½ per Cent. Convertible Pref.	79 −81	4 6 6	Feb, Aug	79½	76½
St.	3½%	Do. 3½ per Cent. Debenture Stock	93 −95	3 13 3	Jan, July	94½	..

In calculating the yield allowance has been made for accrued interest but not for redemption
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share.	Last Dividend	Name.	Price Wed., May 12.	Rate % Yielded.	Dividend Due.	Business Week to May 12 Highest.	Lowest.
		ELECTRIC RAILWAYS & TRAMWAYS— *Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	94	92¾
St.	..	Metropolitan District Railway Ord.	17½—15¾	—	Feb, Aug	18	15⅞
St	..	Do. Extension Pref. (5 per Cent.)	45 —47	..	Feb, Aug	45½	41
St.	3½%	Do. Asserted Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	69 —71	4 18 6	Feb, Aug	70½	..
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	78 —80	3 15 0	Jan, July	79½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	103 —106	3 15 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	94 —96	4 3 0	Mar, Sept	95½	90
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	139 —141	4 5 0	Jan, July	139	..
St.	4%	Do. 4 per Cent. Ditto	94 —96	4 3 0	Jan, July	96	94
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	..	May	..	—
1	0/9¾	Potteries Electric Traction Ord.	5/16—7/16	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	83 —91	4 19 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db.	82 —86	5 16 0	Jan, July	..	..
..	...	UndergdF.Rys.Lon.6% In.bds.with coup.3	35 —37	..	June, Dec	36	35
..	‡	†Do. 5% Prior Lien Bonds..	101 —102	4 18 0	..	101⅞	..
—	4½	Do. 4½% Bonds with coup. 2..............	86 —88	5 2 0	..	87⅞	87
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	—	—	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	84 —88	5 2 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	9/32—11/32	..	..	..	..
1	0 7½	Do. 6% Cum. Pf.	21/32—23/32	6 12 0	April, Oct	..	..
1	2/6	†Babcock & Wilcox Ord. .. xd and bonus	4¼—4½	4 9 0	April, Oct	4 15/32	4 11/32
1	0/7½	†Do. Pref.	1⅜—1½	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7¼—7½	6 13 6	July, Feb	7⅝	7½
5	3,0	Do. 6 per Cent. Pref.	6½—6⅝	4 10 6	Jan, July	—	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	¼—½	..	Feb, Aug	5/16	..
100	1%	Do. 6 per Cent. Prior Lien Dbs (rd.)	94 —96	6 5 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —43	9 4 0	Jan, July	..	..
St.	4½%	BrushE.Eng Co.4½% Perp. 1st Deb.Stock	43 —48	9 8 0	Mar, Sept	..	..
St	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	..	..
5	6/0	Callender's Cable Con. Ord.	9⅞—10⅞	6 15 6	Jan, July	..	—
5	2/6	Do. 5 per Cent. Cum. Pref.	5½—5⅞	4 9 0	Jan, July	5 9/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May		
1	1/6	Castner-Kellner Alkali Co.	1½—1⅞	6 16 0	May, Nov	1 13/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	102 —106	4 4 0	Feb, Aug	101⅞	..
	0 7½	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	7 10 6	March ..	..	..
	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1 1/16	5 13 0	April, Oct	..	..
1	0/8¾	Consolidated Electrical Co.	⅞—1	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1 5/16—1 6/16	7 12 0	April, Oct	1 11/32	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	29/32—31/32	6 4 0	April, Oct	15/16	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	1 —1¼	11 16 0	Jan, July	1 3/16	1
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	95 —98	5 2 0	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1 3/16	7 12 0	Sept	—	—
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 5/16—1 7/16	4 16 9	Sept .. —	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	¼—½	..	Feb, Aug	¼	—
5	2/6	Do. (£5 paid)	1¾—2½	5 0 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	70 - 75	5 6 8	June, Dec	70½	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	5/32	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 3 0	Jan, July	62	..
2	..	Electric Construction Co.	¼—½	..	Jan, July	⅜	..
2	2/9¾	Do. 7 per Cent. Cum. Pref.	1 —1½	9 6 9	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 —64	6 5 0	Jan, July	..	..
10	6/0	General Electric (1900) 5% Cum. Pref....	7⅛—7⅜	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs..........	85 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	17⅜—17⅞	6 2 6	Feb, Aug	17⅜	..
5	2/3	Do. 4½ per Cent. Pref.	4⅝—5½	4 6 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 2 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Wrks.	14½—15½	6 9 0	Feb, Aug	15	..
10	..	Do. 5 per Cent. Cum. Pref.	10¾—11	..	..	10⅞	..
100	4%	Do. 4 per Cent. Debs. (red.)...............	99 —101	3 19 0	April, Oct	99¾	—
1	..	National Elec. Construction Co.	1/16—⅛	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—3/16	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	3/32—5/32	..	May, Nov	5/32	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	83 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	—	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	32 —33½	5 6 6	Mar, July	33⅜	32⅞
100	4%	Do. 4 per Cent Deb. Bonds (1909) ...	101 —103	3 17 6	Jan, July	..	..
1	1 0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2 3/16	4 10 6	..	2 5/32	2 3/32
1	0/6	Do. 5 per Cent. non-Cum. Preference	1 1/16—1 3/16	4 8 0	..	1⅛	—
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	109½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	104 —106	3 14 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104½—106½	4 4 6	June, Dec	106½	—
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106½—108½	4 12 0	..	107¼	—
10	8/	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	¾	..
5	3/0	Do. 6 per Cent. Cum. Pref.	3⅛—3⅜	8 18 0	Apr, Oct	—	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.........	78 — 82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	83 —85	5 5 0	June, Dec	..	..
St.	15,0	Anglo-American	58 —60	5 10 0	F,My,Ag,N	..	..
St.	30,0	Do. Preferred	101½—102½	5 17 6	F,My,Ag,N	103	101½
St.	2 0	Do. Deferred	17⅛—17⅞	2 4 6	F,My,Ag,N	18 1/16	16¾
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91 —93	4 6 6	Jn,Ap,Jy,O	93	91¾
10	6 0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2,0	Direct Spanish Ord.	3 —3½	5 16 0	April, Oct	—	..
5	5,0	Do. 10 per Cent. Cum. Pref.	8½—9	5 9 0	April, Oct	—	..
100	4½%	Do. 4½ per Cent. Deb.	101 — 102½	4 8 0	Jan, July	..	..
20	4/0	Direct United States Cable	12¾—13¼	6 8 0	Ja,Ap,Jy,O	13 1/16	13⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St	25/0	Eastern Ordinary	135 —137	5 2 0	Ja,My,Jy,O	136½	135½
St	17 6	Do. 3½ per Cent. Pref. Stock	86 —87½	4 0 0	Ja,My,Jy,O	87	86
St	4%	†Do. 4 per Cent. Mort. Deb. Stk. (red.)	102½—104½	3 16 6	May, Nov	..	..
St	2,6	Eastern Extension	12⅝—12⅞	5 19 6	Ja,Ap,Jy,O	12¾	12 11/16
St	4%	Do. 4 per Cent. Deb. Stock	101 —105	3 17 6	Feb, Aug	102¼	..
100	4%	†Eastern & S. Af. 4% Mauritius Sub. Debs.	99 —101	3 19 0	May, Nov	..	..
10	16 0	G. N. (of Copenhagen), Ex. Coupon 75 ...	27 —28	6 8 0	Jan, July	27	27⅛
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
..	52,6	Indo-European	62 —64	6 0 0	May, Nov	63¼	..
100	$1	Mackay Companies Common	78 —83	4 16 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	73 —76	5 5 0	Ja,Ap,Jy,O	..	..
1		Marconi's Wireless Teleg. Co.	1 5/16—1 7/16	..	April	[illegible]	¾
100	4	Pacific & European Tel. 4% Guar. Dbs. (red.)	100 —102	3 18 0	June, Dec	—	—
1	[illegible]	West Coast of America	1⅛—1⅜	4 12 0	May	..	..
100	4	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	100¾	..
10		West India & Panama	[illegible]	..	May, Nov	[illegible]	[illegible]
10	[illegible]	Do. 6 per Cent. 1st Pref	9 —9½	6 6 0	May, Nov	9¼	9⅛
10		Do. 6 per Cent. 2nd Pref	8¼—[illegible]	6 5 0	May, Nov	..	..
100		Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	—	..
10		Western Telegraph	13¾—14⅛	4 19 0	Mr,Jn,O,D	14	13 15/16
St.	4	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	101½	..
...	4	Western Union Telegh. $1 000 4% Bonds	93 —95	4 0 0	..	..	..

Share.	Last Dividend	Name.	Price Wed., May 12.	Rate % Yielded.	Dividend Due.	Business Week to May 12 Highest.	Lowest.
		TELEPHONES.		£ s. d.			
100	2⅝	Amer. Telephn. & Telegh. Cap. St.	141 —145	5 13 8	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98 —100	4 0 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	98 —100	5 0 0	Mar, Sept	..	..
5	3,0	Chili Telephone	8 —8½	4 11 6	August ..	8⅝	..
1	0/7½	†Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	15/16	..
1	0/6	†Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	107 —108½	5 10 6	Feb, Aug	107½	..
St.	6%	Do. Def. Stock..................................	123⅞—125¼	4 15 9	Feb, Aug	124⅞	..
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11	5 9 0	Feb, Aug	10¾	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛—5⅞	4 5 0	Feb, Aug	5¼	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.) ...	98 —100	3 10 0	June, Dec	..	..
St.	4%	Do 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	101	..
1	1/0	†Oriental	1 5/16—1 7/16	5 7 6	April, Oct	1 7/16	..
1	0/7½	†Do. 6 per Cent. Cum. Pref.	1 1/16—1 3/16	4 17 6	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	83 —90	4 9 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	..
5	3/0	United River Plate..............................	6⅞—7⅛	8 11 6	July	7	[illegible]
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 13 0	June, Dec	5 1/16	..
St.	4½%	Do. 4½ Deb. St. Red.	104 —105½	4 5 0	Jan, July	—	..
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅝—3⅞	7 14 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust......................	10⅞—11⅛	6 6 0	SpDeMrJu	11	..
10	8/0	Do. 6 per Cent. Pref.	12⅞—13⅛	4 10 6	SpDeMrJu	13⅛	..
10	6%	Submarine Cables Trust (Cert.)............	127 —130	4 12 0	April, Oct	129¼	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅛—6⅜	4 14 0	April, Oct	6¼	..
5	5/0	Do. 10% Non-cum. 2nd Pref.	9 1/16—9 5/16	5 3 0	Jan, July	9 3/16	..
St.	4%	Do. 4% Deb. Stock........................	92½— 94½	4 4 6	June, Dec	93½	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)...	102 —104	4 16 0	Jan, July	104	..
5	3,6	†Brisbane Electric Trams. Invest. Ord....	5⅞—6	5 0 0	May	5⅞	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 16 9	May, Nov	5⅛	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	102 —106	4 5 0	Jan, July	101	..
St.	8%	†British Columbia El.Ry.Df. Ord.	142 —146	5 9 6	Mar, Sept	144½	..
St.	6%	Do. Pref. Ord. Stock	123 —127	4 14 6	May, Nov	126	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock............	109 —112	4 9 0	Jan, July	111	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 0	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 6 8	Jan, July	..	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	98½ 100½	4 4 6		..	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98½—101½	5 0 6	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96 —100	6 0 0	Feb, Aug	98½	..
5	2,0	†Calcutta Tramways (1 to 137,610)	1¼—1½	4 14 9	Mar, Sept	[illegible]	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	99 —102	4 8 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	⅛—⅜			..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 13/16—6 1/16	4 4 9	F,My,A,N	5⅞	..
St.	4%	Do. 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	..
..	5%	†Colombo Tr. & Ltg. 5% 1st Mt. Db.	90 —93	5 7 0	May, Nov	—	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 —86	5 16 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	92 —97	5 3 0	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	3/16—5/16	..	..	—	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	85 —88	5 14 0	Jan, July	—	..
5	6%	Do. 6 per Cent. "B" Ditto	60 —64	9 8 0	Jan, July	—	..
5	1/0	Lisbon Elec. Trams. Ord.	1 —1⅛	4 9 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	94 —99	5 1 0	Jan, July	—	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	91 —94	5 6 0	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	82 —98	5 4 0	Feb, Aug	95	..
100	$1½	†Mexico Trams Co. Com. St.	143 —148	3 7 6	..	148	..
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds....	96½—97½	5 3 0	..	97¼	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	..
St.	4½%	†Do. do. (Nos. 1 to 4,000)	102 —104	4 6 6		103	..
1	1/0	Perth Elec. Trams Ord	[illegible]	6 12 6	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	—	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅝	5 6 6	..	[illegible]	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	100	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	103 —104	..	..	105½	..
..	5%	Do. 30 yr. Gold Bnds.	98 — 99	5 1 0	..	98	..
100	5%	Do. 10 yr. Mt. Bnds	87½— 88½	..	..	85	..
—	$1½	Sao Paulo Tramway, Light & Power Co. $100 Stock............................	156½—158½	6 7 0	..	158	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100 —101	4 19 0	June, Dec	100⅞	..
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5⅞	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	91 —94	4 16 6	Jan, July	..	..
5	3/3	Calcutta Elec. Supply Ord.	6⅞—7⅛	6 12 0	April, Oct	6⅞	..
100	$1¾	Canadian Gen. Elec. Co. Com. St.	120 —123	5 14 0	..	123	..
100	$3½	Do. 7% Cm. Pf. Stock	120 —122	..	..	121½	..
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —101	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario..........	88 — 90	5 11 0	..	89	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1½—2	..	Feb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	89 —92	5 8 0	Jan, July	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½—89½	5 10 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	..
10s	0/3	Kalgoorlie Elec. Power & Ltg. Ord.	5/16—7/16	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	7 10 0	April, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	77½	..
100	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	88½—89½	5 11 6	..	82½	..
St.	$1	Mexican Lt. & Power Co. Com. St.	77 —79	5 17 0	—	78	..
500	5%	Do. 5% 1st Mort. Gold Bnds.	92 —93	5 7 6	..	93	..
100	$1¼	Montreal Lt. Ht. & Power Co. Cap. St....	118 —122	4 18 3	F,My,A,N	120¾	..
1	1/7½	River Plate Electricity Co. Ord.	1⅜—1½	5 6 8	April	1 7/16	..
1	1 2⅝	Do. 6 per Cent. non-Cum. Pref ex rights	1 —1⅛	5 6 6	May	1 1/16	..
St.	5%	Do. 5 per Cent. Deb. Stock...............	102 —103	4 11 3	Jan, July	..	..
5	8/0	Rosario Elec. Co. 6% Pref. (1-20,000)......	[illegible]	5 8 0	April, Oct	5⅝	..
100	$1	Shawinigan Water & Power Co. Ca	85 —105	4 0 0	—	99½	..
..	5%	Do. 5 per Cent. Bds.	107 —109	4 11 6	Jan, July	107½	..
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 — 99	..		98	..
..	6d.	Victoria Falls Power Co. Pref.	[illegible]	5 7 6	Jan, July	[illegible]	..

* In [illegible] the [illegible] allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these

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NOTES.

The International Candle.

As will be seen elsewhere, the National Physical Laboratory have made an important announcement in regard to the photometric units maintained at the Bureau of Standards in America, the Laboratoire Central d'Electricité in Paris, and the National Physical Laboratory in this country. A definite agreement has now been arrived at by which England, America and France will henceforth have the same standard of light, to be known as the "International Candle." It is also satisfactory to learn that the agreement has the approval of the Gas Referees. Hitherto, the French and English standards have been nearly the same, and practical agreement was reached by the standard humidity at Teddington being reduced from 10 litres to 8 litres of moisture per cubic metre of dry air, although the former figure had been accepted by the International Photometric Commission at Zürich in 1907; America has differed to the extent of 1·6 per cent., but in future the pentane candle, the *bougie décimale* and the American candle will all have the same value. America was willing to reduce its standard by 1·6 per cent., and thus come into line, provided France and Great Britain would unite with her in maintaining a constant value, to be known, with the approval of other countries, as the International Candle. Germany presents a more difficult case. According to the new agreement the Hefner assumes a simpler relation than hitherto, being exactly nine-tenths of an International candle, but we hope very much that the Hefner unit will not be maintained. Germany occupies at the present time such an important position in the lamp industry that it will be very unfortunate if lamps continue to be imported into this country marked in Hefner units and known with Hefner efficiencies. To those acquainted with the matter it is, perhaps, unimportant, but the general public, who do not realise such distinctions, cannot discriminate between 11 Hefner candles and 10 English or International Candles, and thus the German lamp will remain at an advantage. The proposal to call the new unit the International candle has been submitted to the International Electrotechnical Commission, and it is to be hoped that, when the time comes, Germany will see fit to fall into line with other countries so that complete unanimity may be the result. To remove at one stroke all the many units which have been a source of trouble for years would indeed be an excellent piece of work.

Electricity Supply Accounts.

As will be seen from another page of this issue, the annual reports and statements of accounts, for the year ended March 31st last, of the municipal electricity and tramway undertakings are beginning to come to hand. These early reports are always of interest, since some indication of the general progress made may be gathered from them. It must be admitted that at the first glance the results achieved by the Leeds and Burton-upon-Trent electricity undertakings, of which the accounts are briefly abstracted elsewhere, are rather surprising. At Leeds the number of units sold for private lighting has decreased by over 530,000, or about 10 per cent., representing a loss in receipts of £7,842, whilst, in spite of an increase of 1,563 H.P., or 18 per cent., in the motors connected to the mains, the revenue from this source shows a diminution of £1,935, due to reductions in the scale of charges, the final result being a total reduction in revenue of £9,288. In spite of this discouraging feature, the gross profit and also the net surplus show increases, due to careful management

and a reduction in the "exceptional" expenditure on renewals. Trade depression, of course, accounts for some of the loss of revenue, particularly as regards power users, but metal filament lamps have played an important part, since it is found that where these are installed consumers have reduced their energy consumptions very considerably. The result of such reduced cost of electric lighting will certainly be a considerable addition of new consumers, but this takes time for its effect to be felt. Meanwhile, owing to its satisfactory financial position, the undertaking is able to regard the temporary depression without concern as to the future.

TURNING now to the Burton-upon-Trent accounts, the effect of metal filament lamps has here been very noticeable, the revenue from lighting consumers, in spite of a larger increase in the number of lamps connected than for several years past, being £6,097, a decrease of £366 compared with the previous year, and also a lower figure than that recorded in 1907. The restricted-hour system of power supply, which Mr. P. J. PRINGLE has so ably advocated, has been, however, the mainstay of the undertaking, and, notwithstanding the depressed condition of trade in the town, the revenue from power users has increased by £534, representing an increase of 33 per cent. in the number of power units sold. The most interesting feature, however, is the fact that the average price of all units sold for motive power is only 0·98d., which low figure should result in a considerable accèss of new business when the trade conditions once again improve. The development of the motor and heating and cooking loads certainly seems to furnish the best results during the temporary reduction in output brought about by the introduction of high-efficiency lamps, and there is no doubt that those undertakings where such a policy has been pursued will continue to show satisfactory financial returns; in this connection it is interesting to notice that, in spite of the unusual conditions prevailing, the Burton-upon-Trent undertaking is able to show a surplus of £836.

Merchant Venturers' Technical College, Bristol.—The new buildings of this college will be opened on June 24th, by Lord Reay, master of the Society of Merchant Venturers.

Imperial College of Science and Technology.—The Goldsmiths' Company has contributed £50,000 towards the extension of the buildings of the Central Technical College, South Kensington, which is in future to form the engineering department of the Imperial College, and will be known as "The City and Guilds College."

University of Bristol.—It is announced that H.M. the King has been pleased to sign a charter for the establishment of a university at Bristol. It will be remembered that a sum of £200,000 has been subscribed for this purpose, and the City Council recently decided to make an annual grant-in-aid equal to the amount of a penny rate.

Iron and Steel Institute.—At the annual general meeting of this institute last week, the Bessemer medal was presented to M. Alexandre Pourcel by Sir Hugh Bell. M. Pourcel was instrumental in introducing the Bessemer and open-hearth processes into France, but is chiefly known in connection with his investigations into the metallurgy of ferro-manganese, which he was the first to manufacture in the blast furnace.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Obock—Djibouti	Apr. 15, 1909	May 15, 1909
Jamaica—Colon	May 6, 1909	—
Dakar—Conakry	May 13, 1909	—
Tangier—Cadiz	May 19, 1909	—

Finsbury Technical College Old Students' Association Magazine.—The current issue of this magazine contains, as its *chef d'œuvre*, a portrait and biography of Mr. P. V. McMahon, president of the association. Other articles deal with "English Compound Locomotive Practice at the Present Day"; "The Position and Future of the Gas Engine," and "Switching and Wiring Systems." The Old Students' Notes, as usual, form a feature of the issue.

Students' Section of the Institution of Electrical Engineers. We are informed that the committee of this section propose to make arrangements to visit numerous large engineering works in Germany. Certain preliminary arrangements have been planned and permission has been asked to visit some important works. These include the works of Messrs. Siemens & Halske, Siemens-Schuckert, Bergmann, and the Allgemeine Elektricitäts Gesellschaft, the Charlottenburg Technical Institute and the Reichsanstalt. The visit will take place about the second week in July, and full particulars can be obtained from the honorary secretary, Mr. E. W. Moss.

Österreichische Ingenieur- und Architekten Verein.—The Council of this Society has decided to give a number of prizes for the best essay on the following subject: "How can Alternating-current Distribution Systems be Protected from the Harmful Phenomena which occur, and which are known as the Higher Harmonics of Current or Pressure Waves, or how can their Origination be Prevented?" The consideration of a number of points has to be included in the discussion of the subject, full particulars of which can be obtained from the secretary of the society at 9, Eschenbachgasse, Vienna. Three prizes are to be given, of value Kr.3,000, Kr.1,000 and Kr.500 respectively.

Municipal Tramways Association.—The meeting of the Managers' Section of this Association will be held on Thursday and Friday, May 27th and 28th, under the presidency of Mr. A. L. C. Fell. The members will be welcomed by Sir Joseph Baxter, chairman of the Newcastle Corporation Tramways Committee, and the meetings will be held in the Town Hall, Newcastle. The subjects to be submitted for discussion are as follows: "Description of the Newcastle Tramways System," by Mr. E. Hatton; "Charges for Energy for Tramway Purposes," by Mr. J. M. McElroy; "Medical Examination and Conductors, what Standard of Same should be," by Mr. J. B. Hamilton; "Time Meters," by Mr. H. Mozley; "Maintenance of Track and Roadway," by Mr. W. M. Rogerson; and "Transfer Tickets," by Mr. A. Ellis. Various excursions in the neighbourhood of Newcastle will be made on the afternoons of the meetings.

Train Despatching by Telephone.—According to "Engineering," on a portion of the western lines of the Canadian Pacific Railway, between Winnipeg and Brandon, train despatching by telephone is to be tried. Instructions have been issued for the installation of the telephone system on the main line between these two points; and if the experiment proves satisfactory, other sections will be dealt with in a similar manner. At present the section of the Canadian Pacific eastern lines between Montreal and Farnham is operated by telephone, and has worked well. The system is the same as that which has been under test on the Burlington and other railway lines of the United States. The 135 mile stretch between Winnipeg and Brandon has 28 stations and three junction points, with 20 daily regular trains and many extras, so that every opportunity will be afforded for an adequate test of the telephone system.

Heavy Electric Traction.—At a recent meeting of the West of Scotland Iron and Steel Institute at Glasgow, Mr. J. M. Scott Maxwell delivered a lecture on this subject. The lecturer began by contrasting steam and electric traction and proceeded to speak of the advantages of the latter under certain circumstances. The mileage of the electrified railways in the United States was, he said, about equal to that worked by steam locomotives in this country. The New York municipal authorities had forced the Central Railroad Co. to electrify their system on account of the large number of accidents that were taking place on that line, owing to the density of the smoke in the company's long tunnel under that city, while the

same course had been followed in Chicago. American public opinion demanded electrification where there were tunnels, but the same statement did not hold good in this country. The lecturer emphasised the importance of electrifying suburban underground lines, as he said that the service would then be more expeditious, cleaner and cheaper, while the traffic would also be heavier. A drawback to development along these lines in this country was that in our railway companies and in our big undertakings the practical engineer occupied a subordinate position. The people in authority had generally more knowledge of the financial and commercial aspect of the business, which might explain why no rapid engineering development took place. In America the man at the head of affairs was acquainted with the other side of the business as well, and was designated a commercial engineer. Mr. Maxwell urged that if progress was not to be hampered in this country, engineers must have greater influence in the administration of railway matters, and interest themselves to a greater extent in local and Parliamentary affairs of legislation.

"New Kind of Glow in Vacuum Tubes."—A Paper having this title was read before the Royal Society on May 6th, by the Rev. S. V. Gill, in which he described experiments made with the object of investigating the nature and causes of a phenomenon observed by the author when occupied with a research connected with palladium foil. A piece of palladium foil, or platinum foil coated with palladium black, was heated to a white heat in air at a pressure of about 0·15 mm. A purple-blue glow was seen to surround the hot metal, while between the glow and the palladium there was a dark space. The thickness of the dark space varied with the temperature of the foil. The glow disappeared when the tube was heated to a high temperature, and returned when it was cooled. It was shown that the presence of the glow depended on a reaction between the gases introduced into the tube, when the palladium was heated, and the disintegrated particles of palladium. Water vapour had to be present in the tube, and the glow could be made to disappear by freezing out the vapour by means of a few drops of liquid air applied to the outside of the tube, or by introducing some phosphorous pentoxide into the tube. The spectrum of the glow showed certain regions which corresponded to portions of the spectrum of carbon monoxide gas. It was also shown that carbon monoxide was present in the tube which showed the glow. No effect was observed when electric and magnetic fields were applied to the glow. The probable cause of the luminosity was the luminous union of carbon monoxide and oxygen brought about by palladium charged with hydrogen, in the presence of water vapour. A second effect was also briefly described; this appeared to be due to the causes which gave rise to thermo-luminosity.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

As already announced in these columns, the fourteenth annual convention of this Association will take place at Manchester from June 21st to 25th inclusive. The proceedings will open on the Monday evening with a reception and conversazione at the Town Hall, Manchester, when the Right Hon. the Lord Mayor of Manchester (Alderman E. Holt) will receive the members. Business will begin at 10 o'clock on Tuesday morning, June 22nd, in the Large Lecture Hall of the Municipal School of Technology in Whitworth-street, Manchester, when the Lord Mayor will welcome the Association, and the president, Mr. S. L. Pearce, chief electrical engineer, Manchester, will deliver his address. A Paper on "Cheap Units," by Councillor A. Sinclair, of Swansea, will also be read. At the conclusion of the meeting the members will be entertained to luncheon in the Town Hall by the Electricity Committee of Manchester; the afternoon will be spent in visiting the Stuart-street, Dickinson-street and Bloom-street electricity stations of the Manchester Corporation. On Wednesday, June 23rd, the Association will migrate to Liverpool, where they will be welcomed at St. George's Hall by Sir Chas. Petrie, chairman of the Tramways and Electric Power and Lighting Committee of the Liverpool Corporation. Papers on "The Influence of Metallic Filament Lamps on the Electrical Industry and on Street Lighting," by Mr. E. E. Hoadley, chief electrical engineer, Maidstone, and on "Modern Cable Systems," by Mr. E. M. Hollingsworth, chief electrical engineer, St. Helens, will then be read and discussed. At the close of the meeting the members of the Association will be entertained to luncheon at the Exchange Hotel, Liverpool, by the Tramways and Electric Power and Lighting Committee. In the afternoon the Lister Drive electricity station of the Liverpool Corporation and the Cunard steamship "Mauretania" will be visited. A special train will be provided for the use of members travelling from Manchester to Liverpool and back. Tickets at reduced fares will be issued, and will also be available by the ordinary trains. On Thursday, June 24th, a meeting will be held at the Municipal School of Technology, Whitworth-street, Manchester, when Papers on "Steam Turbines from the User's Point of View," by Mr. A. S. Blackman, chief electrical engineer, Sunderland, and "Notes on Condensing and Water Cooling Plant" (Travelling Studentship Prize Paper, 1909), by Mr. E. Lunn, assistant electrical engineer, Huddersfield, will be read and discussed. In the afternoon visits will be paid to various works in the neighbourhood, including those of the Lancashire Dynamo & Motor Co., Electromotors, Ltd., Messrs. Connolly, the British Westinghouse Co., the Hyde-road car shed of the Tramways Department, the Polygon sub-station and testing department of the Manchester Corporation and the Municipal School of Technology. The annual dinner of the Association will be held at the Midland Hotel in the evening at 6:30 for 7 p.m. The annual general meeting will be held on Friday morning at the Municipal School of Technology; and the generating stations of the Salford Corporation and the Lancashire Electric Power Co. will be visited in the afternoon. The works mentioned above will also be open to visitors on Friday afternoon.

We are, as usual, making special arrangements for giving full reports, both of the Papers and discussions at this Convention, and our issue of June 25th will contain an account of the proceedings up to the close of the meeting on Thursday, June 24th. THE INDUSTRIAL SUPPLEMENT issued with THE ELECTRICIAN of June 25th will be devoted to matters of special interest to supply engineers.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, May 22nd.

INSTITUTION OF MINING ELECTRICAL ENGINEERS.

6 p.m. Business meeting at the University College of South Wales, Cardiff. Chairman: Mr. S. F. Walker.

MONDAY, May 24th.

NEWCASTLE LOCAL SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Meeting in the Electrical Engineering Lecture Room, Armstrong College, Newcastle-on-Tyne. Paper on "The Wireless Telegraph Installation at Cullercoats," by Mr. Sorensen.

WEDNESDAY, May 26th.

ROYAL SOCIETY OF ARTS.

4 p.m. Meeting at John-street, Adelphi. Lecture on "The Manufacture of Nitrates from the Atmosphere by the Electric Arc," by Herr Sam Eyde.

THURSDAY, May 27th.

MANAGERS' SECTION OF THE MUNICIPAL TRAMWAYS ASSOCIATION.

10 a.m. Meeting in the Council Chamber, Town Hall, Newcastle-on-Tyne

FRIDAY, May 28th.

MANAGERS' SECTION OF THE MUNICIPAL TRAMWAYS ASSOCIATION.

10 a.m. Meeting in the Council Chamber, Town Hall, Newcastle-on-Tyne.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Advances in our Knowledge of Silicon as an Organic Element," by Prof. J. Emerson Reynolds, F.R.S.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 24th, "A" Company	Infantry drill, 6:45 p.m. (Practice for Officers' drill cup competition.)
Tuesday, May 25th, "B" Company	
Thursday, May 27th, "C" Company	
Friday, May 28th, "D" Company	

THE ELECTRIC FURNACE AND ELECTRICAL PR - CESS OF STEELMAKING.*

WITH PARTICULAR REFERENCE TO THE ROCHLING-RODENHAUSER FURNACE.

BY W. RODENHAUSER.

Summary.—The author first briefly considers electric arc furnaces and points out the features and disadvantages of each type. He then passes on to induction furnaces and describes the Rochling-Rodenhauser furnaces installed at Völklingen. The capital cost of the various types of furnaces is also discussed.

Electrically refined steel, with the various furnaces for producing it, has been much discussed in industrial centres during the past few years. A renewed consideration of the subject, however, appears to be justified and demanded by the industry; since, though electric steel refining progressed slowly at first, it is now advancing with rapid strides, and is being readily taken up by the entire industry.

The author first gives a summary of the types of furnaces which have got beyond the "patent" and "test" stages. The following are considered: The Stassano, Héroult and Girod furnaces, on the one hand (*i.e.*, electric arc furnaces); and the Kjellin, Frick and Röchling-Rodenhauser furnaces on the other; the main differences between the two groups are discussed. After Werner Siemens constructed arc furnaces in 1878-79, which closely resembled the Girod furnace, Stassano, in 1898, built the first arc furnace which was applicable to the iron industry.

A critical weakness of the Stassano furnace compared with other arc furnaces is that heat losses cannot be avoided. Also, the roof can only stand the high temperature of the furnace for a short time, although it is composed of expensive magnesite; and a renewal occupies a considerable time, and the cost of renewals is heavy. The electrodes projecting almost horizontally into the furnace are more easily broken than if they were vertical. The entire furnace is arranged so that it can be rotated in order to mix the metal, and thus ensure homogeneity in the product, but it is not likely to be extensively adopted except for small charges.

The construction of the Héroult furnace, which was patented in 1900 and is the best known arc furnace, offers several advantages over the Stassano furnace. As the carbons are arranged vertically there is less chance of heating the roof, which is movable. The furnace does not need to be rotated, and so is more simple in construction. In common with all arc furnaces the question of maintenance of the roof is the weak point, as this needs to be replaced every 14 days. The Girod furnace, which resembles the Héroult, presents the advantage over the latter that the demand for energy is more constant.

In all arc furnaces the place where the carbons pass through the walls must be thoroughly cooled, since without this (1) the carbons will become very hot and oxidise rapidly where the air has access to them, (2) it is difficult to prevent the carbons rubbing on the surrounding masonry where they enter the furnace, causing small currents to escape from one electrode to the other. This applies particularly to the Héroult furnace. The provision of openings in the furnace roof, which is exposed to great heat, is also a drawback, as the artificial cooling required at these aperatures causes a great variation of temperature in the roof, which does not increase its durability, and a considerable loss of heat.

The difference between the Héroult and the Girod furnaces consists in the current leaving the latter furnace by a water-cooled iron electrode in the bottom of the furnace instead of by a second suspended electrode. It appears doubtful if this arrangement presents any advantage from the metallurgist's point of view, for it is evident that there will be a gradual increase in temperature from the water-cooled electrode to the high temperature of the active bath of metal, and that the metal, which is solid near the electrode, becomes first pasty and then liquid farther away from it; also energy is lost through cooling the furnace bottom. Girod, in using water-cooled electrodes in spite of these disadvantages, combines the advantages of the resistance furnace with those of the arc furnace.

The view that the passage of the current through the bath of metal has any great influence on the heat produced in a present-day arc furnace must be abandoned, and in these furnaces the heating must be entirely ascribed to the very localised effect of the arc. In spite of this, however, the passage of the current through the carbon electrode causes a considerable loss of energy.

The conclusions respecting the operation of the arc furnace may be summarised as follows: (1) The temperature of the charge cannot be appreciably increased by resistance heating. (2) The charge is almost entirely heated by the arc, and the heating is very much localised. (3) The passage of the current through the carbon electrodes gives rise to considerable loss of energy, due both to the comparatively high resistance of the carbon and to the water circulation for cooling the apertures where the carbons enter the furnace. This loss of energy is about 10 per cent. The cost of maintenance of the carbon electrodes is also considerable.

Induction Furnaces.—These are primarily due to Ferranti, who in 1887 obtained a British patent for his invention which was constructed too much from the electrician's point of view, and has not attained practical importance. It had the principal points of the Kjellin furnaces, and the construction of the Frick furnace, which has attained some practical importance, is also very similar to that of the Kjellin furnace. The principal difference between them being that in the former the primary windings are placed above and below the annular hearth instead of within it. The grooved annular hearth is the characteristic feature, and as these furnaces have no side doors the operations are watched and regulated by lifting off the covers of the grooved annular hearth section by section. The peculiar shape of the hearth naturally prevents the removal or changing of the slag, and these furnaces are only adapted to conditions where comparatively pure materials are to be melted or alloyed.

The Röchling-Rodenhauser furnace, which has been patented since 1906, has a hearth a very different shape from the induction furnaces just mentioned. This furnace is constructed for single-phase and for three-phase current, having two grooves (*see* Fig. 1) in which metal is melted in the first case, and three in the second. In both cases these groves open into a distinct open-hearth, the working chamber, where all the metallurgical operations take place, while

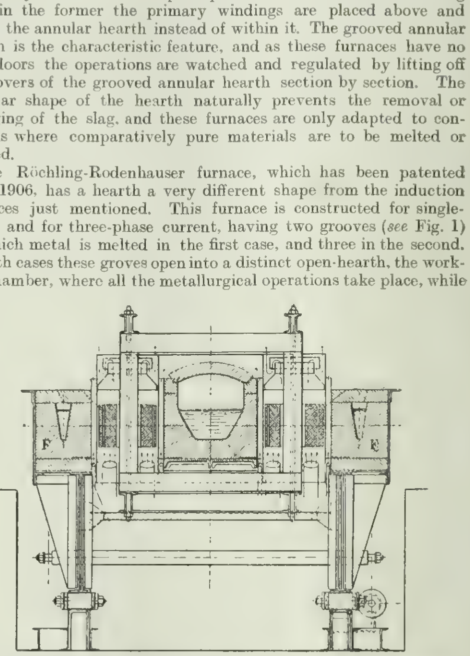


FIG. 1.—8-TON SINGLE-PHASE RÖCHLING-RODENHAUSER FURNACE.

the grooves, which have a comparatively small cross section, form the secondary circuits in which the currents which heat the metal are induced. Thus there is a working chamber surrounded by the transformer which closely resembles the hearth of an arc furnace. Lateral doors are provided and enable the hearth to be observed. As the furnace is so constructed that it can be tilted, one of the doors is provided with a spout for pouring the charge, while the furnace may be charged, or slag-forming material or additions may be thrown in through either of the doors. As the doors are not much above the level of the top of the bath, the slag can be as easily removed in the Röchling-Rodenhauser furnace as in an arc furnace, which is not the case with the other induction furnaces previously mentioned, so that this furnace is very well suited for refining processes.

The central hearth is very similar in form to that of an open-hearth furnace, and this construction offers considerable advantages from the electrical standpoint. In the older furnaces the current in the primary only serves to induce a secondary current in the annular hearth, but in the Röchling-Rodenhauser furnace a distinct secondary winding is provided in which a secondary current is induced by the primary current, and these windings are connected to cast-steel terminal plates which are embedded in the refractory material of the furnace. This refractory material becomes an electrical conductor at the higher temperatures, and this enables an additional electric circuit to be formed, so that the currents induced in the secondary winding pass through the terminal plates to the central hearth and through the bath of metal, heating the bath still further. The conditions in which current is passed through the bath in this furnace are very different from those in which current is passed

* Abstract of a Paper read before the Iron and Steel Institute.

through in the arc furnaces described in the earlier part of this Paper. There is very little wastage of the part of the refractory material which serves as the electrical conductor, and it has even been found that these parts last the longest of any part of the furnace lining.

There is no necessity for changing the terminal plates, and the heavy charges for replacement of electrodes which are incurred with all types of arc furnaces are avoided. In addition, there is no possibility of the bath of metal taking up impurities from the electrodes, as the current-carrying parts in contact with the metal are composed of the same material as the rest of the lining, while with the arc furnaces there is always the danger of the bath taking up impurities from the electrodes. Finally, the very considerable losses of energy which take place due to the passage of current through the carbon rods which form the electrodes are avoided.

In the earlier electric furnaces the power factor was necessarily very low, on account of the large space between the primary winding and the annular bath of metal which constituted the secondary, and the frequency of the supply current had to be reduced to, in some cases, 5 cycles per second, so that the power factor should not be less than 0·6 to 0·7. This resulted in the capital cost of the electric generators and transformers being greatly increased. In the Röchling-Rodenhauser furnace the combination of the heating channels and central hearth, with the secondary windings supplying current to the bath, enables the power factor to be considerably increased, and so permits normal frequencies to be employed; and it is quite possible for a furnace capable of dealing with a 16-ton charge to work on a 25-cycle system.

Since direct current is usually unsuitable, the choice of current lies between single and three-phase, and three-phase furnaces are to be preferred from the point of view of capital cost, particularly in works where there is already plant supplying electric power to

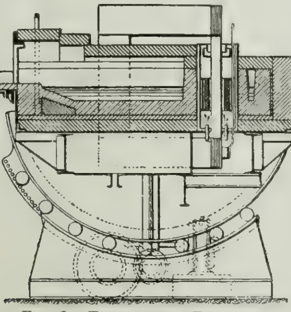


FIG. 2.—THREE-PHASE FURNACE.

rolling mills, &c. In fact, great care is necessary in the choice of the electric supply system for the furnaces, as any increase in the capital cost of the power plant will react unfavourably on the financial results obtained.

Naturally, variations in the load cannot be prevented with any type of furnace, but it is important to distinguish between gradual changes of load made intentionally and unintentional sudden changes of load. All sudden changes of load are practically impossible with the induction furnace. If the induction furnace which is suitable for an electric circuit of normal voltage and frequency has decided advantages over the arc furnace from the point of view of the generating plant, it must be remembered that the induction furnace has the greater capital cost. If the combined capital cost of the arc furnace and transformer be compared with that of the induction furnace, the latter is still the dearer on account of the very special construction of the transformer. This increased capital cost of the induction furnace is insignificant compared with the extra capital cost of the generating plant required for an arc furnace, on account of the great variations of load. It may, therefore, be said, generally, that the cheapest combined plant is obtained by adopting a three-phase furnace, which can work on a circuit of normal frequency and does not take great variations of power.

From the electrical point of view the induction furnace shows far better results than the arc furnace under all conditions. Tests made on a 3½ ton induction furnace at Völklingen have shown an electrical efficiency of 97 per cent., while it is shown in the Paper that 10 per cent. of the total energy is lost in the carbons alone of an arc furnace.

Although an exact calculation of the losses of heat can scarcely be made, it may be said that the heat losses of all modern electric furnaces are about the same, for though the induction furnace is at some disadvantage compared with the arc furnace, on account of the special shape of its hearth and heating channels, the water-cooling of the apertures through which the carbons enter an arc furnace accounts for a considerable loss of heat, and there is more heat lost when the doors were opened than in the induction furnace, where the top layers of slag act partly as a heat insulator.

Metallurgical Conditions.—The advantages of a good electric furnace are: On account of the convenient regulation of the temperature attainable, the phosphorus can be removed till only a trace remains; it is especially suitable for the most thorough desulphurisation; and finally, when the refining is complete, the charge can be left in the furnace as long as convenient without its composition being changed.

Two Röchling-Rodenhauser steel furnaces are working at the Röchling Iron and Steelworks, one of which (Fig. 1) is an 8-ton single-phase furnace, and the other (Fig. 2) a 2-ton three-phase furnace. The 8-ton furnace, which takes 600 kw., takes its power from a 4,000 to 5,000 volt 5-cycle per second generator which existed previously; while the 2-ton furnace, on account of the steady demand for power which it makes, which is characteristic of the Röchling-Rodenhauser furnace, is supplied from the power circuit of the works, just as a motor might be, and takes 200 kw. to 250 kw. at a pressure of 400 volts on a 50-cycle circuit. The high-tension current is supplied direct to the furnace transformers, which are fully enclosed, so there is no chance of the workmen coming in contact with the high tension. While the small furnace is chiefly used in the production of high class tool steel, the larger furnace is producing chiefly structural steel and similar material of which large quantities are required.

There are two points about the working of the Röchling-Rodenhauser furnace that are worthy of consideration; these are the heating up and the maintenance of the heat of the furnace. In order to heat up induction furnaces before charging, it was usual in the past to place an iron ring, which was either screwed or welded together, in the annular hearth, being heated up by the action of the electric current until both it and the hearth were red hot. The fluid metal was then charged into the furnace and heated further until a sufficient temperature was attained to carry out the refining process. This method of heating up requires that molten metal should be charged into the furnace, and this must be first melted in a cupola or in crucibles. This auxiliary melting plant can be dispensed with in the modern electric furnaces, which do not have to be charged with liquid metal. The above-mentioned ring would be embedded in pieces of scrap, turnings, &c., so that when the electric current is switched on, the ring is first heated and it in its turn heats up the surrounding material, which frits together and itself becomes a conductor conveying additional current and increasing the heat of the furnace, so that the entire charge is soon fluid, and the refining process can be commenced.

A further advance has been made in the method by which the furnace is kept hot when not working. Since in a small works the electric furnaces may only be working on day shifts, they must be kept hot during the night and perhaps also a charge may not be finished on Saturday, and so has to be kept hot during Sunday. In such a case only about one-third to a quarter of the normal energy consumption would be required to keep the Röchling-Rodenhauser furnace hot, and at the present time operations can be stopped before the process is completed with only half the charge in the furnace, since when the doors are closed the furnace is air-tight, and only cools very slowly and gradually. The 8-ton furnace at Völklingen has been left for 30 hours without taking any current, and could be heated up again with the normal energy consumption. While the supply of electric current was suspended the furnace did not cool down very much, and after 16 hours' interval the interior of the furnace was still red-hot. This is a proof of the excellent thermal efficiency of the furnace.

A comparison is finally made between the metallurgical conditions in the Héroult furnace, as typical of the arc furnaces, and the Röchling-Rodenhauser, as a typical induction furnace. The term "electro-metallurgical process" is, properly speaking, not correct, and it cannot be too greatly emphasised that, in the opinion of all those who have made a special study of the subject, the electric current should be regarded solely as a source of heat. Any possible chemical action of the electric current may be left out of consideration, so that the advantages of the electric furnace are based entirely on the facilities which exist for heating the bath without introducing impurities, the possibility of attaining very high temperatures and the ease with which this temperature may be regulated. Comparing the above furnaces it has been shown that the refining action can be carried as far as may be desired in either furnace, but the slag must be thinner and more fluid in the Héroult furnace. A point worthy of mention is the homogeneousness of the metal produced in each type of furnace. Although the circulation in the induction furnace, which

is clearly visible to the eye, thoroughly mixes the charge and accelerates the refining process, it is not sufficient to attack the furnace lining to any extent. This is clearly proved by the fact that at the Röchling iron and steel works at Völklingen, the 8-ton furnace works for quite 14 days without any repairs to the lining being needed. The furnace lining is only 350 mm. thick. The lining of a Heroult furnace needs repairs after every charge, while the Röchling-Rodenhauser furnace will work 14 days without repairs, and such repairs require the furnace to be stopped from 24 to 48 hours, according to the amount to be done, the sides of the hearth being the parts chiefly needing repair, and the roof is available for further use after slight patching up. At Völklingen the lining consists of dolomite and tar, and the cover of the hearth is of fireproof stone. With reference to the cost of repairs per ton of steel in these comparatively small furnaces, these are less than the cost of those for an ordinary open-hearth furnace.

An appendix to the Paper contains particulars of tests on the three-phase furnace to determine how far the charge in the furnace was homogeneous. These showed that the chemical composition remained practically unaltered whilst the charge was in the furnace.

OERLIKON ALTERNATING-CURRENT RAILWAY MOTORS, AND THEIR EFFECTS ON TELEPHONE SYSTEMS.*

BY DR. BEHN-ESCHENBURG.

Summary.—Though deduced primarily from experience gained with Oerlikon motors, the results given in the present article are of quite general interest to all connected with single-phase traction, and show how both difficulties of design and outside disturbances set up in neighbouring telephone lines have been successfully overcome until finally the single-phase series commutator motor bids fair to out-rival any of its competitors for main line railway work.

Historical Survey of Telephonic Disturbances on the Seebach-Wettingen Line.—The chief difficulties which were encountered, and had to be overcome before the opening of the first alternating-current railway in Switzerland, viz., the Seebach-Wettingen line, were not in any way due to the system itself, but to secondary disturbances set up in the neighbouring telephone lines. Since, however, this trouble has been successfully overcome without either shifting the existing telephone wires or reducing the originally proposed pressure, one of the greatest objections to the electrification of railways may now be said to have been removed.

The original system consisted of a locomotive, on which was installed a three-phase motor coupled to a generator, which supplied the continuous-current driving motors with energy on the Ward Leonard principle. Here the power was supplied at 15,000 volts 50 cycles, and although at that time only 500 metres of telephone lines ran alongside the electrified portion of the line, disturbances were set up in the former as soon as the latter was put under pressure. The cause of these disturbances were traced back to the harmonics in the pressure wave, for as soon as a pure sine wave was supplied to the line the trouble disappeared. Nor was any trouble experienced when this was superseded by single-phase current at 15,000 volts, 15 cycles, so long as no load was on the system, although the induced potentials and charges in the lines could be measured in the usual way, by means of voltmeter and ammeter.

Along with the 15-cycle frequency came the alternating-current series motors with auxiliary poles. The motors had 8 main poles and 8 auxiliary poles, whilst on the rotor there were 96 open slots and a multiplex lap winding with equalising connections, 168 conductors and 384 commutator bars. The introduction of these motors led to quite new and complicated telephonic disturbances. Whether the locomotive ran light or loaded, a loud singing and whistling was set up in the telephones, the note of which rose clearly as the speed increased, whilst the intensity varied very little with the current and proved also to be independent of the place where the locomotive happened to be travelling. After a length of 18 km. alongside the telephone wires had been electrified, the disturbances became so strong that several metres away from the telephones a sharp whistling noise could be heard, and proper telephone working became impossible.

In a report of March 18, 1907, of the Oerlikon Works to the Federal Telegraph Department, the oscillographic observations of these disturbances were discussed. In this report it was shown that although the pressure curve was smooth when the locomotive was at rest, yet higher harmonics appeared as soon as motion occurred. These ripples were proportional to the speed, *e.g.*, at 22 km. there were 39, at 37 km. 64, at 28 km. 51, and at 35 km. 60. The amplitude of these ripples at all speeds above 20 km. was about the same, and did not alter much whether the loco was running light or drawing a train. This amplitude rose to 20 per cent. of that of the fundamental.

A remarkable thing about these oscillograms is that the amplitude of the pulsations in the current curve rises and falls symmetrically with the fundamental, whilst in the pressure curve they appear to be a maximum when the current is at its highest value, and are thus displaced from the axis of symmetry by an amount equal to the phase displacement. It was further shown that these higher harmonics become more irregular when the two motors work in series than when one motor works alone. The number of ripples agrees with the number of rotor slots passing over the stator at the corresponding speed. Thus at 22 km. the rotor runs at 6 revs. per sec., hence with a frequency of 14·3, $\frac{6 \times 96}{14 \cdot 3} = 40$ teeth pass over the stator surface in one cycle. In the oscillogram 39 ripples were counted.

Compared with the harmonics in the pressure waves of alternators, the observed effects differed from the fact that in the former case the harmonics chiefly occur at no-load and are smoothed down as the load increases, whilst in the latter they appear to come from the current and seem to be independent of the value of the load. This last property also seems to show that the origin of the pulsations is not caused by commutation conditions, which would surely vary with the load; but results seemed to point out that they were set up rather by pulsations in the E.M.F. induced in the main circuit of the motors. To confirm this, the locomotive was drawn by a steam locomotive, and oscillograms were taken with the field excited, but without current in the armature. It was found that the same ripples occurred as before, and the same telephonic disturbances took place. In these machines the rotor slots were open, being 10 mm. wide and 50 mm. deep, the winding being secured by a wooden wedge.

Tests were also taken with alternating-current series motors with entirely different slots. For this purpose a number of 40 H.P. motors were run in the test house in parallel with the overhead line of the railway, so that all pressure variations were transmitted to the latter. These motors had smooth evenly-slotted stator cores with distributed exciting, compensating and auxiliary windings, whilst the 126 slots on the rotor were totally closed. As was to be expected, the ripples were now considerably smaller—being about 2 per cent. of the fundamental—and the telephone disturbances in the crossed lines disappeared, although still detectable in the uncrossed. Nevertheless the oscillograms do not always show the same effects, even under apparently identical conditions, from which it must be inferred that some other local disturbances, *e.g.*, resonance, are at work.

As a result of the above experiments new armatures were built for the Seebach-Wettingen locomotives. These armatures were built with closed and much smaller slots than the previous, whilst the slot axis was skewed with respect to the rotor axis by an amount equal to a slot-pitch.

The stators, commutators and the winding were left as before, but the number of rotor slots was increased to 192. An interesting circumstance might also be mentioned here, viz., that when closed slots were used the resistance connections between winding and commutator were omitted, and despite all theories, the commutation was in no way less perfect than with the old rotors, and after 25,000 km. running the commutator and brushes have still no need of repair. With these new rotors the pulsations in the pressure curves vanished, and the telephonic disturbances in some lines became scarcely noticeable, whilst in others it was so reduced that it could be completely removed by the introduction of certain improvements in the telephone system, which chiefly consisted of increasing the amount of lacing of the wires, and supplying all the lines with discharge coils.

The motors of a third locomotive, supplied by Siemens Schuckert, gave much smaller pulsations than those of the first locomotives. The stators had 56 semi-closed slots, whilst the rotor had a series parallel winding wound in 74 open slots. It is clear from the foregoing that such a ratio of stator slots to rotor slots, possessing only 2 as a common factor, gives comparatively small variations in the reluctance compared with the conditions in the first locomotive.

Theory of the Pulsations in the Motors.—The main exciting coils of the motors carry the current i, which varies approximately as a sine wave, *i.e.*, $i = \mathrm{I} \sin \omega t$. Let R denote the magnetic permeance of the whole magnetic circuit. This varies from a maximum to a minimum, whilst the slotted armature passes over a distance of a slot-pitch over the surface of the main poles. Then if there are Z slots and T revs. per minute the frequency n_1 of the variation of R is $\mathrm{Z\,T}/60 = n_1$. Put $\omega_1 = 2\pi n_1$, then $\mathrm{R} = \mathrm{R}_0\{1 + \mathrm{K} \sin(\omega_1 t + \alpha)\}$, where K is the fraction by which the permeance R periodically varies from its mean value R_0. Neglecting the effect of hysteresis,

* Abstract of a lecture given before the Physical Association (Physikalischen Gesellschaft), Zurich.

the flux due to the current i is $F = ciR$, where the coefficient depends on the winding. Hence we can write for the flux :—

$$F = cI\,R_0\{\sin\omega t + K\sin\omega t\sin(\omega_1 t + a)\}.$$

The E.M.F. produced in the magnet coils by this flux is given by

$$e = c_1\frac{\partial F}{\partial t} = E_1\cos\omega t + E_1 K\frac{\omega_1}{\omega}\sin\omega t\cos(\omega_1 t + a)$$
$$+ E_1 K\cos\omega t\sin(\omega_1 t + a).$$

A second E.M.F. due to the rotation of the armature coils in flux F is

$$e_2 = E_2\sin\omega t + E_2 K\sin\omega t\sin(\omega_1 t + a).$$

The resultant of these two E.M.F.s gives the total pressure of the motor, and it is clear that the pulsations in the magnetic circuit set up similar pulsations in the circuit of the motors, which must appear in the current and again in the flux.

The curves plotted from the above equations agree with those taken with the oscillograph, thereby confirming the correctness of the above analysis. The fact that the value of the oscillations does not vary directly with the current (or load) is chiefly due to the high saturation in the motors. Lastly, it might be repeated that the above trouble was not due to commutation effects but solely to the peculiar construction of the earlier motors. That these disturbances are not caused by a property common to all alternating-current motors is proved from the fact that they were removed by suitable modification in the design, and it is quite possible for such trouble to occur with non-commutator motors, *e.g.*, induction motors under similar conditions. The fact that commutation might give rise to trouble is not disputed, but no evidence of such was present in these instances.

Experimental Data obtained from the Seebach–Wettingen Line.—Since Dec. 1, 1907, this line has been open for public traffic. No trouble has been experienced with the high tension of 15,000 volts, and the insulation of the line is good in all weather, despite the presence of the steam locomotives at the two termini of the electrified portion of the line. The average loss of energy in the line of 20 km. is about 1 H.P. Of late the weight of the trains has been increased to 290 tons and the speed to 60 km. per hour. There are several long inclines of 1 per cent. where a pull of 4,500 kg. at a speed of 40 km. must be developed, requiring an output of 660 H.P. per locomotive. (The motors were originally built for 200 H.P., but yield the required 330 H.P. without difficulty.) The watt-hour consumption per ton-kilometre is 27 to 29, against a theoretical consumption of 23 watt-hours. The power factor under normal conditions is above 90 per cent. As regards the commutators, although no method of lubrication is used, the surface remains quite smooth and the brushes work as satisfactorily as in the best continuous-current motors. Sparking occurs neither at starting nor at the heaviest overloads. It is confidently expected that the locomotives will run 50,000 km. before the commutators need attention.

The toothed-wheel gearing of the motors with the countershaft (which is coupled to the driving wheels by means of cranks) has caused no difficulty and shows no sign of wear, whilst this method of supporting the motors makes accessibility easy and permits the use of open-type motors. Neither motors nor transformers are artificially cooled. Two methods of control have been used, both of which have proved equally satisfactory. The one consists in the use of a large drum controller, the other of separate switches operated by alternating current.

Principles underlying the Design of Alternating-Current Commutator Motors.—The motors are built with commutating poles and compensating windings like continuous-current motors and can be used as such—as indeed they are, when they work as generators for braking purposes. In addition to the reactance voltages, &c., met with in a continuous-current machine, there is an additional E.M.F. induced in the coils under the brushes when alternating current is used, and the designer must keep this E.M.F.—due to the pulsating flux—or, rather its effects, within safe limits. Means for attaining this end consist in artificially increasing the resistance of the circuit of the coils under the brush by using high resistance connections between winding and commutator and carbons with high contact resistance, whilst the magnitude of this E.M.F. is reduced by keeping the flux small, limiting the number of turns short-circuited by a brush and by means of auxiliary poles or windings which compensate this E.M.F. over a wide range of working. The principle of this last method was originated by the Oerlikon Works in a patent dated March, 1904, and consists in the production of auxiliary fields perpendicular to the axis of the main field and displaced from the latter in time. Since, however, this compensation can only occur when the armature coils *rotate* in the auxiliary field, the latter cannot provide satisfactory commutating conditions at starting or at very slow speeds.

This last difficulty has been overcome as follows:—Experience has shown that brush carbons can be made which will not seriously spark so long as the effective pressure between their tips does not exceed 7 volts and the permanent current density does not exceed 15 amp./cm². For mechanical reasons, the width of these carbons must not be less than 8 mm. Now, the pitch of the commutator bars can without difficulty be made equal to 4 mm. Thus the pressure between three bars must not exceed 7 volts. Taking this at the fundamental principle for the design of series motors, and using ordinary lap windings with one turn between adjacent bars, we at once get the largest admissible value for the magnetic flux. Thus, the flux per pole at 15 cycles must not exceed $3{\cdot}6 \times 10^6$ lines, or at 25 cycles, $2{\cdot}4 \times 10^6$. The question now arises whether it is possible to build motors for large outputs with such low fluxes, since the torque of a motor is proportional to the flux. Other firms, *e.g.*, Westinghouse, work with much higher fluxes, but are then compelled to use resistance connections between winding and commutator. Now, it must be remembered that these resistance connections reduce the second factor on which the torque depends, for they occupy about 50 per cent. of the winding space, so that, without these connections, the number of ampere conductors can be increased by about 50 per cent., hence a 50 per cent. greater torque can be exerted. In addition to this, the resistance connections give rise to considerable difficulties owing to the great heat developed. The present Oerlikon design, even of motors up to 1,000 H.P., proposes, therefore, to do away with resistance connections altogether, and work within the above-mentioned limit of 3·6 megalines for the flux.

In this way the commutation both at starting and when running is properly provided for. At the same time it must not be forgotten, when compared with high pressure (600 to 1,500 volts) continuous-current motors, that the pressure between commutator bars is less than 10 volts, whilst in the latter machines it is 15 to 25; in addition to which the danger of breakdown or arc over, due to excessive potential, is much less in the alternating-current motor, owing to its low pressure. Also, when compared with the compensated repulsion motor, or with the three-phase induction motor, the present motor will be found to possess many superior qualities, whilst for speed regulation it is inferior to none.

ELECTRIC CRANES.*

BY H. H. BROUGHTON.

(*Continued from page 49.*)

Summary.—The author here deals with the design and construction of the mechanical equipment of cranes. The mechanism required for effecting the usual crane motions is treated in four sections. The first section relates to lifting mechanism. The article opens with a short discussion on the determination of the size of motor, and a simple expression is given suitable for most ordinary types of jib and overhead travelling cranes. Then follow notes on wire ropes, fla link-chains, the gear ratio, spur and worm gears, shafting, barrels, blocks and hooks, mechanical brakes, limit switches, and the "free-barrel" system. Lifting magnets and safety tongs are also described.

Mechanical Brakes.—In some cases a mechanical brake is required on the lifting gear. Such brakes must allow the machinery to run freely in hoisting, but prevent the load from descending except when the motor is run in the lowering direction. In most forms of mechanical brakes the brake is applied by the action of the load, hence they are called load brakes.

In a Paper read at the Cleveland Convention of the American Foundrymen's Association, Mr. Sawyer divides load brakes used by reputable American firms into two classes: one in which the brake pressure is not reduced in lowering, but the motor acts with the load to cause the brake to slip, and the other in which the motor torque in the "lowering" direction reduces the pressure between the surfaces, allowing the brake to slip and the load to descend.

Mr. Peters has given the following description of the "Weston" load brake.† Referring to Fig. 88, the ratchet wheel R is free to revolve when hoisting, but is held by two

† "Design of the Weston Load Brake," by Ulrich Peters, *Machinery* (New York).

silent pawls P from turning in the lowering direction. The friction nut N is geared to the motor, and the retaining shaft S, with gear pinion, leads to the hoisting drum. The retaining shaft S and friction nut N are threaded right or left-handed, according to the hoisting direction. The friction flange F is keyed to the retaining shaft S, and engages with the friction nut N by means of three jaws which have about 15 deg. angular play. The friction flange F drives the pinion direct through tongued and grooved projections between the pinion and flange. Any tendency of the load to

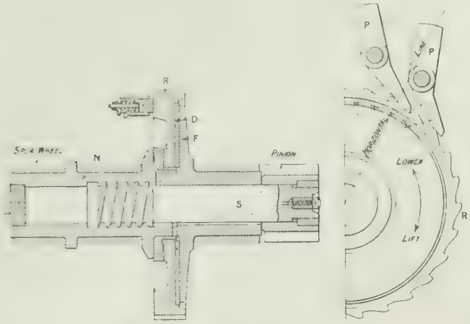


Fig. 88.—Weston Load Brake.

revolve the retaining shaft when the motor is at rest causes the friction flange with the friction disc D to be pressed against the side of the ratchet wheel and the thrust washer of the nut, due to the screwing action of the threads. The friction of this washer against the ratchet wheel, which, as already explained, does not turn in the lowering direction, is sufficient to hold the load. Upon starting the motor to lower, it turns the friction nut and relieves a certain amount of pressure on the washers, until the pressure is overcome so far as to permit the load to rotate the friction flange in

The construction of the "free-wheel" brake drum will be understood from Fig. 89. An iron or steel block with internal notches machined in the periphery, is keyed to the shaft. The outer member of steel or iron, machined all over, is bored out and fitted with a phosphor-bronze bush, the boss of the block being turned to the correct diameter to give a bearing fit through the bush. Four (or other number) case-hardened and ground steel rollers connect the inner block to the outer member.

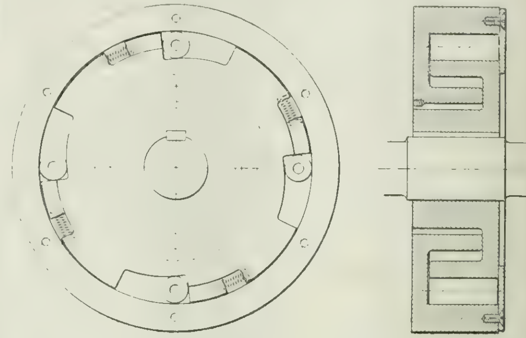


Fig. 89.—"Free Wheel" Brake Drum.

Sector-shaped pieces of cast-iron, pressed against the rollers by means of light steel springs, serve to keep the rollers in exact register. A wrought-iron or steel ring secured to the outer member prevents lateral displacement of the rollers. When the shaft rotates in a clockwise direction, the outer rim is "free" from the shaft, and this direction of rotation is for lifting the load. In lowering, the direction of rotation is reversed. The outer rim is locked to the block keyed on the shaft, by means of the rollers, but as the brake is applied to the outer rim,

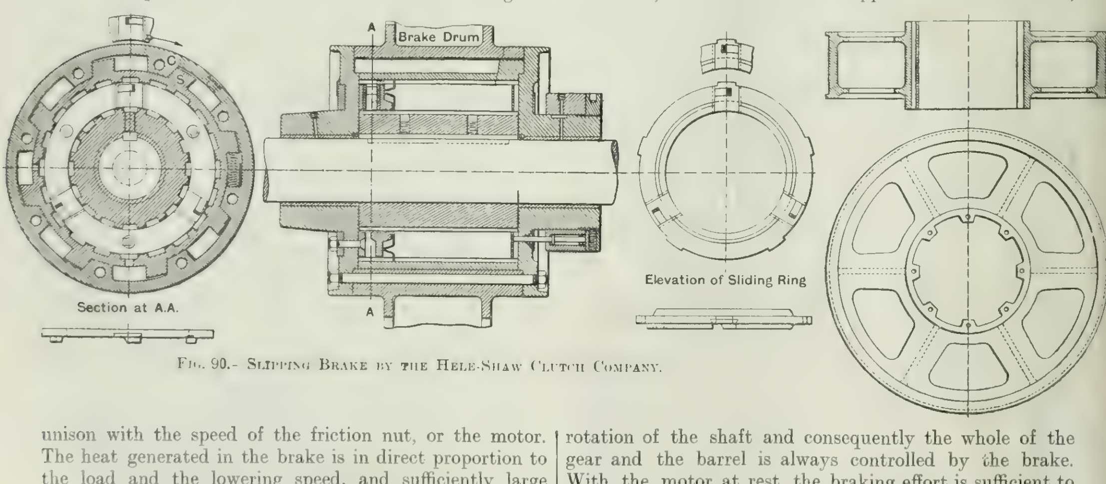


Fig. 90.- Slipping Brake by the Hele-Shaw Clutch Company.

unison with the speed of the friction nut, or the motor. The heat generated in the brake is in direct proportion to the load and the lowering speed, and sufficiently large radiating surfaces must be allowed in the brake so as to prevent overheating. In the article referred to above, it is stated that the required combined area A (sq. in.) of friction nut and thrust washer is from 0·6 SW to 1·0 SW, where W is the lifting capacity in tons, and S is the lowering speed in feet per minute. As to the position of the brake, Mr. Peters states that the best results have been obtained in practice at about 100 revs. per min. of the retaining shaft at the maximum lowering speed.

rotation of the shaft and consequently the whole of the gear and the barrel is always controlled by the brake. With the motor at rest, the braking effort is sufficient to hold the maximum load without any fear of the latter running down.

The overload slipping brake, shown in Fig. 90, by the British Hele-Shaw Patent Clutch Co., has been applied to the hoisting motions of a number of heavy electrically driven cranes, built by Craven Bros., for handling armour plates. For such work it will be seen that if the hook is not at the correct level when the plate is put under the press, the gantry or the crane may be damaged when

the press is put into action. In the construction shown, the clutch is balanced by means of springs introduced between the outer case and the sub-case which exactly balance the load. The pressure is retained on the clutch by means of knife edges in the back. When the overload occurs, the inner case and the outer case have a differential movement which causes the knife edges to slide down one another and so release the load. The latter is thus enabled to be held down at its correct level by the press.

Matthews' patent hydraulic brake, used by Stothert & Pitt on many of their block-setting titans and other heavy

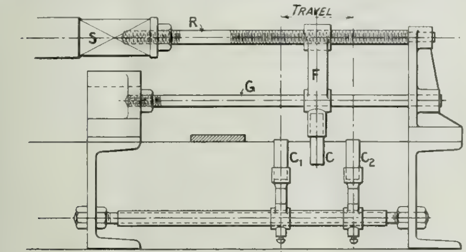


Fig. 91—Overwinding and Overlowering Switch.

cranes, has proved entirely satisfactory under the most exacting conditions of service.

The brake consists of two hydraulic cylinders fitted with pistons, guides, and cross-heads, as shown. The pistons are actuated from crank-discs, which are driven by the main lifting gear of the crane when the load is being lowered. By-passes are provided to connect the ends of the cylinders, and special throttle valves are provided for opening or closing the openings. The cylinders are jacketed with cold water to absorb the heat generated. By means of a ratchet free-wheel clutch, when the load is being lifted, the hydraulic pistons remain at rest so that no resistance is opposed to hoisting.

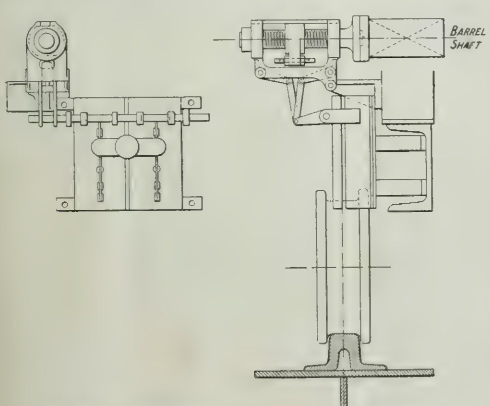


Fig. 92.—Overwinding and Overlowering Switch.

The advantage of this type of brake is that lowering can be performed with exceeding smoothness, and the speed regulated to great nicety.

In addition to the several mechanical brakes described above, a number of compressed air-brakes might be included. Such brakes may be supplied with air by means of a small motor driven compressor mounted on the crane in much the same way as the brakes are supplied with air on an electric train.

Limit Switches.—It is customary to provide a limit switch on the hoisting motion. The function of such a switch is to open the circuit at the critical moment, in order to prevent the blocks and hook being drawn together.

The arrangement shown in Fig. 91 is much used for the purpose. The screwed rod R attached to the barrel shaft S, carries a fixing F which is bored out and threaded at its upper end to mate with the screw R. The fixing is prevented from rotating by means of the guide rod G. In the lower end of the sliding fixing, a carbon-contact C is secured. Underneath are fixed upon appropriate supports two pairs of carbon-contacts C_1 and C_2, the positions of which may readily be adjusted to suit any height of lift. The first pair of contacts is a safeguard against overwinding, and the second pair is provided as a safeguard against overlowering. As soon as the moving contact bridges over either pair of fixed contacts, the motor circuit is broken. There are several ways in which the contacts can be connected in circuit. An obvious arrangement is to connect each pair of contacts to the terminals of the "no-voltage" release coil

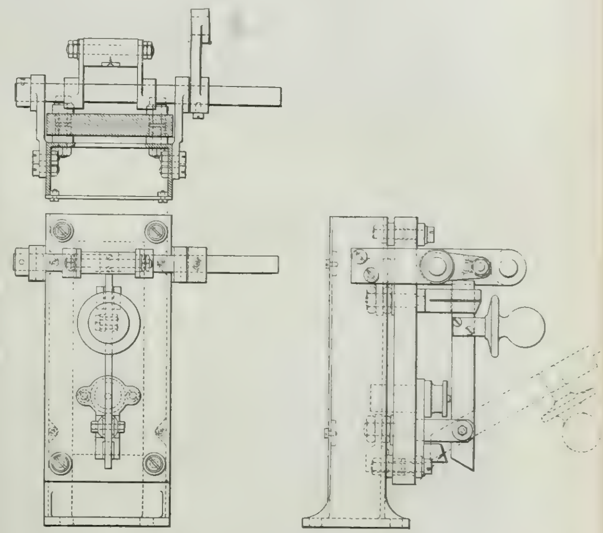


Fig. 93.—Overwinding Switch.

of an ordinary circuit-breaker. This should be mounted in the operator's cabin, as it is necessary to hold the circuit-breaker "in" until current is obtained by turning the controller handle to the first notch in the "reverse" direction.

In Fig. 92 is shown another good form of limit switch. A screwed rod, fixed in the end of the barrel shaft, carries a guided nut which travels along the screwed rod until the adjustable pin strikes one or other of the bell-crank levers mounted at each end, one being for overwinding and the other for overlowering as before. The free ends of the bell-cranks are connected by means of links to an arm which is attached to a shaft carried across the front of the switch. This arm, on being lifted, raises a trigger which causes the switch to open under the action of a strong spring. For continuous current and single-phase alternating current equipments a single-pole switch is necessary, and for two and three-phase equipments a double-pole switch must be provided. The construction and method of mounting the switch will readily be inferred from Fig. 93.

(To be continued.)

THE ELECTRIFICATION OF STEAM-DRIVEN NON-REVERSING ROLLING MILLS.*

BY W. F. MYLAN.

In the United Kingdom much has already been done in the electrification of non-reversing rolling mills, though yet more work remains to be executed, and the question is therefore one deserving of the very closest consideration. The accompanying table gives a list of some of the mills now in operation in this country, together with information as to the type of rolls, size of motor, electrical characteristics of the power supply and the method of applying the motive power to the rolls. It is estimated that in Europe at the present time there are upwards of 230 electrically-driven non-reversing mills in operation, the total horse-power exceeding 200,000.

The electric driving of rolling mills is quite past the experimental stage, and it is not only possible to estimate with accuracy the size and other details of the equipment, but also to determine the actual cost of operation under any given conditions. The choice of a suitable equipment is all important, each case requiring separate consideration; while often the final result is in the nature of a compromise, the best arrangement from the electrical point of view proving impossible of realisation owing to local conditions.

The size of motor required can be estimated from indicator diagrams taken on the engine when the mill is doing its hardest work, though too much reliance must not be placed on these results. Allowance must be made for the increased output required from the motor owing to the higher average speed, so that it is better to determine the horse-power of the motor by calculating the work it will be called upon to do from data already obtained under the same or similar conditions. Knowing the total output of the mill during a certain period, the nature, size and section of the raw material, the size of the finished product and the cycle of operations—*i.e.*, the number and time of the passes and the period of rest—it is possible, by comparison with figures already obtained from other installations, to estimate very closely the horse-power of the motor to be installed.

A properly designed flywheel is of great use in helping to reduce the size of the motor and enabling it to overcome the peak loads without absorbing too great a current from the line. Any demand on the energy contained in the flywheel must be followed by a light-load period to allow the motor to regain its normal speed and it should be remembered that the time taken to extract energy from a flywheel is usually considerably shorter than the time required to return the same amount of energy to it. In the perfect case the light load period is equal to or greater than the overload period. The use of a flywheel for levelling the output demanded of the motor is not generally practicable if the time in rolling one pass exceeds about 30 seconds, and in such cases the introduction of a heavy flywheel is open to very serious objections, as the motor would, after a certain point in the pass, have to pull the flywheel round in addition to supplying the power required for rolling. This is the case in rolling long bars and rails. Here a comparatively light flywheel is desirable, levelling only the smaller peaks and variations in the load, the motor being designed to deal with the main peaks without any external assistance. When heavy flywheels are employed, an automatic device is used to ensure that they take their full share of the load. This is effected on mills with direct-current motors by increasing the strength of the separately excited field and in alternate-current motors by inserting a resistance in the rotor circuit.

The author then deals with the methods of speed regulation employed in electrically-driven rolling mills and with the importance of efficiency in the gearing or other driving arrangements between the motor and mill.

The author next turns to details of some actual conversions. One of these is a cold rolling brass merchant mill which is now driven by a 250 H.P. motor running at 250 revs. per min. This motor is of the slip-ring type and is direct geared to the mill. It is placed underground, thus giving a large additional floor space which, as the mill is in the heart of a large city and rather confined for room, is of the greatest possible value. This mill has two breaking-down rolls and six finishing rolls, driven by a train of wheels. The ingots dealt with are of brass 10 in. wide, 1 in. thick, and varying from 16 in. to 18 in. long. The original engine worked with a boiler pressure of about 50 lb. per square inch, had a single cylinder of 25 in. diameter by 4 ft. stroke, and ran at 53 revs. per min. At no load the engine indicated 60 B.H.P., the average load was 120 B.H.P., and the maximum load 235 B.H.P. The average output has been considerably increased since the mill was converted. It has been found on the average that breaking down 10 in. by 1 in. by 12 in. brass ingots into strips for wires takes 86 units per ton.

Another case is an iron and steel merchant mill which rolls sections of various shapes, sizes and hardness. It consists of five pairs of 12 in. rolls running at 80 revs. per min. as a minimum, and is driven through double helical steel gears. Owing to the methods of working the mill is frequently overloaded, but as the motor is generously rated no trouble has been experienced from this cause. The supply in this case is direct current, and the motor has a normal output of 200 B.H.P. when running at speeds between 200 to 450 revs. per min. The machine is fitted with commutating poles, speed variation being obtained by the use of a field rheostat. Since this mill was electrified an increase in output of over 30 per cent. in material rolled and a decrease in the power consumed of 60 per cent. has been obtained. The current is supplied from a large power plant, equipped with gas engines and turbines, so that the generating costs are very low. Examples of the savings effected by the use of the electric drive in the sheet iron and rail and girder mills are also given in the Paper.

* Abstract of a Paper read before the Leeds Local Section of the Institution of Electrical Engineers.

Details of Some Electrically-driven Rolling Mills in Operation or under Erection in this Country.

Where installed.	Description of mill.	Motor. H.P.	Motor. Speed.	Motor. Supply.	Drive.
Pather Iron & Steel Co.	3 high 12 in. merchant mill	500-1000	375	3 phase, 25 period, 400 volts	Ropes
Etna Iron & Steel Co.	3 high 12 in. merchant mill	500-1000	375	3 phase, 25 period, 400 volts	Ropes
Etna Iron & Steel Co.	3 high 9 in. merchant mill	250	485	3 phase, 25 period, 400 volts	Ropes
English McKenna Process Co.	6 rail mills re-rolling old rails	500	290	3 phase, 50 period, 440 volts	Double helical gears
Excelsior Iron & Steel Co.	Sheet mill	200	...	3 phase, 25 period, 400 volts	Ropes
Redheugh Mills	Sheet mill	350	375	3 phase, 40 period, 400 volts	Ropes
Sir Theodore Fry	Forge mill merchant staff	400	330	3 phase, 40 period, 400 volts	Geared
(Being erected only)	16 in. mill merchant staff	250	385	3 phase, 40 period, 400 volts	Geared
	10 in. mill merchant staff	250	385	3 phase, 40 period, 400 volts	Geared
	8 in. mill merchant staff	250	385	3 phase, 40 period, 400 volts	Geared
	16 in. rail mill	250	385	3 phase, 40 period, 400 volts	Geared
John Summers	3 high merchant mill	325	570	3 phase, 40 period, 400 volts	Ropes
J. Brown & Co.	12 in. merchant mill	200	200-450	230 volts (direct current)	Double helical gear
J. Brown & Co.	12 in. merchant mill	200	200-450	...	Double helical gear
H. Wiggins & Co.	Sheet (nickel) mill	200	300	3 phase, 25 period, 440 volts	Ropes
H Wiggins & Co.	Bar (nickel) mill	150	375	3 phase, 25 period, 440 volts	Geared
W. H. Moore & Co.	Sheet (brass) mill	200	240	3 phase, 25 period, 440 volts	Geared
G. Johnson & Co.	Sheet (brass) mill	250	240	3 phase, 25 period, 440 volts	Geared
The Mint, Birmingham	....	325	365	3 phase, 25 period, 5,000 volts	Geared
		235	...	3 phase, 25 period, 5,000 volts	Geared
		235	...	3 phase, 25 period, 5,000 volts	Geared
Birmingham Metal & Munitions	Sheet (brass) mill	Two 110	360	3 phase, 25 period, 400 volts	Double helical gear
	Sheet (brass) mill	Two 160	360	3 phase, 25 period, 400 volts	Double helical gear
Willans & Robinson	Tube mill	275	360	410 volts (direct current)	Ropes
District Iron & Steel Co.	12 in. merchant and spoke mill	250	...	3 phase, 25 period, 440 volts	Geared
Jones & Colver	Bar mill	200	500	2 phase, 50 period, 200 volts	Belted
British Insulated & Helsby	Copper rod mill	250	350-380	240 volts (direct current)	...
Newcastle	Wire rod mill	130	388	3 phase, 40 period, 440 volts	Geared
	Wire rod mill	130	770	3 phase, 40 period, 440 volts	Geared
	Wire rod mill	130	580	3 phase, 40 period, 440 volts	Geared

The advantages of using an electric motor rather than the older forms of drive are that, owing to the ease with which a constant torque may be maintained, it is possible to run the mill at higher speeds than formerly and thus to obtain more uniform results. This increase in speed presents no difficulty as regards the handling of material, while the constant torque exerted renders the mills practically free from stalling. The increased speed makes for an increased output from the mills, while the large overload capacity enables a widely fluctuating load to be dealt with.

The decreased power costs obtained by using a motor are due to the fact that energy may be purchased at a small cost from one of the numerous supply companies, thus shutting down the wasteful steam boilers and local electrical plant.

A very important advantage which follows on the introduction of electricity is the possibility of arriving at very exact figures (not approximations) of the actual power consumed under any conditions. This information being obtained for each section rolled, enables a very close price for rolling to be determined. From such figures it is possible to tell at a glance whether the mill is in good working order, or by making alterations and taking readings, to see whether the best possible method of handling the material and obtaining the desired result is being adopted.

The extreme simplicity of the control, and the ease with which it is possible to make electrical apparatus practically fool-proof, reduces the labour costs considerably, and this, coupled with the impossibility of an electrically-driven mill racing, render less frequent the stoppages for broken couplings, pinions and rolls. Such troubles are inseparable from a steam-driven mill and are a constant source of annoyance and a big loss, not only due to increased upkeep but to time lost by the mill having to stand whilst the repairs are carried out. The provision of simple and certain protective devices is easily arranged for, which, in emergency, can be relied upon to operate with certainty.

A very material saving in floor space is certain where a mill is converted to electricity, and this is a great advantage as it enables the space around the mill to be used for the more rapid handling of the material required to feed the mill, and for the disposal of the finished product. Very often the motor can with advantage be installed below the floor level, the only gear on the shop floor being the comparatively insignificant control gear.

An electrically-operated mill has in any case less stand-by losses, and in the case of the motor fed from a supply company's main, none at all. In comparing the cost of rolling under the two systems (steam and electricity) this point is important, as in one case the losses are very serious and add largely to the total cost of rolling a certain output. Where a motor is employed for driving a mill a great advantage accrues through being able to start up immediately, and a further reduction in cost of rolling is obtained through less labour being required to handle the same material. A motor requires only intermittent attention, and with emergency devices for stopping it is not necessary to have an attendant standing by continually.

As regards the question of capital cost, that of an electrically-equipped rolling mill is at most only equal to, and in the majority of cases is considerably cheaper than, the corresponding steam equipment. If electrification involves the erection of generating plant the expenditure of a larger sum of money than that involved by putting down a new steam plant is necessary, but there are usually a number of auxiliaries which can be converted to the electric drive with a resulting increase in economy, and this conversion will justify the installation of a special generating plant.

Many mills are taking their supplies from power companies' mains, especially in the Glasgow, Birmingham and the North-East Coast districts. These have proved to be entirely reliable, and operate at a much lower cost than under the old conditions. In one instance, with power at 0·85d. per kilowatt-hour, a saving of over £3,000 was made on one year's working, more than paying for the cost of the equipment. The crux of the whole question of rolling electrically is whether or not a reasonably cheap source of power is obtainable either from a private generating station or from an outside source, and this obtained, electrical rolling will be found to be considerably cheaper than steam.

THE ELECTRICAL TREATMENT OF SEWAGE EFFLUENT.

It will doubtless be remembered by our readers that some time ago the water supply of Nice was equipped with a large ozonising plant for the purpose of sterilising the drinking water. This was necessary, inasmuch as bacteriological examination of the town supply revealed the fact that a certain

FIG. 1.—OZONISERS AND EMULSERS.

amount of matter was present in the water, which could not fail to be somewhat dangerous to the health of the public. Accordingly a motor running at 220 volts on an alternate current, three phase, 25 cycles circuit, driving a pump and dynamo, was installed, the latter giving current at 220 volts, and a frequency of 500 per second. This current was then transformed to 20,000 volts, and passed to a series of ozonisers,

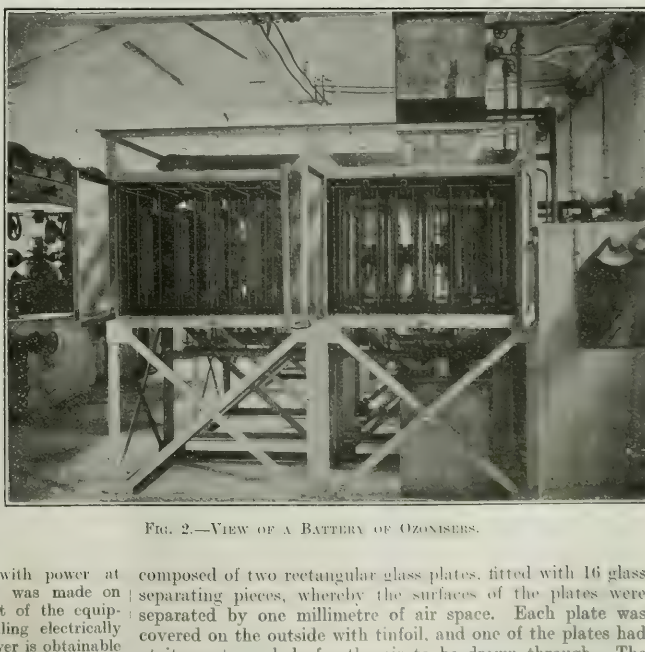


FIG. 2.—VIEW OF A BATTERY OF OZONISERS.

composed of two rectangular glass plates, fitted with 16 glass separating pieces, whereby the surfaces of the plates were separated by one millimetre of air space. Each plate was covered on the outside with tinfoil, and one of the plates had at its centre a hole for the air to be drawn through. The energy required for the pump is 26 kw., while the energy required for the ozoniser is 78 kw. The water,

which is taken from a spring, is delivered by the pump to the first floor, whence it flows into the mixers. The output of each mixer is 120 cubic metres per hour, with a maximum of 150 cubic metres per hour. The water and the ozone are then mixed in suitable nozzles, and after passing through the filters, the clarified water, smelling strongly of ozone, flows into the empty reservoir.

Fig. 1 shows the ozone chambers on the left, from which the ozone is conducted to the main supply on the right, mixed in the emulsers and carried to the sterilising galleries, which are under the floor shown. Fig. 6 shows another view of this equipment, while Fig. 2 shows more clearly one of the ozone chambers. Fig. 3 shows the outlet of the ozonised liquid, and Fig. 4 the electric plant required. So successful was this plant, which was installed under the Otto processes represented by the Lahmeyer Electrical Co., of New Oxford-street, London, W.C., that a second installation is being put in at Nice, the first one of which is treating five million gallons of water per day, and they have received an order for the treatment of a ten million gallon supply for the City of Paris.

There is now a further development of the treatment of water by means of ozone. The exceedingly good results, which have

Fig. 3.—Outflow of Sterilised Water.

already been furnished in connection with town supply drinking water, by passing a high pressure electric current over dielectrics, has induced a consideration of the application of the same processes to the treatment of sewage effluent. The principle of the system is particularly simple. Air is drawn through the ozonisers and is then carried to a mixing chamber which affords thorough contact between the ozone and the water, and the mixture is then carried through a sterilising gallery, by which means the liquid is thoroughly saturated. Ozone is well known for its bactericidal powers, and thus all pathogenic germs are eliminated. The action of ozone is particularly noticeable where the presence of bacillus coli is found in large quantities, such as in wells which have become contaminated by sewage, and the overflowing of water sources in times of storm on to the land where contamination takes place. Germs of typhoid and enteric are also particularly susceptible to the influence of ozone. Taking therefore the system in which it is required to treat 25,000 gallons of sewage effluent per hour or 600,000 gallon per day, the solids in suspension in the water to be treated may be allowed for at the rate of three grains per gallon, or 42·8 grammes per 220 gallons; the total weight would be 230 lb. per 24 hours. As the matter in suspension would be very fine, it would be necessary to employ a coagulant, such as sulphate of alumina, and to pass the mixture through a precipitation tank, but a roughing tank would usually be sufficient to treat this amount of suspended matter. For pumping purposes a centrifugal pump is employed to raise the effluent to a height of 10 metres, at the rate of 31·1 cubic metres per second, and taking the efficiency of the pump at 0·6 the necessary power is 6·8 H.P. For the production of ozone, allowing one gramme per 100 gallons, 246·4 grammes would be necessary for 112 cubic metres, and the energy expended would be 7,392 watts. Taking into account the efficiency of the alternator this would involve the expenditure of 14·4 H.P. The exciter absorbs 0·57 H.P., and the total power for the whole plant would be 21·72 H.P. The plant required to deal with this output would

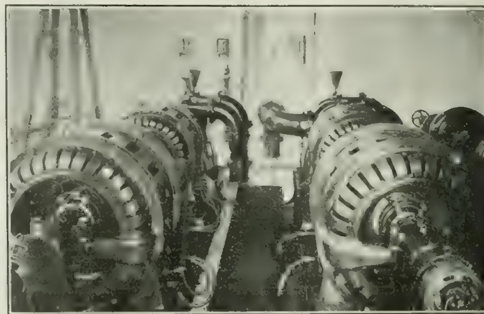


Fig. 4.—View of Electric Plant.

be a centrifugal pump, a 15 kw. single-phase alternator of 500 cycles, 220 volts, with an exciter, a distributing board complete with instruments for control and measurement, a single-phase transformer converting from 220 to 15,000 volts at 500 cycles with a coil absorbing power of 15 k.v.a., a seven-element battery ozoniser for 246·6 grammes of ozone, absorbing about 1,056 watts per element, and an emulser composed of 100 aspirators mounted in a cylindrical iron box with an enamelled interior, each having an output of 1·12 cubic metres per hour under a pressure of 13 ft.

For an output of double the capacity the pump power required would be 13·8 H.P., the energy consumption in ozonisation 14,850 watts, and the total power for the alternator

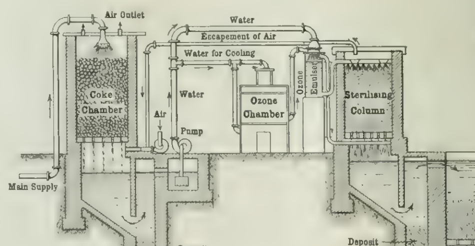


Fig. 5.—Diagram showing Arrangement of Plant.

43·85 H.P. Two transformers of the type mentioned above would be required, and the element battery and emulser sections would have to be doubled in capacity. These groups of emulsers are mounted on a tank of bonded cement, above the sterilising galleries, so that the level of the water in the sluices placed in the galleries is 13 in. above the pebbles. This water level should also be 26in. below the aspirator level in the emulser groups. The depth of the tank is 6 ft., and a pipe in bonded cement connects the lower part of the tank with the water inlet of the galleries. The arrangement is clearly seen in Fig. 5.

The sterilisation galleries are composed of large tanks in masonry, covered over with pure cement in order to render them watertight, every gallery having an interior dimension of about

18 ft. by 5 ft. For the smaller capacity of 25,000 gallons of sewage effluent per hour, one such gallery is sufficient, the capacity being doubled for the larger figure mentioned. The lower portion of the gallery which is 4 ft. 6 in. in height between the base and the grids supporting the pebbles, forms a reserve of ozonised water, and is furnished at the bottom with a hydraulic joint; this allows the outlet of the water, but retains the gas, which must therefore rise into the gallery among the mass of pebbles. The water falls into the cistern by a sluice, which can be used to gauge the output. The body of the gallery is 8 ft. in height above the grid which carries pebbles for a height of about 6 ft. It is important that these pebbles should be thoroughly smooth and carefully cleaned from any traces of clay or earth; they should also be non-porous and non-ferruginous. The ozonised air is conducted from the battery of ozonisers by a stoneware conduit as far as the emulser, and the air which accumulates at the upper part of the emulser tank is conducted under the grid by a similar pipe, which runs the whole length of the gallery. The part of the pipe which is exposed to the gallery is perforated in order to allow the freeing of the ozonised air, by which means a thorough sterilisation is obtained between this and the water flowing over the pebbles to meet it.

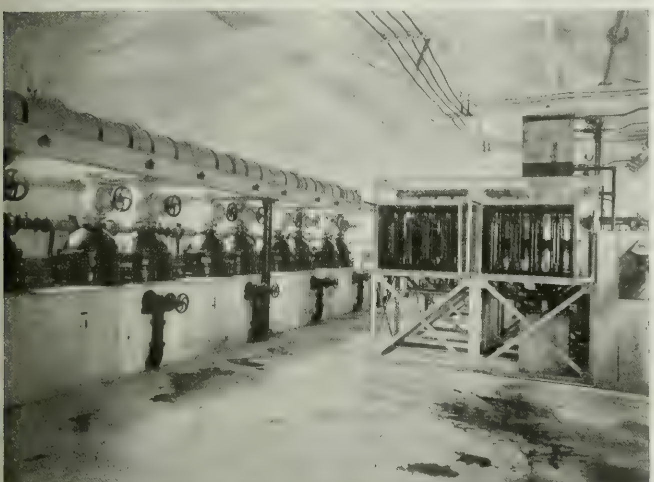


Fig. 6.—General View of Ozonisers and Emulsers.

That this scheme is anything but visionary is shown by the actual success of the ozone processes, as developed by the firm mentioned. In addition to the installations mentioned above, this apparatus has already been installed for drinking water at Dinard and Cosne, at each of which places 528,000 gallons are treated per 24 hours, Chartres where 1,210,000 gallons per 24 hours are treated, Armentieres 660,000, Avranches 506,000, a second installation for Dinard 506,000, &c., while at the following towns installations have been erected or are in the course of construction to deal with six million gallons per day:—Villefranche, Beaulieu, Saint Jean, Eze, La Turbie, Gabbe-Roquebrune, Mentone, Monaco, Monte Carlo and other towns.

Where iron appears very largely in solution it is necessary to precipitate this before using the ozone apparatus, but it may be roughly taken that for the treatment of one million gallons per day of sewage effluent, the cost of the whole of the plant necessary would be between £3,000 and £4,000, while the working expenses for such a system can be gauged from the figures of power required, given above. This is in such strong contrast with the extensive works which are at present laid down for the treatment of sewage effluent, in many cases absorbing a considerable acreage of valuable land, that the subject is well worth careful investigation by our municipal engineers.

THE INTERNATIONAL CANDLE.

We have received from the National Physical Laboratory the following important memorandum in regard to an international standard of light:—

In order to determine as accurately as possible the relations between the photometric units of America, France, Germany and Great Britain, comparisons have been made at different times during the past few years between the unit of light maintained at the Bureau of Standards, Washington; at the Laboratoire Central d'Electricité, Paris; at the Physikalisch-Technische Reichsanstalt, Berlin, and at the National Physical Laboratory, London.

The unit of light at the Bureau of Standards has been maintained through the medium of a series of incandescent electric lamps, the values of which were originally intended to be in agreement with the British unit, being made 100/88 times the Hefner unit.

The unit of light at the Laboratoire Central is the bougie décimale, which is the 20th part of the standard defined by the International Conference on Units of 1884, and which is taken, in accordance with the experiments of Violle, as 0·104 of the Carcel lamp.

The unit of light at the Physikalisch-Technische Reichsanstalt is that given by the Hefner lamp burning at normal barometric pressure (76 cm.) in an atmosphere containing 8·8 litres of water vapour per cubic metre.

The unit of light at the National Physical Laboratory is that given by the 10 c.p. Harcourt pentane lamp, which was prescribed for use by the Metropolitan Gas Referees, burning at normal barometric pressure (76 cm.) in an atmosphere containing 8 litres of water vapour per cubic metre.

In addition to the direct intercomparison of flame standards carried out recently by the national laboratories in Europe, one comparison was made in 1906 and two in 1908 between the American and European units by means of carefully seasoned carbon filament electric standards, and as a result of all the comparisons, the following relationships are established between the above units:—

The pentane unit has the same value within the errors of experiment as the bougie décimale. It is 1·6 per cent. less than the standard candle of the United States of America and 11 per cent. greater than the Hefner unit.

In order to come into agreement with Great Britain and France, the Bureau of Standards of America proposed to reduce its standard candle by 1·6 per cent., provided that France and Great Britain would unite with America in maintaining the common value constant, and, with the approval of other countries, would call it the International candle. The National Physical Laboratory, London, and the Laboratoire Central d'Electricité, Paris, have agreed to adopt this proposal in respect to the photometric standardisation which they undertake, and the date agreed upon for the adoption of the common unit and the change of unit in America is April 1, 1909.

The following simple relations will, therefore, hold after that date:

Proposed new unit = 1 pentane candle
= 1 bougie décimale
= 1 American candle
= 1·11 Hefner unit
= 0·104 Carcel unit.

Therefore, 1 Hefner unit = 0·90 of the proposed new unit.

The pentane and other photometric standards in use in America will hereafter be standardised by the Bureau of Standards in terms of the new unit. This, within the limits of experimental error, will bring the photometric units for both gas and electrical industries in America and Great Britain, and therefore the electrical industry in France, to a single value, and the Hefner unit will be in the simple ratio of 9/10 to this international unit.

The proposal to call the common unit of light to be maintained jointly by the national standardising laboratories of America, France and Great Britain the "International candle" has been submitted to the International Electrotechnical Commission, and through it to all the countries of the world which are represented on that Commission.

It is hoped that general approval will be secured, and that in the near future the term "International candle" for the new unit will have official international sanction.

A NOTE ON THE PRODUCTION OF STEADY ELECTRIC OSCILLATIONS IN CLOSED CIRCUITS AND A METHOD OF TESTING RADIO-TELEGRAPHIC RECEIVERS.*

BY J. A. FLEMING, D.SC., F.R.S., AND G. B. DYKE, B.SC.

Summary.—The authors show that by using two closed oscillatory circuits placed, say, 50 ft. to 150 ft. apart, the equivalent, for testing purposes, of radio-telegraphic stations with open oscillators at very large distances can be obtained. A description is given of the apparatus at University College, London, and of tests on various detectors.

In testing radio-telegraphic detectors the difficulty is generally to obtain facilities for working in actual stations and at various distances. The first-named author has, therefore, been seeking for some years past for a method of testing receivers within very moderate distances so as to afford all the advantages to be obtained by working over long distances without any of the disadvantages. This has now been achieved by the use of closed electric circuits or magnetic oscillators instead of electric oscillators. In a previous Paper† two formulæ were given: one for the radiation in watts from a linear oscillator of the Hertzian type of length l, and the other from a square closed circuit of area S, on the assumption that the oscillations were persistent oscillations having a root mean square value, a, and a frequency, N. These formulæ were

$$W = 87 \times 10^{-23} l^2 a^2 N^2 \text{ (for the open or electric oscillator),}$$

$$W = 4 \times 10^{-38} S^2 a^2 N^4 \text{ (for the closed or magnetic oscillator),}$$

where W stands for the radiation in watts, l for the length of the linear oscillator and S for the area of the closed or magnetic oscillator. Hence, for any such frequencies as are used in radio-telegraphy and for such dimensions as are generally possible, an open or linear oscillator has much greater radiative power than a closed oscillator of about the same linear dimensions. Accordingly, if two closed-circuit oscillators are placed at a certain distance apart and oscillations set up in one of them, and the other one used as a receiving circuit, the current in the receiving circuit can be made extremely feeble when the oscillators are separated by not more than a few hundred yards, and we can avail ourselves of such a means to provide what is the equivalent to two radio-telegraphic stations with open or linear oscillators separated by many hundreds of miles.

In order to supply the necessary conditions for quantitative work, one of these closed circuits must be made the seat of perfectly constant oscillations, damped or undamped, by preference damped oscillations. The appliances which have now been in use in the radio-telegraphic research laboratory at University College, London, for many years past for this purpose are as follows: The source of E.M.F. may be an induction coil or transformer. If an induction coil, it is preferably operated by large secondary cells, the primary current being interrupted by some good form of mercury coal-gas break. We have used for this purpose with great advantage the Béclère mercury coal-gas break. We have also used with even greater advantage for some time a mercury turbine break by Schall, thus converted into a coal-gas break which will work for hours at a time for many months without the slightest attention. To obtain perfectly constant results it is necessary to cause a jet of air to impinge upon the spark-gap to destroy the arcing which otherwise would take place, and, as shown in another Paper,‡ the result of this air blast is to remove the causes of the irregularity in the discharge current. It is also desirable to enclose the spark balls in a cast-iron chamber for silencing purposes.

The form of spark-gap used by the authors consists of a cast-iron chamber, S (Fig. 1), closed by a lid with a glazed peephole in it, the distance of the spark balls being adjustable by a screw, and a glass jet, J, being arranged so as to cause a steady jet of air from a small Lennox blower under a pressure of 16 in. to 20 in. of water, to impinge upon the spark-gap. An aperture is left in the cast-iron chamber, through which this air escapes. By using a small spark-gap not more than 3 mm. in length, and a suitable pressure of air, it is possible to maintain oscillations of great constancy in a circuit which includes the spark-gap S, a suitable condenser, C_1, and the closed circuit L_1, which constitutes the radiator. The radiator is preferably made by winding 8 or 10 turns of stranded insulated wire upon a square wooden frame, which may be anything from 2 ft. to 8 ft. or 10 ft. inside. The condenser may be an ordinary leyden jar, or preferably an oil condenser consisting of metal plates placed in anhydrous paraffin oil. The high-frequency capacity of this condenser can then be measured accurately, and also the inductance of the radiative circuit and the frequency of the sparks can be ascertained by a spark counter. The mean square value of the current in the oscillatory circuit can be determined by a hot-wire or thermo-electric ammeter inserted in it, or in a circuit, M, inductively coupled to it. Signals can also be automatically sent by interrupting the primary circuit of the transformer or induction coil by a key operated by a punched tape.

At a distance, say, of 50 ft. to 150 ft. or more, another square circuit may be set up consisting of a similar square coil of insulated wire, L_2 (Fig. 2), and a condenser, C_2. A convenient form is one consisting of fixed semi-circular plates and a number of movable semi-circular plates fixed on a shaft, which can be rotated, so as to bring the second set of plates more or less in between the first set, the vessel being filled with a highly insulating oil. Two of such closed oscillatory circuits can be set up within a large building.

To test a radio-telegraphic detector of any kind it is first necessary to be certain that the detector *per se*, when unconnected to the oscillatory receiving circuit, is not directly affected by the spark at the distance at which the sending and receiving circuits are set up. Then any particular type of oscillation detector, D (Fig. 2), can be tested as to sensibility by inserting it, either in series with the condenser of the receiving circuit, or in parallel with the condenser of the receiving circuit. The detector D is associated with a telephone, T, and a battery, B, shunted by resistance R as usual. The use of the closed circuits has this great advantage, that, being directive radiators and absorbers, it is possible, by a displacement of the

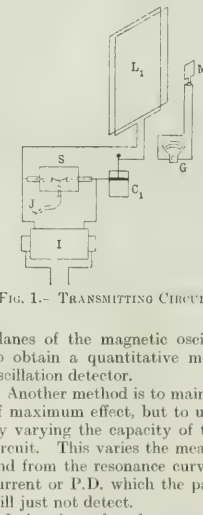


FIG. 1.—TRANSMITTING CIRCUITS.

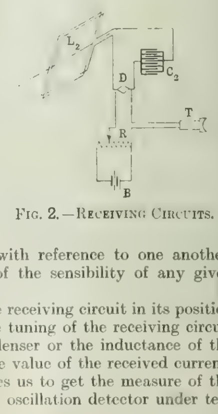


FIG. 2.—RECEIVING CIRCUITS.

planes of the magnetic oscillators with reference to one another, to obtain a quantitative measure of the sensibility of any given oscillation detector.

Another method is to maintain the receiving circuit in its position of maximum effect, but to upset the tuning of the receiving circuit by varying the capacity of the condenser or the inductance of the circuit. This varies the mean square value of the received current, and from the resonance curve enables us to get the measure of the current or P.D. which the particular oscillation detector under test will just not detect.

It has been found convenient to denote the relative telegraphic value of detectors by stating the angle in degrees through which the receiving coil has to be rotated from the zero position that good audible signals can be obtained on the telephone. If a note is made of the value in amperes or milliamperes of the current in the closed transmitting circuit, this can always be recovered, and if the spark length and spark frequency are the same, we can always be sure that the sending circuit is in a constant and similar condition when comparative tests are made.

The closed receiving coil is conveniently made by winding silk-covered copper wire, No. 16 S.W.G., on a square mahogany frame, which can be revolved on pivots carried on a baseboard, which can itself be set at any required angle. In general appearance it resembles an instrument used in physical laboratories under the name of an earth inductor, for obtaining small induced currents by means of the rotation of a coil in the terrestrial magnetic field.

Some Fleming oscillation valves of a new type were found to be so sensitive to oscillations that no position in which the receiving circuit could be placed was so completely a position of zero mutual induction that these valves, when used with a telephone, gave no signals from a tuned transmitter. Such valves were called zero valves. Others could not detect signals until the coil had been turned through 5, 10 or 20 deg. from the zero or minimum position. A magnetic detector

* Abstract of a Paper read before the Physical Society. A short account of the discussion appeared in our issue of April 16th, p. 26.

† "On Magnetic Oscillators as Radiators in Wireless Telegraphy," by J. A. Fleming. THE ELECTRICIAN, December 27, 1907, and January 3, 1908.

‡ "The Effect of an Air-blast upon the Spark Discharge of a Condenser charged by an Induction Coil or Transformer," by J. A. Fleming and H. W. Richardson. (See p. 175 of our last issue).

inserted in series with the coil could not detect the signals from the transmitter until the coil was turned through 15 deg. An electrolytic detector of a particular make required a rotation of 40 deg., and a carborundum detector required 45 deg. rotation of the coil to give audible signals on the telephone. These measurements are not given as absolute and final measurements of the relative sensibility of all magnetic, electrolytic or crystal detectors.

SIDE-ROD SINGLE-PHASE LOCOMOTIVE.*

A type of single-phase locomotive, designed to reduce the maintenance charges on rolling stock of this class, has recently been designed and built by the General Electric Co. and the American Locomotive Co. The distinguishing feature is the mounting of the motors on top of the frames and connecting them to the driving wheels by rods and cranks. Two 800 H.P. single-phase 15 cycle motors will form the equipment of the locomotive, which is designed to develop a tractive effort of 30,000 lb. at a speed of 18 miles per hour, and to have a maximum speed of 50 miles per hour. The locomotive has been equipped temporarily with two 400 H.P. motors for testing purposes.

The frame and running gear are not unlike those of the steam locomotive. There are three pairs of 49 in. coupled driving wheels, a radial two-wheeled pony truck at one end and a four-wheeled bogie truck at the other end. The total wheelbase of the locomotive is 36 ft. 3 in., but the rigid wheelbase is only 10 ft., which permits rounding the sharpest curves. The weight when fully equipped will be 250,000 lb., of which 162,000 lb. will be carried by the three driving axles. This gives a weight per driving axle much higher than that on either the New York Central or the New Haven electric locomotives, although slightly less than the maximum weight employed on high-speed steam locomotives.

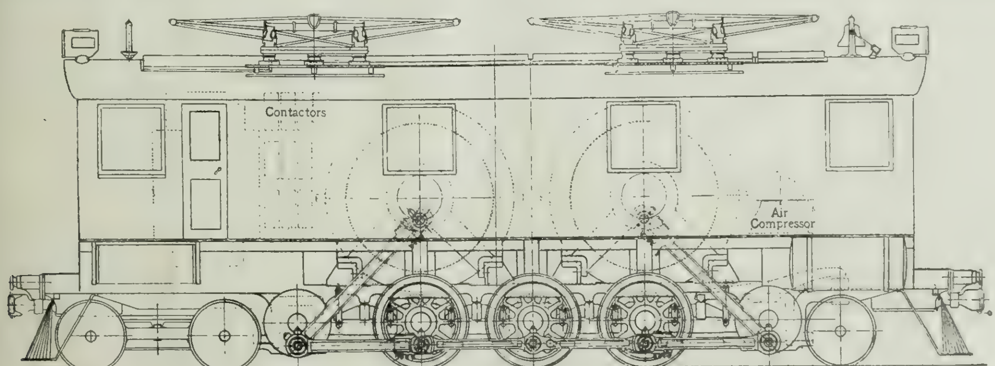


Fig. 1.—Single phase Locomotive with Cranks.

The motors start as repulsion motors with short-circuited armatures, and as the speed increases are changed over to series repulsion motors, thus giving the motors high starting torque and eliminating running with short-circuited armatures. The starting tractive effort is about twice the running effort on the same input. By mounting the motors on top of the frame, extra large bearings may be employed, and the air-gap may be reduced to a minimum, since there is no danger of the armature dropping on the pole-pieces. Also the motors being carried on the frame of the locomotive and near the centre, there are no severe shocks produced by dead weight on the axles, and the moment of inertia of the locomotive around its vertical axis is reduced to a minimum.

The arrangement of connecting rods between the motors and the driving wheels is illustrated in Fig. 1 herewith. Two jackshafts, 10 in. in diameter, and supported in bearings rigidly fixed in the locomotive frames, extend across the frames outside of the end driving wheels. Quartered crank arms are shrunk and keyed on both ends of these jackshafts and similar crank arms are attached with flexible couplings to both ends of each motor armature shaft. Inclined connecting rods extend from each motor crank arm to the corresponding jackshaft. To the same crank pins on the jackshafts are connected the driving-wheel side rods. For each revolution of the motor armatures, therefore, the driving wheels make one complete revolution, and the motors revolve in exact unison, due to the mechanical connection through the driving-wheel side rods. The object of using the jackshaft is to permit a horizontal drive between the spring-supported part of the locomotive and the driving wheels. This is necessary in order to provide for vertical play between the spring-supported part and the non-spring-supported wheels with a negligible variation in the distance between crank centres.

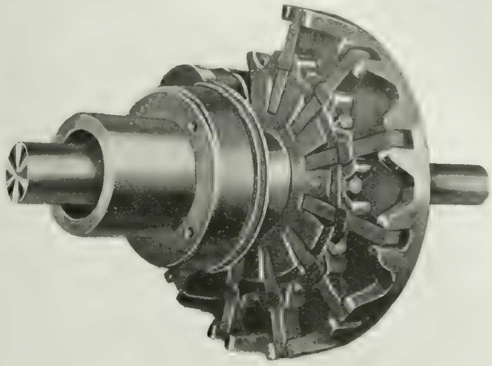


Fig. 2.—Flexible Coupling.

An interesting mechanical detail is the flexible coupling (*see* Fig. 2) inserted between the motor armature shaft and the motor crank arm. The motor crank arm and its counterweight are formed in one piece, which is bored out to fit over an extension of the motor armature shaft. Just outside the armature bearing the armature shaft is enlarged in diameter, and notches are cut out to form seats for eight sets of radial leaf springs. On the inside surface of the crank-arm counterweight suitable notches are formed to seat the other end of the leaf springs. The sets of springs are fastened to the counterweight by bolted lugs which fit over the spring bands.

* Abstracted from the "Electrical World."

THE ELECTROLYTIC THEORY OF THE CORROSION OF IRON AND ITS APPLICATIONS.*

BY W. H. WALKER.

Summary.—The author first describes the fundamental conceptions involved in the modern electrolytic theory of the corrosion of iron, and then develops this theory from the facts now known, showing that the older carbonic acid theory advocated by Dr. Friend can be, and is, included therein. Finally he points out some practical applications of this theory to the problem of corrosion as met with in engineering practice.

In accordance with the almost universally accepted electrolytic dissociation theory, when a salt dissolves in water a certain proportion of the dissolved molecules are regarded as dissociated or broken

* Abstract of a Paper read before the Iron and Steel Institute.

up by the water into component parts called ions. These ions frequently act as whole molecules do, but differ from real atoms in that they carry relatively large charges of electricity. Water itself is somewhat dissociated into two ions oppositely charged—the positive hydrogen ion composed of one atom of hydrogen, and the negative hydroxyl ion composed of one atom each of oxygen and hydrogen.

In the case of pure iron in water a condition perfectly analogous to that of electrolytic solution pressure is found to exist. Water itself is dissociated to a small but perfectly definite extent into its ions, hydrogen (H) and hydroxyl (OH). When a strip of pure iron comes into contact with water, it sends into the water iron atoms in the form of positively charged ions. Hydrogen as a metal has a much smaller solution pressure than iron, and hence an equivalent number of hydrogen ions plate out on the iron strip (leaving the free hydroxyl ions with their negative charges to balance the iron ions with their positive charges), and an electric current flows from the iron by means of the iron ions to the solution, and by means of the hydrogen from the solution back to the iron again, thus completing the circuit. The deposited film of gas, however, offers a great resistance (called polarisation) to the flow of the current and the action ceases.

The solution of the iron, in the first instance, depends upon the number of the hydrogen ions present. This number of hydrogen ions, or the concentration of these ions, is increased by the addition of any acid. So weak an acid as carbonic increases the number, but to a relatively small amount; while a strong acid, like hydrochloric or sulphuric, adds to the number to such an extent that the solvent action becomes violent, and the deposited hydrogen comes off as a stream of gas.

It is this aspect that Dr. Friend has ignored, and he concludes that, when pure iron is placed in water free from oxygen and carbonic acid, no iron is dissolved, because, under such circumstances, no iron was detected by him by the ordinary test for iron ions, namely potassium sulphocyanate. But, on the other hand, he finds that, when the minute amount of carbonic acid which naturally adheres to the iron and to the sides of the containing vessel is present, iron will dissolve, and under these conditions can be later precipitated by oxygen as rust. Upon these observations he throws out the entire electrolytic theory of corrosion, and states: "We thus see that the electrolytic theory of corrosion is untenable." Even though the entire accuracy of the experimental work just noted be granted, the fact remains that these data in no way contradict the electrolytic theory, but in reality they confirm it.

Dr. Friend did not detect the iron ions in the water in which his iron strip had stood, simply because his analytical methods were not sufficiently refined. A very delicate test for the presence of the iron ion is the blue colour obtained with potassium ferricyanide solution, while phenolphthalien becomes intensely red in the presence of hydroxyl ions. If a piece of iron be placed in an aqueous solution containing potassium ferricyanide and phenolphthalien, which, to prevent convection currents, has been thickened with a little ordinary gelatine, a bright blue colour is formed at those points at which the iron is passing into solution, and a bright red colour where the hydrogen is plating out.

Since the presence of the polarising film of hydrogen arrests the further solution of the iron, in order for the reaction to proceed this hydrogen must be removed. The destruction of the hydrogen film in ordinary corrosion is accomplished by the oxygen of the atmosphere, which is dissolved in the water. Also, any substance which dissolves or reacts with hydrogen accelerates corrosion.

It was formerly thought that the action of oxygen as a factor necessary in corrosion was simply to oxidise the iron ions thrown into solution, and to precipitate them as rust. While it is true that this reaction does take place, and is indeed the most striking function that oxygen performs, it is in reality a secondary one, which is simply incidental to corrosion and not a necessary part of the action. Its real accelerating effect is due to the fact that it depolarises the hydrogen which is set free by the reaction, and separates out on the metallic iron.

This is proved by a number of now well-known phenomena. Thus, when a piece of iron is placed in ordinary water exposed to the air it will dissolve or rust. If there be placed in the water with this piece of iron a piece of platinum, the solvent or corroding action of the water will not be changed. If now the platinum and iron be electrically connected, a marked increase in the rate of the solution or corrosion of the iron is noticed.

Another example is found in the action of zinc in water containing an electrolyte. If a strip of zinc and a piece of iron be placed in water containing a very little salt, the iron will corrode rapidly, while the zinc will be but slightly attacked. The usual explanation for this phenomenon is that the zinc protects itself with an adherent film of zinc oxide or hydroxide, while the iron produces a non-adherent voluminous hydroxide which does not protect. If now instead of being separated the two strips of metal be placed so as to touch each other, the iron no longer corrodes, but the zinc very rapidly passes into solution. The explanation consistent with the electrolytic theory is that the zinc in the first arrangement corrodes, because its surface does not catalyse the reaction $H_2 + O = H_2O$ with sufficient rapidity to remove continually the hydrogen. The film of hydrogen, therefore, forms on the zinc and protects it. When the two strips are united, the greater solution pressure of the zinc forces a larger number of zinc ions into the solution, and the next result of the flow of the current is that the zinc soon becomes anodic over its entire surface, while the iron becomes the cathode and is not dissolved.

Some important conclusions may be drawn from a consideration of the factors involved. Since before the iron can form rust it must first pass into solution, and in so doing cause an electric current to flow from the iron at that point to the iron at some other point, any circumstance which will aid the flow of this current will accelerate the solution of the iron. Differences of potential resulting from a segregation or uneven distribution of any impurities which the iron or steel may contain will do this. Hence we should expect that the speed of corrosion would increase in accordance with the percentage of impurities present. The simplest way, of course, to insure an absence of segregation is to eliminate altogether those materials not needed in the iron. It has been found that a steel made under such conditions that the total impurities are reduced to 0·05 per cent. resists corrosion to an extent equal to the iron of our forefathers. The steel companies have been slow to accept this general proposition, but it is gratifying to know that material of this purity may now be obtained on the open market.

Since iron can pass into solution only by assuming the ionic form, and having at the same time an equivalent amount of hydrogen pass from the ionic condition to the gaseous state, the speed of the reaction will depend upon the number of hydrogen ions present in the solution. The effect of free acids has already been noted; but the presence of any material, such as alum or magnesium chloride when subjected to pressure, or other materials which by hydrolysis will form an acid, will also accelerate corrosion.

If, on the other hand, the hydrogen concentration be reduced, the corrosion of the iron will also be decreased. Such a condition may be most easily realised by adding to the water a strong alkali, which, owing to the presence of a large number of hydroxyl ions, decreases thereby the number of the hydrogen ions. This is the probable explanation why the iron of Dr. Friend's experiment did not corrode in the presence of oxygen and hydrogen.

This fact has an important bearing upon the question which has been lately much discussed, as to whether concrete will protect iron from corrosion. Inasmuch as Portland cement, when it sets or hardens, liberates a large quantity of caustic lime, which is a strong alkali, and since good concrete is therefore saturated with this strong alkali, the answer to the question must be in the affirmative. Iron or steel will not corrode when embedded in concrete. But caustic lime is soluble in water, and poorly made concrete is not impervious to water. Therefore, if iron be embedded in concrete through which water at any time be allowed to percolate, this calcium hydrate will be slowly but surely dissolved and washed away, and with it will disappear the inhibiting action of the concrete, and iron embedded therein will surely rust. To insure absolute protection of the reinforcing members of concrete construction, therefore, such concrete must be sufficiently dense and carefully made to render it practically waterproof. This is not an impossible condition.

The fact that the presence of a metallic iron surface accelerates the corrosion of zinc has an important bearing upon the protection of structures where both an iron and zinc surface are exposed. Since oxygen is necessary to insure the continuous removal of the hydrogen film, it is obvious that if no oxygen be allowed to reach the iron through the water, no corrosion can take place. This fact teaches us much regarding the corrosion of boiler shells and tubes. Pitting may be entirely avoided if the air be removed from the feed water before its introduction into the boiler. This may best be done by the employment of an open feed water heater, or, what is better still, a feed water heater connected to the dry vacuum pumps of the condenser. If such treatment is not possible, the air may be removed from the feed water by drawing the water through a closed box containing scrap iron; the oxygen in the water is used up in corroding the scrap iron instead of the boiler tubes. Or, the oxygen in the water may be absorbed by feeding into the boiler with the water a very small quantity of an alkaline solution of a tannin material. Such a solution of alkaline tannate will break up under the pressure and temperature of the boiler, with a formation of a pyrogallate of the alkali, and this rapidly absorbs the oxygen. Soda ash, or rather alkali, is of course useful, but not because of its effect upon the oxygen content, but because, as has already been explained, corrosion

is inhibited by thus decreasing the hydrogen ion concentration of the water.

Tin is a metal which, like copper, accelerates the corrosion of iron by aiding in the oxidation of the hydrogen set free by the reaction. If, therefore, in the manufacture of the so-called tinplate, which is sheet iron or steel covered with a layer of metallic tin, there be imperfections or pin-holes in the tin coating, these channels through the tin to the iron will become centres of corrosion which rapidly destroy the plate. It is impossible to detect these imperfections by a simple inspection, and hence users of tinplate have been unable to test the quality of their raw material from this point of view. Since the iron must pass into solution at these exposed points in the tin coating, their presence may be easily located by flowing upon the tin surface a solution of gelatine or glue in which is dissolved some potassium ferricyanide. When the jelly has stiffened the iron will pass into solution through the holes in the tin and, reacting with the ferricyanide, will leave a bright blue spot in the jelly. Variations in the quality of tinplate may thus be easily detected.

The author has already shown * that "mill scale" or magnetic oxide of iron is strongly electro-negative to iron. Since mill scale is insoluble in water and cannot of itself enter into the reaction, its only function must be analogous to that of platinum or other insoluble conductor of this kind, viz., to furnish a surface on which the hydrogen liberated by the dissolving iron can separate and be catalytically oxidised to water again. This is also true of the black oxide protective coatings cometimes used upon iron and steel, as, for example, that of the Bower-Barf process. Just as is the case in mill scale, these coatings are very serviceable so long as the whole coating is intact. But so soon as a portion of the metallic iron is exposed, this portion corrodes all the more rapidly on account of the presence of the surface of scale on which the oxidation of the hydrogen and consequent depolarisation can go on. Hence, if it were possible to remove the mill scale entirely from steam boiler tubes, for example, pitting would be largely eliminated, and the life of the tubes prolonged.

Many more examples of the application of the electrolytic theory to problems of corrosion could be given, but these will suffice to make clear the general applicability of the theory, and its usefulness in the investigation of a subject of such fundamental importance to manufacturers and users of iron and steel. The Paper is accompanied by several illustrations showing the actions described.

INTERPOLE DESIGNS.†

BY W. B. HIRD.

Summary.—The author first discusses the design of interpoles for continuous-current machines, and then shows that their adoption can be justified even in the case of small machines at moderate speeds. A saving is shown in first cost, due to the use of smaller air-gap and longer armature, and also a better efficiency can be obtained.

Designers are by no means unanimous concerning the extensive use of interpoles. Continuous-current designs may be considered as falling into (1) Those where the conditions are such that no satisfactory solution is possible without forced commutation of some kind; (2) where the given conditions allow of a satisfactory solution without any special commutating devices. In the first class fall generators and motors running at abnormally high speeds—*e.g.*, generators direct coupled to steam turbines or motors driving the modern type of high-lift turbine pumps; also motors in which a high range of speed variation by means of shunt regulation is required. It is possible in these, by the use of interpoles, to work with values of the reactance voltage five or six times as great as would be admissible in an ordinary machine, and with careful design the results are entirely satisfactory. There has been no great difference of opinion as to the advantages of the device for machines of this class, although some designers prefer the use of a compensating winding spread over the main pole-face. A very different state of affairs exists, however, on the question as to whether the use of interpoles is legitimate in the case of those machines which can be satisfactorily designed without using any special commutating device.

In spite of warnings from high quarters in discussions on Papers and in the technical press, the use of interpoles in normal designs has been increasing and is becoming more and more frequent, and the continued trend to an increased use of interpoles in comparatively small machines appears to indicate that there is more in it than a mere fashionable whim. Before considering the use of interpoles in machines of small output and ordinary speeds the author describes a simple method of arriving at the dimensions and windings of the interpoles.

One of the simplest formulæ for calculating the reactance voltage is that published by Mr. Mavor in a Paper read at the International Engineering Congress in 1901. In a slightly modified form this formula is $\rho = \frac{ecfm\pi l}{pn}$, where ρ is the reactance voltage, e the E.M.F. generated in the armature, c the armature current, m the number of turns in one section, l the gross length of armature core, p the number of poles, n the number of magnetic lines per pole, f the number of lines per unit length of core due to 1 ampere flowing in one turn of the short-circuited coil. The value of f varies to some extent with the size of slot, the relative length of conductor in the slot, and in the end winding, &c., but for ordinary machines it does not materially differ from 20 lines per inch length of core. The value of the reactance voltage given by the formula is the maximum value, and on the assumption that the current in the short-circuited coil varies as a sine curve, the mean value will be $\frac{2}{\pi}\rho$, say, $0{\cdot}636\rho$, and to obtain good commutation it is necessary that a field be provided under the interpole such as to generate a voltage in the short-circuited coil equal to $0{\cdot}636\rho$.

If the number of turns in the coil is m, and if R be the number of revolutions per minute, D the diameter of the armature, and λ the length of the interpole measured parallel to the shaft, the E.M.F. generated in a magnetic field of density B will be $m \times \pi DR/60 \times \lambda \times B$, and must be equal to $0{\cdot}636\rho$. Thus

$$B\frac{\lambda}{l} = 0{\cdot}636\frac{ecf}{pn\pi DR/60}.$$

if the interpole shoe is made of the same length as the armature core $\lambda = l$, and the formula gives directly the value of B required in the interpole gap. It is usual, however, to make λ less than l whenever possible, the advantages being to lessen the leakage between interpole and main pole and also to minimise the interference with the freedom of ventilation which an interpole extending over the whole length of core would produce. Also the value of B in the interpole air-gap is increased, and with a high value the reluctance of the magnetic path surrounding the short-circuited coil, and consequently the value of the reactance voltage, is not appreciably affected by the presence of the interpole, as would be the case with a low value of B due to $\lambda = l$.

The width of the interpole shoe is not involved in the formula given above; it is determined by the consideration that if the coil undergoing reversal is in the interpole field for too short a proportion of the time of short-circuit the reversal will not be properly carried out, whilst, on the other hand, the very considerable leakage which takes place between the interpole and the neighbouring main pole of opposite polarity makes it advisable to keep the width as small as possible, so as to leave the actual distance from pole shoe to pole shoe as large as practicable. Various recommendations have been made; a simple one is width equal to one slot pitch plus one tooth width. It would appear, however, in practice, at any rate in the case of machines where the reactance voltage can be kept down to reasonable limits, that considerable latitude is possible in the choice of a pole width.

Sufficient ampere-turns must be provided to neutralise the armature ampere-turns in addition to those required to give the requisite value of B in the air-gap. It will be seen, therefore, that the number of ampere-turns required are considerable; in fact, they are frequently in excess of the number required on the main poles. As, however, the interpole can usually be made of small section, so as to keep the mean turn of the winding short, the number of ampere-turns can be obtained with only a relatively small expenditure of copper.

Although the arrangement of using fewer interpoles than main poles gives good results on small machines—say, 20 H.P. motors, in which the reactance voltage is not excessive—it has not been found satisfactory in machines of any considerable size; and where it is done, the field strength of the interpoles must be correspondingly increased.

To return to the question of dynamos and motors of comparatively small sizes and working at ordinary speeds, in order to justify the use of interpoles it must be shown that such machines can be by the use of interpoles made either better or cheaper than could be done on ordinary lines of design.

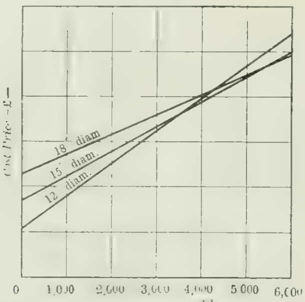
First, in regard to cost. The material and labour expended on the interpoles are counterbalanced by the use of a reduced depth of air-gap, allowing of smaller magnets carrying less copper, reduced number of commutator parts, saving both labour and material in the commutator, and, lastly, the possibility of working with a greater

* "Journal" of the American Chemical Society, 1907, p. 1259.

† Abstract of a Paper read before the Glasgow Local Section of the Institution of Electrical Engineers.

length of armature core relatively to the diameter. The last means does not appear, up to the present, to have been fully taken advantage of. If we consider a dynamo as consisting of two ends, the parts of the machine outside the two parallel planes which pass through the ends of the armature core, and of an active part included between these planes, and then vary the core length—*i.e.*, the active part—leaving everything else as before, and plot the cost of manufacture of different machines so obtained against core length, the points should be very approximately on a straight line, for every addition of, say, 1 in. in core length will mean an equal addition of material and of labour. The curve will remain a straight line with increasing lengths until a point is reached where the increased distance between bearings requires that the mechanical parts of the machine shaft and bearings be strengthened, when a slight addition in cost will result.

If, however, the curves are plotted with d^2l instead of length as base line, as in the accompanying figure, and if it be assumed for the moment that the output of the machine, watts revs. per min., is proportional to d^2l, the points where these lines cross show the different lengths at which it is advantageous, from the point of view of economy in first cost, to pass from one diameter to the next larger diameter. The curves are fairly in accordance with ordinary present practice, and the actual scale of cost price can be filled in for any individual line of machines. The curves indicate that the economical lengths for the different diameters dealt with are considerably in excess of those usually met with. The statement, however, is true only on the assumption that the output increases proportionately to the length. In ordinary designs this assumption is not true, because of the sparking limit to output; but if interpoles are used this sparking limit is removed so as to allow of, at any rate, a nearer approach to the economical length.



As to whether the heating limit will not prevent the output of the machine being increased proportionately to its length, when the length becomes so great as to require increased diameter of shaft, stronger spider, &c., the increased impediment to the circulation of air in the inside of the core makes the increased temperature rise more marked, and it would appear that some method of forced ventilation compelling the air to come in contact with the heated surfaces might be devised to remove this limit to output also. Something more is wanted than merely stirring the air with fan blades—a definite circulation along a predetermined path is required; but if it be true that forced ventilation is the necessary consequence of forced commutation, it may be confidently anticipated that such a system will be forthcoming. Such devices, far from being a confession of weakness, are an added strength in enabling a larger output to be obtained from a cheaper machine.

The fact that interpole designs for normal outputs are becoming more and more common seems to show that the manufacturers using them find that they cheapen the cost of manufacture, and this, in spite of the fact that although the advantage to be gained by increased armature length is clearly recognised no very striking departure has been made in the manufacture of machines with long armatures. Present interpole designs rely mostly on the saving to be obtained by the use of reduced air-gaps and smaller commutators with fewer parts. The possible output of a machine as limited by sparking having been increased by forced commutation, it is to be expected that heating should now be found the limiting condition, and the logical conclusion appears to be that the next step is to devise improvements in the methods of getting rid of the heat, so that full advantage may be taken of the increased freedom which the interpoles give from sparking limit.

Finally, as to whether a machine for ordinary outputs will be improved or the reverse by the introduction of interpoles and by the modifications of design which such a use of interpoles involves. In designs on ordinary lines there is a great temptation from economical reasons to press up the reactance voltage to the highest limit, and to work with the lowest possible factor of safety. Thus it is not an uncommon experience to find modern generators working perfectly satisfactorily under ordinary circumstances, but having a reactance voltage so nearly up to the highest safe value that if the brushes are not in exactly the best position, or if the commutator has been allowed to get at all out of condition, they will flash over from brush to brush if the load be suddenly thrown off. Cases of that kind appear to be entirely removed by the use of interpoles, and there seems every reason to believe that an extended use of this method of construction would lead to better, not to worse, machines, as far as commutation is concerned. As to mechanical troubles arising with machines in which the air-gap is smaller, and the length between bearings greater than present practice, the suggested lengths of air-gap for interpole machines are still made greater than the very small gaps to be found in induction motors in which the mechanical difficulties have been successfully overcome, and also that the maximum lengths suggested still give a ratio of length to diameter much smaller than those commonly in use in the days of bipolar smooth-core machines.

On the score of efficiency it may be contended that increasing the losses to such an extent as to require forced ventilation will lower the efficiency of the machine. But the increased losses correspond to a more than proportionately increased output, and therefore to a better efficiency. In conclusion, it is submitted that the logical consequence of the use of forced commutation appears to be a still further increase in armature lengths which may necessitate the introduction of forced ventilation, and it offers the means of progressing towards the smallest and cheapest satisfactory machine for a given output.

METALLIC FILAMENT LAMPS.*

BY O. BRANDT.

In consequence of the great improvements which have been made in the art of manufacturing metallic filaments, especially from the point of view of efficiency in running, length of life and high candle-power, it may be of interest to examine some of the makes from these points of view.

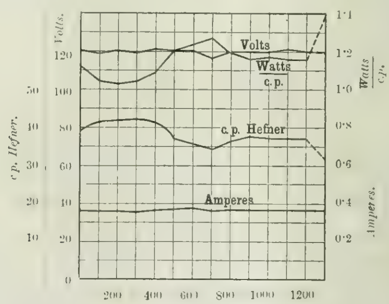


FIG. 1.—OSRAM LAMP NO. 1, 32 C.P., 122 VOLTS.

Four osram lamps were tested, the normal voltage being 122; two of them gave 32 Hefner candle-power and the other two 50 c.p. They were of an old type, so constructed that they could only be used with the filament pointing downwards in a vertical direction, whereas, of course, since that time, the method of manufacture has been so improved that they are capable of burning in any position. Figs. 1, 2, 3 and 4 give the results of the running of these lamps. Lamps 1, 3 and 4 were still burning after 1,600 hours, while No. 2 broke after 1,400 hours. During the first 300 hours there was a distinct increase in the light emission; the maximum illumination is reached between 200 and 400 hours, the current meanwhile remaining almost steady. It will be noticed that the 32 c.p. lamps gave more than their nominal candle-power both before the beginning and after the end of the tests; but this was not the case with the 50 c.p. ones.

The two next osram lamps were for 125 volts, and gave respectively 32 c.p. and 50 c.p. They were constructed to burn in any position. The tests were conducted in all cases on alternate current from the Berlin mains at 120 volts; at this voltage the nominal candle-power was not actually reached. The tests were carried out during the winter months, and the voltage, which was nominally 120, occasionally rose in the evenings to 128 and 130, but these

* Abstracted from the "Elektrotechnische Zeitschrift."

fluctuations produced no effect on the osram lamps. The first of the two lamps had its filament inclined at an angle of 45 deg. to the vertical, while the other was fixed with its filament pointing upwards. The test was discontinued after 1,400 hours, with the results given in Figs 5 and 6.

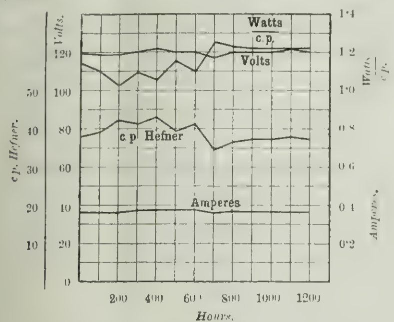


Fig. 2.—Osram Lamp No. 2, 32 c.p., 122 Volts.

The next two lamps were of the "Just" tungsten make, from the Augsburg factory. Small hooks are mounted inside the bulb for keeping the filament in position. Both lamps were 40 c.p. at 120 volts, and were marked on the socket "Type A." One lasted 77 hours, while the other burnt for 100 hours. The three next lamps

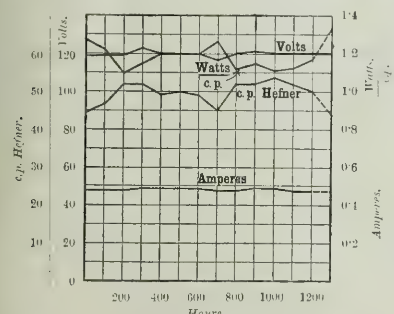


Fig. 3.—Osram Lamp No. 3, 50 c.p., 122 Volts.

were "Sirius" colloid ones for 25 c.p. at 125 volts, made by Pintsch, of Berlin; these lasted about 150 hours. Then there were three Zirkon lamps for 38 c.p. at 120 volts, made by Dr. Hollefreund, of Berlin, which are said to be capable of burning in any position. The first was mounted with its filament pointing vertically upwards,

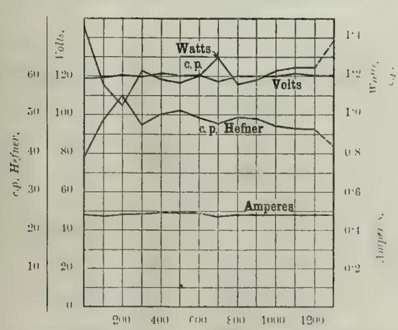


Fig. 4.—Osram Lamp No. 4, 50 c.p., 122 Volts.

and lasted 100 hours; the second pointed vertically downwards, and lasted 200 hours; while the third pointed in a horizontal direction, and lasted 15 hours. This shows clearly the effect which the position of the lamp has on the length of life. After this three Bergmann lamps for 32 c.p. at 125 volts were tested; two of them lasted for 200 hours and the third for 82 hours. Finally, two "Anker" lamps, made at the Rixdorf works near Berlin, were tested. They gave rather more than 50 c.p., and lasted 180 and 390 hours respectively.

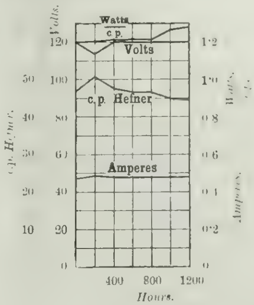


Fig. 5.—Osram Lamp No. 5, 50 c.p., 125 Volts.

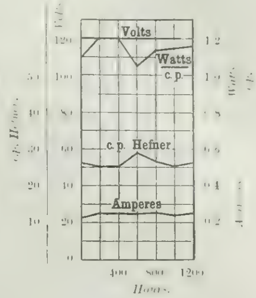


Fig. 6.—Osram Lamp No. 6, 32 c.p., 125 Volts.

It is quite possible that many of these lamps would have done much better on direct current, and it must be admitted that the variations of voltage on the town mains put the lamps to a rather severe test.

SOME NOTES ON INSULATING MATERIAL.*

BY G. H. FLETCHER.

Summary.—The author describes the properties and gives particulars of tests on various insulating materials, more particularly those used in the winding of coils for electrical machinery.

Insulation has two features, namely, its ohmic resistance and its dielectric strength. These are often confused, although they are quite distinct. Often the insulation with the highest ohmic resistance has the lowest breakdown point. For instance, air has a very high insulation resistance but a comparatively low dielectric strength. It is, then, a mistake to suppose that because a machine has a high ohmic insulation resistance, the insulation is necessarily good. Even the reverse may be the case, for a machine may have a comparatively low insulation resistance, and yet may stand several thousand volts without puncturing. Of course, in some cases, such as telegraph and telephone work, where small currents are used, and leakage currents must be a minimum, insulation with a high resistance is important, a high dielectric strength not being so necessary. But in high-tension work the dielectric strength is the more important. The properties of good insulation are as follows:—High insulating resistance, great disruptive strength, flexibility or elasticity (that it may be bent without cracking) in the case of coil insulation; it must be mechanically strong and tough, so that it cannot be easily torn or split; it must be capable of standing high temperatures without softening or suffering permanent injury, and it should be unaffected by gases or acids with which it may come in contact.

The author then gives some curves showing the dielectric strength of air.

The material fulfilling most of the conditions of an ideal insulator is mica. This is used to a large extent in every field. Various kinds of mica are used for different purposes. For the making up of tubes and slot insulation, Indian mica is invariably used, the dielectric strength of this being higher than that of amber mica. For insulating the segments of commutators amber mica is used, because for this purpose insulation of a soft nature is needed, dielectric strength being of little importance, as the voltage between bars is usually less than 20. Other kinds of mica are used, but Indian, and Canadian amber are the two kinds which are most extensively so. One of the chief features of mica is the ease with which it can be built up into plates of any size and thickness. "Micanite" is made by building up thin pieces of mica with shellac varnish, and pressing the sheets between steel plates under great pressure and at a temperature of about 200°F. A point about micanite which is both an advantage and a disadvantage is the fact that when heated it becomes soft and pliable. Nearly all alternator windings are insulated on that portion which fits in the core slot, by means of micanite in thin sheets, wound round the coil before the shellac is

* Abstract of a Paper read before the Dick, Kerr Engineering Society.

dry, and then pressed under a high temperature to the desired size. Mica is also used to insulate the turns of the coil from each other, being interwound between the turns. The sheets used for this purpose are made by building up two or three layers of mica, flaked as thin as possible, upon Japanese paper or parchment paper. This paper gives the sheets mechanical strength. This method of insulating coils is much better than making tubes to fit the slots and winding the coils through them.

Good Indian mica of 1 mil thickness breaks down at 4,000 volts, but as the thickness increases, the breakdown pressure per mil thickness is not as high as this. Amber mica is not so uniform as Indian, and the breakdown point is not quite so high. A sample of 3 mils thickness broke down at an average of 6,500 volts. A sample of mica from South Africa broke down at 9,900 volts, the thickness being also 3 mils. A sample twice this thickness sparks through at 13,000 volts.

Many other substances are used in the insulation of electrical machinery, paper insulation perhaps being the most common. Particulars are given by the author of the amount of moisture absorbed by various papers and of breakdown voltages. It is seen that leatheroid is very absorbent, and as this is used to a large extent to protect the micanite on high-tension windings, it is important to see that it is dried out properly before being put into use. Leatheroid is not at its best an excellent insulator, but its toughness makes it a useful material for protecting other insulation. The best flexible insulation is "empire cloth"—linen cloth, treated with a mixture containing a large percentage of linseed oil, and rolled to a given thickness. The dielectric strength of empire cloth is comparatively high, a thickness of 0·007 in., breaking down at about 4,000 volts.

The following list gives the dielectric strength of other insulating materials :—

Material.	*Damp breakdown.*	*Breakdown when baked one hour.*	
Cartridge paper, 0·003	800	780	Flash test.
Redrope paper, 0·01	1,200	1,420	
" " 0·005	1,000	1,000	
Manila paper, 0·008	1,220	—	
Leatheroid, 0·01	1,270	3,000	
" 0·015	3,650	5,100	
Fuller board, 0·020	5,000	5,000	
" " 0·030	6,000	6,000	
Two-ply empire cloth and mica combination 0·026	24,000	OK at 27,000	
Asbestos, 0·125	3,200	6,800	
Micanite, 0·012	—	16,000	
Wood (maple), impregnated with linseed oil, 0·3125	—	OK flash test 12,000	
	-	Breaks down at 10,000 in 1 min.	
	—	" " 7,000 in 2 min.	
	-	Stands 5,000 for 10 min.	
Black fibre, 0·142	—	13,000	Flash test.
Red fibre, 0·18	—	14,000	

The papers are often treated with varnish, this increasing the dielectric strength considerably. The chief desiderata for varnish are (1) flexibility, (2) no chemical action (on removing the varnished covering from a wire, the copper is sometimes found to be coated with a green oxide ; this is due either to acid in the varnish, or acid absorbed by the varnish from the atmosphere), (3) non-absorption of moisture, (4) high dielectric strength. The following results show the dielectric strength of varnishes on various materials and also the effect of drying :—

	Breakdown point.			
	0·01 *Fuller board.*		0·01 *Redrope paper.*	
Varnish.	*Before baking.*	*After baking.*	*Before baking.*	*After baking.*
Shellac	2,718	4,670	1,495	1,780
Armalac (black)	2,880	5,090	1,555	1,670
Sterling varnish	3,925	5,420	2,155	2,060
Standard varnish	4,110	6,240	—	-
Not treated	1,490	3,660	1,340	1,275

Varnishes containing linseed oil are liable to absorb moisture. The insulation of oil-cooled transformers is considered by itself, as oil affects some kinds of insulation considerably. Rubber covered cables and insulation should be avoided because, as is well known, rubber is soluble in oil. A rubber covered cable should not be placed inside an oil-cooled transformer at all, as the oil will creep along the braiding and attack the rubber. Our standard treatment serves well for transformers. A standard treatment is a layer of half lap linen tape, varnished and dried three times. The oil soaks to the coils through this uniform covering, but does not appreciably affect the varnish. Two standard treatments puncture at 9,000 volts. Transformer oil is another important item, and care should be exercised in the selection of a good quality. The two fundamental functions of transformer oil are, first, to conduct the heat from the coils and core to the case. (The latter should have as large a surface as possible, to radiate the heat to the surrounding atmosphere.) Second, to insulate ; filling up the air spaces in the windings, and between the winding and core. The four essential points are : (1) freedom from acid, (2) high dielectric strength, (3) high flash point, (4) freedom from water or moisture.

The following are some figures taken on various samples of transformer oil, with a $\frac{1}{10}$in. spark-gap between balls of 1 cm. diameter :—

Specific gravity.	*Flash point.*	*Breakdown voltage.*
0·924	159°C.	8,800
0·901	187°C.	6,900
0·884	170°C.	7,800
0·883	179°C.	8,600
0·896	173°C.	6,300

While dealing with oil, it would be well to mention that switch oil, like that just dealt with, should have a high dielectric strength ; but, in order that it may not be readily displaced by an arc, it should be more viscous than transformer oil. Since arcing is continually taking place in the oil, it is essential that it should not readily carbonise. Also, as in the case of transformer oil, the flash point must be high. A factor which enters into the subject is that of specific inductive capacity. This, of course, does not apply to direct current circuits, but in alternating current high-frequency or high-pressure machines. Mica, an insulation largely used in such machines, has a large specific inductive capacity (5·0). This allows a capacity current to pass through which, though practically harmless to the mica insulation, yet may burn any dirt or other semi-conductor on the surface of the mica. The same destructive action takes place between the bent and the adjacent straight coils of an alternator or induction motor, which in some parts of the winding are at a maximum difference of potential.

If a sheet of mica or micanite is subjected to a high electrical pressure for any length of time it will be noticed that the insulation becomes quite warm, due to dielectric hysteresis. A micanite tube $\frac{1}{8}$ in. thick subjected to a pressure of 12,000 volts for one hour gave a temperature rise of 60°F. The heating is also due to a sort of bombardment which takes place in the micanite if it is not well pressed. Small sparks flying from one piece to the next, resulting in heating, and also in a more or less harmful disintegration of the particles. Another action is that of osmosis, and great discretion should be exercised in the employment of fibrous and hygroscopic material for direct-current insulation.

The author concludes with a few remarks on jointing and testing. Transformer and alternator coils should be tested for short-circuit between the turns before assembling, as this may save a great amount of time and labour. This can be done by placing the coils on a laminated iron limb, and using one coil for excitation. The volts should be brought up to about 50 per cent. more than normal. This should be maintained for about 10 minutes, when any short-circuit may be detected by the heating of the coil at the shorter turn. The test for an induction motor of the slip-ring type is made by opening the rotor circuit, and bringing up the stator volts to 25 per cent. over normal. This will show up any short-circuit in either stator or rotor windings.

THE IMPERIAL INTERNATIONAL EXHIBITION.

With the advent of early summer, the general public, and especially the by-no-means-small proportion of that public living around the area called London, has forcibly brought before its notice the various "Exhibitions" to be opened for instruction and recreation. Perhaps we should have put recreation first, as in a great many cases "instruction" is simply the excuse for a day's round of pleasure and excitement. When we were told about this time last year that the elaborate buildings, machinery and electrical plant brought together and erected in the Franco-British Exhibition were to be totally demolished in about six months' time, there were many who refused to give credence to the report. These doubting ones are now justified, for the buildings and grounds in which the Franco-British Exhibition was held at Shepherd's Bush last year will still be familiarly known as the Great White City this year under the guise of the Imperial International Exhibition, 1909, which was opened with due pomp and ceremony by the Duke of Argyle yesterday.

The many and various applications of electrical energy in this vast Exhibition which were to be seen last year have been amplified, and in some cases very decided improvements have been made. This, from the electrical engineer's point of view, is very satisfactory, in that it shows the "man in the street" how electricity is becoming more and more essential to his everyday well-being. The visitor is brought, in almost every case, by either electric trains or electric cars, and when he arrives at the Exhibition he finds most

of the principal features electrically operated, and electricity the medium for giving him the wonderful illumination effects at night. As regards these electrical features, we propose at present to give a general idea of the alterations that have been made since the closing of the White City last year.

The general scheme of current supply remains much the same as described in THE ELECTRICIAN of May 15, 1908, with the exception that whereas last year a certain amount of power was obtained from the Parsons turbine and Westinghouse gas engine in the Machinery Hall, this year that source of supply is not available. To make up for this a new sub-station has been erected immediately on the south side of what used to be the Machinery Hall, so that practically the whole of the current for power and lighting is obtained from either the Hammersmith Borough Council or the Notting Hill Electric Lighting Co. The new sub-station is divided into two enclosed sections. On the one side are three 200 kw. transformers, bringing the feeder pressure of 2,200 volts down to 440 volts, the pressure used throughout the Exhibition, and the switchgear, &c., belonging to the Hammersmith Borough Council. On the other side the distribution panels belonging to the Exhibition authorities are placed. The feeders from the transformers come on to the 'bus bars and the area of supply, including the six buildings in what was the Court of Arts, is split up into six sections by means of double-pole switches at the switchboard. The other sub-stations have also been divided up so that the plant belonging to the supply stations is entirely separate from that owned by the Exhibition authorities.

In sub-station "A" the two 400 kw. motor converters, which were formerly driven by the Kensington supply at 5,000 volts three phase are now fed by the Hammersmith supply at 2,000 volts two phase. To effect this step-up, two Berry transformers have been installed. These are practically the only alterations that have been made in the scheme of supply from that in use last year.

Coming to the most important electrical feature of the Exhibition, the illumination of the grounds and buildings, the great outstanding innovation is the very extensive use of high candle-power metallic filament lamps. In the majority of cases these have displaced arc lamps and the authorities claim that for illumination and effect much better results are obtained, as the best of well-regulated arcs will flicker at times. These lamps are to be seen in use at the Cascade, the old Fine Arts Palace, the new Imperial Tower, most of the bandstands, and in a portion of the roadway on the south side of the Machinery Hall.

In the Cascade some 90 200 c.p. metallic filament lamps are placed underneath the glass-work, graded in batches of five different colours. The lanterns on the partitions on the top of the cascade also have five 55-watt metallic lamps, each lamp being of the corresponding colour to the five different coloured lamps used underneath the cascade. It is curious to note in connection with this that the colour effects are obtained by switches operated by hand at the switchboard. It is also interesting to note that two new electrically-driven direct-coupled Rees Roturbo pumps of 250,000 gallons per hour capacity have been installed to supply the water for the cascade. The motors for this work are each of 50 H.P., and have been made by the Electric Construction Co. As these pumps have no foot valves a direct motor-driven centrifugal air extractor has been installed by the Rees Roturbo Co. for priming purposes when starting up.

The Fine Arts Palace, which, it will be remembered, was not lighted at all last year, has now about 72 200 c.p. metallic lamps. These are placed in very handsome cases with opalescent globes, and, in the day time at any rate, might easily be mistaken for small arc lamps. Metallic filament lamps in use for outside lighting are to be seen in the road on the south side of the Machinery Hall, where 12 200 c.p. lamps are suspended from ornamental standards similar to the method employed for arc lamps. Most of the towers and lanterns are also now fitted with metallic lamps, and it is hoped by this means to obtain a perfectly steady light and consequently better effects. The metallic lamps in use are of the well-known "Osram" type, made by the General Electric Co.

The general outlining of the buildings by carbon filament lamps has been extended on a very lavish scale. The Machinery Hall court, which was not previously illuminated, has now some 5,500 lamps placed on the adjacent buildings, and the Imperial Tower, an imposing and entirely new structure in the centre of the grounds, is illuminated by about 6,000 lamps. Another innovation is a series of panoramas, in the Machinery Hall, depicting health resorts; these require about 3,000 lamps of various colours to give the necessary effect. The remainder of the lighting is practically the same as was seen last year.

From these notes it will be seen that the use of electricity at the White City, tremendous as it was last year, is still more vast this year, and we therefore propose to describe in detail some of the new electrical features in a later issue.

PRECISION MICROMETERS.

It goes without saying that both in the laboratory and workshop the micrometer is a very useful instrument. This being so, and considering the extent to which these instruments are used, we are surprised to learn that up to the present it has always been necessary to import them from abroad. But as the Englishman is always desirous of purchasing home-made goods, we are pleased to be able to announce that Messrs. Elliott Bros. are now making precision micrometers at Lewisham, for which they hope to have the support of the engineering trade in this country.

FIG. 1.—MICROMETER FIXED TO ADJUSTABLE CARRYING ARM FOR BENCH WORK.

As regards the actual micrometers nothing more need be said except that they come up to the standard set by Messrs. Elliott's other well-known instruments. They are made in 1 in. and 2 in. sizes, reading in thousandths, and with or without a ratchet head.

In connection with these micrometers two very interesting pieces of apparatus have been designed, which we illustrate in the accompanying figures. Fig. 1 shows an attachment whereby the micrometer can be used on the bench. It consists of a heavy cast-iron base with an adjustable carrying arm, which, it is claimed, can be moved in practically any direction. Everyone who has had a certain amount of gauging to do, especially with small pieces, knows how very awkward it is to handle the micrometer entirely with one hand, and the necessity for some means for holding the instrument while

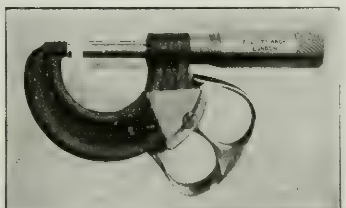


FIG. 2.—MICROMETER WITH FINGER ATTACHMENT.

leaving both hands free is very evident. This attachment allows this to be done. The micrometer can also be so turned in it that the light falls fairly on to the divisions on the frame and the positions of the markings on the thimble can then very easily be read off.

Fig. 2 is a finger ring attachment for enabling the micrometer to be carried on the third and little finger of the right hand, while the thumb and first finger are left perfectly free to move the screw. The frame of the ring is, as will be seen, formed very much like the finger holes in a large pair of scissors, so that the curves are convenient to the fingers, and the whole apparatus can be held in the right hand an almost unlimited time without fatigue. The arrangement is intended for use when a large number of small pieces have to be gauged. These can be taken in the left hand and placed quickly between the measuring surfaces.

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SUB-STATIONS AND POWER DISTRIBUTION.

Modern central station practice has been directed towards the concentration of electrical generating plant in large power stations and the distribution of electrical power from such centres to local sub-stations. In fact, it is largely on the economy resulting from the adoption of such methods that the large electric power supply companies have based their hopes of success. It is true, however, that many people have their doubts whether such power supply schemes, with their long transmission lines and necessarily considerable power losses, can compete successfully with smaller installations scattered over the districts served by the power companies; and one is reminded by the Paper read last week by Mr. A. J. J. PFEIFFER before the Institution of Electrical Engineers, of the controversy which raged some few years ago round this question. Although the Paper is chiefly devoted to a comparison of the capital and running costs of steam, gas and oil engines (the author advocating the adoption of oil engines of the Diesel type in medium-sized power stations, except where the latter are situated in the immediate neighbourhood of coal centres), the feasibility of installing local oil-engine plants instead of sub-stations supplied from a main power station is also discussed.

With the comparison made by the author between the various prime movers we do not at present propose to deal,

beyond calling attention to the fact that the advocates of internal combustion engines—both of the gas and oil type—usually compare the actual results of steam practice with the hypothetical results of the alternative prime movers, the latter figures being often estimated from brief experience of the cost of running the plant in question. Central station engineers know very well that the figures obtained with plant run under the varying conditions experienced in practice almost invariably fall far short of those which might be expected from the results obtained with the plant under test, or otherwise favourable conditions. There is no doubt that economical running is possible with internal combustion engines, but this is usually obtained at the expense of increased capital charges, as compared with steam plant, and as the high cost of Diesel engines is generally admitted, we can hardly agree with the author when he takes the cost of a steam plant power station as £24·5 per kilowatt, and of one with oil plant as £23 to £25 per kilowatt.

It is, however, with the question of sub-station distribution that we are more particularly concerned. The author considers the case of a large distributing system in London, having an outlying generating station feeding 10 sub-stations, each subject to a maximum load of 1,600 kw. Five miles of duplicate cables are allowed for the transmission lines to each sub-station, and the losses in transmission and conversion are taken as 14 per cent. The figures for capital and operating costs given by the author are based largely on particulars obtained from Mr. J. H. Rider's recent Paper before the Institution. In regard to capital cost, it seems from Mr. Rider's remarks during the discussion on Mr. Pfeiffer's Paper last week that the author has gone astray in basing his capital cost for the sub-stations on the figure given by Mr. Rider for the Shoreditch sub-station of the London County Council tramways, which is the most expensive sub-station on the system. Again, the capital cost of the generating station to contain plant of 15,500 kw. capacity is based on £20 per kilowatt of plant installed, which figure, as we pointed out in connection with Mr. Leonard Andrews' Paper, is too high for a modern steam turbine station. The Greenwich generating station, which is frequently referred to as an instance of a higher cost per kilowatt, does not furnish a basis for comparison, owing to the exceptional nature of the plant and buildings.

It will be seen from our account of the discussion elsewhere in this issue that Mr. Rider also criticised the operating costs of the sub-stations, his experience showing that these should be reduced to nearly one-half; but more serious was the alteration necessary in the central station operating costs. The author, whilst taking the figures given in Mr. Rider's Paper for coal, oil and wages, has altered Mr. Rider's figure of 0·018d. for repairs and maintenance to 0·043d. It should also be noticed that Mr. Rider's figures were for only the first section of the Greenwich station, and since January 1st of the present year the costs of that station work out at only 0·261d. per unit, instead of 0·291d. given in Mr. Rider's Paper and 0·316d. given by Mr. Pfeiffer. The steam turbines are, it is stated, largely responsible for the considerable reduction in the fuel costs at Greenwich, that item since January of the present year working out at only 0·197d. per unit. This result should prove very gratifying to those engineers who have advocated the adoption of steam turbines from the point of view of economical running, apart from considerations of reduced space and capital outlay. As regards economy, therefore, the case for the local oil plants is by no means so favourable as Mr. Pfeiffer makes out, and the saving shown in total cost by adopting this type of plant will be converted into a loss in all cases of moderate or high load factor, if the costs of the Diesel plant are worked out with oil at a more usual figure than 50s. per ton—say, 60s. per ton—or are taken from actual practice.

Even under the most favourable conditions, however, we think there are important disadvantages against such a scheme as that proposed by the author. In the first place the management of a number of isolated plants cannot be carried out so satisfactorily or so economically as where the plant and staff are located in one station. The generating plant will also be better maintained in the latter case, and in times of breakdown the advantages of control from one central point cannot be over-estimated. There is also the important advantage that a large generating station, of whatever type, benefits through diversity factor, lower cost per kilowatt and lower costs per unit. The transmission costs must reach a certain figure before these advantages can be disregarded. Another feature is that oil engines cannot take big overloads—this is mentioned by the author—so that besides the necessity of running a considerable amount of idle plant to take care of fluctuating loads, the pressure regulation is also liable to be unsatisfactory; whilst in the case of a failure of one machine the others running, unlike the usual transforming plant in a sub-station, are unable to take up the load. Reliability is one of the most important points to be considered by central station engineers, and that oil plants possess this characteristic is by no means certain. Indeed, we are in a position to know that oil engines under certain conditions have been unsatisfactory and unreliable; and this fact, taken in conjunction with the undoubted inaccuracy of the comparative figures given by the author for the cost of operation in the two cases, should go far to show that engineers are proceeding on the right lines in generating high-tension current as economically as possible in a central power station and transforming at sub-stations to meet local requirements.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electric and Petrol Electric Vehicles. By W. Poynter-Adams. Part II. of "Motor Car Mechanism and Management." (London: Charles Griffin & Co.) Pp. x.—184. 5s. net.

"To those acquainted with the science of electrical engineering the coming of the electric road-vehicle is looked for with confident anticipation," are the author's opening words, and he strengthens them later on. A bold statement: we would suggest adding "only" between "with" and "the."

We are far from denying, however, that in one restricted class of road motor traction electricity has established itself almost exclusively; and that in another class, somewhat less restricted, the few experiments that have been made have been very promising. For town work, to replace a carriage, the

battery car has come to stay. Like the horse, but unlike the ordinary car, it has only a limited "radius of action"; but its radius is greater than that of the horse, and it can do its full output day after day: while, over the ordinary car, it has, for this work, many advantages. If the battery can be improved the car will improve *pari passu*; otherwise it is not very far from its limit. Its use will probably increase greatly; and, as it need never be charging during peak time or fog, it will afford a very welcome additional load to the station engineer.

The other class is where a dynamo and motor are used to replace the gear box in a petrol vehicle. The idea has many most valuable advantages on paper, and we sincerely hope that they will be found equally conspicuous in practice after extensive road running, without counterbalancing defects. If so, the system, in one or more of its numerous forms, will have a considerable future for motor omnibuses. One car is mentioned as being actually on the road.

It is always a little difficult to know how much to tell an outsider; and to remember that axioms to us are mysteries to him: Mr. Adams succeeds fairly well, but we sometimes wish he would not try and tell the truth: it is so confusing to the outsider. It is far wiser sometimes to take the bull by the horns and say, "The following is not strictly a correct explanation, but if you will act on it as if it were, you will find you come to the right conclusions." Immoral? Let the engineer, who in his work really thinks of the surrounding medium and not of the wire, cast the first stone.

Nevertheless Mr. Adams's book is one which every electric car owner should, after reading, pass on to his driver. It gives most things that the latter ought to know—but which he often does not. It deals simply and fairly plainly with chassis, battery, motors, and charging; and has several excellent chapters on general management and driving. The glossary at the end will stand much revision. The definition of "pulley" is perhaps hardly required; but to define it as "a wheel or drum, *varying very greatly in shape*, keyed on to a shaft, &c.," suggests a wire wheel after a collision.

If a few simpler diagrams were given where the text does not really require them the beginner could easily be lead up step by step to the more complex ones; as it is, we fear, he will often cut them, as hieroglyphs beyond his ken.

Before bringing out a second edition Mr. Adams should give the book to two or three drivers and ask them to mark the parts they don't understand, and (the same thing) the parts they think are wrong. The comments may startle him, but they will make his second edition much nearer perfection. The book is well and neatly got up, and well illustrated.

C. W. S. CRAWLEY.

La Télégraphie sans Fil. By I. VAN DAM. Second edition. Paris: (Ch. Béranger.) Pp. xiii.—234.

This excellent textbook has been thoroughly revised, rendering it undoubtedly one of the best which has been published in French, at least from the point of view of the wireless telegraph engineer. The author very properly assumes that his readers have some knowledge of electricity and of mathematics, and spends but little space on ancient history. The result is that, though the book is not a large one, it contains a very great amount of information which is of direct use to telegraphists in regard to both theory and practice. There are, of course, some errors which it would be well to correct in any later edition. For instance, on p. 48, the conclusion drawn from Fleming's calculation of the capacity of an aerial wire as to the rate of radiation of energy is most misleading. The average rate of radiation over a second or more may amount to only one watt, but since almost every type of detector responds to the train of waves, caused by a single spark, it is the rate of radiation during a spark that is of consequence. This rate is, of course, many hundreds of times that of the time average of radiation of energy, and is the chief factor in determining the range of the station.

This and a few similar mistakes, however, detract but little from the general excellence of the book, which will be read with interest not only by students but also by engineers.

ECONOMICS OF MEDIUM-SIZED POWER STATIONS.

We give below an account of the discussion which took place at the meeting of the Institution of Electrical Engineers last week, when Mr. A. J. J. Pfeiffer read his Paper on this subject. An abstract of this Paper appeared in our last issue.

Mr. J. H. RIDER referred to the attention now being paid to internal combustion engines, and said he had not been quite converted by the author to the use of Diesel oil engines. He asked the author to explain the reference in the Paper to variations in the speed of oil engines as 1/300. It was usual, when speaking about speed variations, to express them as a percentage of the angular velocity. In making comparisons between the cost of a power station with its sub-stations and Diesel engine sub-stations, the author gave the cost of 10 sub-stations as £175,000, based upon the figures which he, the speaker, gave of the Shoreditch sub-station. The author took land at £3·25 per kilowatt. In his, Mr. Rider's, desire to be above suspicion in the figures he gave in his Paper he took the most expensive sub-station they had on the whole system. The £3·25 per kilowatt for land referred to a site that cost £10,000. They had sub-stations quite as large on land that only cost £825; in fact, the average of the whole of the sub-stations was only £4,000, so that with the land and similarly with the buildings the author had gone astray in taking his (Mr. Rider's) figures as a basis on which to work out the cost of his sub-stations. He was only able to deal with the figures given for the 33 per cent. load factor in the table dealing with the cost per unit of sub-station output, because they happened to coincide with his experience and related to 49 per cent. load-factor for the central station. He did not know what sub-station Mr. Pfeiffer had in his mind when he gave the operating cost per unit as 0·08d. He could give figures based upon the whole of last year's working, therefore not hypothetical at all, where the oil, waste and stores cost 0·001d. (for the same load factor) and not 0·004d.; salaries and wages 0·041d. and not 0·055d.; maintenance and repairs 0·007d. and not 0·02d.; making a total of only 0·049d. per unit for operating the sub-stations, as against the author's 0·08d. Again, the first three items in the table of pence per unit for central station output were taken from his, the speaker's, paper, but the author did not take the figure the speaker gave, and which was for actual results, of 0·018d. for maintenance and repairs. He took a hypothetical figure—0·043d. Mr. Rider then gave some actual figures based upon recent working. Since Jan. 1 last, instead of 0·291d. the works cost at Greenwich was only 0·261d., and coal had gone down from 0·23d. to 0·197d., largely due, he thought, to the excellent working of the turbo-generators. In the table on the last page of the Paper, where the author made a comparison between a central station—sub-station scheme and a Diesel oil-engine scheme, it was seen that for 33 per cent. load factor he gave a difference in favour of the Diesel engine of 0·112d. per unit. If the corrected figures were now put in, and the author's figure for oil was modified by taking oil, not at 50s., but 60s., since in a previous table he gave it as 60s., the result was in favour of the steam central station and sub-stations. That showed that figures could prove anything. The author had given no details of the prime movers and had taken a lump sum per kilowatt; in fact, they were not told what the actual costs were of any single job. He asked the author whether he seriously thought that a Diesel oil engine scheme was a practical one in a large city, where oil tanks, water-cooling towers, silencers, &c., all went to increase the cost of land and increase the trouble of working. He asked the author regarding the water used for cooling the cylinders. How much water was required? Did much evaporate from the towers? Was it a nuisance in the neighbourhood? In making comparisons between Diesel sub-stations and motor-generator stations the small overload capacity of the Diesel engine must be taken into account. The Diesel engine had an overload capacity of only 20 per cent., whereas the speaker's sub-stations had an overload capacity of 100 per cent.

Mr. W. B. ESSON said that some three years ago he had occasion to compare the relative costs, using steam, gas and oil engines, and had arrived at the conclusion that for 500 H.P. units steam plant was the most economical. Mr. J. F. C. Snell in a Paper read last year, also came to that conclusion. In regard to the size of the Diesel engines, he knew of a case similar to that referred to in the Paper and could give the results of the working. They were 300 H.P. three-cylinder engines running at 160 revs. per min., coupled to 200 kw. alternators with a frequency of 75, the flywheels being of cast iron, of such dimensions as to reduce the cyclic irregularity to 1/300. The oil consumption came out at 0·72 lb. per kilowatt-hour at an average load on the engine of only 125 kw., the sets apparently working between [illegible] and [illegible] load. In the oil engine there were practically no standby losses, and if such of the engines in the station as were running were fully loaded, the oil consumption was practically independent of the load factor. That, of course, was not so with steam. They had as making up the total consumption of steam in the steam engine a variable quantity, depending upon the number of units generated, and a constant quantity, practically independent of the number of units generated. He thought the author had greatly exaggerated the steam standby losses in the Paper. If the curve in Fig. 6 was redrawn so that instead of showing the fuel consumption per kilowatt-hour it showed the total consumption of fuel for particular load factors, the author arrived at the extraordinary result that for no-load at all the consumption was one-third of the total fuel used when the station was running on a load factor of 50 per cent. This, of course, was quite absurd, and far too high. In a case he had to advise on in Calcutta,

where oil was cheap and coal dear, and where the use of oil had been decided on anyway, the question arose as to whether ordinary oil engines or Diesel oil engines should be used. The Diesel engine being much more economical in fuel consumption than the ordinary oil engine, it might be thought the former would be the best to use. In the calculations it came out that the ordinary oil engine used 87 tons of oil per annum, whereas the Diesel engine used only 37 tons ; but notwithstanding this, he came to the conclusion that it was cheaper to use the ordinary oil engine and 87 tons of oil per annum than the Diesel oil engine and 37 tons per annum, because the saving in fuel would not compensate for the extra capital outlay and depreciation on the Diesel engine. The case as to whether a suction gas engine should be used instead of a Diesel engine had to be solved in the same way. Suction gas could sometimes beat Diesel engines because of the extra capital outlay on the latter. It depended on the hours of running. The author gave the cost of the Diesel oil as 48s. per ton. He, the speaker, had been told by Diesel engine makers that the oil delivered to their works in the North cost 55s. per ton, and delivered to London the cost of the oil was 51s. 6d. per ton.

Mr. H. Leslie Dixon (Leatherhead & District Electricity Co.) spoke as a user of Diesel engines. At Leatherhead they were originally steam-condensing, and owing to the poor load factor and small output the coal costs were over 1·0d. per unit generated. With Diesel engines their present fuel costs were 0·29d. per unit generated on the 1908 output of only 170,000 units, a result better than the majority of stations of similar size could show. The cost of repairs was also low, and on three years running did not exceed 40s., the total works cost per unit generated being 0·762d. for last year. In another similar electric supply station equipped with Diesel engines, with which the speaker was acquainted, the engines had been in use nearly six years, and a few pounds covered the cost of repairs during that time. An important feature was the cleanliness of the cylinder interior and valves in working, due to the perfect combustion, although burning a heavy oil. It had therefore only been found necessary to draw pistons once a year, when the piston top was generally found to be cleaner than that of a petrol engine using light spirit. The ease of working was remarkable, an ex-stoker driving the two 120 b.h.p. Diesel engines, and there had been no trouble. They could start up from cold without any preparation and get on to the 'bus-bars with a 120 h.p. set in 45 secs., which was a valuable feature in central station work. The engines at the two stations referred to were not English made, but were built by Sulzer Bros.

Mr. H. W. Handcock thought it would be interesting to mention some results which had actually been achieved with the Diesel engine, and, incidentally, he could quite bear out the very good results obtained at Leatherhead. The actual figures were as follows : In 1905, when the steam plant was at work, the cost of fuel per unit generated was 1·044d., and the total works costs 1·933d. In 1906 there was a mixed system ; in 1907, working entirely with Diesel engines, the cost of fuel was down to 0·3245d., the works cost being 1·238d., and in 1908 the cost of fuel was only 0·29d., and the total works costs 0·762d. The result was that, in spite of metallic filament lamps, they were able to show a substantial dividend. In the year 1906 the cost of oil was 63s., in 1907 it was 66s., and in 1908 it rose to 70s., delivered at the generating station, and was down again at 66s. in the present year. When the Diesel engines were first started, oil was in the neighbourhood of 40s. per ton. Some time ago it was said that oil might go up to 90s. per ton, and others said that it might go down to 35s. per ton. They had a feeling of uncertainty as to what the price might eventually be. Taking next a station at Hindhead, which was converted to Diesel engines some time before Leatherhead, the cost of fuel per unit generated in 1904 with non-condensing plant was 1·67d. per unit, in 1906 with the Diesel engines it dropped to 0·432d., and in 1907 to 0·356d. In small stations it appeared that great advantage resulted from the use of Diesel engines, but it was only fair to say that the Diesel engines required more skilful attention than steam engines. As the Paper dealt with gas as well as with oil, he was bound to say that he had obtained equally economical results with the gas engine, and suction plants gave an exceedingly good account of themselves. He thought there would be a great race in the future between the two. The capital outlay, however, of Diesel engines, compared with gas and steam, was high. It might possibly happen in the case of municipal undertakings that if the period of loan were unduly short it might be better finance to use a cheaper though less economical engine. The best immediate results from very economical and well built, but expensive, engines, like the Diesel, were obtained where the depreciation account could be spread over the whole life of the engine.

Mr. H. M. Sayers said there was no doubt about the exceedingly high thermo-dynamic efficiency of the Diesel oil engine, and one of the features of the tests that had been made was the remarkable consistency of those results, viz., from 0·42 lb. to 0·46 lb. per brake horse power-hour, covering the full load range of the tests. The small Diesel engines were as economical as the large ones, an advantage not possessed by steam engines and gas engines. Nevertheless, the Diesel oil engine had not made the progress that might have been expected, partly due, no doubt, to the natural conservatism of engineers and others ; but the difficulty of getting information in advance concerning Diesel engines was very serious. He thought the author had given the prices of the Diesel oil engines a little too low. He thought that for an average size £20 per kilowatt was more like the figure, or an addition of 20 per cent. to steam plant figures. It was true that there was a saving on the buildings, and also that there were no boilers, gas producers and condensers, but the price of these was actually paid to the Diesel Company. It looked as though the price of the Diesel engine had been very carefully worked out to make the total cost of the engine equal to the price of a good steam plant with boilers and condensers. The most important thing that had prevented the extensive use of Diesel engines was the uncertainty as to the supply and price of the oil. He did not think, however, that the uncertainty would continue. The price of the Diesel engine would fall when the patents expired, and the large demand for the engine would tend to increase the sources of supply of the oil ; for example, small coal. Average bituminous coal gave off 70 per cent. of high class oil. That was about 1 ton of oil per 4 tons of coal. If 1 ton of oil would do the work of 4 or 5 tons of coal the carriage of the ton of oil would be very much more economical than the carriage of 4 tons of coal and the average price of the fuel might be less than the equivalent coal. He was not at all sure that pipe lines from the coal pits to the big towns would not assist materially in solving the smoke nuisance and also the power distribution question.

Mr. Leonard Andrews showed a diagram in which he had reproduced Mr. Pfeiffer's curves of thermal efficiencies of steam and gas plants at different load factors, and in which he had also plotted the actual efficiencies obtained at 30 steam and gas installations, as published in his recent Paper. It would be seen that the author's hypothetical curves coincided with the actual results for both steam and gas. He thought, however, that those interested in the development of internal combustion engines must recognise that steam results were steadily improving. In his own Paper he had assumed a steam efficiency 10 per cent. higher than the actual recorded results, and he now showed a third curve constructed on this basis, which, he thought, fairly represented the true position as regards steam efficiencies. It would be seen that even after making this amendment, the difference between steam and gas engine efficiencies corresponded to a saving of $1\frac{1}{2}$ lb. to 2 lb. of coal per kilowatt-hour for any load factor. He hoped that Mr. Pfeiffer would be persuaded to complete this diagram by including a number of oil plant efficiencies obtained under actual working conditions. The actual working result Mr. Esson had given of 0·72 lb. of oil per kilowatt-hour was equivalent to a thermal efficiency of 26 per cent., which corresponded very closely to the figures in the Paper. He disagreed with the author's estimate of cost of fuel for steam and gas plant. He thought 15s. per ton for steam coal was much too high for an average figure, and no one would think of paying 25s. per ton for coal to be consumed in gas producers for an installation of the size upon which the author had based his estimates. One of the results shown in the diagram as closely corresponding to the author's efficiency curve was obtained with coal costing 9s. per ton. The price of coal varied very much in different parts of the country, but he thought 12s. per ton was an outside figure to allow as an average for either steam or gas to compare with 60s. per ton for oil. By accepting the author's figures for relative efficiencies, and taking the cost of coal at 12s. per ton, the total works costs for a 33 per cent. load factor came down to 0·455d. for steam and0·3 48d. for gas as compared with 0·374d. for oil, which confirmed Mr. Handcock's experience that there was little to choose between gas and oil as regards works costs. He was interested to note that the price of steam plant had apparently risen during the past few weeks since he read his Paper on Gas Engines, when he had been severely criticised for taking £14 per kilowatt as the cost of steam plant, whilst no one had objected to the author's figure of £24·5 per kilowatt.

Mr. H. S. Russell said a large number of station engineers were considering the use of oil engines for small and medium sized stations, for which there was a very large field in this country. The oil engine would also be found useful for large stations with low load factors. He did not think that engineers had studied sufficiently the large economy that could be obtained in existing steam stations with Diesel engines to supplement their present plant. In one station the total cost per unit when only steam plant was used came out to 1·131d., but when a Diesel engine was run for 24 hours and the steam sets used only for the peak load the cost per unit was 0·65d., *i.e.*, was reduced by 45 per cent. That could be done in many other stations. It was a fact that they used a separate pump for each cylinder in the early days, and that was abandoned in favour of one single plunger pump. The practice now, in the case of the British makers of Diesel engines, was to use one pump with a separate plunger for each cylinder to ensure the equal distribution of fuel at all loads. Another advantage of working with a separate plunger was, seeing the way the Diesel engine worked, that the governing was done by varying the time during which the suction valve of the pump was open, that it was quite simple to find a device by which the suction valve could be kept open for any cylinder, and therefore the oil could be returned to the reservoir.

Mr. Mordey asked whether it ran steadily under all those conditions.

Mr. Russell : Yes. If the oil costs taken over the whole average load were 0·24d. per unit, then that, of course, would correspond to a consumption of about 0·72 lb. per kilowatt-hour, about the figure mentioned by Mr. Esson. As to the two-cycle engines, the author spoke of them as something new, but they had been tried in this country seven years ago, were found unsatisfactory, and were abandoned. In fact, a two-cycle engine was shown at the Glasgow Exhibiton. He thought the author was mistaken in his idea that the use of a two-stroke cycle would necessarily reduce the cost of the engine. It was imagined by some that two-cycle engines would give twice the power of four-cycle engines with the same size cylinders and stroke, but that was not so, as, owing to heating limitations, it would be necessary to run at only half the speed. He asked the author to confirm in his reply the figure given in the Paper for the cyclic irregularity of the Daimler Motor Co.'s sets, because it seemed to him that a variation of only 1/160 was rather bad for the parallel running of alternators. Most alternator makers in this country insisted on a variation of 1/250 or 1/300. He did not agree that oil engines would only run without smoke down to one-fifth load, as his experience was that they would run without smoke at one-eighth or one-tenth load. His opinion was that an engine was not running satisfactorily unless it was absolutely smokeless, except just when starting up. As to the figures,

he disagreed with Mr. Andrews' criticism of the author's figures for oil and gas plant. He thought there was not a single station working with suction gas plant at a cost of less than 2d. per unit, but results with Diesel plant showed 0·4d., 0·5d. or 0·6d. The author was wrong in thinking that the Diesel engine took as much lubricating oil as the gas engine, and Diesel engines used a cheaper grade of oil. The first Diesel engine was made in this country 13 years ago. That particular engine last year was taken down and removed to Stockport where it was being re-erected, and on examination it was found that the parts were in excellent condition. In regard to Mr. Sayers' remarks as to the supply of oil fuel, he thought it was clear to most of them that coal prices had varied quite as much. The hundreds of thousands of horse power of Diesel engines at present working in the world consumed less than a thousandth part of the oil output.

Mr. W. H. Booth said that when one knew there was something like 350,000 H.P. of Diesel oil engines at work it must be recognised that that engine had come to stay. It was true that with the Diesel engine it was absolutely necessary that everything should be in good order, but that was possibly a recommendation. It was not possible to run either gas or oil engines in poor condition. It was claimed that steam engines would always run, but was that an advantage if they ran inefficiently? In a test he had made he noticed that the exhaust was exceedingly hot, and there was a small exhaust pipe which caused considerable back pressure. In the test he got an efficiency of 31 per cent., and if the exhaust pipe had been larger he believed this would have exceeded 31 per cent. In some other tests he had obtained 44 per cent. efficiency on the indicated horse-power, and 31 per cent. on the brake horse-power. Considering the very high temperature and pressure of the exhaust in oil engines, it had occurred to him that possibly something might be done in the way of using the exhaust in a turbine. When gas at a temperature of 900 deg. or 1,000 deg. was being turned away, that must mean a loss of considerable power. He had recently gone into the question of using Diesel engines, and had come to the conclusion that they would be more efficient and cheaper than steam, but some steam had to be provided for certain operations and this had prevented further consideration. As to the oil suitable for such engines, there was a large expanse of bituminous clay in this country which contained a considerable amount of hydrocarbons. He would like to ask the author if it was not possible to apply gas to the Diesel engine, as it was a very simple process to compress gas, and Diesel had originally intended to use gas as well as oil as fuel. With reference to the final temperature of the exhaust, he suggested the cooling of this before discharge, for it would reduce the work to be done in pushing aside the atmosphere.

Mr. J. E. Dowson (communicated) asked the author to give his authority for the figures he had put forward for the efficiency of the oil engine. He would be glad to know if the author's figure of 11 per cent., which the friction of the engine, pump, &c., were supposed to absorb, was correct, as it was stated in the Paper that the mechanical efficiency was only 76 to 77 per cent. In the Paper the author said that for light loads there should be small units for the oil engine, to prevent nuisance from smoke, but no such precaution was necessary with gas power. Also with one gasholder serving all the engines there was no need to have the same number of producers as of engines. There could be three large producers (one in reserve) instead of five smaller ones, and the number of scrubbers would be reduced proportionately. The heat efficiency of the gas plant would also be higher, and the standby losses would be smaller, if there were fewer producers. His estimate for a suitable gas plant came out considerably under the author's estimate of £23. 10s. per kilowatt. He also drew attention to the high price of 25s. per ton taken for coal for gas plant.

The author reserved his reply for the "Journal."

CORRESPONDENCE.

MOTOR CONVERTERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your last issue you gave a report of the discussion at the Institution of Electrical Engineers on this subject.

Mr. Hallo in his reply to my criticism about the unfairness of comparing the factor K in his tables 1 and 2 for the converter part of a motor converter with 33 per cent. wattless current to a plain rotary converter giving 30 per cent. wattless current, has thought it advisable to recommend me to read the Paper again, and to see that the wattless current referred to was the current which was actually in the stator and not in the rotor, and which therefore was actually supplied as leading wattless current to the line.

Mr. Hallo's statement is completely wrong, for he defines on p. 15 the current I_{2wl} for the motor converter as wattless current per rotor phase, and although he acknowledges in the example preceding these tables that for 35 per cent. wattless current supplied to the 'bus bars, the total wattless rotor current must be 60 per cent. (for the reasons stated in the discussion I believe 75 per cent. would be nearer the mark) he makes his comparison for a ratio of 33 per cent. ($I_{wl} = \frac{1}{3} I_w$).

Also in the pamphlet of Messrs. Arnold and La Cour "Kaskadenumformer," published in 1904, from which the theoretical part of Mr. Hall's Paper is taken, it is stated with ample clearness that the wattless current I_{2wl} refers to the rotor only. Arnold and La Cour, on p. 20 of their pamphlet, give a table for a wattless rotor current of 33 per cent., and a second table for 66 per cent. Mr. Hallo, however, in his Paper, has reprinted only the table for 33 per cent. wattless current in the rotor, and has made his misleading comparison.—I am, &c.,

Trafford Park, Manchester, May 15. E. Rosenberg.

THIRD RAIL IN ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I regret that circumstances prevent me from coming into the open to meet Mr. Dawson, and I quite agree with him as to the general undesirability of anonymous letters; for his and your readers' information I may say, however, that I am one of the army of obscure operating engineers who usually silently listen to the criticisms, generally undeservedly severe, and almost always ignorant, of the plant they operate. Mr. Dawson's reply on matters of fact is hardly convincing; he avoids replying to the points raised in my letter, and quotes the opinions of gentlemen who, however wide their experience in other matters, have no experience of third-rail work. The opinion of Herr Wittfeld, who has had experience of both types, is of no great value, the Berlin-Gross Lichterfelde line being too small an undertaking to provide the data necessary to determine the value of the type of traction employed; I have seen the line, and its equipment could hardly be called either model or modern. The opinion of the chief engineer of a large unelectrified railway system would not be, in this case, as valuable as that of a permanent way inspector in charge of a section of railway equipped with third rail.

In my letter of May 7th I confined myself to correcting some mis-statements obvious to any engineer operating a third-rail railway.

Abler pens than mine have attacked successfully the many other disabilities of the single-phase system, and the disadvantages of the third rail as applied to the L.B. & S.C. must have been grave indeed if they alone counterbalanced the increased cost of equipment and running due to the single-phase system.

Surely the general construction of the L.B. & S.C. cannot be very different from that of the N.E. Railway, the Metropolitan Railway and the L.Y. Railway. It would be of the greatest interest to railway engineers if Mr. Dawson would give a few details of the actual difficulties encountered in the third-rail scheme for the L.B. & S.C. Railway, and would also state the cost of the present track equipment so that some comparison might be made with the cost of third-rail work, the general impression being at present that for suburban work the overhead construction is three to four times as expensive as third-rail construction.

If Mr. Dawson admits that the L.B. & S.C. has been electrified on the single-phase system due to special circumstances on that line not existing on other suburban railways, I apologise for the suggestion of bias. Mr. Dawson, however, so far as I have read his writings, advocates the single-phase system as the only one suitable for suburban or interurban traction, and in view of this it was difficult not to feel Mr. Dawson had some bias. I, however, willingly accept his assurance of his perfect impartiality.

I am much obliged to Mr. Dawson for his offer to convince me of my errors, and if he will respect my anonymity in the Press, I would be pleased to accept his offer. I may hope, however, that I shall convince him, not he me.—I am, &c.,

May 14. Railway Engineer.

A NEW SYSTEM OF WIRELESS TELEGRAPHY USED BY THE TELEFUNKEN COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: From patent considerations I particularly avoided in my recent article describing the methods by which our new "singing spark" system works, and simply detailed its effects. I shall describe these methods for the first time in a lecture

which I am delivering on June 4th in Cologne before the Verband Deutscher Elektrotechniker. This diffidence will be understood by every technical man when I say that at the present time we have no less than 20 applications for patents relating to this new system under consideration by the German Patent Office. Further, none of these many applications have yet been objected to by the Patent Office, which, as is well known, is very careful in its examination, on account of a prior application by von Lepel.

To my knowledge nothing is known about these 20 applications by either von Lepel or Simpson, so that when the latter, in spite of this, states that our new system uses the same means and is nothing more or less than an imitation of that due to von Lepel, of which we have become acquainted by long protracted negotiations, his assertions, mildly speaking, are very bold and wholly void of any foundation. Any word in contradiction might therefore be quite superfluous.

In spite of this I will deal with the matter in the hope that it may have the effect of clearing the air.

We have no knowledge of the methods used by von Lepel at the present time. We know no more than what his generator was like in April, 1907, when we broke off our preliminary negotiations on account of his arrangement being then quite unserviceable.

His first patent application was dated August, 1907, or five months after this unsuccessful discussion.

Negotiations entered upon at the beginning of 1908 were of a quite commercial nature. Our oft-repeated request for the disclosing of his system, which, he said, was wholly re-designed and improved, was rejected by von Lepel, as was our demand for information regarding the contents of his patent applications—a rather unusual proceeding during preliminary negotiations over a patent!

Only one single patent has been granted to von Lepel in France (313,298). I suppose this is his master patent, as it deals with a generator for producing electrical oscillations. Supposing that von Lepel is working under this patent, it is easy for me to decide the question whether von Lepel and the Telefunken Company are using the same means. Von Lepel's patent protects a method in which, as can easily be gathered, spark discharges are *not* employed. I stated in my article, and I repeat it here, that, on the contrary, the Telefunken arrangement is a purely spark method and is, in fact, the method described by M. Wien in the "Physikalische Zeitschrift" for December, 1906, or nearly a year before von Lepel's application for his master patent. The Telefunken arrangement is physically, if I may say so, the exact antithesis of that described in von Lepel's patent. There must be an error somewhere; perhaps von Lepel is using a new arrangement regarding which the patents are not yet published. We must, therefore, await them.

I must take this opportunity of correcting one, among many, of the numerous mistakes: Dr. Kiebitz is not, nor has been, attached to the Telefunken Company, but works quite separately from this undertaking. He has belonged, as an engineer, to the Reichs Telegraphen-Versuchsamt (research department of the National Telegraphs) for many years, and works there, from a quite scientific side, on the problems of wireless telegraphy.—I am, &c.,

Berlin, May 11. GRAF ARCO.

ACTINIC PROPERTIES OF BRUSH DISCHARGES.

TO THE EDITOR OF THE ELECTRICIAN.

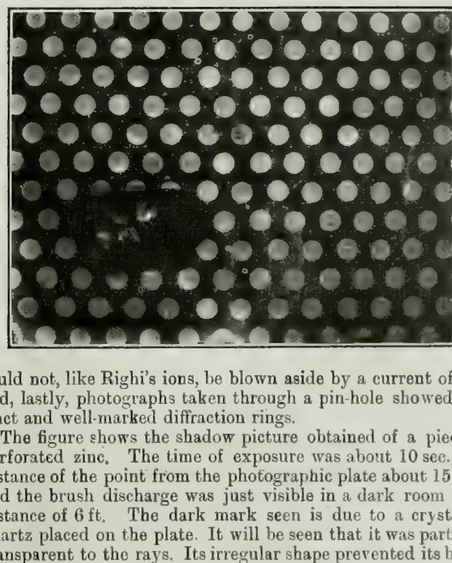
SIR: Considerable interest has lately been aroused by experiments tending to show that the passage of an electric current round a sharp corner is accompanied by the emission of electrons which will produce an effect on a photographic plate, such effect being taken as proving that an electric current, or the electrons constituting it, are possessed of inertia.

While we do not wish to make any assertion as to the correctness or otherwise of this result, we would like to point out a possible source of error against which any one experimenting in this direction would do well to guard, and this lies in the powerful actinic properties of the light given by a brush discharge which is scarcely visible to the eye.

A faint brush discharge from a point or sharp edge, which is quite invisible in a dark room at a distance of a few feet, is accompanied by the emission of a large amount of ultra-violet radiation, so much so that an exposure of a photographic plate to these for a few seconds at the distance of about 1 ft. is sufficient to turn it black.

This was first noticed in some tests made in pursuance of some of Righi's work on the discharges from points. Righi found that when a point was electrified so as to give a brush discharge streams of ions were driven from it along the lines of force. These could be caught with a plate of insulating material such as ebonite, which then became electrified. If this ebonite was then dusted over with a mixture of sulphur and red lead, the electrified portions became, so to speak, mapped out. If any object were placed in the path of the ions a shadow was thrown which came out on dusting the plate.

The experiment was tried of substituting a photographic plate for the sheet of ebonite, and an excellent photograph was at once obtained which was at first thought to be due, like the other effect, to the action of ions driven along the lines of force. It was soon found, however, that this was not the case, but that the picture was a true photograph taken by a wave motion radiation, and obviously nothing more nor less than ultra-violet light. The magnification of any shadow thrown by an object was found to be exactly that which would be due to a radiation travelling in straight lines, and very different from that obtained with the sulphur and red lead pictures previously mentioned. Further, quartz was found to be transparent to the radiation, although glass was opaque. The radiation



could not, like Righi's ions, be blown aside by a current of air, and, lastly, photographs taken through a pin-hole showed distinct and well-marked diffraction rings.

The figure shows the shadow picture obtained of a piece of perforated zinc. The time of exposure was about 10 sec., the distance of the point from the photographic plate about 15 cm., and the brush discharge was just visible in a dark room at a distance of 6 ft. The dark mark seen is due to a crystal of quartz placed on the plate. It will be seen that it was partially transparent to the rays. Its irregular shape prevented its being completely so.

In view of the obviously powerful nature of the ultra-violet radiations which may be produced if any brush discharges are present, even if these are of the feeblest, and probably even if they are invisible to the eye, it is advisable that experimenters on this subject should take particular care to prevent their being mislead by these effects.—We are, &c.,

C. J. WATSON.
Birmingham, May 17. E. A. WATSON.

DIESEL ENGINES IN SMALL GENERATING STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of the 7th inst. contained a report of a Paper read by Mr. H. Boot on "The Design of Electric Power Works" at a recent meeting of the Institution of Municipal Engineers.

The author is quoted as having stated that the electric generating plant at Chichester is interesting as being one of the first, if not the first, to employ Diesel engines as prime-movers. As a matter of fact Mr. Boot has no right whatever to claim any credit for being a pioneer in advising Diesel engines for station work. Four southern undertakings successfully operating Diesels, long before a brick was laid at Chichester, were Hindhead, Guildford, Leatherhead and Lewes, to say nothing of a number of traction sets in use elsewhere.

To Messrs. Handcock & Dykes the honour is really due of first advising the use of Diesels in small lighting stations, and it is nearly six years ago that they ordered the first of three Diesel sets for the Hindhead & District Electric Light Co. and, later, advised the Leatherhead undertaking to change over from steam to Diesels.

The results obtained have well justified the advice of Messrs. Handcock & Dykes, as the total works-cost per unit generated has fallen at one station from 1·71d. with steam to 0·762d. with Diesels, while at another station the economy is even more pronounced.—I am, &c.,

H. Leslie Dixon, Engineer and Manager.

Generating Station, Leatherhead, May 16.

ENGLISH TECHNICAL EDUCATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am glad to note that Dr. Pohl advocates the maintaining and further development of evening technical classes, which are (though suffering from the indifferent or unduly curtailed elementary education of many of the students) doing useful work among engineering apprentices.

An advantage evening classes possess is not always recognised, namely, that it is possible for some of the lectures to be given by a man who is engaged in actual engineering practice. Such a lecturer is likely to know the exact immediate needs of his students, who of course will be mainly apprentices. He may even be in a position to be familiar with their daily work. In any case the fact of his being in actual practice allows him to put matters in such a way that he obtains the confidence of the students, and there is a mutual understanding. The great difficulty, it is to be presumed, is to find men engaged in engineering business with sufficient spare time to devote to this work of education.

The work is often a change of labour to such men, and consequently does not become the burden it certainly is to the technical teacher who has spent the day in class, laboratory and lecture room.—I am, &c.,

Chelmsford, May 12. Charles H. Wright.

THE "G.B." SURFACE-CONTACT SYSTEM IN THE MILE-END ROAD, LONDON.

We have been favoured by the G.B. Surface Contact Company with a copy of the following letter:—

82, Victoria-street, S.W., April 5, 1909.

G. L. Gomme, Esq.,
Clerk to the London County Council,
Spring-gardens, S.W.

G.B. Tramways.

Dear Sir: I am obliged for the copy of the report of the Highways committee of the London County Council and note that the Chief Engineer and the Chief Officer of the Council's tramways are of opinion that the experiments so far carried out do not satisfactorily remove all the objections which they brought to your notice in July, 1908, and as the result of which they recommended the discontinuance of the system.

I have again examined the reports of these officers, dated respectively September 1st and August 26th last, and now enclose the Chief Officer's statement of defects with my note thereon. I refer in the same way to the two main defects referred to in the Chief Engineer's statement.

You will see that all the points have been dealt with except one or two which I have already reported I did not consider it necessary to deal with as they presented no difficulty or uncertainty.

I am sorry I have not had an opportunity of going over these points in detail either with the committee or with the officers in question, as I am sure it would only have been necessary to examine them one by one to dispose of them.

The trial runs have been few and short in duration, but as they showed that the main difficulty was overcome, and as they revealed nothing that was not obviously capable of easy remedy, I did not think it necessary to delay making my recommendation, believing that ample opportunity would be found for clearing up the two outstanding points.

(Signed) W. M. Mordey.

Notes on Defects of G.B. System.

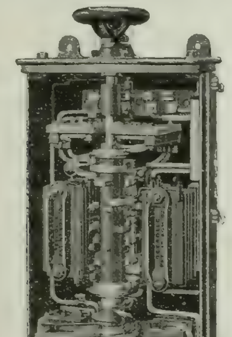
Summary of Defects. Statement sent by Chief Officer of tramways to W. M. Mordey, dated August 26, 1908:—	Notes by W. M. Mordey, April 5, 1909:—
(a) Broken Stud Heads.	
Causing cracked stoneware T-pieces through which water and other matter leaks, thus making the studs sticky in action, so that when a car passes they either remain dead or alive.	Using cast steel instead of cast iron will prevent breakage. In trial 1,000 T-pieces examined, more than 100 slightly cracked, but only one had allowed water or other matter to leak in.
In several instances the shank of the stud under the head was found broken.	This can be prevented by suitable adjustment of the head.
In a few cases the cement joint between the T-piece and the cable pipe became defective, probably due to the vibration of the heavy traffic.	No such case found on trial track.
(b) Leakage between Stud Head and Rail. Causing—	
1. Live studs, the circuit being maintained through an arc between the carbon contact and the cable by leakage from the stud head to the rail through wet road refuse.	These live studs are now prevented.
2. Excessive leakage to earth during adverse weather conditions.	This leakage is quite unimportant, so far as cost is concerned. On the average it is certainly not as much as $\frac{1}{50}$th of a penny per car-mile.
(c) Defects in Stud Mechanism causing Live Studs.	
1. Defective enamelling on "knock-on" causing rust and consequent stickiness.	No such case found on trial track.
2. Some of the trouble in the studs was probably due to the small current-carrying capacity of the leads.	Tests already reported show current-carrying capacity sufficient. Further borne out by condition of studs on trial track.
3. Destructive effect of gas generated when arcing took place between the carbon contact and cable.	No evidence of this found. In any case arcing, which is supposed to cause it, is now prevented.
4. Insulators to which springs were attached found broken.	Prevented by small insulators of improved design at the cost of less than 1d. each.
5. Flexible leads getting jammed between the spring and the guide.	None found on trial track—might be caused occasionally by arcing, which is now prevented.
6. Stickiness in studs probably caused by carbon deposit and moisture.	Absence of arcing and reasonable drying of conduit will prevent this.
(d) Resistance Studs.	
1. Not properly designed for current which they had to carry. 2. Unsuitable design of stoneware T-piece making it most difficult to connect up stud even with a very small lead	Both these avoided by proposed modification of special work.
(e) Access Box Covers. See Chief Engineer's statement.	These have been already partly dealt with. They present no serious difficulty.
(f) Ventilation. See Chief Engineer's statement	Already reported on. This presents no difficulty.
(g) Skates. See Chief Officer's statement—Summary. After referring to preliminary difficulties, he proceeds: "The cars inspected by the Board of Trade, and all cars subsequently run in service were fitted with two three-coil skates. The great disadvantage of this arrangement was that the magnets absorbed an abnormal amount of energy."	The energy absorbed is now less than that taken up by one 16 c.p. lamp.
The G.B. Company were requested to submit a design for a two-skate equipment which would allow for the necessary gap for the plough carrier between the two skates. This design has, I believe, been prepared, but whether this would give any better results than those obtained from the skate equipment originally designed by the G.B. Company is extremely doubtful.	It is a great improvement. It halves the energy and doubles the speed.

Great disadvantage of the two-skate equipment would be that each stud would be operated twice when a car was passing.	This seems to give rise to no difficulty, but in report of March 31st I point out that one of the collectors can very probably be dispensed with altogether.
Defects in Collector Skates.	
1. Being insulated with wood sheathing, the water and mud permeates the fibres and causes electrical leaks of considerable magnitude during wet weather.	
2. The large area of highly magnetic metal under each car is responsible for the collection of a large quantity of metal débris, resulting, in some cases, in very serious short-circuits.	Greatly improved results should be obtained with the new design. No trouble met with in trial runs.
3. The magnet must of necessity be carried close to the level of the road, consequently any displacement of setts or wood block paving results in the fouling of the skate therewith and breakage of the equipment.	Risks from this cause are very slight with the L.C.C. standard of paving.
4. Breakage of the collector chains in service resulting in short-circuits and damage to equipment generally.	I agree, and had arranged for steel instead of cast-iron chains. This would prevent breakage.

DOUBLE REVOLUTION DRUM TYPE STARTERS.

The tendency now-a-days, especially in electrical work, is towards extreme simplicity, and when we consider the class of labour frequently put in charge of electrical machinery, it is easy to understand that the demand for "mistake-proof" apparatus is quite a natural one.

In the early days of variable speed motor working, starting up a motor on a weak field was a fairly common occurrence, and even



Double Revolution Drum Type Starter (A. Reyrolle & Co.)

now manufacturers of variable speed motors frequently receive back for repairs machines which have been subjected to this somewhat violent treatment. With a view to providing apparatus which will obviate any possibility of mistake, Messrs. A. Reyrolle & Co. have recently put on the market a modification of their well-known drum type starter, and this apparatus appears to combine the maximum of safety with simplicity in an effective manner.

When starting up a motor with a "Reyrolle" double-revolution starter regulator, which we illustrate in the accompanying figure, the operator first brings the operating handle to the starting position and "waits there until the motor starts," after which he completes the first revolution, and thus brings the motor up to its normal speed. A further slight movement of the handle automatically throws over a switch inside the casing, which short-circuits the starting resistance and makes the necessary connections to the regulating resistance, and continued movement cuts this into circuit and speeds up the motor in the usual way. During the whole of this operation the motor is safeguarded against overloading and also against a failure in the supply, by means of a combined overload and no-voltage circuit-breaker, which is put in by the operating handle, but which is entirely independent of the latter, immediately the circuit is made. The makers will be pleased to send full particulars and prices of this apparatus to any of our readers who are interested.

THE BRISTOL RECORDING PYROMETER.*

BY P. LONGMUIR, B.MET., AND F. SWINDEN, B.MET.

In a Paper read before the American Society of Mechanical Engineers in 1906 Prof. Bristol described a low-resistance thermo-electric pyrometer designed to meet the severe conditions of ordinary shop use. This pyrometer has entered largely into American works practice, but so far as the authors know is new to this country, hence the following experience with an installation of the latest design will be of value to those interested in temperature measurement.

The accuracy and utility of the thermo-electric pyrometer as introduced by Le Chatelier are now beyond question. From the purely works' point of view two difficulties lie in the delicacy of the galvanometers and in the decay of the platinum and platinum-alloy thermo-elements. An example of the latter is found in the effect of reducing atmospheres, and platinum thermo-couples have a comparatively short life when used in flues, gas mains or similar situations. Even in oxidising atmospheres, such as annealing furnaces for the production of malleable cast iron, the cost of the platinum thermo-couples, when continuously used, is an appreciable factor per ton of castings annealed.

One distinguishing feature of the Bristol pyrometer is the use of an inexpensive thermo-element. The E.M.F. of these thermo-couples is much greater than that developed by platinum alloys; hence, a Weston milli-voltmeter replaces the delicate high-resistance instrument essential to platinum couples. The thermo-couple wires are insulated by asbestos cord, and then coated with carborundum paint, further protection being afforded by means of a metallic tube. The couple wires are comparatively thick (about No. 5 gauge), hence the difficulty arising from variations in the resistance of the thermo-element with varying temperature is almost eliminated.

The recorder presents many interesting features. The records are made on a smoked chart, graduated in time and degrees Centigrade or degrees Fahrenheit. The chart, set to correspond to the time of the day, is revolved by clockwork, and, at short intervals, is brought in contact with the pointer of a milli-voltmeter actuated by the thermo-electric current. This vibration eliminates friction between the pointer and chart, but the intervals are so short that a continuous line results. The chart gives a 24 hours' record, and is entirely visible. The charts are subsequently fixed by soaking for a few seconds in a fixative, and, after drying almost spontaneously, are quite hardened, and may be filed for reference. Changing records and fixing occupies only a few minutes per 24 hours; this, and winding up the clock, represents all the attention required.

An important feature, and one which is not always allowed for, is the temperature of the cold junction. The net E.M.F. produced in any thermo-electric circuit is dependent on the difference in temperature of the hot and cold junctions. Many instruments are calibrated and supplied to read correctly with a cold junction temperature of from 15°C. to 20°C. Others neglect the cold junction entirely. Bristol has designed a unique "compensator" which automatically corrects for variations in temperature of the cold junction. It consists of a glass bulb with a short stem, into which two platinum wires are fused. These are in turn connected within the bore of the stem by a loop of fine platinum wire. The compensator is placed in the circuit at the cold junction, and if the temperature rises the mercury with which the bulb is filled rises up the stem, cutting out a certain portion of the platinum wire, and reducing the resistance of the circuit. The compensator is so calibrated that for a given circuit the reduction in resistance just counterbalances the diminution in E.M.F. due to the rise in temperature of the cold junction.

A complete installation has been thoroughly tested on a blast furnace belonging to the Sheepbridge Coal & Iron Co., Chesterfield. A platinum thermo-couple leading to a Roberts-Austen pyrometer is permanently installed in the same blast main. Comparisons made during the test run extending over several months showed good agreement in readings obtained, and examples of the curves are given in the Paper. The installation was finally removed to the authors' laboratory in order to re-standardise, and thereby ascertain the effect of continuous exposure in a temperature range of 600°C. to 700°C. Visual examination of the thermo-couple and protecting tube

* Abstract of a Paper read before the Iron and Steel Institute.

showed no change in condition. Comparison with a previously standardised platinum-iridium thermo-couple in a temperature range up to 900°C. gave remarkably concordant results. The bulkiness of the Bristol thermo-element junction renders standardisation by the usual methods—boiling and solidification points—somewhat difficult as regards manipulation. Hence the method adopted of comparison at various temperatures with a previously standardised platinum couple.

Exact information as to the normal working life of the couple was desired, and this has not been obtained. The results show that, under the conditions described, the thermo-electric properties of the couple have not been materially affected. The mechanism of the recorder is admirably suited to works conditions. Strong magnetic fields may possibly affect the readings, but this difficulty is not often encountered. The real trouble in the case of most recorders, that of vibration and shock, is practically overcome.

PARLIAMENTARY INTELLIGENCE.

FOLKESTONE, SANDGATE AND HYTHE TRAMWAYS BILL.

A House of Commons Select Committee commenced consideration of this bill last week.

On Friday Mr. STEPHEN SELLON said it was fatal to a scheme to have to make extensions on a different system. Overhead and surface-contact systems would not work satisfactorily together. The arrangement between the British Electric Traction Co. and Wolverhampton Corporation for interchange of traffic on the overhead and the Lorain surface-contact lines was abandoned because it would not work. The Lorain system was not only more expensive as to first cost, but also in the more serious matter of working costs. The Lorain system studs must project above the road, as a rigid skate was used, and the noise was greater than with overhead wires. The Wolverhampton Corporation system showed a loss of £1,291 for the year ended March, 1908. Sandgate and Hythe approved a few years ago proposals to use the overhead system in their districts. He thought the offer now made to Folkestone was a generous one. There was not the same difficulty in interchange of traffic between conduit and overhead lines as between surface contact and overhead lines, and in the case of surface contact there was a greater weight of equipment to carry than on the conduit system cars. If the cost per car-mile were 6·51d. at Wolverhampton and 6·72d. at Birmingham, the question of the price the Corporation tharged themselves for current had to be considered. At Wolverhampton it was 1⅛d., which was fairly low.

Mr. C. E. C. SHAWFIELD, chief engineer of Wolverhampton Corporation's electricity supply and tramways undertakings, and Mr. A. BAKER, manager of Birmingham Corporation tramways, gave evidence to the effect that the Lorain system could be worked commercially and successfully. Mr. Baker said he had come to the conclusion that there was no inconvenience whatever from the studs. The Dolter system had proved unsatisfactory.

Yesterday (Thursday) the chief constable of Folkestone and several business men having premises on the route of the proposed overhead section of the tramways in Folkestone gave evidence in favour of the construction of that section. It would be a mistake to drop the lines in Folkestone which the promotors proposed to construct, if at all, on the overhead system.

The consideration of the bill had not been concluded when we went to press.

NORTH-WEST LONDON RAILWAY BILL.

A select committee of the House of Commons (presided over by Sir J. COMPTON-RICKETT) continued the consideration of this Bill on 13th inst.

Mr. R. SELBIE, general manager of the Metropolitan Railway, gave evidence against the Bill. The Metropolitan Co., he said, served all the requirements within half a mile on either side of the Edgware-road, and were making alterations at Baker-street to allow a through service to the City.

Sir JOHN WOLFE-BARRY, who was chairman of the advisory board of the Traffic Commission, said that the Commissioners came to the conclusion that a tube railway from the Marble-arch to Victoria would best meet public needs. The extension to Victoria was required in the public interest, and he feared that the proposal now made to stop at Edgware-road would place a serious obstacle in the way of the through communication.

On Friday Mr. FITZGERALD, K.C., addressed the committee on behalf of the promoters, the British Electric Traction Co. That company had a capital of £5,000,000, a yearly income of £200,000, and an investment of £220,000 in Consols ready to be used for construction of the line. They were prepared to take deferred shares to the amount of £400,000. The powers authorised for the Victoria extension had expired.

The committee unanimously found that the preamble had not been proved.

CENTRAL LONDON RAILWAY BILL.

On Tuesday a House of Commons Committee (presided over by Sir J. Compton Rickett) commenced the consideration of this bill.

Mr. FITZGERALD, K.C., for the promoters, said it was proposed to make an extension of the existing line at the Bank to Liverpool-street, terminating under the existing railway stations of the G.E. and N. London Railways. It was also proposed to construct two subways—one at the Museum station, connecting with the Holborn station of the G.N., Piccadilly & Brompton tube, and the other at the Bank, running to the booking hall of the City & South London Railway.

Sir HENRY OAKLEY, chairman of the company, said that since the introduction of motor omnibuses the company found that the passengers on the short distances showed a considerable reduction. Omnibuses saved the people the trouble of getting into lifts and running along platforms. When the company lowered its fares the traffic gradually came back again. The outlay on the extension would be £300,000, and to get a 5 per cent. return on that the company would have to carry 4,000,000 passengers per annum, which was equal to 12,000 per day for 300 days.

Mr. F. Ree, general manager of the L. & N.W. and the N. London Railways, and Mr. J. F. S. Gooday, general manager of the G.E. Railway, gave evidence in support of the bill.

On Wednesday Mr. BALFOUR BROWNE, K.C., on behalf of the Metropolitan Railway Co., opened the opposition to the bill. He asked the Committee to say that the proposed line was pure competition and nothing else. That was nothing but a block line, which was entirely in the interest of the G.E. Rly. Co., and it was to do nothing but share the Great Eastern traffic that came to Liverpool-street.

Sir CHARLES M'LAREN, M.P., in his evidence, pointed out that since they electrified their line the result from the public point of view was a success, but to the company it had been most disastrous, as, although they carried more passengers, their dividends had dropped considerably. The fares were too low.

The Chairman intimated that the Committee could not pass the bill with the provision in it that the Central London Co. was not to extend its line north or east, or that it should not make an exchange station with any other company. After discussion a new clause was drafted, and yesterday (Thursday) the Committee found the preamb'e of the bill proved.

LONDON COUNTY COUNCIL (TRAMWAYS AND IMPROVEMENTS) BILL.

A Select Committee of the House of Commons (presided over by Sir Geo. Doughty) has been considering this bill this week. The bill authorises the construction of various additional tramways, &c. In regard to the proposal for the extension of the double line of tramway along Farringdon-road to the City boundary, after hearing evidence the chairman said the Committee had come to the conclusion that the extension of the line would be to the public advantage, but they desired from the Council an assurance that there should be no unreasonable delays at the terminus.

Mr. ERSKINE POLLOCK, K.C., for the promoters, said a clause should be prepared to satisfy the Committee.

The CHAIRMAN said in those circumstances the Committee found that part of the preamble proved.

The Committee also approved the proposals in regard to the proposed extension of the tramway from the existing line in Battersea Park-road over Battersea Bridge to Beaufort-street, Chelsea.

OLDHAM CORPORATION BILL.

A Select Committee of the House of Commons considered this Bill last week. The tramway clauses proposed to construct additional lengths of tramway, &c., in the outlying districts at an estimated cost of £193,100. After evidence had been given by the tramways manager (Mr. L. Slattery) and the borough surveyor (Mr. Foote), the clauses were adjusted by the Committee. The clause to authorise the use of the trackless trolley system was struck out by agreement, and a clause to regulate fares was inserted to meet the requirements of the Board of Trade. A provision empowering the Corporation to run motor omnibuses in and out of the borough was by agreement amended to limit the operation of the borough.

In the electricity supply clauses power was sought to take over any provisional order for any of the adjoining districts, to enable the Corporation to enter into arrangements for the supply of electricity in bulk, to authorise undertakers in Chadderton, Royton, Crompton, Lees and Limehurst, to supply individuals and firms just outside the boundary, &c. The Lancashire Electric Power Co. opposed clauses 45 and 46 (as to bulk supply and the transfer or orders), but the Committee decided to retain them. An application by Springhead Council to be included within the scope of clause 44 was rejected.

Tramcar Drivers' Hours.—In the House of Commons on Monday, Mr. GWYNN asked the President of the Board of Trade if there were any regulations governing the number of hours that the driver of an electric tramcar might work at a stretch; and if such regulations were carefully observed on the London United Tramways

In reply, Mr. W. CHURCHILL said that no such regulations had been issued by the Board of Trade. The powers of the Board in regard to tramways were limited to intervention on grounds of public safety. He was prepared to consider information brought before him, and to act so far as statutory powers allowed.

Telegraph (Arbitration) Bill.—The Postmaster-General has introduced a bill into the House of Commons to give further powers to the Railway and Canal Commission to determine differences with respect to telegraphs (including telephones).

Baker Street & Waterloo Railway Bill.—This bill, which sought an extension of time for the construction of the authorised railway from Edgware-road to Paddington, has been withdrawn.

North Metropolitan Electric Power Supply Co. (Ltd.)—This bill has now been read a third time in the House of Lords, and as it has already been through the House of Commons it now only awaits Royal assent.

London United Tramways Bill—On Friday a Select Committee of the House of Lords (Lord Ludlow presiding) rejected this bill, by which the London United Tramways Co. sought running powers over the London County Council's tramway system, &c.

LEGAL INTELLIGENCE.

Gould v. Lehwess.

On Tuesday Mr. Justice Phillimore commenced the hearing of this action.

Mr. J. R. Atkin, K.C., for the plaintiff, said the claim was for the recovery of £3,200, the price of certain storage batteries. Plaintiff was the inventor of a storage battery known as the Gould battery, the manufacture of which was controlled in America by a company, of which Mr. Gould was president. Plaintiff, however, retained his property in British and European rights. In 1906, a company called the Electrobus Co. was formed in this country, and defendant was apparently largely interested in it. Mr. Lehwess went over to America to see Mr. Gould to secure English rights on behalf of the Electrobus Co. He had a series of interviews with Mr. Gould and suggested that a company should be formed in England for selling and manufacturing the batteries in London and for negotiating with the Electrobus Co. for the use of them. Mr. Gould refused to have anything to do with such a company unless it guaranteed a cash capital of at least £25,000. Defendant said there would be no difficulty about that. The price of the English rights to the patent was fixed at $60,000, and Mr. Lehwess made it clear that he wished Mr. Gould's interest to be in shares in the company. That was agreed to, and it was further arranged that Mr. Gould should have the control of the company and should have 55 per cent. of the shares allotted to him fully paid up. In pursuance of this arrangement Mr. Lehwess deposited $10,000 in a New York bank as a guarantee that he would carry out the arrangement entered on on Nov. 1, 1906. It was agreed that defendant should form a company in England to be called the Gould Storage Battery Co. for introducing the Gould battery into England. Plaintiff on Nov. 30, 1906, cabled defendant "Do I understand that £25,000 in cash has been paid?" to which defendant replied "All shares issued cash. About 4,000 reserved." Relying upon that representation plaintiff sent over 15 sets of batteries of 42 cells each, which were supposed to be paid for by the company at the price of $860 per set. A further set were sent later. There was a stipulation that a test should be made of the batteries in London, and an expert of Mr. Gould's works was sent over to give a demonstration in the presence of an independent engineer. The batteries, said plaintiff, passed all the tests stipulated for in the agreement. Defendant contended that in accordance with his agreement with plaintiff he formed the Gould Storage Battery Co. of England with a nominal capital of £25,000. In accordance with the agreement plaintiff received 55 per cent. of the share capital. He denied that he was personally liable for the amount of the contract which he said was due by the company, if by anybody. The whole of the shares that were issued were issued to the Asister Banking Corpn., of the Channel Islands. That company paid nothing for its shares, but Mr. Gould remained under the impression that they had done so. Plaintiff alleged that by conducting tests, &c., of the batteries in question and other methods defendant made it impossible for him to carry out his agreement, and therefore he was entitled to jugdment.

Mr. Chas. A. Gould gave evidence to bear out counsel's statement and described the way in which the tests were interrupted.

On Wednesday defendant (Dr. Lehwess) gave evidence, and said that by his cablegram: "All shares issued. Cash about £4,000 reserved," he meant that of the 25,000 shares 21,000 had been issued fully paid and that 4,000 shares had been reserved to be issued for cash. Later on he saw the plaintiff in New York, and pointed out the defects which had been discovered in the batteries, and he told plaintiff that when the batteries had passed the test he would pay for them, the plaintiff said, "Very well; I will look to you." Witness did say that plaintiff knew that no money had been paid for shares except that which had been paid by the seven signatories. In the Spring of 1908 his holding in the Electrobus Co. was about 12,000 to 14,000 shares. He took no part in controlling the Electrobus Co. The batteries were hired out to the Electrobus Co., but they proved very unsatisfactory. In cross-examination witness said that he thought a great deal of the misunderstanding that had arisen was due to the fact that plaintiff had but an imperfect acquaintance with English company procedure.

The case was proceeding when we went to press.

Block Light Co. v. Thos. A. Field & Co.—On Wednesday Mr. Verey, Official Referee, heard this action for the recovery of damages for negligence in storing 683 cases of electric light globes, &c. It was alleged that defendants had stored the goods carelessly, exposing them to the weather, with the result that they became so soddened and stained as to be of no market value. Defendants denied the allegations, but after hearing evidence the Official Referee gave judgment for plaintiffs for £266. 5s. and costs.

Consolidated Nickel, Tin & Copper Mines v. Crompton & Co.

The hearing of this case was resumed before Mr. Muir Mackenzie, K.C., on Wednesday.

Mr. Craggs was further cross-examined. He said that plaintiffs were not consulted as to what the strength of the fuses should be. The fuses were the lightest they could get the motor to start with. Upon the system adopted at the time the fuses would not go until you got a current which was about three times as powerful as was required for ordinary running.

Mr. John T. Leach, attached to the Bristol office of Messrs. Crossley Bros., said he was three weeks erecting the plant. There was no difficulty about the engine; it was sufficiently powerful three times over to work the pump. Two of the men who were working the engine seemed a bit careless. When he went down to the mine on Dec. 27, 1907, he looked at the governor and thought it had been taken to pieces, and not put together properly, but Jenkins denied that. Witness put it right in about 20 minutes.

Defendants' case had not concluded when we went to press.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

West Ham Corporation invite applications for the position of electrical engineer and manager of their electricity undertaking. Candidates must have had considerable experience in important electricity undertakings, and have a sound knowledge of the commercial management of electricity supply. Application forms, &c., from the town clerk, Mr. Fred. E. Hilleary, Town Hall, West Ham, to whom applications must be sent by 5 p.m. Tuesday, June 1. See also an advertisement.

The managers of the Technical College, Dundee, invite applications for the position of lecturer in electrical and mechanical engineering. The person appointed will have full charge of the electrical department, and must be competent to take the senior branches of mechanical engineering. Salary £350. Applications to the Director of Studies, Technical Institute, Dundee, by June 15. See also an advertisement.

The appointment of lecturer in the physics and electrical engineering departments at the Sunderland Technical College is now vacant. Salary £150 per annum. Applications to the Secretary, Mr. T. W. Bryers, 15, John-street, Sunderland, before Monday, May 31. See also an advertisement.

Sheffield Electric Light committee invite applications for the position of deputy manager and chief assistant of the electric supply department. The commencing salary will be in accordance with the qualifications of the candidate selected, the maximum being £300, rising by biennial increments of £25 to £400 per annum. Candidates must have had workshop training, practical experience in the working of electricity undertakings, &c. Applications to the general manager (Mr. S. E. Fedden), electric supply department, Commercial-street, Sheffield, by May 29.

A technical assistant is required by a firm of chartered patent agents; must have had experience in drafting specifications and dealing with official objections and a knowledge of electrical matters is desirable. See also an advertisement.

The Governors of the Borough Polytechnic Institute, London, invite applications for the position of head of the chemistry department for day and evening work. Commencing salary £300 per annum.

Mr. H. H. Clare has been appointed station engineer at Woolwich at £180, and Mr. H. W. Mansfield has been promoted to the position of works foreman.

Aberdare.—An adjourned inquiry into the application of the Council for permission to borrow £17,000 for electricity supply works was held on Tuesday.

Evidence in support of the application was given by Mr. S. Sellon and Mr. C. S. Vesey Brown. The latter stated that the Northern Counties Electricity Supply Co. had introduced electricity supply in several towns similar to Aberdare, where the residents were mostly coal miners. In those towns a large number of houses occupied by colliers, of a rental of from £15 to £25 a year, had been supplied with electricity. Compared with those towns, the chances of supplying small houses in Aberdare with electricity were better.

Mr. W. A. Chamen, general manager of the South Wales Electrical

Power Distribution Co., was of opinion that it was not possible to work the proposed undertaking at a profit, assuming Mr. Sellon's figures as to estimated gross profits were correct. He thought there would be a loss of £200, and the estimated consumption of 150,000 units in Aberdare was too high.

Mr. Starks considered the area to be supplied was too small to make a profitable scheme.

Aberdeen.—At the last meeting of the Council the Electricity committee recommended that the city electrical engineer (Mr. J. Alex. Bell) be allowed to provide a small stock of electric heating and cooking apparatus for hiring out.

Mr. Gray, who moved the adoption of the report, said that as the hiring out of gas stoves was not to be discontinued, he did not see where the objection should come in regarding the present proposal. Members who were opposed to the hiring out of cooking apparatus had already in their own places of business and in their homes gas stoves, and if that was so he failed to see any difference in principle between the hiring of a gas stove and an electric stove.

A long discussion ensued, but ultimately the recommendation was agreed to.

Acton.—On Wednesday the Council decided, by eight votes to five, not to lease their electricity undertaking to the Metropolitan Electric Supply Co.

Amalgamated Society of Engineers.—The 58th annual report of this Society (for the year ended December last) has been issued.

The general secretary (Mr. Jenkin Jones) calls attention to the fact that the membership decreased during the year from 110,084 to 108,120, compared with an increase of 5,213 in the previous year. As the total admissions were 7,044 (compared with 11,302) and the deaths 1,321 (1,260), the exclusions (chiefly for arrears of contributions) were obviously very numerous. The Society has a balance in the general fund of £324,472, a decrease of £168,544 compared with a gain of £80,555. The aggregate funds, including general office balances, general fund investments, superannuation reserve fund and branch balances, were £673,201 (against £809,630). The abstract statement of receipts, &c., of all the branches shows average arrears per member of 6s. 1¾d.

Argentina.—The "Review of the River Plate" says the Provincial Government have approved the plans for the conversion of La Plata tramways to electric traction.

The public electric lighting of Ituziango by the Cia. Alemaña Transatlantica de Electricidad was inaugurated recently.

The Cia. de Electricidad de la Provincia have asked for a concession for an electric tramway between Banfield and Almirante Brown, Buenos Ayres.

Asylum Lighting.—Surrey County Council have adopted a recommendation to adopt electric instead of gas lighting at Brookwood asylum, and about £4,000 is to be spent on electrical and steam plant.

Australasia.—Dunedin (N.Z.) Harbour Board have authorised an outlay of £1,800 for electric cranes.

The Royal Commission on the question of vehicular communication across Sydney Harbour have reported in favour of the construction of separate subways for tramways, railways and other vehicular traffic. The Commission recommend the construction of a tramway subway from North Sydney to Barton-street Circular Quay at a cost of £460,000, that the stations should be near the surface so as to avoid the necessity for lifts and that the subway be sufficiently large to permit of the use of standard size rolling stock.

Barnes.—The Council have resolved that from the end of the September quarter the price for current for lighting be reduced from 4d. to 3½d. per unit subject to discounts and for heating and cooking from 1½d. to 1¼d. per unit. The average price obtained for public lighting for the past year was 1·43d. per unit, and this figure remains unaltered.

Beckenham.—The Urban Council have elected Mr. A. H. Dykes (Messrs. Handcock & Dykes) as chairman of the Electricity committee for the ensuing year.

Bermondsey (London).—During the year ended March 31, 58 new consumers, with an applied demand of 602·61 kw., were connected, and 39 existing consumers extended their supply equal to 317 kw., making a total increase for the year of 919·61 kw., against 576·72 kw. in 1907.

Bethnal Green (London).—Hackney electricity department is preparing a scheme for the supply of electricity in bulk in this district.

Bridlington.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £5,100 for extensions of the electricity undertaking.

Brighton.—The Lighting committee have decided to reduce the charge for current to large power users. An agreement has also been entered into for the supply of energy to the railway works, and the committee offer to supply electricity to the Britannia Mills, Portslade (subject to wayleave, &c.) at 6d. per unit for the first hour's average daily use of the maximum demand and 2d. per unit after for lighting. Motors up to 100 H.P. rated capacity would also be installed, and there would be a fixed charge of £265 per annum (£66 5s. quarterly), plus 0·6d. per unit metered; but in the event of the price of coal exceeding 16s. per ton delivered in the Council's bunkers, an extra 0·05d. per unit per 1s. per ton of such increase or part thereof in proportion be paid in addition to the aforementioned 0·6d. per unit.

Chili.—The Compania Electrica de los Andes have secured a concession to utilise the waters of the river Aconcagua to the extent of 1,000 H.P. for generating electrical energy for lighting and traction in Los Andes and district.

Clacton.—A special meeting of the Council was held last week to consider the revenue account of the electricity undertaking for the past year.

The electrical engineer (Mr. H. W. EVERITT) stated that several large consumers had used less energy and there had been fewer arc lamps in use; and old and new consumers were taking advantage of the metallic filament lamp, which reduced current consumption more than half. The engines had run 300 hours more than last year, but the average load on them had been 11·25 per cent. lower. The battery had also received 140 hours more charging. The average consumption of gas in the engines per kilowatt hour was 2 cub. ft. higher than last year, due to smaller average loads on the engines. The extra cost of running could only be attributed to the extra current put into the battery, the increased amount of oil used, and the lower average load and increased gas consumption.

In the discussion it was suggested that the electricity and gas and water undertakings should be placed under one management, and that the front should be lighted by arc lamps.

The whole question was referred to the Electricity committee for report.

Cork.—The strike of the tramway employés, which has lasted for some weeks and caused the complete suspension of the service for over a fortnight, has been settled, and the public service resumed.

Damaging Telegraph Cables.—Reuter's Agency states that an indictment has been found against the master of a dredger belonging to an American company for breaking two submarine cables belonging to the Commercial Cable Co. The charge against the skipper is a violation of United States statutes enacted for the protection of telegraph cables. The damage on this occasion took two days to repair and caused considerable interruption in telegraphic business. The penalty is stated to be either a fine of $5,000 or two years' imprisonment.

Dock Cranes.—The North-Eastern Railway Co. have decided to erect two large electric cranes at their Middlesbrough dock for loading and unloading vessels.

Electrical Exhibitions.—An interesting exhibition, organised by the Hornsey Borough Council electricity department, has been held this week at the Athenæum, Muswell Hill, London, N. The exhibition was opened on Monday by the mayoress, Mrs. E. A. Ebblewhite, and among the exhibitors were:—

Messrs. SIEMENS BROS. & Co., who showed the "O.S." and "Kalkos" systems of simple wiring in several styles, the installations being mounted on a large three-panel board, complete with fuse boxes, switches, brackets, lamps and fittings. Tantalum lamps in various stages of manufacture were also shown. The SUN RAY REFLECTOR Co. had a number of their patent Nosma reflectors for all kinds of electric lamps on view. These reflectors are of silvered glass with a special form of capping, preventing the ingress of air to the inner lining of the glass, the life being prolonged and the efficiency preserved thereby. Mr. J. A. RITCHIE, of Muswell Hill, had an island stand, showing in the four sides metal filament lamps of various kinds, a good selection of artistic fittings, bells, private telephones, &c.

J. W. CARPENTER (LTD.), Muswell Hill, exhibited artistic fittings for lighting, radiators, hanging and stand lamps and small arcs.

The ARTISTIC GLASS ENGRAVING Co., Holloway, exhibited some attractive signs fitted with Peacellier's patent automatic contact breaker, which occupies only 9 in. by 3 in., is comparatively inexpensive and can be fitted to either alternating or continuous current. Several signs or lanterns can be operated by one contact breaker.

F. COTTRELL (Ltd.), Crouch End, had a stand with fittings of various kinds. H. W. Sutton, Enfield and Muswell Hill, showed metallic filament lamps and several examples of specialities in fittings and cooking apparatus. The British Vacuum Cleaner Co. showed a portable set with electric motor driving the vacuum pump. The Electrical Co. also exhibited.

A successful electrical exhibition was also held last week at the Town Hall, Hereford. The exhibits included displays of electric motors, electric cooking and heating apparatus, arc and metallic filament lamps, electric light fittings, &c. Among the firms exhibiting were the Union Electric Co., Dick, Kerr & Co., the British Prometheus Co., Harding Bros., R. E. Walker, &c.

SPECIAL NOTICE.

NOW READY.——Vol. LXII. of "THE ELECTRICIAN" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

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Electric Ambulances.—We are glad to learn that the electric motor ambulance, which has become a familiar sight and has done very successful work in the City for some time, is now assisted by a second electric ambulance of similar appearance and capable of even greater speed. Both ambulances have been on duty in King Edward-street this week, but the new one is to be ultimately stationed in New-street, Bishopsgate.

Electricity v. Gas.—At the meeting of the Welsbach Incandescent Gas Light Co., on Tuesday, Lord Weardale said the results of the past year's trading had been affected by depressed trade, and the competition of the metal filament electric lamp. A large section of the public had been induced most wrongly, as they thought, to believe that electricity was at last a cheaper illuminant than gas, and though they had over and over again challenged those misstatements, a great deal of damage had been done.

Felixstowe.—Mr. James Swinburne has been appointed aribtrator in a dispute between the Council and the Suffolk Electricity Supply Co. as to the character of the extensions to the plant at the generating station. The main question is whether the new plant shall consist of one 150 kw. unit or two 75 kw. sets.

Fire.—A somewhat disastrous fire occurred on the premises of Simplex Conduits (Ltd.), at Newcastle-on-Tyne, last week. The company have opened other premises in Pilgrim-street, and have made arrangements to obviate any delay in the execution of orders.

Hackney (London).—The Electricity committee report that there is an increasing demand for electrical energy for power in the Hackney Wick district.

Halifax.—A Board of Trade inquiry was held on Wednesday into the application of the Corporation for sanction to double the tram line in Northgate, and to lay a single line in George-street. There was considerable opposition, and after taking evidence the inspector (Major Druitt) intimated that he would report in due course.

India.—The Burma Railways Co.'s Malagon station goods yard is to be lighted by 45 B.T.-H. flame arc lamps.

Plant has been purchased in India for the electric lighting of the Chandpur station of the Assam-Bengal Railway.

Calcutta and Bombay firms have been asked to tender for the electric lighting of the city of Bhopal. Eight miles of roads and several city palaces are to be lighted electrically.

International Code Telegraphy.—The London Chamber of Commerce has received a notification from the Postmaster-General of the following principal points in which the regulations relating to Code have been altered by the Lisbon International Conference, 1908:—

1. An express stipulation has been inserted in order that there may be no doubt as to the condition which was previously implied, namely, that the standard of pronounceability to which artificial code words must conform is the *current* usage of the eight languages specified.

2. The Administrations of Great Britain, France and Germany have been authorised to give the approval of the International Telegraph Union to such codes as are voluntarily submitted and are found upon examination to be prepared upon a proper basis.

This slight modification in the Regulations affecting Coding has been adopted in order to "check the increasing use of Codes which transgress a reasonable standard of pronounceability and which therefore tend to considerably diminish the efficiency and retard the speed in working of the International Telegraph Service."

Light Railways.—Application has been made to the Light Railway Commissioners for an order extending the time for complying with the Headcorn and Maidstone Junction Light Railway Orders, 1906 and 1907, and authorising the use of power other than steam, purchase of electric current. &c.

London County Council.—On Tuesday it was agreed to lend Bermondsey £5,262 for electric lighting.

Electric Lighting Acts (Amendment) Bill.—The Parliamentary Committee recommended that an attempt be made to get the following amendments of this Bill adopted by Parliament:—

(i.) That London County Council shall be entitled to be heard before the Board of Trade on any order, or consents affecting London, made under clauses 1, 3, 4, 6, 7 and 8.

(ii.) That clause 11 be amended so as to provide that a person shall be entitled to the use of a certified meter without extra charge for such certification by the undertaker supplying electricity, and that the inspector of such undertaker shall take into consideration the size of the meter as being suitable to the requirements of particular premises.

(iii.) That clause 15 shall not apply to existing consumers.

Mile End-road Tramways.—The Highways committee recommended that the reconstruction of the above tramways should be executed by Messrs. Dick, Kerr & Co. as an extension on their present contract. The estimated cost is £30,250.—Carried.

L.C.C. Tramways.—A service of electric cars is now running from Tottenham Court-road to Finsbury Park.

London Telephone Service.—A new central battery exchange o the National Telephone Co. was opened on Saturday last, to take the place of the old exchange for the Dalston area. The new exchange is fitted with all the latest improvements in telephone plant, apparatus, and accessories.

Middlesbrough.—An inquiry was held here last week into the application of the Council for sanction to borrow £10,000 for cable extensions, &c. There was no opposition.

Newton-le-Willows.—The Council have applied for a further extension of their electric lighting order.

Obituary.—The death occurred on 13th inst. of Mr. John Castell Evans, senior demonstrator in applied chemistry at Finsbury Technical College.

Portugal.—Coimbra Municipality have been granted permission to borrow 150,000 milreis for the construction and working of an electric tramway in the town.

Presentation.—On the 14th inst. the Bradford City electrical engineer (Mr. Thos. Roles) was presented with a silver rose bowl by the staff on the occasion of his marriage.

The presentation was made at a smoking concert at which there was a large muster of the staff. The chair was occupied by Mr. C. W. Salt (chief assistant engineer), and Mr. C. B. Holdsworth said that though Mr. Roles was a strict disciplinarian he was kindly and considerate in his dealings with the staff, and he could rely upon their loyal support.

The presentation was then made by Mr. W. Jones, works superintendent. The toast of "Mr. and Mrs. Roles," proposed by the chairman, was received with musical honours.

In acknowledging the gift Mr ROLES said that, although the trade of Bradford had not been very satisfactory of late, they could congratulate themselves on an increase of 10 per cent. in the units consumed during the past year, and he looked forward to a further increase in the coming year. In the matter of electric lighting they had done very well and builders were now wiring houses through as soon as they were put up in readiness for a supply of current. There was a good deal of work on now in connection with the extension of plant, and he trusted that with the new plant they would reduce the working costs.

Private Bill Legislation.—The Torquay Electric Tramways Co. (Ltd.), intend to apply for leave to introduce into the Torquay and Paignton Tramways Bill clauses to transfer to the Company the powers conferred on the Dolter Electric Traction (Ltd.) by the Torquay Tramways Act, 1904, with regard to the construction and working of certain tramways, to extend time for the construction of the lines, to authorise the use of the overhead system on one route, to make provision for purchase by Torquay Corporation of the existing tramways and tramway, No. 1 proposed to be authorised by the Bill at one time, to enable the Corporation to purchase tramway No. 2 in Paignton (in the event of its not being purchased by Paignton Urban Council) on the same terms as the purchase of tramway No. 1, subject to the right of the Council to repurchase such tramway.

Provisional Orders Revocation.—The Board of Trade have revoked the Heysham Electric Lighting Order, 1904, as from May 7, and the Saffron Walden Electric Lighting Order, 1904, as from May 10

Rawtenstall.—The municipal electric tramways were opened for traffic on Saturday. Electric current was switched on by the chairman of the Electricity committee (Councillor Coupe). The system will be extended to Bacup shortly, and, including the Bacup section, the entire scheme will cost £144,544.

Russia.—The construction of an electric railway from Moscow to Troïtza-Serguiev is being commenced.

St. Pancras (London).—London County Council has written to the Borough Council with regard to the proposal of the latter to take money from the electricity reserve fund and invest it in a loan of £12,000, to the electricity department for machinery and plant.

The Finance committee of the L.C.C. are (they state) advised that to advance money in this manner is not such an investment as was authorised by the St. Pancras Electric Lighting Order, 1883. The Borough Council would, in the opinion of the committee, be well advised to make an arrangement with the County Council to reduce the period of the loans (42 years) so that outstanding loans may be made repayable within periods based on the probable life of the plant, &c.

The Finance committee of the Borough Council, in a report, state that they are advised that to advance moneys out of the reserve fund in the

manner proposed is quite in order. After carefully considering the points raised they are of opinion that the local authority should adhere to their decision to borrow the whole sum requisite from the reserve fund.

St. Petersburg.—It is reported that the Municipal Council propose to issue a loan of about 10,000,000 roubles for various works, including the extension of the telephone system.

Southampton.—The general manager of the tramways has been directed to obtain tenders for a motor-driven air compressor.

Southwark (London).—The Council have applied to the L.C.C. for sanction to borrow £2,130 for house services, meters, &c., during 1909-10.

Wireless Telegraph Notes.—The public is to be provided with a working example of wireless telegraphy at the Travel and Sports Exhibition at Olympia, London, in July. The Marconi Wireless Telegraph Co. will establish a complete installation, enabling visitors to send messages direct from the exhibition to ships at sea. There will also be facilities for telegraphing by wireless methods within the building.

Woolwich.—Three testing stations are to be established, and mains extensions are to be carried out at a cost of £162. Tenders are to be invited for pipework for the cooling pond at Plumstead station.

Workhouse Lighting.—At an extraordinary meeting of the Guardians of South Dublin Union last week a previous resolution in favour of gas lighting was rescinded, and it was decided to conditionally accept the tender of the Ampere Electric Co. for electric lighting.

York.—At a special meeting of the City Council on Wednesday it was decided to postpone until the June meeting the recommendation of the Tramways committee to accept the tender of Dick, Kerr & Co. for the construction and equipment of tramways at an estimated cost of £78,827.

Electro-Harmonic Society.—The annual general meeting will be held at the Institution of Electrical Engineers, 92, Victoria-street, London, S.W., on Wednesday, May 26 at 4 : 30 p.m. to receive the accounts for the twenty-third session, to elect officers, &c.

During the past season 58 new members have been elected, 59 resigned, 12 were struck off the register for non-compliance with rule 11 and two members died. The total membership is 625. Total receipts, including balance forward (£83. 15s. 5d.), were £425. 4s. 11d., and after paying expenses, including cost of six concerts, the balance at the bank and in hand was £63. 19s. 3d., but there are subscriptions due estimated to realise £20, making the balance £83. 19s. 3d.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Belfast.—A sub-committee has been appointed to report upon the question of the charge made for current for traction, as the manager (Mr. Nance) alleges that for the year ended March 31 last his department was overcharged to the extent of about £1,220.

The city electrical engineer (Mr. T. W. Bloxam), in his report for the year ended March 31, states that the revenue from the sale oi current for lighting and power, &c (but excluding tramway supply) was £37,010, an increase of 4·2 per cent.

The number of units sold for lighting was 2 055,935, an increase of 2·2 per cent ; the number of units sold for power was 1,587,989, increase of 8 per cent The total cost of production had been reduced by 11 per cent., partly due to increased economy effected since the turbine machinery commenced operation and partly due to reduction in price of coal. The cost per unit supplied to the tramways had been reduced by 13 per cent , which effected a saving of nearly £3,000 to that department. The net profit was £9,270, making, with balance from last year (£2,098), a total of £11,368, which has been allocated as follows: General purposes £5,000 and depreciation fund £6,368. The equivalent of 8 c.p. lamps connected is 325,211 (including 4,695 H.P. in motors), an increaseof 10·4 per cent. ; and there are applications for a further equivalent of 35,709 8 c.p. The number of consumers is 1,971, an increase of 196. The maximum combined load last winter was 6,309 kw. (3,284 kw. lighting and 3,025 kw. tramways), and the maximum tramway load occurred on March 5 (being the day of the heavy snowstorm), 3,300 kw. The maximum lighting load was on Dec. 15, and was 3,443 kw.

In response to a request from a large consumer asking that a combined flat rate for lighting and power should be fixed, Mr. Bloxam recommended that such a combined rate should be provided in the case of consumers using over 40,000 units per quarter for power, the rate to be fixed at 1·1d. per unit until further notice. The recommendation was agreed to.

An experiment is being made as to the relative merits of electricity and gas for street lighting. Hitherto there has been little public electric lighting in Belfast, and, in order to demonstrate the merits of modern arc lighting, four flame arc lamps have been erected at two central points in the city.

Burnley.—For the year ended March 31 the total income of the tramways department was £62,668. 16s. 11d., including £61,910. 16s. 3d. from passenger receipts, or 12·088d. per car-mile against 12·691d. in 1907-8.

Expenses were £40,950. 9s. 3d. (7·995d. per car mile, against 7·924d.). Gross profit was £21,718. 7s. 8d. After meeting interest, sinking fund, &c., £6,000 was placed to reserve and £2,380. 16s. 8d. carried to borough fund. 12,176,782 passengers were carried, a decrease of 179,176, and the car miles run 1,229,224, an increase of 26,894. The gross total capital expended is £193,096. 2s., an increase of £6,860. 5s. 1d. during the year.

Burton-on-Trent.—The accounts of the electricity department for the year ended March last show total capital expenditure £82,579.

Revenue was £12,444 and expenditure £6,575, and after providing £5,029 for interest, sinking fund and redemption fund, the surplus was £837 (against £1,105 in previous year). The borough electrical engineer and tramway manager (Mr. P. J. Pringle) says, in his report, some £69 is being paid (under repairs to machinery) out of revenue for improvements of a capital nature, so that with £26 provided out of revenue on account of stock motors and £44 received on account of hire of the motors, there is really a surplus of £139 in addition to the £805 placed to renewals fund. The figures in the accounts are for 53 compared with 52 weeks. The use of metallic filament lamps has shown a marked effect on the accounts. Cost of fuel rose 4·2 per cent. Revenue increased £183, and expenditure £451. Gross profit is £5,866 (£6,105). For private lighting the total lamps connected are 33,615 8 c.p. (31,775). The reduced charge of 5d. flat rate and the rebates on the maximum demand system reduced the revenue by £400, and the outside arc lighting charge has been reduced to 4d. per unit. Revenue from private lighting is less than six years ago, although the lamp connections have increased by 43 per cent. The units sold for power were 533,390 (401,690), and applications are in hand for supply for motors aggregating about 500 H.P. The average price of current for power was 0·98d. Works costs were 0·810d. (0·812d.), total costs 1·033d. (1·055d.), and capital charges 0·79d. (0·86d.). Out of 775·5 H.P. in motors 526·25 H.P. was on the restricted hour system, which took 67·5 per cent. of the total power and 80 per cent. of the total motor supply. The revenue from the restricted hour consumers was £1,515 (£1,010).

The accounts of the tramways department show capital expenditure £105,640 (increase £11) :—

Total receipts (exclusive of M.R. Co.'s running) were £14,183 (£14,908), M.R. Co.'s running, &c., £926 (£1,014), operating expenses (exclusive of M.R. Co.'s running, &c.) were £11,303 (£10,504). Car-mileage was 425,843 (430,913), plus M.R. Co.'s running, 49,690 (54,464). Cost of power (at 2d. per unit for first 100,000 units and 1½d. after) was £3,489 (£3,403), and after paying working, power and management expenses the gross surplus was £3,188. After providing for interest and contributions to redemption, sinking and renewals funds there was a deficit of £2,747. The current used per car-mile on Corporation cars was 1·26d. (1·19d.) units at an average cost of 1·74d. (1·64d.). The cost of fixing Pringle emergency skid brake to all cars working on steep gradients, and the alteration of the design of sanders from intermittent to continuous and placing them so as to discharge close to the wheel, has been charged to revenue.

The accounts were presented to and approved by the Council last week.

Crewe.—The profit on the past year's working of the electricity undertaking amounted to nearly £1,000, of which £500 has been applied to relief of rates.

Dundee.—The total receipts of the municipal tramways system for the past year amounted to £62,801, an increase of £2,228 over 1907-8. The total number of passengers carried was 16,778,000.

Grimsby.—The accounts of the electricity department for the year ended March 31 have been approved by the Electric Lighting committee.

The accounts show total revenue £17,142, total expenditure £7,802, and gross profit £9,264. After paying interest and sinking fund the net profit was £3,184 (against £2,442 in 1907-8), of which £500 has been devoted to relief of rates. The equivalent of 78,934 8 c.p. lamps was connected (against 72,039), the number of consumers being 697 (595). 2,043,158 units were sold, including 749,959 to private consumers, 684,500 to the railway company in bulk, 479,791 to tramways and 128,908 for public lighting.

In the report of the borough electrical engineer (Mr. W. A. Vignoles) it is pointed out that although there is an increase of 102 in the number of consumers, the revenue only increased by £38, owing to extended use of metallic filament lamps, slackness of trade, &c. The total costs of generation were 0·592d. (against 0·661d.) and the total working costs were 0·875 (against 0·912d.).

Launceston (Tasmania).—The total capital expenditure of the municipal electricity department is £166,871.

Last year's revenue was £17,683 (compared with £16,287 in 1907). The gross profit was £9,605 (against £8,855), and after meeting capital charges the surplus was £2,108 (£1,557) of which £2,092 was placed to reserve ; works costs were 0·827d. (0·846d.) per unit and total costs 1·264d. (1·362d.). 462,502 (482,542) units were sold for private lighting, 587,065 (389,332) for power, 106,880 (79,128) for heating and 376,839 (357,878) for public lighting. The equivalent 8 c.p. lamps connected at

Dec. 31 were 39,002 (37,913), and the revenue per 8 c.p. lamp was 5s. 3¾d. (5s. 6¾d.) 235 (178) motors of 1,067 H.P. (799 H.P.) were connected. The ratio of expenses (including capital charges) to receipts has dropped from 90·43 to 88·08 per cent. Metallic filament lamps are supplied free to the equivalent of the old carbon lamp free supply, and the consumer pays any excess at cost price. The demand for current for radiators and irons is still increasing and appears to be greater, in proportion to the population, than anywhere else in the Australian Commonwealth.

Leeds.—The revenue account of the electric lighting department was submitted to the Tramways and Electricity committee on Monday, when it was reported that the total receipts were £104,148. 1s. 2d., including £73,086. 12s. 7d. from private lighting (against £80,928. 6s. 3d.), £5,149. 18s. 4d. (£4,661. 10s. 3d.) from street lighting, and £25,911. 8s. 2d. (£27,846. 10s. 7d.) for power. The total receipts for 1907-8 were £113,436. 8s. 1d.

Working expenses were £34,270. 19s. 11d., against £35,276. 6s., and extraordinary renewals cost £2,138. 11s. 7d., against £13,372. 9s. 7d., leaving a gross profit of £67,738. 9s. 8d., against £64,787. 12s. 6d. Income tax, interest and redemption fund absorbed £59,490. 7s. 8d., against £57,865. 19s. 9d., leaving a surplus of £8,248. 2s., against £6,921. 12s. 9d. 12,395,118 units were sold, against 12,412,861, and the average price per unit was 2·02d., against 2·19d. Expenses (including extraordinary renewals, interest and redemption fund) were 1·86d., against 2·06d., and the surplus 0·16d. against 0·13d. The capital expended during the year (less credits) was £37,130. 10s. 6d., against £35,424. 11s. 2d., bringing the total capital expended to £916,913. 17s. 3d. Out of the surplus £3,000 has been transferred to the newly-formed reserve fund, and the balance (£5,248. 2s.) has been applied to relief of rates, bringing the total contributed to date for this purpose to £45,866. 13s. 4d. The equivalent of 313,627 35 watt lamps was installed at March 31, against 317,890 in 1908, a decrease of 4,263. For private lighting 5,241,523 units were sold, against 5,771,597, and for street lighting 988,785 against 895,009; the average price obtained being 3·01d., against 3·08d., the units sold per lamp installed were 19·69, against 21·25, and the revenue per lamp installed 4:11·34d., against 5:5·47d. At March 31 there was an aggregate of 9,942 H.P. installed, against 8,379, an increase of 1,563 H.P. The units sold for power amounted to 6,164,810, against 5,746,255, the average price per unit was 1·01d., against 1·16d., the units sold per horse-power installed were 686, against 754, and the revenue was £2. 17s. 8d., against £3. 13s. 2d.

The decrease in the equivalent number of lamps installed for private lighting is due to the growing use of metallic filament lamps and the substitution of these lamps reported to the department represent a reduction equal to 11,490 35 watt lamps. The extension of the use of electric lighting, which is generally regarded as the inevitable result of the low cost at which this form of illumination can be obtained, has not yet made itself very appreciable in Leeds. The decrease in revenue from power sales is due to a reduction in the scale of charges. The various items of ordinary expenditure show a reduction, including coal (notwithstanding an increase of 24 per cent. in its average price), of which the quantity used was 26 per cent. less than in 1907-8. The total ordinary working expenses per unit were 0·67d. (the same as in 1907-8) and the total charges were 1·86d., against 2·06d. Of the capital expended during the year £15,558. 18s. 3d. was for generating plant and £21,571. 12s. 3d. for extension of mains, sub-stations and meters. An additional 3,000 kw. steam turbo-alternator is comprised in the extensions at the generating station, increasing the capacity of the plant to 15,740 kw. The maximum load upon the plant has been 8,220 kw., compared with 8,300 kw. in 1907-8.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Electricity committee of STEPNEY (London) Borough Council, invite tenders for the supply during the period ending June 30, 1911, of ampere-hour meters, demand indicators and time switches, and arc lamps. Specifications, forms of tender, &c., may be obtained from the borough electrical engineer and manager, Mr. W. C. P. Tapper, 27, Osborn-street, Whitechapel, E., where tenders must be delivered by noon of June 14. See also an advertisement.

SOUTHAMPTON Corporation invite tenders for the supply of sundry heavy cables for l.t. trunk mains required by the electricity department in accordance with the specification, particulars and conditions which may be obtained from the borough electrical engineer, Mr. H. F. Street. Tenders must be delivered at the office of the town clerk, Mr. R. R. Linthorne. See also an advertisement.

GRIMSBY Corporation invite tenders for supply, delivery and erection of two superheaters for two Stirling boilers, and the renewal of dripping bars in existing cooling towers. Specification, &c., from the borough electrical engineer (Mr. W. A. Vignoles). Tenders by first post Monday, June 7. See also an advertisement.

Tenders are invited for supply of 50 coin attachments (suitable for coins of different values) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for eight sections of common battery switchboard and subscribers' apparatus for Hawthorn Exchange for the Postmaster-General's Department, VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of a branching multiple magneto switchboard to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specification may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of one photometer, &c., to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specification from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

The Powell Duffryn Steam Coal Co. (Ltd,) ABERAMAN, Aberdare, want tenders by 10 a.m. June 7 for supply of stores, including electrical goods, ironmongery, gunmetal fittings, indiarubber goods, &c. Forms of tender from Aberaman. Tenders to the Directors, 101, Leadenhall-street, London, E.C.

POPLAR (London) Guardians want tenders by 6:30 p.m. May 26 for supplying and fixing two electric fans in the workhouse laundry. Forms of tender, &c., from the Clerk, 45, Upper North-street, Poplar, E.

DUDLEY Corporation want tenders by noon June 10 for supply and erection of a motor-generator, with switchgear. Specification, &c., from the Borough Electrical Engineer.

COLWYN BAY AND COLWYN District Council want tenders by May 27 for supply of cables and accessories, carbons, meters, boiler accessories and engine-room stores. Forms of tender from the Clerk.

BURY Corporation want tenders by 9 a.m., June 2, for the erection of an electricity generating station at Chamber Hall, Bury. Specification, &c., from the Borough Engineer and Surveyor.

Tenders are invited for the electric lighting of Mount Pleasant Chapel, LEEK. Specification, &c., from Mr. Hy. Ellerton, Derby-street, Leek.

HORNSEY Council want tenders by 4 p.m., May 28, for coal for electric lighting station, &c. Forms, &c., from the Town Clerk.

Tenders are invited for the supply, alternatively, of one 1,000 kw., 1,250 kw. or 1,500 kw. d.c. dynamo and engine to the City of MELBOURNE. Tender form, conditions, specification, &c., can be obtained from the agents of the Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter Square-buildings, London, E.C. Tenders, addressed to the chairman of the Electric Supply committee, Town Hall, Melbourne, by 2 p.m. July 14.

Tenders are invited for the supply of 69,750 incandescent lamps to the City of MELBOURNE. Specification and forms from the agents of the Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by noon, June 1.

Tenders are also invited for supply of 1,125,000 flame and 70,000 ordinary arc lamp carbons for MELBOURNE Corporation. Tender form, specification, conditions, &c., from the agents for Melbourne City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon, May 25.

Tenders are also invited for supply of telephone material to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W.

CAPE TOWN Corporation invite tenders for street lamp fittings for electric lighting. Specification from Messrs. Davis & Soper, 54, St. Mary Axe, London, E.C.

The Direction of Public Works, Madrid, will receive offers until June 8 for a concession for the construction and working of an electric tramway from the VALLVIDRERA line to Tibidabo, in competition with the offer submitted by the Sociedad Anónima El Tibidabo.

TENDERS RECEIVED AND ACCEPTED.

Whitehaven Council received the following tenders for the supply of castings for feeder pillars and lamp columns:—

W. Lucy & Co. (accepted)	£56	16	0	British Insulated & Helsby Cables	£70	15	0
Falkirk Iron Co.	145	5	0	Hardy & Padmore	67	2	0
Callender's Co....	115	14	6	Mackenzie & Moncur...	65	13	6

The borough electrical engineer (Mr. P. W. Sankey) states that a large difference in prices may be partly accounted for by the fact that in some cases makers' standard patterns required alteration to accommodate the switch panels supplied under another contract.

The London County Council have accepted the tender of Dick, Kerr & Co. for overhead equipment at £2,511. 5s. 2d.

The troughing portion may be sublet to Mr. H. C. Philcol; the bases to R. A. Bradshaw & Sons; the poles to the British Mannesman Tube Co.; the trolley wire to F. Smith & Co.; the pole straps and small work to B. C. Martin; the M.I. span-wire cross to the Leys Malleable Casting Co.

For the erection of the first portion of the Abbey Wood car shed the London County Council have accepted the tender of F. & G. Foster at £16,982.

Southwark Borough Council have placed orders with Venner & Co., Gillespie & Beales and the Electrical Co. for meters.

Cleckheaton Council have accepted the tender of Siemens Bros. & Co. for supply of cables for 12 months. There were 11 tenders.

The Governors of Sir Titus Salt's Hospital, Shipley, have accepted the tender of R. Lindley, Jun., for electric lighting installation, and that of the Keighley Electrical Engineering Co. for an electric lift for invalids.

Bristol Council have accepted the tender of F. & W. Bracher for wiring work, &c.,at Avonbank station at £397; that of P. John & Co. for wiring Kingstown Close schools at £169. 8s.; and that of the Oliver Arc Lamp for arc lamp carbons at £200.

Stepney (London) Council have accepted the tender of Foster Bros. for pipework, hotwell, &c., at £3.989. There were seven tenders, varying in amount from that of the accepted tender to £6.337.

For supply of motor-driven pumps the tender of the Rees Roturbo Mfg. Co., at £1,969 (with patent ventilated motors) has been accepted. For this contract there were nine tenders, two being incomplete, and the amounts varied from that of the accepted tender to £3,150.

E. Newbold & Co. have secured the contract for the electric light work, &c., at the Kensington (London) Guardian's Offices, &c., at £169.

Siemens Brothers Dynamo Works (Ltd.) have secured the contract for the supply of carbon filament lamps and Tantalum metal filament lamps for the borough of Partick.

Dudley Education committee have accepted the tender of Dudley Electrical Co. for wiring the new high school for girls.

Surbiton Council have accepted the tender of Pasterfield & English for extending the generating station buildings.

Whitehaven Council have accepted the tender of Whipp & Bourne for switchgear for feeder pillars.

Sunderland Council have accepted the tender of Crompton & Co. for arc lamp carbons for six months.

Lewisham (London) Council have accepted the tender of H. Hooper for wiring the strong rooms at the Town Hall at £20. 12s. 6d.

S. Hodgson & Co. have secured the contract for wiring the Brighouse secondary schools.

Cleckheaton Council have accepted the tender of Siemens Bros. & Co. for the supply of cables at £723. 8s. 6d.

Large Gas Engines.—Messrs. Ehrhardt & Sehmer have recently received three repeat orders (aggregating 3,000 H.P.) for large gas engines to be direct coupled to electric generators. Last week the firm received a repeat order from the Skinningrove Iron Co. for a 1,200 H.P. engine, to work on blast furnace gas. This is an extension to two smaller engines of the same make now in course of erection, and they have also just received an order for an identical engine for use in a large chemical works in this country where one of their 1,200 H.P. engines has been running on Mond ammonia recovery producer gas during the past two years.

BUSINESS NOTICES.

The Cowper-Coles Engineering Co. (Ltd.) has been formed, with offices at Grosvenor-mansions, 82, Victoria-street, S.W., to develop the business of Sherard Cowper-Coles & Co. and to carry on the work of electro-metallurgists and chemical engineers.

Mr. H. V. Kramer, late managing director of Kramos (Ltd.), has, we are informed, severed his connection with that company, and has formed, in conjunction with the Witton Engineering Works, Birmingham, the Witton-Kramer Electric Tool & Hoist Co., to carry on the manufacture and sale on a larger scale of the electric suspension and mono-rail trolley hoists, electro-lifting magnets, portable electric drills and grinders, and brake solenoids.

The Electric Lighting & Tramways Accessories Co. has started business at 73 and 75, Finsbury-pavement, E.C., with Mr. A. W. Boreham, late of the Consolidated Supply Co. and the British Electric Car Co., as manager. Telephone No. 9844 London Wall.

Chas. Wm. Shackleton and Chas. David Lavington (trading as Polesworth Electrical Appliance Co.), Polesworth, Warwickshire, have dissolved partnership. Debts by Mr. Shackleton.

Geo. Cooke and Wm. H. Sellers (trading as Geo. Cooke & Co.), electrical engineers, Hawthorn-street, Wilmslow, have dissolved partnership. Debts by Mr. Cooke, who continues.

Wm. Baker and Walter Anderson, electrical engineers, 14, High-street, Sutton, Surrey, have dissolved partnership, and the share of Wm. Baker in the business has been assigned to Geo. J. Hawkins, who will continue the business in partnership with Walter Anderson. Debts by Messrs. Anderson and Hawkins.

Alfd. Chas. Cossor, the elder, and Frank Cossor (trading as A. C. Cossor & Son), barometer, thermometer, &c., makers, 12, Clerkenwell-green, London, E.C., have dissolved partnership. Debts by Mr. Frank Cossor.

Plant for Sale.—Messrs. G. Elliott & Co., 186-188, Long-lane Bermondsey, London, S.E., have for sale two compound Marshal steam engines coupled to two Crompton dynamos, and also threel dynamos. Further particulars are given in an advertisement.

Whitsuntide Holidays.—To obtain the greatest benefit from a holiday it may be accepted that a change of air is essential. The country is now looking its best, and the facilities for comfortable and expeditious travel is an inducement to spend the Whitsun recess away from home. The A.B.C. programme of the Great Central Railway contains particulars of over 300 seaside and inland health resorts in the Midlands and the North, which can be reached in quick time at very low fares. To those wishing to remain nearer London the Vale of Aylesbury, Chiltern Hills, and Stratford-on-Avon particularly appeal. Those who prefer walking or cycling have the beauty spots of Middlesex, Herts, and Bucks to select from. The company provide express corridor and buffet car accommodation on trains which leave Marylebone on Friday, Saturday, Sunday and Monday, May 28 to 31, and full particulars of times of departure, fares and other information are given in the programme, of which copies may be obtained free at Marylebone Station, at any of the Company's town offices and agencies, or by post from the Publicity Department, 216, Marylebone-road, London, N.W.

CATALOGUES, &c.

TRANSFORMERS FOR USE WITH INSTRUMENTS.—Messrs. Siemens Bros. & Co. have issued a reprint of an article from "THE ELECTRICIAN," of March 12 last describing a multiple-range pressure transformer specially designed to meet the requirements of laboratory and research work. Current transformers for a working pressure of 12,000 volts are also described and the results of numerous tests on these instruments were given.

"GUTTAFLEX."—The Armorduct Mfg. Co. have a pamphlet ready dealing with a new rubber braided flexible cable.

"GRAL-ARC" FITTINGS.—High c.p. metallic filament lamps have to some extent, encroached upon the field of arc lamps, and for this reason many makers have designed fittings which shall be capable of taking metallic filament lamps of candle-powers up to 500, among these being the Armorduct Mfg. Co.

TELEPHONE CABLES.—Messrs. Siemens Bros. & Co., have ready an artistic pamphlet dealing with underground telephone cables, profusely illustrated both with views of the machinery for manufacturing these cables at the Company's Woolwich works and also with three-colour plates made from actual sections of the ordinary and composite telegraph and telephone cables, manufactured at Woolwich. After a short introduction the catalogue proper gives a specification of the Siemens underground cables, the sizes of conductor generally employed for telephone work being furnished in a table. To facilitate the determination of the gauge of conductor and type of cable necessary to ensure efficient transmission of speech or to meet certain definite conditions, an extract is appended from Sir John Gavey's Presidential Address to the Institution of Electrical Engineers in 1905, which outlines the principles followed in British Post Office practice. Clauses from the agreement between the Post Office and National Telephone Co., respecting the standards of telephone transmission are also given. A portion of the catalogue is devoted to an exhaustive specification of the various parts of these cables, and this section should form a useful addition to the numerous "catalogue-text books," which makers are now issuing. The various cables manufactured, including those of the telephone and telegraph composite type, are, as stated, illustrated in three colours, full details of their diameter, weight and capacity being also provided.

ELECTRIC FANS.—The Electric and Ordnance Accessories Co., of Birmingham, have issued their fan catalogue for the coming season. These fans, which were dealt with in the last issue of "The Electrician" INDUSTRIAL SUPPLEMENT, include fans of the desk, ceiling and porthole types, suitable for use on both alternating and direct current. The A.P. fan, which is one of the firm's specialities, can easily be adapted by means of some slight adjustments for use either as a desk, wall or ceiling fan, and in addition a breeze can easily be sent in any horizontal direction. These fans have been specially constructed to conform to the requirements of the British Admiralty, and we are informed that they are being used very widely.

"BRUSTON" TRANSFORMER SWITCH.—Messrs. Morris & Lister, of Coventry, are distributing a pamphlet dealing with a new transformer switch, which they have placed on the market for use with metallic filament lamps. The use of this switch, it is claimed, adds considerably to the economy of metallic filament lamp installations, as the no-load losses in the auto-transformers (although small) mount up considerably during the hours when the lamps are not in use. By means of this switch, however, the transformer is cut out of circuit when all the lamps are switched off.

SIMPLEX-ISARIA FANS.—Simplex Conduits, Ltd., have ready a new fan catalogue. We described this apparatus in the last issue of our INDUSTRIAL SUPPLEMENT.

MOTORS.—The Langdon-Davies Motor Co. Ltd., of Deverell-street, Southwark, S.E., have sent us a pamphlet showing the many uses to which their well known motors can be put. This includes illustrations of the first Langdon-Davies motor, now in the South Kensington Museum, and of the more modern types of motors applied to fans, organ blowers and hoists.

HART ACCUMULATOR.—The 1909 edition of the catalogue of the Hart Accumulator Co., of Stratford, just issued, deals very fully with the Hart storage batteries, full details of the various parts being given, with instructions for working the finished battery. Hart batteries are made in several types, including those specially designed for lighting, for use with 25 volt metallic filament lamps, and on traction work. They can be supplied in both glass and lead-lined boxes as required.

THE STEREOMETER.—Messrs. Siemens Brothers & Co. have sent us a copy of a supplement to their catalogue No. 506, dealing with the Stereometer, an instrument for localising foreign bodies by means of the X-rays. This important new instrument, and its methods of application, are fully described and illustrated. We understand, however, that in addition to the information given this localising apparatus has the advantage that it does optically what all previous types of localisers have done with cross threads, &c., whilst it is said to be more accurate than anything that has previously been designed for the purpose, and is constructed with the precision of a microscope. It has been found that with the stereometer foreign bodies in the eye can be localised with great accuracy. The instrument is portable and can (it is urged in its favour) be employed by anybody.

BANKRUPTCIES, LIQUIDATIONS, &c.

A receiving order has been made against Joseph Cunnington, Grace Smith and Harry P. Allison (trading as Laing, Wharton & Cunnington), electrical engineers and contractors, 7, Gt. Newport-street, London, W.C. First meeting of creditors May 25, and public examination June 23, at Bankruptcy-buildings, Carey-street, London, W.C.

Thos. Ward, late managing director of Electrical Instrument Manufacturers (Ltd.), failed to attend for further examination at Edmonton Bankruptcy Court on Monday. The examination and an application for the adjudication of the debtor were adjourned.

The first meeting of creditors of John R. W. Middleton and Alfd. E. E. Daniels (trading as Middleton & Co.), electricians, 11A, King-street, Dover, will take place on May 22, at 68A, Castle-street, Canterbury, and the public examination on May 27 at the Guildhall, Canterbury.

Lancelot W. de Grave, electrical engineer, 19, Queen-street, Derby, has been adjudicated bankrupt.

Voluntary Liquidation.—Marples, Leach & Co. (Ltd.) is to be wound up voluntarily. A meeting of creditors will take place on May 29, at 28, Artillery-lane, London, E.C. Claims by July 14 to the joint liquidators, Messrs. Robt. Clements and Geo. Ambach, Adnil-buildings, Artillery-lane, London, E.C.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

February 10, 1909.

3,217 HOOKHAM & HOLDEN. Prepayment electricity meters. (Addition to No. 2,769/08.)
3,232 WILLIS. Electric switches.
3,280 JOHNSON & STEELE-BROWN. Life-guards for electric tramcars.*
3,300 NORTH. Electricity meters.
3,311 WILKINSON. Electrical wiring.

February 11, 1909.

3,345 LEA. Fusible cutout.
3,352 CARTER. Dynamo-electric machines.
3,369 ROBERTS. Signalling on electric tramways and railways.
3,371 HOLMAN. Arc lamps. (Addition to No. 27,536/08.)
3,397 KNUDSEN. Transmission of electrical impulses for telegraphy, typesetting and the like.
3,434 PHILLIMORE. Joints in aluminium cables.
3,437 NEALE & POWELL. Electric-driven mechanism.

February 12, 1909.

3,486 HOLMES. Rotary electric switch.
3,509 BERNER. Grapnels for raising submarine cables.
3,511 BOSCH. Armatures for magneto induction machines. (Date applied for, 20/11/08.)*†
3,513 DIEPPE & KNOLL. Arc lamps.
3,517 LAKE. (Cutler-Hammer Mfg. Co., U.S.) Multiple switch starting devices.*
3,518 HOLLOWAY & TANNER. Electrical switches.
3,533 PECK. Control systems for electric motors.
3,539 JOHANNSEN. Switchboard equipments.*

February 13, 1909.

3,545 EWART. Device for transforming continuous electricity into alternating electricity.
3,547 BANDFIELD. Guard or shield for insulators of telegraph and telephone line wires.
3,554 FENNEL & PERRY. Electric radiators.
3,556 FENNEL & PERRY. Lamp-holders.
3,560 TANNAHILL. Electrical controllers.
3,592 TAUSSIG. Electrolysis of alkali, chlorides or the like.
3,599 GRUNWALD. Electrical induction furnaces. (Date applied for, 7/5/08.)*†
3,618 GRAY. Low-tension ignition contrivances of internal-combustion engines.
3,621 PEAUCELLIER. Contact making and breaking device. (Date applied for, 4/5/08.)*†
3,626 COWPER-COLES. Electro-deposition of metals.

February 15, 1909.

3,666 RICHARDSON. Series adaptors and fittings for electric lamps.
3,674 BOWRON. Locking devices for holders for electric glow lamps.
3,709 KOLEMINE & JUAN. Electrical heating devices. (Date applied for, 19/3/08.)*†
3,717 RANDALL. Telephones.
3,718 SALES & GRIMAUD. Telautographic and like instruments.*
3,746 TRIN. Electric mine lamps. (Date applied for, 19/12/08.)*†
3,759 BOSCH. Lubricating the interrupter cams of magneto-ignition apparatus. (Date applied for, 31/10/08.)*†

February 16, 1909.

3,798 CARR. Manufacture of telegraph and like insulators.
3,812 HANCHETT, BARRATT & JONES. Electric resistances.
3,814 DENNY & JOHNSON. Electrical torsiometer.

3,831 Storer. Armature windings for dynamo-electric machines. (Date applied for, 2/3/08.)*†
3,836 Williamson. Portable electric light fixtures.*

February 17, 1909.

3,877 Tucker. Electrical switches.
3,897 Böhm. Electric incandescent lamps.
3,904 Codd. Detachable contact-breakers.
3,951 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of incandescent electric lamp filaments and apparatus therefor.*

February 18, 1909.

3,973 Hannz. Electrical current convertor.
4,022 Materikin. Electromagnetic apparatus suitable for operating mechanism from a distance.*
4,026 & 4,027 Schiessler. Wireless telephony. (Date applied for, 30/3/08. Comprised in No. 7,028, 30/3/08.)*
4,028 Schiessler. Electric condensers. (Date applied for, 30/3/08. Comprised in No. 7,028, 30/3/08.)*
4,029 Rhodes Motors & Fielden. Starting device for dynamo-electric machines.
4,030 Unterberg und Helmle. Contact-breaker for magneto-electric sparking apparatus for internal-combustion engines. (Date applied for, 8/8/08.)*†
4,034 De Martis. Electric batteries.*
4,035 Sweeney & Treat. Cable or telegraph code.*
4,038 Codd. Magneto-ignition apparatus.

February 19, 1909.

4,057 Peake. Electrical pyrometers.
4,093 Brook & Hirst. Switches and automatic circuit-breakers.
4,111 Curtis, Mackley & Adams Mfg. Co. Actuating the contact arms or levers of electric switches.
4,122 Körting. Alternating-current arc lamps.*
4,125 Marconi & Marconi's Wireless Telegraph Co. Receivers for wireless telegraphy.
4,136 Glover. Supplying tramcars with power from electric cables.
4,164 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of filaments or coherent conductors of refractory material.*

February 20, 1909.

4,173 Aitken. Telephonic apparatus.
4,175 Ruthenburg. Electrodes for electric furnaces.
4,181 Stansfield & Hatt. Controlling the voltage of dynamo-electric machinery.
4,228 Murray. Cut-outs.*
4,248 Leitner. Variable-speed dynamos.
4,250 B.T.-H. Co. (G.E. Co., U.S.) Electric switches.*
4,252 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Röntgen-ray apparatus.*

February 22, 1909.

4,270 Conner. Signalling and ringing key.
4,271 Conner. Electromagnetic counters.
4,317 Siemens Bros. Dynamo Works & Payne. Motor starting switches, valves and like apparatus.*
4,374 Buchanan. Continuous-current dynamo-electric machines.
4,376 Smith & Granville. Inductance coils for telephone cables and the like.

February 23, 1909.

4,399 Conner. Electrical relay.
4,404 Kennedy. Electricity integrating meters. (Addition to No. 9,254/08.)
4,416 Sweetser. Reducing electric currents for low voltage incandescent lamps.
4,425 Siemens Bros. Dynamo Works, Broadhead & Hawkins. Electromagnetic systems for controlling lights on railway trains.
4,459 Fonteyn. Electrically-heated cooking ranges or stoves.
4,472 Allgemeine Elektricitats-Gesellschaft. Controllers for dynamo-electric motors. (Date applied for, 24/2/08.)*†
4,480 Nikiforoff. Relay for telephone and weak alternating currents.

February 24, 1909.

4,501 Aitken. Telephone sub-stations systems.
4,553 Aktiebolaget Elektrometall. Electric furnace. (Date applied for, 10/3/08.)*
4,558 Societe Francaise Electrolytique. Extraction of metals from their ores and the like. (Date applied for, 25/2/08.)*†
4,560 Bayliss. Metallic conduits.
4,561 C. Wust et Cie. Locking device for switch boxes. (Date applied for, 15/4/08.)*†
4,594 Siemens Bros. & Co. (Siemens & Halske A.-G., Germany.) Electromagnetically operated switches, relays and the like.

February 25, 1909.

4,614 Willis. Electric switches.
4,630 Conner. Telephone and switchboard lamp jacks.
4,652 Maschinenfabrik Oerlikon. Single-phase alternating-current electric commutator motors. (Date applied for, 26/2/08.)*
4,672 & 4,673 Berry. Electrical heating apparatus.
4,690 Fairweather. (Landers, Frary & Clark, U.S.) Vapour lamps. (Date applied for, 19/9/03. Application No. 1,979, 19/9/08.)*
4,703 Stachow. Magnetic ore separators.*
4,704 B.T.-H. Co. (A.E.G., Germany.) Protective devices for electric generating and distribution systems and apparatus.
4,705 Allgemeine Elektricitats-Ges. Protective devices for alternating-current systems. (Date applied for, 25/2/08.)*†

February 26, 1909.

4,762 Peukert. Producing electrical oscillations of high frequency. (Date applied for, 17/3/08.)*†
4,801 Bellino & Tosi. Directed wireless telegraphy. (Date applied for, 7/3/08.)*†

February 27, 1909.

4,825 Dadge. Electric switches.
4,837 Derain. Electric generators giving constant pressure under varying speeds. (Addition to 2,195/08.)*
4,863 Fairless & Dixon. Magnetic locking device.*
4,882 B.T.-H. Co. (G.E. Co., U.S.) Automatic regulators for electric circuits.* (Addition to No. 5,037/07.)
4,909 Grassot. Watt-hour meters. (Date applied for, 31/7/08.)*†

SPECIFICATIONS PUBLISHED.

1908 Specifications.

105 Schreiber. Secondary battery. (Post-dated 17/7/08.)
3,995 Mordey & Fricker. Electrolytic electricity meters.
4,717 Richardson. Electric signalling apparatus for railways.
5,089 Savart & Graindorge. Electric sound-producing apparatus. (Date applied for, 31/10/07.)
5,097 Bristol. Portable electric accumulators.
5,137 Harrison & British Insulated & Helsby Cables. Circuits for simultaneous telegraphy and telephony.
6,008 Horstmann & Horstmann Gear Co. Electric meters.
6,338 Moseley. Secondary electric batteries or accumulators.
13,787 B.T.-H. Co., Carter & Martin. Electric meters.
13,982 Hadida. Telephones.
14,537 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.
15,470 Pearne. Electric selective systems.
17,206 Bradburn. Telephone apparatus. (Date applied for, 25/2/08.)
17,622 Allgemeine Elektricitats Ges. Electrically-operated cranes and lifts. (Date applied for, 23/8/07.)
18,905 Watson & Eaton. Telephone indexes.
19,118 McKenna. (Gluhlampenwerk Anker Ges.) Electrical glow lamps with metal filaments.
19,659 Thompson. (Von Inwold & Von Inwold.) Incandescent filaments for electric lamps.
19,871 Opsahl. Oil Switches for electric currents.
19,890 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke Ges.) Electrical potential regulators or speed-controlling devices. (Addition to No. 14,725/07.)
20,300 Kitsee. Telegraphic relays.
20,600 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Signalling telegraphs.
20,671 Daniels. Telephone instruments. (Date applied for, 10/4/08.)
21,195 Ruthardt & Co. Rotary current breakers for magneto-electric ignition apparatus. (Date applied for, 10/10/07.)
21,761 Allgemeine Elektricitats Ges. Cooling the commutators of electrical machines. (Date applied for, 15/10/07.)
22,179 Kitsee. Electric telegraphy.
22,409 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Closed-circuit signal installations.
22,740 Myschkin. Electric motor for high-tension currents.
23,071 B.T.-H. Co. (G.E. Co., U.S.) Electric furnaces.
23,340 Siemens Bros. Dynamo Works & Lydall. Detection of faults in overhead lines for high-tension alternating electric currents.
23,602 Hallock. Controlling devices for electric motors. (Date applied for, 8/11/07.)
23,834 Creed & Coulson. Telegraphic apparatus.
23,963 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Alternating-current commutator electric machines.
24,052 Carstens. Electric signalling apparatus.
24,241 Societe d'Electricite Nilmelior. Electric ignition devices. (Date applied for, 16/12/07.)
24,711 Brown & Ross. Electric ignition devices for internal combustion engines.
25,264 Van Raden & Co. & Metz. Accumulators. (Date applied for, 7/2/08.)
25,557 B.T.-H. Co. (G.E. Co., U.S.) Wire, and the manufacture therefrom of coherent bodies of refractory material suitable for use as glow bodies or filaments for incandescent lamps.
25,855 Bosch. Magneto electric ignition apparatus. (Date applied for, 31/9/08.)
26,053 Egner & Fredriksson. Aerial electric cables. (Date applied for, 2/12/07.)
26,449 & 26,450 Hartmann & Braun Akt.-Ges. Hot-wire electric current measuring instruments. (Date applied for, 6/3/08.)
26,485 Mayer. Trolley wire suspenders. (Date applied for, 21/12/07.)
27,236 Justice. (Kiddle & Baumann.) Electric generators.
28,147 Gibbs. Electrolytic cells. (Date applied for, 17/12/07.)
28,548 Bosch. Magneto electric ignition apparatus. (Date applied for, 25/9/08.)

1909 Specifications.

275 Orling, Oldenbourg & Spiegelberg. Electro capillary contrivance. (Date applied for, 6/1/08.)
1,092 Taylor. Electric accumulator sub-stations. (Date applied for, 29/11/07.)
1,510 Siemens Bros. Dynamo Works (Siemens Schuckertwerke Ges.) Fuse holders

COMPANIES' MEETINGS AND REPORTS.

West India & Panama Telegraph Co. (Ltd.)

The sixty-fourth ordinary general meeting was held on Wednesday, under the presidency of Mr. WALTER BISHOP KINGSFORD.

The MANAGER and SECRETARY (Mr. R. T. Brown) read the notice calling the meeting.

The CHAIRMAN then said the accounts show that our total receipts for the half-year amounted to £34,871, and are thus £2,391 less than those for the corresponding half-year of 1907, which were £37,262. Strictly speaking, the actual net decrease in traffic and other receipts amounts to £3,391, but owing to our having been enabled this half-year to bring in an extra £1,000 from income tax account, the decrease is reduced to £2,391 net.

Turning to the expenses side of the account, you will no doubt have noticed that the expenditure for the half-year—namely, £22,160—is £868 less than that for the corresponding period. The net result is £12,711, which, with £1,467, interest on investments, and £1,132, the balance brought forward from the last account, makes an available total of £15,310. You will have seen from the report that the Directors propose to pay the half-year's dividend of 6s. per share on the first preference shares and 18s. per share on the second preference shares, the latter on account of accrued dividends to Dec. 31, 1908, carrying forward £739 to the next account. By this payment of 18s. per share the second preference shareholders will receive 6s. per share more than they did in the preceding half-year. The balance-sheet shows that up to Dec. 31 last there remains an arrear of £6,069, or, in other words, 26s. per share, which, as you know, is payable out of the first available profits.

As to the traffic receipts for the current half-year, we are somewhat disappointed to find that, up to the end of April they show a decrease of £1,657, as compared with those for the corresponding four months of 1908. This seems to show clearly, I am afraid, that at present there is little or no indication of any improvement in West Indian trade, on which, of course, our traffic receipts mainly depend.

At the last meeting I informed you that the plant for the installation of wireless telegraphy between British Guiana and Trinidad was on the point of being shipped from London. I am pleased to say that the installation has now been completed in British Guiana, and the contractors have almost finished the establishment of the station at Trinidad. It will, I think, be interesting to you to know that the mainmasts at both places (one in British Guiana and one in Trinidad) are 225 ft. high—that is to say, 23 ft. higher than the Monument in the City of London. You can easily imagine that the transport overland of this heavy material has been a work of no little difficulty. We are informed that the installation will probably be finished by the end of this month. As I said at the last meeting, we hope that this will prove an important and useful addition to our cable communication between the two colonies. I now move the adoption of the report and accounts and the declaration of the dividends.

Mr. HENRY HOLMES seconded the motion, which was carried.

The retiring director (Sir John Cameron Lamb, C.B., C.M.G.) was re-elected, as were the retiring auditors, and a vote of thanks to the Chairman, Directors and staff brought the proceedings to a close.

BARNSLEY & DISTRICT ELECTRIC TRACTION CO. (LTD.)—At the meeting yesterday (Thursday) the directors reported that the total revenue for the past year was £9,577 and the expenditure £7,824. After paying debenture interest, &c., the profit was £1,752, which with £262 brought forward made a total of £2,015. A sum of £200 has been placed to depreciation and reserve, £300 to sinking fund for redemption of loans and debentures the preference dividend absorbed £1,319, leaving £196 to carry forward. The traffic receipts showed an increase of £462 over those of 1907, but the expenses were higher.

BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)—The report for 1908 states that the trading results have been affected by trade depression and severe competition. The trading profit is £64,771. Deducting expenses on surplus land and buildings (£4,471), interest on debentures (£7,525), on temporary loans (£1,884) and on mortgage debenture stock (£49,654), the balance is £1,236, which, together with £11,341 brought forward, has been more than counterbalanced by the appropriation required for the prior lien debenture redemption fund and other special expenditure, leaving a debit balance to be carried forward of £6,521. The falling off in the volume of business has been chiefly in the home markets, export business having maintained about the same volume as last year. A substantial sum has been expended out of revenue during the year for the maintenance of buildings, machinery and plant, and the directors do not deem it necessary to provide for further depreciation in the year's accounts. A comparison of the past year with the three preceding years shows the turnover to have been about the same. The total expenditures for factory, operating, selling and administration expenses had declined by 20 per cent. compared with 1905 and 1906, and 10 per cent. compared with 1907. Orders to date slightly exceed those for the corresponding period of last year. There is some appearance of a revival in trade.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—Lord Vaux of Harrowden stated on Tuesday that the poor results of the company's operations during 1908 were due to the fact that they had been going through a period of extraordinary trade depression, and although the prospects now seemed a little brighter, they were still far from having emerged from the state of stagnation into which business generally, and their own industry in particular, had fallen. Last year in all departments the volume of orders was very much below the average. The largely extended uses of metallic filament lamps had for the time affected the engineering side of the industry severely. They believed that the new lamp would further popularise the electric light, and that the reduced cost of current would attract many fresh consumers; although, therefore, the immediate effect had been to check orders for new generating plant, they felt that that would only be a temporary phase, and they were looking forward to a considerable impetus in the demand for power-house plant. They had been ngotiating for, and hoped shortly to complete, arrangements by which they would acquire selling rights for a metallic filament lamp which had proved to be very successful and was now being sold in large numbers on the Continent. Some of the larger tramway undertakings had lately taken to building their own car bodies, and the regular car-building shops were suffering from a lack of work. New promotions of tramways and light railways had been very few, a state of affairs which must be largely attributed to legislative obstacles. Efforts are being made to bring home to the Board of Trade that further progress in the direction of improved facilities by means of light railways and tramways had been, and must continue to be, seriously hampered until these obstacles were removed. The aggregate of orders so far booked this year show a satisfactory increase over that for the corresponding period of last year, and they were hoping that that improvement would continue. They were investigating and developing along certain special branches of electrical industry which they hoped might prove valuable. One of those consisted in the conversion of exhaust or waste steam into electric power. They had lately met with substantial success in securing contracts of that class of plant, and it was their intention to energetically exploit that field and other special branches.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—During 1908 6,765,792 units were sold, an increase of 23 per cent. over sales in 1907. The number of houses connected increased from 3,721 to 4,396, and the equivalent connections in 8 c.p. lamps from 320,863 to 378,835. Notwithstanding that the price of current for power was reduced 25 per cent., the gross revenue has increased by nearly £12,000—(from £103,360 to £115,287. Costs (largely due to the high price of coal) have also increased by £11,014. An abnormal outlay has had to be incurred in repairs, particularly to the engines and boilers at the Emambagh-lane station, and the amount of the cost, in excess of the average, has been charged to renewals fund. £60,220. 14s. 11d. has been expended during the year on capital account, chiefly on extensions of mains, additions to machinery and meters. The demand for electricity in Calcutta is increasing in a remarkable manner. The net profits were £58,188. 0s. 4d. (compared with £57,275. 13s. 11d.), added to £4,160. 17s. 9d. brought forward. Deducting interim dividend (at rate of 6½ per cent. per annum on the ordinary shares) the preference dividend and other items, the available surplus is £41,668. 13s. The directors recommend that £15,000 be placed to credit of depreciation and renewals, and that a final dividend at the rate of 9½ per cent. be paid on the ordinary shares (making 8 per cent. for the year). £3,303. 15s. 4d. is to be carried forward.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—The report for the year ended Dec. 31 states that the balance profit is £61,614, added to £45,107 brought forward, making £106,721. Interest absorbed £13,500, preference dividend £10,000, and the appropriation for depreciation of buildings, plant and machinery £11,087, leaving £72,134. It is proposed to pay an ordinary dividend of 10 per cent (less tax), (part paid in November last); also a bonus of 5s. per share (less tax), carrying forward £45,884. In view of the additional burdens proposed to be placed on income, the directors have thought it expedient to alter the principle on which dividends have hitherto been calculated, and they, therefore, propose that for the future all dividends and bonuses shall be paid subject to the deduction therefrom of income tax. Considering the extremely unfavourable conditions which prevailed during the whole of 1908, the directors consider there is every reason to be satisfied with the results of the year's operations. Depressed trade has resulted in the business secured by the company being restricted both at home and abroad. No new undertaking of any importance in the electrical industry was carried into effect during the period under review, the orders secured by the company being confined almost exclusively to extensions of networks and supply stations already in existence.

The advent of the metal filament lamp had the temporary effect of reducing the volume of cable orders, but the directors have no misgivings on that account, being convinced that that development would so benefit the industry in the near future that it must largely increase the company's operations. The uncertainty as to the action of Parliament in regard to the electric supply of London had also been a factor in limiting cable-laying work, as until the passing of the recent act regulating supply in the metropolis all extensions there were practically at a standstill. A fair trade was, however, done in rubber wires and cables, and the board had every reason to be satisfied with the operations of the Anchor Cable Co. The extensions of the business in the colonies and abroad had received the constant consideration of the board, and taking into account the paucity of orders on the market, and the generally adverse conditions prevailing, they considered the company had secured a very fair proportion of the contracts available. The operations of the German Co. had tended materially to assist business in that country, and elsewhere in Europe, although the electrical trade on the Continent had also suffered from depression and from unusually severe competition. The factories at Erith and Leigh had, on the whole, been fairly well occupied during the year, and are so now, but their capacity in both cases is largely in excess of the existing demand. Considerable expenditure had been incurred on the erection of a new testing station at the Erith factory to meet the ever-increasing requirements of the various Government departments and of the industry.

GRAVESEND & NORTHFLEET ELECTRIC TRAMWAYS (LTD.)—The total revenue for 1908 was £11,207. 0s. 7d., compared with £13,058. 9s. 5d. for 1907. Deducting expenses (including repairs and maintenance and interest) there remains £788. 0s. 5d., added to £271. 16s. 3d. brought forward, making £1,059. 16s. 8d. In view of heavy renewals required, the directors recommend that £1,000 be allocated to reserve and renewals fund and that the balance (£59. 16s. 8d.) be carried forward. The continued depression of the local industries is responsible for the serious diminution of nearly £2,000 in traffic receipts. A reduction of 10 per cent. was made in the car-miles run, but owing to a dispute with Gravesend Corporation as to the accuracy and suitability of the meters by which the company's supply is sought to be measured it has not been possible to take credit in the accounts for any saving in the consumption of electrical energy. The report states that the attitude taken up by the Corporation has left no alternative to the company but to seek to recover by an action at law the large amount by which the company has been over-charged.

JOHNSON & PHILLIPS (LTD.)—For the year ended Dec. 31 the profit on trading account, &c., after making provision for bad and doubtful debts, and after charging to revenue upwards of £3,427 for maintenance of buildings, plant, &c., amounted to £10,037. 7s. 8d., making, with £6,873. 7s. 1d. from 1907, £16,910. 14s. 9d. After deducting £2,000 for depreciation on buildings, plant, &c., £1,559. 18s. remuneration of directors, &c., £8,139. 8s. 9d. interest on debenture stock, and £4,530.5s.6d as reserve for debenture sinking fund, £681. 2s. is carried forward. The directors regret to report a considerable falling off in the profits for the year owing to the low prices ruling in the electrical trade, and also the general depression in trade and natural decrease in business done. The cable business, however, has been fairly well maintained, and shows signs of a decided improvement, which is considered highly satisfactory, forming as it does the major part of the business. The outlook is, therefore, promising, and the directors have every confidence in the good prospects for the ensuing year.

THAMES IRONWORKS, SHIPBUILDING & ENGINEERING CO. (LTD.)—At the meeting on Friday Mr. A. M. Alexander stated that their electrical department had done its share of work in connection with the Walton-on-Thames pumping station, and, besides orders for work of various kinds for the London County Council Tramway Department, and other public authorities, they had supplied a large quantity of apparatus.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—At the meeting on Friday, Mr. G. F. M. Cornwallis-West stated that he thought the shareholders would agree that the directors were justified in passing the dividend. During the past year the company had suffered a serious decline in its receipts, practically entirely due to the terrible state of trade in the district served by the company. They spent a considerable sum in maintaining the permanent way and rolling stock, and also in renewals of the line. They carried 936,700 fewer workpeople than in 1907. They had a credit of £2,000 to meet the £5,297 which they contemplated spending in renewals. Their financial position would be greatly strengthened by the adoption of the board's proposal. The parcels traffic showed considerable development, and new sources of revenue under that heading were being attached. Their power and running expenses increased by £700, owing to the cost of fuel.

RANGOON ELECTRIC TRAMWAY & SUPPLY CO. (LTD.)—On Tuesday Mr. Frank Tobin said the company had earned the dividend on the preference shares in addition to paying interest on the debenture stock during the past year, and the present year's results would be better than those for last year. The tramways had proved fairly satisfactory, the takings, which had been affected by the monsoon being of exceptional duration, totalling just under £50,000. Expenses had been 60 per cent., and it was hoped to get this percentage down to 50 on the current year. The public lighting department was satisfactory.

NEW COMPANIES, STATUTORY RETURNS, &c.

NEW COMPANY.

AUTOMOBILE ELECTRIC LIGHTING SYND. (LTD.) (103,032.)—Reg. May 15, capital £5,000 in £1 shares (2,500 deferred), to adopt an agreement with the Polkey Automobile Electric Lighting Synd., for the acquisition and exploitation of certain patents or rights or privileges, and to carry on the business of mechanical and electrical engineers, generators, distributors and suppliers of electricity. Private company. First directors, J. Polkey, W. Peto and A. R. Lancaster. Reg. office, Queen's College, Paradise-street, Birmingham.

STATUTORY RETURNS.

W. T. GLOVER & CO. LTD.)—Return to March 29 gives capital as £214,850 in £1 shares (100,000 preference), all of which have been taken up. £1 per share has been called up on 67,000 preference and 50,000 ordinary shares, and £117,000 has been received. £97,850 is considered as paid on the remainder. Mortgages and charges, £176,000.

HOWARD ASPHALT TROUGHING CO. (LTD.)—Return to March 29 gives capital as £20,000 in £1 shares (1,000 deferred), of which 1,007 ordinary and 1,000 deferred have been taken up. £7 has been received and £2,000 is considered as paid. Mortgages and charges, nil.

MELTON MOWBRAY ELECTRIC LIGHT CO. (LTD.)—In return to March 24 capital is £25,000 in £5 shares, of which 4,000 have been taken up. £20,000 has been received. Mortgages and charges, £20,000.

MORTGAGES AND CHARGES.

BRITISH PROMETHEUS CO. (LTD.)—Issue on April 22 of £200 debentures, part of series created Oct. 30, 1907, to secure £3,500, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees.

COWANS (LTD.)—Debenture, dated May 4, to secure £3,000, charged on company's undertaking and property, present and future, including uncalled capital. Holders, W. T. Glover & Co. Also trust deed of even date, further securing above debenture, charged on company's lease of Victoria Works, Springfield-lane, Salford. Trustees, A. L. Ormrod and C. Cooper.

ELECTRO-MECHANICAL BRAKE CO. (LTD.)—Mortgage on sums of money due or to become due from the Leeds City Tramways, dated April 15, 1909, to secure £575. Holders, Metropolitan Bank.

MAWDSLEYS LIMITED.—Particulars of £2,000 second debentures, created April 26, have been filed, the amount of the present issue being £1,200. Property charged: Company's property, present and future, including uncalled capital. No trustees.

NEW SYSTEM PRIVATE TELEPHONE CO. (LTD.)—Issue on May 4 of £1,000 debentures, part of a series of which particulars have already been filed.

CITY NOTES.

MEMORANDA (May 20).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $24\frac{3}{16}$d. per oz. Consols $85\frac{1}{4}$—$85\frac{3}{8}$ for money and account. Consols Pay Day, June 1; Stock and Shares Continuation Days, May 25 and June 9; Ticket Days, May 26 and June 10; Pay Days, May 27 and June 11; Mining Shares Carry Over Day, May 24.

PRICES OF METALS (London).—*Copper*, cash, $59\frac{1}{4}$; three months $59\frac{15}{16}$. *Lead*, English, $13\frac{1}{8}$—$13\frac{3}{8}$; foreign, cash, $13\frac{3}{8}$; three months, $13\frac{5}{8}$—$13\frac{11}{16}$; *Spelter*, cash, 22—$22\frac{1}{8}$; three months, $22\frac{1}{4}$—$22\frac{1}{2}$. *Tin*, English, 131—133; foreign, cash, $131\frac{1}{4}$, three months, 132—$132\frac{1}{4}$. *Iron*, Cleveland, cash, 47/$10\frac{1}{2}$, and three months, 48/7. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CASTNER-KELLNER ALKALI CO. (LTD.)—The directors have declared an interim dividend at the rate of 10 per cent. per annum for the six months ended March 31.

MOUNTAIN & GIBSON & THORNEWILL (LTD.)—The name of Mountain Gibson is one which has been before the electrical industry for many years, and the firm has become well known as leading manufacturers of electric railway and tramway rolling stock, trucks and accessories. There are very few municipalities or companies owning electric tramway undertakings, either in this country or abroad, but have placed orders with the firm for either rolling stock or acceessories. These owning bodies include the Corporations of London, Birmingham, Glasgow, Belfast, Dublin, Manchester, Salford, &c., as well as extensive electric traction undertakings in India, South Africa, South America and the Continent of Europe. The expansion of both the home and foreign trade of the company necessitates larger works, and has led to a contract to acquire the freehold and leasehold works and undertaking of Messrs. Thornewill & Warham (Ltd.), engineers, at Burton-on-Trent, which are favourably situated and are of a character generally to add considerably to the facilities for conducting the combined company's general business. A prospectus which has just been issued, and which will be found set out in abridged form in this issue of THE ELECTRICIAN, invites subscription at par for 60,000 shares of £1 each and 808 5 per cent. debentures of £50 each in the combined business of Mountain & Gibson & Thornewill (Ltd.). The interest upon the latter security is payable half-yearly in February and August, the first payment falling due on Aug. 1 next. The debentures are secured by a trust deed containing a general floating charge on the undertaking. The profits of the Mountin & Gibson business for 1908 were at the rate of £6,386 per annum. The assets of the new company are estimated at £171,770, less liabilities which are to be paid off out of this issue, £53,772. Should the whole of the present issue be subscribed, £40,400 will be available as working capital for the new company. The abridged prospectus on another page contains further particulars.

REUTER'S TELEGRAM CO. (LTD.)—For the year ended Dec. 31 the balance was £5,429. 10s. 10d., including £148. 10s. 5d. brought forward. An interim dividend of $2\frac{1}{2}$ per cent. was paid in October, and the directors now declare a dividend of 4s. per share, equal to $2\frac{1}{2}$ per per cent., making 5 per cent. (tax free) for the year. £693. 18s. 10d. is carried forward.

RUBBER TANNED LEATHER CO. (LTD.)—A company with the above title has this week invited applications for 125,000 shares of £1 each at par. The chairman of the company is Lord Suffield (chairman of the Westminster Electric Supply Corpn.), and several of the other directors are interested in rubber. The company's patents relate to a process of rubber tanning which, it is claimed, has been brought to a high degree of perfection, and which can be used for a large variety of purposes for which at the present time pure rubber or a more or less expensive rubber compound has to be employed.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed June 4 a special settling day in and have granted a quotation to scrip (fully paid) for £1,250,000 6 per cent. 50-year mortgage bonds of the *Mexico Tramways Co.* The committee have been asked to grant a quotation to a further issue of $51,500 30-year 5 per cent. $500 gold bonds of the *Kaministiquia Power Co. (Ltd.)*.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 12	1,342	...	50	67,319	– 33
Airdrie	" 7	213	+ 1	18	3,955	– 72
Anglo-Argentine	" 13	36,893	– 1,847	19	749,616	+ 49,716
Ayr Corporation	" 15	234	+ 1	52	14,429	– 311
Baker St. & Waterloo Ry.	" 15	3,110	– 10	19	63,710	+ 5,260
Barnsley	" 7	164	– 4	18	2,9 2	– 71
Barrow	" 7	209	– 16	18	3,716	– 276
Bath Electric Trams, Ltd.	" 12	778	+ 49	19	12,264	+ 4.4
Birmingham Corporation	" 15	6,383	+ 19	7	42,531	+ 4.5
Birmingham & Mid.	April 30	8.8	+ 60	17	13,607	+ 82
Blackburn Corporation	May 12	1,135	– 33	7	8,137	+ 1.0
Blackpool and Fleetwood	...	...	...	...	...	...
Bolton Corporation	" 16	2,319	– 5	7	16,172	+ 9
Bombay	April 15	R36,620	– R1,610	15	R578,436	+ R39,841
Bournemouth Corporation	May 12	1,575	+ 149	6	10,392	+ 127
Bradford Corporation	...	...	...	...	...	...
Brighton Corporation	" 16	836	+ 62	7	6 0.8	+ 573
Bristol Trams & Carriage	" 14	6,391	+ 532	25	124,124	+ 10,779
Burnley Corporation	" 15	1,235	– 8	7	9,103	+ 341
Burton Corporation	" 16	286	– 32	7	1,717	– 25
Bury Corporation	" 16	1,145	– 46	†7	8,010	– 99
Calcutta Tramways Co.	" 15	R18,088	+ R2,262	19	R347,778	+ R92,528
Camborne-Redruth	" 15	118	+ 1	20	2,271	– 95
Cardiff Corporation	" 15	2,032	– 13	7	13,871	– 41
Cavehill	" 7	83	+ 6	18	1,183	– 165
Central London Railway	" 15	5,453	– 1,172	19	101,144	– 9,955
Charing C., Euston & H'stead	" 15	3,8?0	+ 520	19	73,180	+ 12,455
Chatham & Dist. Lt. Rys.	" 13	788	– 6	19	13,941	+ 1,294
City & South London Rly.	" 16	2,986	+ 25	19	62,290	+ 423
City of Birmingham	" 7	2,739	+ 20	18	48,242	– 473
Colchester Corporation	" 12	161	– 29	...	...	...
Cork Electric Trams Co.	...	...	...	...	...	...
Croydon Corporation	" 14	1,452	+ 27	5	9,453	+ 607
Devonport & Dist. Trams	" 7	354	– 126	18	6,605	– 330
Dover Corporation	" 15	174	– 10	7	1,239	– 5
Dublin & Lucan Railway	" 14	145	+ 25	19	2,217	+ 180
Dublin United	" 14	5,333	+ 169	19	94,615	+ 1,121
Dudley-Stourbridge	" 7	774	+ 25	18	13,231	– 211
Dundee Corporation	" 12	1,165	– 71	‡52	61,301	+ 2,025
East Ham Council	" 15	984	+ 150	§6	6,527	+ 1,193
Exeter Corporation	...	...	...	...	...	...
Gateshead & Dist. Trams	" 7	953	– 14	18	17,550	– 103
Glasgow Corporation	" 15	17,606	– 75	50	848,471	– 16,482
Glossop Trams	" 15	125	– 10	20	2,343	– 81
Gravesend—Northfleet	" 7	193	– 3	18	3,309	– 122
Great Northern & City Rly.	" 15	1,439	– 138	19	29,170	– 3,536
Gt. Northern, Piccadilly, &c.	" 15	5,716	+ 159	19	110,130	+ 7,120
Greenock & Port Glasgow	" 7	554	+ 55	18	8,520	– 92
Hartlepool Tramways	" 7	211	+ 17	18	3,631	– 116
Hastings Elec. Trams Co.	" 13	925	+ 43	19	15,481	– 395
Hong Kong	" 15	$9,125	+ $1,123	19	$156,944	+ $11,456
Huddersfield Corpn.	" 15	1,557	– 29	6	10,829	+ 469
Hull Corporation	" 15	2,330	– 87	6	16,114	+ 4
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	" 12	121	– 32	6	781	– 49
Ipswich Corporation	" 15	335	– 39	7	2,379	– 111
Isle of Thanet Co.	" 15	410	...	§24	9,758	+ 293
Jarrow	" 7	113	+ 19	18	1,916	+ 179
Keighley Corporation	" 13	158	+ 3	6	1,027	+ 38
Kidderminster & District	" 7	92	+ 2	18	1,526	– 57
Kilmarnock Corporation	" 15	184	– 2	52	7,762	– 301
Lanarkshire Trams Co.	" 13	1,216	– 72	19	22,733	– 1,416
Lancashire United	" 12	1,313	– 29	19	23,526	+ 311
Leamington	" 7	156	+ 6	18	2,662	+ 120
Leeds Corporation	" 15	6,136	– 78	7	43,093	+ 227
Leicester Corporation	" 15	2,158	– 164	...	...	...
Leith Corporation	" 16	541	+ 23	‡52	26,933	– 122
Lincoln Corporation	" 15	109	– 6	7	863	+ 34
Liverpool Corporation	" 8	10,775	+ 61	‖18	190,433	– 820
Liverpool Overhead Rly.	" 16	1,261	– 182	20	25,906	– 1,855
Llandudno & Colwyn Bay Ry	" 7	205	+ 102	23	3,692	+ 1,162
*London County Council	" 8	35,395	+ 2,104	§5	191,737	+ 19,014
London United	" 15	6,158	– 691	‡22	102,346	– 5,424
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	" 15	175	– 9	6	1,152	– 46
Manchester Corporation	" 15	14,645	– 532	7	97,375	+ 2,371
Mersey Railway	" 15	2,095	+ 139	19	37,364	+ 1,032
Merthyr	" 7	204	+ 1	18	3,659	– 3
Metropolitan Dist. Railway	" 15	10,018	+ 910	19	185,126	+ 16,450
Metropolitan Elec. Trams	" 7	6,113	+ 618	18	100,6 6	+ 11,673
Middleton	" 7	337	– 10	18	5,536	– 240
Nelson Corporation	" 15	131	– 9	†6	923	– 26
Newcastle-on-Tyne Corp.	" 15	3,703	+ 19	7	25,271	– 7
Newport (Mon.)	...	...	...	...	...	...
Northampton Corporation	" 14	474	+ 34	§7	3,016	+ 248
Oldham, Ashton & Hyde	" 7	556	– 30	18	9,722	– 660
Oldham Corporation	" 16	1,804	– 136	7	14,627	– 611
Perth (N.B.) Corporation	" 12	140	+ 2	52	7,883	– 97
Perth (W.A.) Elec. Trams	" 14	1,342	– 21	19	27,919	+ 49
Peterborough	" 7	106	– 15	19	1,840	– 135
Portsmouth Corporation	...	...	...	...	...	...
Potteries	" 7	1,743	– 51	18	31,319	– 1,118
Preston Corporation	" 12	726	– 24	6	4,112	+ 99
Rotherham Corporation	" 13	592	– 25	6	3,738	– 41
Rothesay	" 7	108	+ 8	13	1,371	– 17
Salford Corporation	" 17	4,253	– 397	‡7	30,576	– 353
Sheerness	" 7	15	– 8	18	783	– 106
Sheffield Corporation	" 16	5,400	– 271	§7	41,160	– 438
Singapore Trams	" 15	$9,928	– $201	19	$153,340	+ $1,059
South Metropolitan	" 7	752	– 9	18	12,599	+ 360
South Staffs	" 7	735	– 30	18	14,625	– 821
Southend Corporation	" 12	395	+ 48	6	2,631	+ 517
Southport Tramways	" 7	204	+ 2	18	4,274	+ 113
Stalyb'dge, Hyde, &c., Jt. Bd.	" 15	720	– 15	§5	5,124	– 2
Sunderland Corporation	...	...	...	...	...	...
Sunderland District	" 12	432	– 8	28	12,372	– 300
Swansea Trams	" 7	914	– 8	18	15,875	+ 351
Swindon Corporation	...	...	...	...	...	...
Taunton	" 7	38	– 2	18	627	– 61
Tynemouth and District	" 7	163	+ 16	18	2,581	– 79
Tyneside Trams Co.	" 12	403	+ 22	19	7,576	+ 578
Wallasey District Council	" 15	880	+ 38	§6	5,979	+ 121
Walsall Corpn.	" 15	492	– 47	19	9,503	– 790
Warrington Corpn.	" 13	365	– 8	6	2,289	– 50
West Ham Corporation	" 6	2,248	+ 142	5	12,207	+ 1,278
Weston-super-Mare	" 7	89	+ 5	18	834	+ 104
Wolverhampton Co.	" 7	395	– 58	18	7,111	– 803
Wolverhampton Corpn.	" 12	771	...	19	14,043	...
*Worcester	" 7	273	+ 2	18	4,371	+ 1
Wrexham	" 7	87	– 7	18	1,665	– 47
Yorkshire W.R. Trams	" 16	1,217	– 79	20	22,361	...
Yorkshire Woollen District	" 7	917	+ 2	18	15,321	– 470

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share.	Last Dividend	Name.	Price Wed. May 19.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to May 1?. Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9¼ –10	6 ? 0	Mar, Sept	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾ –10½	4 9 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10½ –10¾	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 –105	4 5 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½ –4¾	5 15 9	April, Oct	..	..
St.	4½%	†Do. Do. 1st Debs.	93 –96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½ –9	5 11 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	? –3¼	4 2 ?	Mar, Sept	..	..
St.	4%	Cent l Elec. Sup. Co. 4% Guar. Db. Stock	99 –102	3 18 ?	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾ –4½	6 1 ?	Feb, Aug	4½	—
5	2/3	Do. 4½ per Cent. Pref.	4½ –4¾	4 12 0	Feb, Aug	4½	4½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	?3 –1??	3 19 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 –101	4 ? 0	..	100½	—
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ –4¼	5 ? 6	Jan, July	..	—
5	2/6	Chelsea Electric Supply Ord.	3¾ –4¼	4 ? 3	March ..	3??	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 –105	4 7 6	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10¾ –11	5 19 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾ –12¼	4 13 0	Jan, July	12?	12?
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 –123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 –104	4 6 6	Jan, July	..	..
5	..	County of Durham Elec. P.D. Ord.	1? –2¼		April, Oct	—	—
5	5%	Do. 5 per Cent. non Cum. Pref.	3¾ –3¾	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8¾ –8¾	5 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾ –11¼	5 6 6	Mar, Sept	10?	..
St.	4½%	Do. 4½% Deb. Stock (red.)	106 –109	4 ? 9	Jan, July	..	..
St.	4½%	†Do. Second Deb. Stock	99 –102	4 ? 0	May, Nov	101½	101⅜
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ –5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 –1??	4 19 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7½ –7¾	5 11 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7½ –7⅞	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝ –6⅞	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94 –97	4 3 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 –101	3 19 0	April, Oct	..	—
St.	4½%	Kent Elec. Power Co.	85 –89	5 1 0	Jan, July	..	—
3	1/9⅜	London Electric Supply Ord.	1¾ –2¼	3 6 8	Mar, Sept	..	—
5	3/0	Do. 6 per Cent. Pref.	5 –5¼	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92 –96	4 3 6	Jan, July	95	94
5	3/0	Metropolitan Electric Sup. Ord.	4¾ –5	6 0 0	April, Oct	4¾	4¾
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾ –5¼	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107 –110	4 2 0	June, Dec	—	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85 –88	3 19 6	Jan, July	..	—
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –93	4 12 0	June, Dec	..	..
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4⅞ –5	4 2 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	86 –90	5 0 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅞ –5	2 10 7	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 –5¼	4 17 6	Feb, Aug	—	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	98 –100	4 0 10	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 –101	4 19 0	..	—	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91 –93	4 17 10	Jan, July	—	..
10	8 0	Notting Hill Electric Ord	11½ –12½	5 12 0	March ..	—	..
5	4 6	Oxford Electric Ord.	6 –5½	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 –97	4 2 6	Jan, July	..	—
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅞ –9⅜	5 7 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 –7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85 –90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	⅝ –⅞	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¼ –3¼	6 8 0	April	2?	..
St.	..	Do. 5% 1st Mort. Stk. Red.	1?2 –1?4	..	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	? –?	4 14 0	..	..	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.	1⅛ –1¼	5 7 0	Feb, Aug	..	—
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 –103	4 7 6	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	⅞ –1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 –?	10 0 0	April, Oct	2?	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 –84	5 7 3	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9⅛ –9?	5 4 0	Mar, Sept	9½	9?
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛ –5?	4 11 0	Jan, July	5¼	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	97 –99	4 1 0	Jan, July	93¾	93
1	..	Bath Elec. Trams Pref. Ord.	⅛ –¼	..	April	¼	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ –?	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88 –92	4 18 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 –92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8¾ –9¼	6 9 9	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ –9	4 9 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99 –100	4 1 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅞ –1⅛	..	June, Dec	⅞	?
10	3/0	Do. 6 per Cent. Cum. Pref.	2⅞ –3⅛	8 13 0	Feb, Aug	2?	2?
St.	5%	Do. 5 per Cent. Perpetual Debs.	85 –89	5 12 0	April, Oct	89	87½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 –70	6 8 6	May, Nov	..	..
St.	2½%	Central London Ordinary Stock	69 –71	4 18 6	Feb, Aug	70⅛	69¾
St.	4%	Do. 4 per Cent. Pref. Stock	85 –87	5 13 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	5? –54	4 11 6	Feb	62½	..
100	4%	Do. 4 per Cent. Debs.	102 –104	3 16 6	Jan, July	103½	1?3
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 –94	4 5 0	Jan, July	94	92½
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ –5¼	4 1? ?	April, Oct	5½	4?
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 –101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31½ –32½	4 ?2 0	Feb, Aug	32¼	31⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 –112	4 9 0	Feb, Aug	..	—
St.	5%	Do. (1896)	10? –10?	4 11 0	Feb, Aug	—	..
St.	5%	Do. (1901)	10? –1?5	4 1? 0	Feb, Aug	..	—
St.	5%	Do. (1903)	93 –9?	5 4 0	Feb, Aug	9?½	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 –101	3 19 0	May, Nov	—	—
10	6/0	Dublin United Trams. Ord	—	4 1? 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	13 –14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	½ –¾	..	Feb, Aug	..	—
10	..	G. Northern, Picc. & Brompton 4% G.Pf.	8½ –?	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 –9?	4 3 6	Jan, July	95½	9?¾
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2 –2¼	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	82 –87	5 3 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	6¼ –6¾	8 5 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6¾ –7¼	7 13 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	87 –89	5 1 1?	Jan, July	..	—
5	1 3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ –1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	59 –6?	6 13 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9⅞ –10⅛	5 17 6	Feb, Aug	10⅛	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 –95	5 7 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	? –?	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	4¼ –5¼	9 10 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	8? –?	4 1? 8	Jan, July	..	..
10	2/6	London United Trams. 5% Cum. Pref.	2¼ –3¼	12 15 0	Jan, July	3¼	3
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	7? –7?	5 5 0	Jan, July	73½	..
St.	—	Mersey Con. Ord. Stock	1 –2	—	Feb, Aug.	—	—
1	10½	Metropolitan Elec. Tramways Ord.	? –?	—	..	?	..
1	—	Do. Deferred	? –?	..	April..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	? –?	5 15 0	Feb, Aug	?	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	9? –9?	4 12 0	Jan, July	97½	9?½
St.	½%	Metropolitan Railway Consolidated	38¼ –39¼	1 5 3	Feb, Aug	39⅜	39
St.	3%	Do. Surplus Lands Stocks	70 –72	4 3 0	Feb, Aug	71½	70
St.	3½%	Do. 3½ per Cent. Preference	88 –90	3 18 0	Feb, Aug	90	88
St	3½%	Do. 3½ per Cent. "A" Preference	82 –84	4 3 6	Feb, Aug	83⅜	79½
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82 –84	4 3 6	Feb, Aug	84	81
St.	3½%	Do. 3½ per Cent. Debenture Stock	93 –95	3 13 3	Jan, July	94	..

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shr.	Last Dividend	Name	Price Wed., May 19.	Rate % Yield-ed. £ s. d.	Dividend Due	Business Week to May 19 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 –94	3 14 6	Jan, July	93¾	...
St.	..	Metropolitan District Railway Ord.	17 –17½	–	Feb, Aug	17⅞	17
St.	..	Do. Extension Pref. (5 per Cent.)	44 –46	..	Feb, Aug	46¼	45¾
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	69 –71	4 18 6	Feb, Aug	70	96½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	78 –80	3 15 0	Jan, July	79¾	78¾
St.	4%	Do. 4 per Cent. Midland Rent-charge	103 –106	3 15 6	Jan, July	104	..
St.	1½%	Do. Guar. Stock 4 per Cent.	92 –94	4 5 0	Mar, Sept	95½	94⅛
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	141 –143	4 8 9	Jan, July	142½	101
St.	4%	Do. 4 per Cent. Ditto	94 –96	4 3 0	Jan, July	96	...
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼–¾	–	May	..	–
1	0/9⅜	Potteries Electric Traction Ord.	5/16–7/16	..	April, Oct	..	–
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛–¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	83 –91	4 19 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝–⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	72 –76	5 5 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	82 –86	5 16 0	Jan, July	..	..
..	...	UndergdE.Rys.Lon.£ In.bds.with coup.3	36 –38	..	June, Dec	36⅜	35⅞
..	5	Do. 5% Prior Lien Bonds	101 –102	4 18 0	..	102	101⅞
–	4½%	Do. 4½% Bonds with coup. 3	87 –89	5 1 0	..	88¾	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½–1	–	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½–3	–	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	86 –90	5 0 0	Jan, July	–	–
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	9/32–13/32	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	13/32–[illegible]	6 12 0	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.	4 7/16–4 9/16	4 10 6	April, Oct	4 17/32	4 13/32
1	0/7½	Do. Pref.	1⅜–1½	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅛–7½	6 13 6	July, Feb	7½	7 15/16
5	3/0	Do. 6 per Cent. Pref.	6⅝–6¾	4 9 0	Jan, July	–	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 –108	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 –96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	½–½	..	Feb, Aug	1⅝	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	96½–97½	6 2 6	..	96⅜	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	40 –44	9 2 0	Jan, July	..	..
St.	4½%	BrushE.Eng Co.4½% Perp. 1st Deb.Stock	43 –48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 –33	13 13 0	Jan, July	..	–
5	5 0	Callender's Cable Con. Ord.	9⅝–10⅛	6 15 6	Jan, July	10	–
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼–5⅝	4 9 0	Jan, July	5¼	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 –107	4 4 0	Nov, May	..	..
1	1/6	Castner-Kellner Alkali Co.	1 13/16–1 15/16	6 16 6	May, Nov	1 27/32	1 13/16
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 –105	4 4 0	Feb, Aug	–	..
	0 7½	Chadburn's (Ship) Telegraph Ord.	15/16–1 1/16	7 1 6	March ..	..	–
	0/7½	Do. 6 per Cent. Cum. Pref.	15/16–1 1/16	5 13 0	April, Oct	..	..
1	0/8⅜	Consolidated Electrical Co.	⅝–⅞	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1 3/16–1 5/16	7 12 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	15/16–1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	1 –1¼	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	95 –98	5 2 [illegible]	Jan, July	..	..
1	0/7½	Davis & Timmins	⅞–1⅛	..	Mar, Sept	..	–
5	2/0	Dick, Kerr & Co. Ord.	1⅛–1 5/16	7 12 0	Sept	1¼	1 3/16
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 [illegible]–1 [illegible]	4 16 9	Sept	1 3/16	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 –104	4 6 9	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅓–½	..	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1½–2½	5 0 0	Feb, Aug	..	–
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	70 –75	5 6 8	June, Dec	..	–
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 –87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16–5/16	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅝–⅞	..	May, Nov	..	–
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 –63	7 3 0	Jan, July	..	..
2	..	Electric Construction Co.	¼–½	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1 –1⅜	10 4 0	July	1⅛	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 –64	6 5 0	Jan, July	..	–
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛–7⅜	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 –88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11⅝–11⅞	6 2 6	Feb, Aug	12⅝	11⅞
5	2/3	Do. 4½ per Cent. Pref.	4⅞–5⅛	4 6 0	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 –108	4 2 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Wrks.	14⅛–14⅝	6 10 0	Feb, Aug	[illegible]	14 11/16
10	..	Do. 5 per Cent. Cum. Pref.	10⅝–11	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 –101	3 19 0	April, Oct	99¼	..
1	..	National Elec. Construction Co.	5/16–7/16	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛–⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅜–⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 –86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	[illegible]	–	..	..	..
1	..	Do. 6 per Cent. Cum. Pref.	5 –5½	–	..	..	..
12	24/0	Telegraph Construction & Maintenance	32½–34	5 6 0	Mar, July	33⅜	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	101 –103	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	[illegible]	4 11 3	..	2⅜	2⅜
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛–1 5/16	4 8 0	..	1⅜	1⅜
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 –111	4 10 0	..	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Db.Sk.(red.)	102 –104	3 17 6	June, Dec	103½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb.(red.)	104½–106½	4 4 6	June, Dec	105⅛	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	107 –109	4 11 9	..	..	107½
10	8	J. G. White & Co. 6% Cm. Pref.	9 –10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅞–1	3 15 0	Apr, Oct	–	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅞–3⅜	8 18 0	Apr, Oct	–	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	78 –82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞–3⅜	–	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red)	63 –65	5 5 0	June, Dec	..	..
St.	15/0	Anglo-American	68 –69	5 10 0	F,My,Ag,N	68⅜	68⅛
St.	30 0	Do. Preferred	101½–102½	5 17 6	F,My,Ag,N	102¼	101¼
St.	2 0	Do. Deferred	17¾–17⅞	2 6 6	F,My,Ag,N	17⅝	17¼
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91½–93½	4 5 6	Jn,Ap,Jy,O	[illegible]	[illegible]
10	6 0	Cuba Submarine Ord.	8½–9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent	17 –18	5 11 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	2¾–3⅜	5 18 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½–9	5 [illegible] 0	April, Oct	..	..
100	4½%	Do. 4½ per Cent. Deb.	100½–102½	4 8 0	Jan, July	..	..
20	4/0	Direct United States Cable	13 –13½	6 8 0	Ja,Ap,Jy,O	13	13⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (red.)	100½–102½	4 7 6	June, Dec	..	..
St.	15/0	†Eastern Ordinary and Bonus	133 –135	5 4 6	Ja,My,Jy,O	133⅝	132¼
St.	17 6	Do. 3½ per Cent. Pref. Stock	86¾–87	4 0 6	Ja,My,Jy,O	86⅝	85½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	102½–104½	3 16 6	May, Nov	104⅛	103½
10	6 6	Eastern Extension 6% and bonus	12⅜–12⅞	5 8 6	Ja,Ap,Jy,O	12⅝	12⅛
St.	4%	Do. 4 per Cent. Deb. Stock	100½–102½	3 17 6	Feb, Aug	..	..
25	4%	Eastern & S.Af. 4% Mauritius Sub. Debs.	99 –101	3 19 0	May, Nov	..	..
10	15/0	Gt. Nthn of Copenhagen, Ex. Coupon 76	27 –28	6 8 0	Jan, July	28	27
100	4½%	Halifax & Bermudas 4½% 1st Mt. Db.(red.)	104½–106½	4 7 6	June, Dec	..	..
25	5/6	Indo-European	61½–62½	5 15 9	May, Nov	61½	..
100	$1	Mackay Companies Common	75 –82	4 16 0	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	73 –76	5 5 6	Ja,Ap,Jy,O	–	..
1	..	Marconi's Wireless Teleg. Co.	1 1/16–1 3/16	..	April	..	..
1	4%	Pacific & European Tel.4%Guar.Dbs.(red.)	100 –102	3 18 0	June, Dec	..	..
5	1/3	West Coast of America	1⅜–1⅝	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	100 –102	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅞–1	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref	9 –9½	6 6 0	May, Nov	9⅛	..
10	6	Do. 6 per Cent. 2nd Pref	8⅞–9	6 3 0	May, Nov	9⅛	..
100	5%	Do. 5 per Cent. Debs.	101 –103	4 17 0	Jan, July	..	..
10	5/0	Western Telegraph	13⅝–14⅛	4 19 0	Mr,Jn,O,D	14⅛	14⅛
St.	4%	Do. 4 per Cent. Deb Stock (red.)	101 –103	3 17 6	June, Dec	102¼	102
..	4%	Western Union Telegh. $1 000 4% Bonds	93 –95	4 6 0			

Shr.	Last Dividend	Name	Price Wed., May 19.	Rate % Yield-ed. £ s. d.	Dividend Due	Business Week to May 19 Highest	Lowest
		TELEPHONES.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	143 –144	5 11 6	..	143⅞	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98½–100½	3 19 6	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	98 –100	5 0 0	Mar, Sept	..	–
5	3/0	Chili Telephone	8 –8⅜	4 16 9	August ..	8 11/32	8 5/16
1	0/7½	Monte Video Telephone Ord.	⅞–1	6 0 0	Nov	1	..
1	0/6	Do. 5 per Cent. Pref.	13/16–15/16	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	107 –108½	5 10 6	Feb, Aug	109½	..
St.	6%	Do. Def. Stock	123½–124½	4 16 0	Feb, Aug	124⅛	123¼
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¼–11	5 9 0	Feb, Aug	10¼	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½–11	5 9 0	Feb, Aug	10 15/32	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜–5⅞	4 5 0	Feb, Aug	5 11/16	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 –100	3 10 0	June, Dec	98⅜	98½
St.	4%	Do 4 per Cent. Deb. Stock (red.)	110 –112	3 18 0	Jan, July	100¾	..
1	1/0	Oriental	1 5/16–1 7/16	5 7 6	April, Oct	1 5/16	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16–1 3/16	4 17 6	April, Oct	.	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 –90	4 9 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 –102	4 8 0	Jan, July	101½	..
5	3/0	United River Plate	6⅞–7⅛	6 11 6	July	7 1/16	6⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 13 0	June, Dec	5¼	5 1/16
St.	4½%	Do. 4½ Deb. St. Red.	101 –105½	4 5 0	Jan, July	–	..
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3¼–3¾	8 0 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10¾–11¼	5 5 0	SpDcMrJu	11	10⅜
10	3/0	Do. 6 per Cent. Pref.	12⅞–13¼	4 10 6	SpDcMrJu	13⅛	12 13/16
10	6%	Submarine Cables Trust (Cert.)	127 –130	4 12 0	April, Oct	130	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅛–6⅜	4 14 0	April, Oct	6 5/16	6 1/16
5	5/0	Do. 10% Non-cum. 2nd Pref.	9 11/16–9 13/16	5 1 6	Jan, July	9 11/16	9½
St.	4%	Do. 4% Deb. Stock	95½–96½	4 4 0	June, Dec	94	93
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 –104	4 16 0	Jan, July	..	..
5	3 6	Brisbane Electric Trams. Invest. Ord.	5¾–6	5 0 0	May	5⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4 15/16–5 1/16	4 16 9	May, Nov	5 3/32	5
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	105 –107	4 4 0	Jan, July	105¾	104
St.	8%	British Columbia El.Ry.Df. Ord.	142 –146	5 9 6	Mar, Sept	144	143
St.	6%	Do. Pref. Ord. Stock	123 –127	4 14 6	May, Nov	125	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	109 –112	4 9 0	Jan, July	111	110½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	101 –103	4 7 0	April, Oct	...	..
100	4½%	Do. Vancouver Power Debs.	101 –104	4 6 8	Jan, July	..	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	98½–100½	4 4 6	–	99⅜	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98½–100½	5 0 6	Mar, Sept	99⅛	99¼
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96 –100	6 0 0	Feb, Aug	93	97¾
5	2/0	Calcutta Tramways (1 to 137,610)	4¼–4¾	4 14 9	Mar, Sept	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅝–5¼	4 15 0	Jan, July	..	–
1	4½%	Do. 4½% 1st Deb. Stock (red.)	99 –102	4 8 0	Jan, July	¼	..
St.	..	Cape Electric Tram Shares	⅛–⅜	..	..	..	..
5	1/3	†City of Buenos Ayres Trams Co. (1904)Sh.	5⅜–5⅞	4 5 6	F,My,A,N	5 25/32	5 21/32
St.	4%	Do. 4 per Cent. Deb. Stock	100 –103	4 2 6	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	90 –93	5 7 0	May, Nov	–	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 –86	5 16 0	June, Dec	..	–
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 –98	5 2 0	Feb, Aug	97	96½
1	..	Kalgoorlie Elec. Trams Sh.	1/32–3/32	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	87 –90	5 11 0	Jan, July	86	86½
5	6%	Do. 6 per Cent. "B" Ditto	61 –66	9 4 0	Jan, July	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 –1⅛	4 9 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 –1¼	4 16 0	Jan, July	–	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	91 –95	5 5 6	Jan, July	92	91½
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	91 –94	5 6 0	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	93 –96	5 4 0	Feb, Aug	95¼	..
100	$1½	Mexico Trams Co. Com. St.	143½–150½	3 6 6	..	150	146½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	96½–97½	5 3 0	..	97⅛	96⅜
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 –105	4 6 0	Feb, Aug	103½	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 –104	4 6 6	..	101½	..
1	1/0	Perth Elec. Trams Ord	31/32–33/32	6 12 6	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	105 –106	4 15 0	Jan, July	–	.
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6½–6⅝	5 6 6	..	6 9/16	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 –101	4 9 0	..	100	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	106 –107	..	..	107	102⅜
..	5%	Do. 30 yr. Gold Bnds.	97½–98½	5 1 6	..	98½	97¼
100	5%	Do. 10 yr. Mt. Bnds	88½–89½	..	..	89⅜	87⅛
–	[illegible]	Sao Paulo Tramway, Light & Power Co. $100 Stock	156⅝–158	6 6 6	..	157½	156½
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100 –101	4 19 0	June, Dec	100⅜	100½
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 –101	4 11 0	Feb, Aug	100⅜	100
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛–5⅜	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½–10	6 0 0	..	9⅞	9 13/16
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	91 –94	4 16 6	Jan, July	92⅜	..
5	3/3	Calcutta Elec. Supply Ord.	6½–7	5 14 0	April, Oct	6 31/32	6⅞
100	$1½	Canadian Gen. Elec. Co. Com. St.	120 –123	5 14 0	..	122½	121
100	$3½	Do. 7% Cm. Pf. Stock	120 –122	..	..	121½	120¼
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 –101	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	88 –90	5 11 0	..	89	–
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1½–2	..	Feb, Aug	..	–
St.	5%	Do. 5 per Cent. Deb Stock	89 –92	5 8 0	Jan, July	91¼	90½
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½–90½	5 10 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½–2	–	..	–	..
10s	0/3	Kalgoorlie Elec. Power & Ltg. Ord.	3/16–5/16	..	..	9/32	¼
1	0/7½	Do. 6 per Cent. Cum. Pref.	23/32–27/32	8 6 0	April, Oct	13/16	¾
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	76 –80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	89½–90½	5 10 6	..	90⅛	89⅛
St.	$1	Mexican Lt. & Power Co. Com. St.	77 –79	5 17 0	–	77⅛	77
500	5%	Do. 5% 1st Mort. Gold Bnds.	92½–92⅞	5 8 0	..	92¼	92⅛
100	$1½	†Montreal Lt. Ht. & Power Co. Cap. St.	119 –123	4 17 6	F,My,A,N	121⅛	121
1	1/7½	River Plate Electricity Co. Ord.	1⅜–1½	5 6 8	April	1 7/16	1 13/32
1	1 2⅜	Do. 6 per Cent. non-Cum. Pref	1 –1⅛	5 6 6	May	1 1/16	1
St.	5%	Do. 5 per Cent. Deb. Stock	102 –108	4 14 3	Jan, July	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅜–5⅝	5 6 6	April, Oct	..	–
100	$1	Shawinigan Water & Power Co. Ca	98 –100	4 0 0	–	99½	98¼
..	5%	Do. 5 per Cent. Bds.	107 –109	4 11 6	Jan, July	108¼	107⅜
St.	4½%	†Do. 4½ Per. Con. Mt. Db. St.	96 –98	4 12 0	–	97½	96⅛
..	6d.	Victoria Falls Power Co. Pref.	27/32–32/32	5 7 6	Jan, July	28/32	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these

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NOTES.

Revocation of Patents.

It will be remembered that recently the Comptroller of the Patent Office revoked a Bremer patent held by the British Westinghouse Company and a Högner patent held by Messrs. Körting & Mathiesen, on the ground of insufficient manufacture in this country. These decisions have now been reversed by Mr. Justice Parker owing to the peculiar circumstances affecting the manufacture. Briefly, it may be said that the Westinghouse Company acquired Bremer patents in 1901, and proceeded to manufacture, but the lamps that were sold were not successful and acquired a bad reputation. In 1902 Högner, of Messrs. Körting & Mathiesen, obtained patents for what is stated to be the same invention, and this firm, owing to large experience in arc lamps, produced a successful lamp and began importing into this country. The Westinghouse Company adopted the course of coming to terms with Messrs. Körting & Mathiesen, by which the latter paid royalties to the former on imported lamps; the Westinghouse Company also obtained a free licence to work the Högner patent. They then continued to make Bremer lamps. It will readily be seen, however, that under these conditions successful competition against Messrs. Körting & Mathiesen would be extremely difficult. In fact, so difficult is the position that Mr. Justice Parker considered the output of lamps, although admittedly small in comparison with the number imported, to be consistent with a *bona fide* attempt to work the patent in this country. The position of the Högner patent is not so strong, but as matters stand, failing developments in patent litigation, it is not to be revoked.

Discussions at the Institution.

In our Correspondence columns this week, Mr. E. W. Cowan makes certain suggestions for improving the character of the discussions upon Papers at the Institution of Electrical Engineers. Briefly, these suggestions stipulate that members should submit a brief summary of their remarks when sending in their names, so that the chairman may discriminate more easily; that the author should be given a definite time in which to reply; and that Papers should be discussed by "compartments." It is difficult to say exactly what promotes a good discussion. Very largely the question lies in the hands of members themselves. For some reason or other, some speakers seem to object to the idea of sending up their names, and they reserve their remarks to a chance 10 minutes' free time at the end of the list. This is altogether undesirable. It is difficult to arrange adequate time for a discussion unless it is known at the beginning of the meeting how many members wish to take part therein. Equally it is difficult to reserve sufficient time to enable the author to reply. In many cases if time is reserved for the author then the discussion is cut short, and vice versa, because, very generally, the criticisms and reply are insufficient for a subsequent meeting. Of course, a discussion may be carried over with the idea of a second Paper being read, but this is somewhat unfair to the author that follows, and this course is therefore unpopular. Undoubtedly, it would often be interesting to have debate rather than discussion, as suggested by Mr. Cowan; this method appears to be followed to a considerable extent by our American friends, but there are pros and cons, and if the time is short probably the formal discussion is the better of the two.

The Design of Electrical Machinery.

WHEN examining dynamos and motors constructed some 10 years ago, or even of more recent date, one is nowadays struck by the liberal amount of iron in their field magnets and armatures. The excessive competition in the electrical industry during the past few years has resulted in such a reduction of prices that manufacturers of electrical machinery have had to pay much attention to methods for securing the greatest economy in construction. Continental and American machines have, at times, provided many examples of the economical use of material, and Papers read before the Institution of Electrical Engineers during the last two or three years, notably one by Messrs. MACFARLANE and BURGE in December last, show that English manufacturers are by no means behind in economic dynamo and motor design. The output limits of early continuous-current machines were usually determined by considerations of sparking, but the use of interpoles, which is now becoming very general, has practically eliminated that trouble, so that rise of temperature has become the most important factor. This being the case, it is not surprising that improved methods of ventilation have been receiving much attention. One system which is being tried is to incorporate a fan in the armature itself, by fixing blades on the spider, but it is interesting to note that in the recent discussion on interpole design at a meeting of the Glasgow Local Section of the Institution of Electrical Engineers, a brief account of which appears on another page of this issue, Mr. W. W. LACKIE favoured a separate fan for forced ventilation. Although objections may possibly be raised against the complication thereby introduced, we do not see why forced ventilation should not be regarded as a necessary means of obtaining the maximum output and efficiency from a given machine, in the same way that condensers are employed for increasing the output and efficiency of steam engines.

Insulating Materials.

IN our issue of May 21st we published an abstract of a Paper by Mr. G. H. FLETCHER on the subject of Insulating Materials, in which it was stated that on removing the varnished insulating covering from a wire the copper was sometimes found to be coated with a green oxide. In our correspondence columns this week Mr. J. S. S. COOPER takes exception to this statement, pointing out quite correctly that green oxide of copper does not exist. But that in itself would not prevent the formation of some salt intermixed with oxide, thus giving a green tint. As the result of testing, Mr. COOPER has failed to find any trace of copper, and he reaches the rather curious conclusion that "the green matter is thus seen to be some obscure organic salt of copper, so exceptionally deep in tint that a quantity sufficient to stain some feet of tape a vivid green was not enough to respond to the delicate ferrocyanide test." Copper is a metal which can be detected so readily that this conclusion seems rather strange. Whether the salt were organic or inorganic there should be little difference in this difficulty. Verdigris is often looked upon as the substance in question, but if this were the case there should be no trouble in making certain of the fact. Upon referring, however, to a Paper by Messrs. GERMANN and HILLS on Dielectrics in our issue of May 14th, it will be noticed that the authors ascribe the green colour to the formation of a compound resulting from the chemical action by acids, in the cotton, upon the linseed oil. We do not know whether this has been definitely proved, but it seems at least more probable than the suggestion of an obscure organic salt.

The National Telephone Co.

AMONG the important events in the telephone world must be included the annual dinner of the National Telephone Co., which took place last week. This event was, perhaps, tinged with melancholy at the idea that it might be the last of such dinners, and also by considerable uncertainty on the part of the staff as to their future. It is to be hoped that all will yet go well, for it would be a bad testimonial to a Government department if conditions under private enterprise were the preferable of the two. Mr. GEORGE FRANKLIN, the president, in replying to the toast of the "National Telephone Co." gave some interesting figures. As showing the magnitude of the royalty paid by the company to the Post Office at the present time, he stated that if the Postmaster-General, after acquiring the business, kept the telephone accounts as the company had done, he would be in a position to present a "Dreadnought" to the country at least once in five years. In regard to the working of the company, the total number of messages over the system had reached 1,323,000,000, and the cost to the subscriber per message had been 0·49d. Irate subscribers will be surprised to learn that the average time elapsing from the moment when the subscriber begins a call till the operator answers "Number, Please," is only 4·70 seconds, and that the time from the commencement of the call until the subscribers are connected is only 38 seconds. In giving some engineering details Mr. FRANK GILL mentioned that although much of the work might be described as electrical engineering, they could not compete with the supply companies in giving current at 1d. per unit; in fact, the electrical energy for telephone operations worked out at about £16,400 per unit, and it would be necessary to have 16,000,000 conversations in progress at the same time to equal the power consumed by an ordinary 16 c.p. incandescent lamp. Nevertheless, we complain of the inefficiency of the telephone receiver.

Institution of Mechanical Engineers.—The annual conversazione was held on Friday evening last, at the Institution, St. James's Park, Westminster, and was well attended, the guests being received in the large hall by the president, Mr. J. A. F. Aspinall. The entertainment provided, which was as excellent as usual, included the band of H.M. Scots Guards, vocal and instrumental music, electrophones and a lecturette on "Flight in the Immediate Future." Mr. F. W. Lanchester was to have been responsible for the lecturette, but, unfortunately, was prevented by ill-health, his place being taken by Mr. P. L. Gray. The subject being one of great importance at the present time, much interest was taken in the remarks of the lecturer, which were well illustrated by models.

Cable Interruptions.	Date of Interruption.
Jamaica—Colon	May 6, 1909
Dakar—Conakry	May 13, 1909
Tangier—Cadiz	May 19, 1909

Royal Society.—Among the Papers read at the meeting yesterday was one on "The Absolute Value of the Mechanical Equivalent of Heat in Terms of the International Electrical Units" by Prof. H. T. Barnes.

Derby Result to South America (via Eastern-Madeira).—The race for the Derby was run at Epsom, Surrey, at 3:6 p.m., on Wednesday, and occupied 2 min. 49 sec. The result was announced at Valparaiso, Chili, at 3:10, or 1 min. 11 sec. after the finish at Epsom.

Tramways and Light Railways Association.—The "Official Circular" for May contains, besides various matters relating to the Association, a copy of the recent judgment in the rating appeal case, Blackpool and Fleetwood Tramways, and a reprint of an article from the "Municipal Journal," entitled "Halfpenny Fares."

Corps of Electrical Engineers.—We are asked to announce that the athletic and cycling trials and championship sports of this corps will be held at the Stamford Bridge Ground, Fulham-road, Chelsea, on Wednesday next, June 2nd, at 6:30. These sports are in the nature of eliminating trials and the successful competitors will be chosen to represent the corps at the Territorial Force Sports which take place at the Stadium on June 26th. Swimming sports will also be held at the Westminster Baths, Great Smith-street, to-morrow evening, at 9 o'clock. Tickets and full information can be obtained from the hon. sec., Q.M.S. G. A. Applebee, Headquarters, Regency-street, Westminster, S.W.

Electric Progress in France and Austria.—A correspondent of the "Electrical Review and Western Electrician" states that there is considerable activity in the Pyrenees region of France in the way of electrical enterprises. One of these is an electric railway which has lately been authorised, and the erection of which will soon be started. It includes three separate sections, one of which will run from Auch to Lannemezan and have standard-gauge track, with a second section leading from the intermediate station of Castelnau-Magnoac to Tarbes. The third section runs from Arreau to Saint-Lary. A hydro-electric plant will be erected in the valley of the Oule, in order to supply the current for these lines, as well as the already existing electric railroads from Tarbes to Bagneres and others in this part of the Pyrenees. The Southern Railroad Co. is carrying out this work. An electric railroad is also to be constructed in Austria between Klosterneuberg-Kierling and the town of Gugging, the project having lately been approved by the Minister of Railroads. A local syndicate has obtained the concession for building the line. An electric railway from Koloszvar to Klausenberg, 15 miles long, is also to be constructed.

Electricity Supply in Paris.—In an article in a recent number of "L'Industrie Electrique," M. A. Soulier explains the present position of electricity supply in Paris and also shows how the many scattered stations and systems are to be coordinated to some extent during the next few years. The old power stations are being gradually suppressed and are being replaced by sub-stations on the same sites, which will allow a greater amount of power to be successfully dealt with without increasing the floor space. The actual generation of energy will be confined to two large stations outside Paris, and on the banks of the Seine, where coal and water supplies will be easily available, and where, for these reasons, the economical conditions will be more favourable than those existing at present. From the technical point of view the operation of the proposed sub-stations will possess many points of interest, as both asynchronous and synchronous motors will be used for driving the motor-generators, while rotary converters will also be employed. As regards distribution, the same variety will be observed, since, besides employing three, two and single-phase alternating currents, direct current on the three and five-wire systems will also be employed. The interest attaching to all these installations will be increased still further if the scheme of using the power of the Rhone for supplying Paris with electricity should one day be realised.

Electricity Supply in Rheinhessen.—According to "Engineering," the districts of Worms, Alzey, Oppenheim and Mainz, in the Rheinish province of Hessen, have come to an agreement with the Rheinische Schuckert Gesellschaft and the Siemens-Schuckert Werke whereby about 100 towns and villages are to be supplied with electricity. The agreement is for a period of 50 years, but can be terminated at the expiration of 30 years, when the municipal associations will have the option of taking over the whole plant. The equipment generally will, in any case, become the property of the associations after 50 years, though the power plant proper will remain the property of the company. The generating stations will probably be built near Rheindürkheim and Osthofen. The utilisation of water power is not contemplated, but the machinery for the water works at Osthofen and elsewhere will be driven electrically. The tariff rates are to be the following: For light, 5d.; for power, 3d.; for heating and cooking, 1½d. per kilowatt-hour, subject to discount. Electricity meters are to be let for one month at 2½d. for five lamps, 3½d. for 10 lamps, 6d. for 30 lamps, and 7d. for 50 lamps. Street lamps will be charged 3½d. per kilowatt-hour, or a lump sum for the year. For the first 10 years the company alone will have the right of putting down installations, though other firms are to be considered. The company will therefore grant certain facilities—*e.g.*, give each subscriber who enters into a contract before supply is opened two lamps free of charge. The installation tariff is to be revised at intervals of three years. The whole province has about 400,000 inhabitants, mostly engaged in agriculture and small industrial works.

National Physical Laboratory.—Vol. V. of "Collected Researches" has just been issued by the National Physical Laboratory, and contains the following reprints :—

"Magnetic Decliniation at Kew Observatory, 1890 to 1900," by C. Chree, Sc.D., LL.D., F.R.S.

"Observations on Recalescence Curves," by Walter Rosenhain, B.A.

"Eutectic Research.—No. 1. The Alloys of Lead and Tin," by W. Rosenhain, B.A., and P. A. Tucker.

"The Variation of Manganin Resistances with Atmospheric Humidity," by F. E. Smith. (*See* abstract in THE ELECTRICIAN, Vol. LXII., p. 222.)

"On the Secular Changes of the Standards of Resistance at the National Physical Laboratory," by F. E. Smith.

"On the Determination of the Constants of Mercury Standards of Resistance," by F. E. Smith.

"Comparison of the Board of Trade Ampere-Standard with the Ayrton-Jones Current Weigher, with an Appendix on the E.M.F. of Standard Cells," by T. Mather, F.R.S., and F. E. Smith.

"Experiments on Wind Pressure," by T. E. Stanton, D.Sc.

"A New Fatigue Test for Iron and Steel," by T. E. Stanton, D.Sc.

"Notes on Screw Threads," by H. H. Jeffcott, B.A.

"The Determination of Phosphorus in Phosphor Tin," by W. Gemmell and S. L. Archbutt.

"On a Method of Comparing Mutual Inductance and Resistance by the Help of Two-Phase Alternating Currents," by Albert Campbell, B.A. (*See* abstract in THE ELECTRICIAN, Vol. LXII., p. 931.)

"On Compensation for Self-Inductance in Shunt Resistances," by Albert Campbell, B.A. (From THE ELECTRICIAN, Vol. LXI., p. 1000.)

The collection of these Papers in a handy form will no doubt be welcomed.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 28th (to-day).

MANAGERS' SECTION OF THE MUNICIPAL TRAMWAYS ASSOCIATION.

10 a.m. Meeting in the Council Chamber, Town Hall, Newcastle-on-Tyne.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Advances in our Knowledge of Silicon as an Organic Element," by Prof. J. Emerson Reynolds, F.R.S.

THURSDAY, June 3rd.

ROYAL INSTITUTION.

3 p.m. Meeting at Albemarle-street, Piccadilly, W. Lecture on "A Modern Railway Problem"; "Steam *v.* Electricity," by Prof. W. E. Dalby. (Lecture I.)

FRIDAY, June 4th.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Researches in Radiotelegraphy," by Prof. J. A. Fleming, F.R.S.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week :—

Tuesday, June 1st, "B" Company	Practice for officers' drill cup competition at 6.30.
Thursday, June 3rd, "C" Company ...... Friday, June 4th, "D" Company	Officers' drill cup competition at 7 o'clock.

SOME TESTS AND USES OF CONDENSERS.*

BY W. M. MORDEY.

Summary.—The general question is discussed whether condensers can be used commercially in competition with over-excited synchronous motors for the improvement of power-factor in distribution. Tests are given of Mansbridge low-tension condensers and Moscicki high-tension condensers. A comparison of capital and running costs is in favour of condensers under certain conditions. Finally, the use of condensers for extinguishing or preventing arcs is considered.

The idea of using condensers for providing idle leading current to compensate the idle lagging current due to self-induction in alternate-current working seems to have been first proposed in 1891, in this country by Mr. Swinburne, and in France by Hutin and Leblanc.† The principle was not new. At the Crystal Palace Electrical Exhibition in 1891, Mr. Swinburne showed some paper condensers made for high-tension work. He also wrote and spoke on the subject.‡ Hardly any progress was made so far as practical applications went. And then conditions changed, and the subject no longer attracted attention. There was a period when the capacity of the cables in distribution systems in many cases provided a good deal of compensation, and we find Mr. Swinburne saying in his Presidential Address of 1902, that "it is hardly worth while discussing condensers now as there is generally excess of capacity in systems, so that the current leads relatively to the pressure."

But now the growth of the motor load is making a difference, and in many cases there is a real need for the improvement of the power factor in supply systems, for various reasons, such as keeping down the loss in the mains and increasing the useful output of generators and reducing their cost. The loss in the mains is inversely proportional to the square of the power-factor, thus :—

Power-factor ...	1	0·9	0·8	0·7	0·6	0·5
Loss ...	1	1·24	1·56	2·04	2·78	4·0

As to the effect on cost and output, it is sufficient to quote Mr. Miles Walker's interesting Paper, read before the Manchester Local Section, on Jan. 12, 1909, on "The Improvement of Power Factor in Alternating-current Systems," in which he refers to one case where the rating of some turbo-alternators was raised 50 per cent. owing to their being used at nearly unity power-factor.§

For the improvement of power-factor two methods may be compared—the use of condensers and the use of over-excited synchronous motors.‖ The latter method is practically the only one that has so far obtained engineering recognition. I am glad to be able to give some particulars of one interesting example of its use, for which I have to thank Mr. Fedden, of the Sheffield Corporation. He has installed a specially designed motor made by the British Thomson-Houston Co. It has a capacity of 600 k.v.a., and consists of a two-phase motor for 2,000 volts 50 ∾ with a direct-current exciter and an induction motor for starting up, all on one shaft. It is used at intervals during the day to keep up the power-factor of the system and to reduce the excitation of the main turbine generators, which are in a station two miles away. At the present time the average day load is about 4,000 k.v.a., at an average power-factor of 0·7, equal to an actual load of 2,800 kw. The compensating motor raises the power-factor on an average to 0·83, reducing the apparent load from 4,000 to 3,380 k.v.a., thus releasing 620 kw. of capacity in generators, and in cables between the two stations. These figures correspond to a load on the motor of nearly 1,000 k.v.a.

Having had occasion to use condensers for some experiments on arcs, which are alluded to later, the opportunity was taken to investigate some of their qualities to see to what extent they might be considered suitable for use on alternate-current systems. The results seem to point to such use being now within the region of practical engineering.

There are many kinds of condensers, including those in which the electrodes are separated by air or oil, but for our present purpose only two types will be considered :—

1. Paper condensers of the kind described by Mr. Mansbridge before this Institution last year,¶ and
2. The Moscicki type of glass condenser.

* Paper read before the Institution of Electrical Engineers on Thursday last.

† "La Lumière Electrique," XL., pp. 201 and 257, 1891.

‡ See, for example, THE ELECTRICIAN, Jan. 1, 1892: "The Probable Future of Condensers in Electric Lighting," by James Swinburne, pp. 227-228 (from "Industries").

§ "Journal," XLII., p. 602.

‖ The quality possessed by such motors which makes them available for this purpose—illustrated by the V-curves connecting armature and field current—was described by the author in a Paper on "Testing and Working Alternators," read March 23, 1893, Vol. XXII., p. 116.

¶ "Journal," Vol. XLI., p. 535, 1908.

The former are made, by a continuous process, of paper coated on one side with a thin metal layer like the so-called silver paper used for packing tea. These have the great advantage that if they are pierced they are self-healing, the metal being vaporised so as to produce a space clear of metal round the fault.

They appear, however, only to have been made for low pressures, and therefore, so far as the author's present knowledge of them goes, a number of them must be placed in series for high-pressure working.

The Moscicki condensers, which are not at present being made in this country, consist of specially formed glass tubes closed at one end and coated inside with silver deposited chemically, the outside coating being sometimes applied in the same way and sometimes dispensed with altogether, the outer electrode consisting in this case of a mixture of glycerine and water, in which the tubes are immersed. These condensers are said to be largely used for wireless telegraphy, for which purpose the metal coating is made very thick in order to lessen the resistance and the damping effect. They are being used in some cases abroad for power-factor improvement on extra high-tension transmission lines. They seem to be very suitable for this purpose, as by the use of a suitable thickness of glass they can be made to withstand a very high voltage.

No information regarding the losses was obtainable for either of these condensers. I have therefore had some tests made of both types by Mr. Wild, of the Westminster Testing Laboratory. The results obtained are only to be taken as approximately correct, instrumental difficulties introducing some uncertainty in the measurement of power in apparatus having power-factors of only about 0·01. It is believed, however, that the results may be relied upon for the low-tension paper condensers within 5 per cent. each way, and for

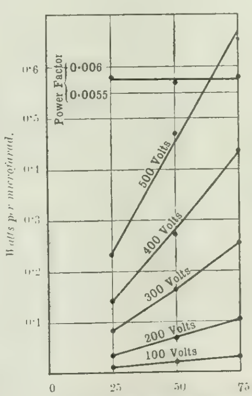


FIG. 1.—TESTS OF LOW VOLTAGE PAPER CONDENSER (MANSBRIDGE CONDENSER).

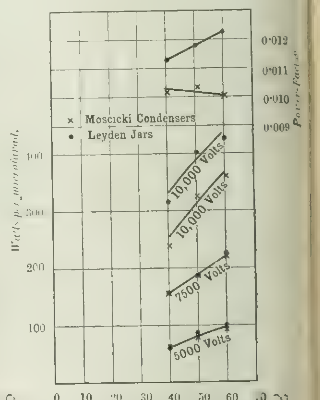


FIG. 2.—TESTS OF HIGH VOLTAGE GLASS CONDENSERS (MOSCICKI CONDENSERS AND LEYDEN JARS).

the high-tension glass condensers within $7\frac{1}{2}$ per cent. each way at the highest voltages and 15 per cent. at the lowest.* A Mansbridge condenser made for 500 to 600 volts direct current, and having a capacity of about 10 microfarads, was tested with alternate current at various pressures from 100 to 500 volts and at 25, 50, and 75 ∾.

The results of the tests are shown in Fig. 1, which gives the loss in watts per microfarad at various voltages and frequencies, and the power-factor at various frequencies. The capacity, as shown by the proportionality of current to pressure and to frequency, was almost constant. The power-factor was also found to be nearly constant at all frequencies from 25 to 75 ∾. The variation of power-factor with voltage was less than the instrumental errors within the limits

* The Mansbridge condensers were tested with a wattmeter of the reflecting deflectional type. It was ascertained that the error due to the self-induction of the pressure coil did not exceed $1\frac{1}{2}$ per cent. on a power-factor of 0·015 at 50 ∾.

The Moscicki condensers were tested with the same wattmeter in conjunction with a 100 to 1 potential transformer. The potential transformer brought into the measurement an error of the order of 20 to 25 per cent. In order to obtain a sufficient deflection on the wattmeter it was necessary to cut down the non-inductive resistance in series with the pressure coil to such an extent that another error was brought in of the order of about 20 per cent. This error was in the opposite direction to that involved by the use of the potential transformer. Both these errors were determined with a fair degree of accuracy, and were allowed for in the final result.

of the tests. The curve for power-factor shows the mean results for the three highest voltages. It will be seen that the loss of energy was small.

Having found the qualities of a low-tension condenser, it would seem that no difficulty should be met with in using a number of such condensers in series for high-tension work, as the conditions in each section as to voltage, loss, and power-factor, will be the same when used in such a series as when used singly. The British Insulated & Helsby Cables (Ltd.), who made the condenser tested, have, in answer to the author's question, suggested 500 volts per section for a condenser so made up for 10,000 volts, and state that it would occupy about 2 cubic ft. per microfarad, and they think the price would be about £27 per microfarad. They, however, state that they have had no experience of condensers so made up or used. The above tests and information, however, enable a tentative comparison to be made with the 10,000 volt Moscicki condenser tested.

This Moscicki condenser consists of eight tubes, having a total capacity of 0·03 microfarad. It is intended for alternate-current working at 10,000 volts. Each tube is 2 in. in diameter and 2 ft. 9 in. long, or with connections 3 ft. 2 in. Owing to instrumental difficulties, it was impossible to obtain the same degree of accuracy with these tests as with the paper condensers, and the range of voltage and frequency over which it was practicable to make them was also less. As a matter of curiosity some tests were made of a set of six Leyden jars of ½ gallon size, having a total capacity of 0·015 microfarad. They were kindly lent to the author by Mr. Campbell Swinton. The curves representing watts lost per microfarad on different voltages and frequencies are shown in Fig. 2 for both these glass condensers. They are similar in their character to those obtained from the Mansbridge paper condensers. At 5,000 volts and at 7,500 volts the loss in watts per microfarad in the Moscicki condenser and in the Leyden jars is the same, but at 10,000 volts there is a marked difference. There is some brush discharge in the Leyden jars from 5,000 volts upwards. The losses in the Moscicki

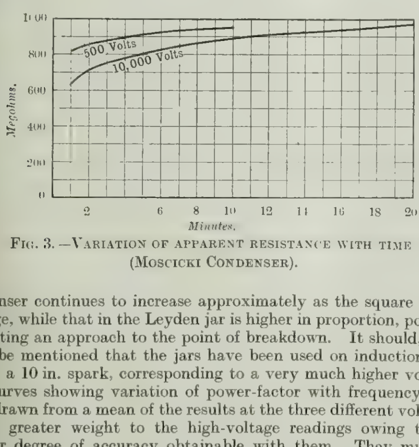


Fig. 3.—Variation of apparent resistance with time (Moscicki Condenser).

condenser continues to increase approximately as the square of the voltage, while that in the Leyden jar is higher in proportion, possibly indicating an approach to the point of breakdown. It should, however, be mentioned that the jars have been used on induction coils giving a 10 in. spark, corresponding to a very much higher voltage. The curves showing variation of power-factor with frequency have been drawn from a mean of the results at the three different voltages, giving greater weight to the high-voltage readings owing to the greater degree of accuracy obtainable with them. They must be accepted with some reserve, owing to the less degree of accuracy in these tests. They show, however, that the Moscicki glass condenser works with a loss of about 1 per cent. of the kilovolt-amperes dealt with.

It was thought to be of interest to find the variation of the apparent resistance of the Moscicki condenser and to find how its C^2R losses so ascertained compared with the energy losses found in the alternate-current test. The author was enabled to make this resistance test by using a 10,000-volt secondary battery kindly placed at his disposal by Mr. Campbell Swinton.* The apparent resistance so ascertained is shown in Fig. 3, readings being taken at 500 and at 10,000 volts. Unfortunately, the readings were not continued long enough to reach the steady condition, the current slowly falling—that is, the apparent resistance slowly rising—even after 20 minutes' application of the pressure. As these curves only start with the result at the end of 1 minute, they afford no indication of what the apparent resistance would be within the time of a half-period. It will be seen that any C^2R loss based on these resistance curves will

* This battery, which was made by Mr. Swinton, comprises 4,800 secondary cells, each cell consisting of a test tube 4 in. long by ¾ in. diameter, the whole being conveniently arranged for charging in a number of parallel sets of 80 cells in series. The charging current is arranged to be 8 milliamperes.

account only for an insignificant proportion of the total losses with alternate current.

In comparing Figs. 1 and 2, it must be remembered that the power-factor, and not the watts per microfarad, is the proper basis, seeing that the loss (as well as the kilovolt-amperes per microfarad) appears to rise as the square of the pressure in any given condenser. The proper basis of comparison is the loss in a paper condenser, made up in sections for high-pressure use in one case, against the loss in the special high-voltage glass condenser of the same capacity. From the results shown in Fig. 1, a 10,000-volt Mansbridge condenser would lose about 190 watts per microfarad at 50 periods; and from Fig. 2, the Moscicki 10,000-volt condenser would lose about 320 watts per microfarad, the loss in the latter case being less accurately measured than that in the former.

It is satisfactory to find the losses are so small. They are respectively about 0·6 per cent. and about 1 per cent. of the kilovolt-amperes dealt with. These losses are of the same order as the magnetising losses in transformers of good design. With such small losses as these, no difficulty should be experienced in preventing objectionable heating. Condensers lend themselves very well to arrangements giving large cooling surface. In the Moscicki type, the tubular form ensures this. The Mansbridge type can be subdivided to give any desired cooling surface.

It is perhaps a large assumption to make that condensers have reached such a stage as to justify a direct comparison with synchronous motors. It is felt, however, that a little encouragement and experience would probably enable makers of condensers to justify such an assumption, and therefore the author ventures to make the comparison. In sub-station work, at least where motor-generators or rotary converters are used, or industrial work where synchronous motors are used, it should always be possible to arrange by over-excitation to provide a considerable amount of power-factor correction at a small increase in the cost of the machinery. But there are many conditions in alternate-current supply where self-induction cannot be compensated in this way. In some cases the expense of special over-excited synchronous motors running without load may be fully justified, the Sheffield case being an example. But the objections to the use of running machinery are very great. If condensers can be made to work reliably, even at the same capital and working cost as motors, they would be preferable. In any event, a comparison may be useful.

The simplest case will be to assume that either the motor or the condenser would be placed in a generating station or in a sub-station, and that the motor would not be used for any other purpose. It would be much more favourable to the motor to take the case of an over-excited motor or rotary converter doing other work, but to deal with that it would be necessary to know all the conditions. On the other hand, it would be more favourable to the condensers to dis-

Table.

Capacity in Kilovolt-amperes of Motor, or in Microfarads of Condensers required for a load of 1,000 kw. at various Power-factors to be Corrected to Unity or to any other Power-factor.

Power-factor of load.	Kilovolt-amperes required at leading power-factor 0.	Capacity required in microfarads at 50 ~.			
		2,000 volts.	5,000 volts.	10,000 volts.	20,000 volts.
0·99	142	113	18	4·5	1·13
0·98	203	162	26	6·5	1·62
0·97	251	200	32	8·0	2·00
0·96	292	233	37	9·3	2·33
0·95	329	262	42	10·5	2·62
0·90	485	386	62	15·5	3·86
0·85	620	494	79	19·7	4·94
0·80	750	598	96	23·9	5·98
0·75	882	703	113	28·2	7·03
0·70	1,020	814	130	32·5	8·14
0·65	1,165	930	148	37·0	9·30
0·60	1,333	1,065	170	42·5	10·68
0·55	1,520	1,210	194	48·5	12·10
0·50	1,732	1,380	221	55·0	13·80

The figures in column 2 represent the whole wattless component corresponding to the various power-factors in column 1 with 1,000 kw. real load. The kilovolt-amperes or capacity required for correction to any power-factor less than unity will be equal to the difference between the wattless component in the uncorrected circuit and that in the circuit after correction. Thus, to bring up a 1,000 kw. circuit from 0·75 to 0·95 power-factor requires 882 − 329 = 553 k.v.a. if a synchronous motor be used. With condensers working at 5,000 volts 50 ~ it will require 113 — 42 = 71 microfarads.

The kilovolt-amperes required for correction are independent of frequency and voltage. The capacity required is inversely proportional to the frequency and to the square of the voltage.

tribute them about the system. For example, they could be placed close to large motors, and switched in or out by movement of the motor switch—that would give effective correction at all loads without involving any attention.

We may confine ourselves to a comparison of a case where, if any correction is to be effected, it must be by either a synchronous motor or a condenser, and will take the simplest case and assume a synchronous motor or a condenser installed at a generating or sub-station, for the compensation of a circuit requiring 1,000 kw. at 10,000 volts, 50 periods, with a power-factor of 0·8. We see from the table above that to give unity power factor, this would need a motor of 750 k.v.a., or a condenser having a capacity of 24 microfarads. The cost of the motor erected with foundations, switchgear, and accessories will not be less than £1,100. Such a machine would certainly not take less than 40 kw. to run it at full load, and 20 kw. at light load. Let us assume a mean of 30 kw. and that it is used for 12 hours a day only. This gives a total annual consumption of 131,400 units.

The cost of a condenser of 24 microfarads for the above conditions would be about £720 with switchgear and accessories. The loss in this condenser will not be more than 1 per cent. of its apparent load —7·5 kw. at full load. In practice, the condenser would be in sections, some of which would be switched out as the load fell, but we will assume that it is all kept in circuit for 12 hours a day. The total annual consumption would be 32,850 units. Although there are good reasons why the energy used in such a device should be charged at the average works cost, it is preferred to take it on a lower basis of about the cost of the coal, say, 0·25d. per unit. No spare is provided in either case, and no charge is included for upkeep, capital charges, attendance, or lubrication, nor is the account in either case credited with any sum to represent the increase of useful capacity and efficiency or reduction of cost of the generating plant. We then get the following comparison :—

	Synchronous motor.	Condenser.
Capital cost	£1,100	£720
Annual cost of energy wasted	137	34·2

These figures speak for themselves. They would be still more striking if the comparison included necessary spare apparatus, and particularly if any attempt were made to provide a similar total correction, often more effectively, by subdivision into smaller motors placed about the system. It will be clear that a large condenser could be sub-divided without disadvantage, but in the case of synchronous motors such sub-division would involve a considerable increase of cost and loss. No attempt has been made to compare the cost of condensers with the added cost necessary to make ordinary motors or rotary converters available for power-factor correction in addition to their ordinary work, but the low capital and working cost of the condensers points to a comparison, even on this basis, being possibly favourable to the latter.

The author ventures to draw renewed attention to this subject in the hope that something may now be done in the direction of satisfactorily using condensers on alternate-current systems.

In conclusion, it may be of interest to give the result of some experiments on the use of condensers for preventing or stopping the formation of arcs under certain conditions. In investigating the action in a surface-contact tramway system recently, the author found that trouble was experienced due to the formation of persistent arcs at the underground contacts. When the road was wet and dirty a small leakage current passed from the live contact stud under the car over the surface of the road to the rails. When the car had passed and the underground contact-piece had separated its proper distance from the live conductor, this leakage current was sufficient to maintain an arc across the air-space of the contact-maker, thus keeping the stud alive so long as the arc persisted. It was found that with a terminal voltage of about 560 volts the voltage between the stud and the rail was usually about 400 to 440 volts, and the voltage across the arc about 120 to 160 volts. Sometimes arcs would persist for a few seconds with not more than 0·6 ampere, and they would often persist when the leakage current was over 1 ampere—this latter condition, it will be seen, corresponds to a resistance of the leakage path from the stud to the rail of a maximum of 440 ohms.

The prevention of these arcs by increase of gap, or by other structural alterations was not found to be practicable, and it therefore remained to try to find some means for preventing their formation, or for immediately putting them out if they were formed. For this purpose experiments were made with a condenser, which was found to be quite effective.

Two conditions may be given :—

(A) A suitable condenser placed across the gap prevents any arc being formed, however small the gap—for example, it was not possible to maintain an arc across a gap of even $\frac{1}{64}$ in.

(B) If the arc is formed and it is then shunted by a suitable condenser it will at once go out.

The minimum safe capacity for these two cases was found to be as follows :—

Amperes.	Condition (A).	Condition (B).	Amperes.	Condition (A).	Condition (B).
—	microfarads	microfarads	—	microfarads	microfarads
1·5	1	2	2·5	3	6
2·0	2	4	3·0	4	8

It was found quite practicable to extinguish the arcs by shunting them by a condenser carried on the car, one terminal being connected to the collector or skate, the other to a small wire brush hanging down under the rear platform of the car, and making successive contacts with the studs. It was also found that the arcs could be put out by placing the condenser in shunt across the leakage path instead of across the arc itself, or with two condensers in series across the resistance and the arc, with a middle connection to the junction between them. It was not necessary that the condenser should be in a discharged condition, the arc being put out, whether the condenser when applied was discharged or when it was charged to the full voltage of the circuit, in which latter case the effect would be produced in whichever direction of polarity the condenser was applied. The arcs could also be put out by a resistance shunt, but there are objections to that, and in any case it need not be examined here.

The author wishes to express his thanks to Messrs. Isenthal & Co., for the use of some Moscicki condensers, and to Mr. A. E. Levin for substantial assistance in the experiments and in preparation of the Paper.

DISCUSSION.

Mr. G. F. Mansbridge noticed, in connection with paper condensers, that the author in describing their self-sealing properties, considered that the metal was "vaporised." He, the speaker, thought that it might be well to qualify that expression. When treating the foiled paper in the dry condition before making it up into the condenser special provision was made for obtaining a large spark at the weak spots, and there was no doubt that under those conditions some of the metal was actually "vaporised." He thought that the action was not quite the same in the finished condensers, since the conditions were then less favourable for the production of a large spark. He considered that the chief cause of thesealing-up effect was not the vaporising of the tin, but the breaking up of the thin film under the action of heat into tiny, disconnected patches. He pointed out that by the process of manufacture the tin was first broken up into very fine powder, and then, after being uniformly spread on the paper, was reconstituted into a coherent film by the action of the burnishing rollers. Under these conditions, the film necessarily possessed little cohesion, and readily became again disintegrated by a small amount of heat. That point might at first sight appear a minor one, but he thought it was of importance, because the idea of vaporising the metal seemed to suggest something like an arc, whereas even with a comparatively high voltage on a condenser there was nothing like an arc. The effect might be likened to an attempt to form an arc between the ends of two extremely fine wires. Obviously in this case the arc would become self-destructive. With regard to the supply of condensers for high-tension work, he thought it was purely a question of supply and demand. At the present time the Helsby Company and other firms were making low-tension condensers by the thousand, whereas they received orders for but few high-tension condensers. It was, therefore, much more convenient from the manufacturing point of view to take low-tension condensers and put them in series, rather than to alter the winding machines and put in special papers for high-tension condensers. Given a sufficient demand, there was no reason, so far as he knew, why high-tension condensers should not be built up direct, and inasmuch as there would be a considerable saving of material and labour by building high-tension condensers in this way, instead of assembling low-tension plates, he would strongly recommend direct building. If, however, it was proposed to run low-tension condensers in series, he suggested as an alternative that the pressure should be lowered by transformation and put on to the condensers in parallel because the effective capacity would be the same, and there was an obvious advantage in not having 10,000 volts or even 2,000 volts across the terminals. He asked at what temperature the test given in Fig. 1 was taken and whether it was the same in all the tests ; he presumed it was somewhere about 60°F. The insulation and the dielectric strength of condensers and other factors depended so much on the temperature. He would like also, if possible, to separate the C^2R losses from the dielectric losses. He thought the author referred to the C^2R losses with regard to the actual insulation resistance of the condenser. He, the speaker, meant the C^2R losses in the electrodes. The Mansbridge condensers at present on the market were designed primarily for only comparatively small currents, such as were met with in telegraphic and telephonic work ; the quantity of tin was therefore kept down as low as possible. For that purpose there was ample conductivity in the foiled paper as at present used, but if condensers were required to run at full load for anything like 12 hours a day he would rather use a little more tin, and also a greater

number of connections to the electrodes, so as to bring down the C^2R losses in the electrodes themselves. If those losses could be separated from the dielectric hysteresis losses he thought it might give them some useful information. He thought that a reduction in the thickness of the wax in the condenser might possibly reduce the dielectric loss, but he was not prepared to make that as a definite statement. He thought the experiments on the arcs were particularly interesting, in view of the rather paradoxical effect obtained compared with the effect of a cable relay. Mr. S. G. Brown used a condenser across a doubtful contact to maintain the current and to prevent a break in continuity. The author had used the condenser across the break to ensure the break. In treating the foiled paper for condensers it was usual to burn out all the weak places by passing the paper in a continuous strip over a metal roller. This roller was connected to one pole of a supply at 100 volts, and the other pole was connected to a rubbing contact on the tin side of the paper, so that whenever a defect passed over the roller there was a momentary spark, and the defect was eliminated. Now, it was a curious fact that although there was plenty of current available yet by putting a condenser of appreciable capacity across the mains there was a considerable increase in the number of faults detected—double or treble the number of weak spots being picked up when the condenser was connected. That seemed to have a bearing upon both the experiments shown by Mr. Mordey. One might put an appreciable resistance in series with the condenser and still get the same effect.

Mr. W. B. Esson thought that the reason why the condenser had not made the progress that might have been expected of it was because it had never been, until recently, an engineering piece of work. He believed that the Stanley Mfg. Co., of America, at one time supplied as part of their ordinary equipment for two-phase motors a couple of condensers. He did not know what success they had with them, though evidently their utility had been recognised. He thought the Moscicki condenser was a thorough engineering piece of work. Some time ago he conducted some experiments using these condensers running at 6,000 volts night and day for the best part of a week. Nothing happened, so presumably they were all right, and there was no reason to believe that they would not work for years continuously in the same way. As to rectifiers, which Mr. Mordey called compensating motors, these had been used with great success on a 90 miles transmission line in India. There they had had trouble originally with lagging current, because they used induction motors; but later they installed synchronous motors for the large powers, not only for the purpose of compensation, but to do useful work. These were over-excited in such a way as greatly to increase the power-factor, and thus increase the plant capacity of the station. That was a case in which compensating motors were actually used for the purpose described by the author, but there was no doubt that in many instances the condenser would be used as being much more convenient and also cheaper, if it could be made quite reliable.

Mr. J. E. Taylor thought that, as the application of the condenser was likely to increase, the method of measuring the losses was rather important. He thought there were better methods available than the use of a wattmeter. Where only small capacities were concerned, as in the case of the Moscicki condenser, the Duddell thermo-ammeter lent itself very well to the measurement of C^2R losses, and it could be used in such a way that there was no self-induction. With self-induction and low power-factor the measurement was very difficult, but by including in the measurement circuit a fine filament of wire of known resistance and of negligible capacity, it was possible to determine with accuracy those C^2R losses in the circuit simply by varying the known resistance in the circuit. The idea was that when one put a known resistance into the circuit so that one got the maximum C^2R developed in the known resistance then the resistance was equal to the remanent dissipation resistance in the circuit.

Mr. G. L. Addenbrooke (communicated) thought there was no doubt that the cheap and reliable form of condenser would find many applications in heavy engineering, as had already been the case in telephone and telegraph work, since the mechanical method of making condensers was introduced. He thought the author's results for power-factors were too low. He tested a Mansbridge condenser some time ago by the electrostatic method and obtained a power-factor about double that of the author's. Similar figures to those given in the Paper he had obtained on a Muirhead condenser, which was a more expensive article. He thought it would be wise to take the power-factor of those condensers as not under 1 per cent., which was the figure the author allowed in an example of their use at the end of the Paper. He had not had an opportunity of testing a Moscicki condenser, but was under the impression that the power-factor of that type was also above that given, and he was surprised that the power-factor of the Leyden jars tested by Mr. Mordey came out so near that of the Moscicki condensers, as he understood that the silvering direct on the glass reduced the losses considerably, compared with tin foil applied as it was to Leyden jars, and some tests he had made some time back bore out that assumption. An example would show how important such a small difference was from the practical point of view. Taking the condenser suggested by the author for 10,000 volts and 1 microfarad capacity, and occupying a space of about 2 cubic ft., at 10,000 volts that condenser would take a current corresponding to 31 apparent kw., and therefore the loss at 1 per cent. power-factor would be 310 watts. He thought the experience of members would show that 310 watts expended within 2 cubic ft. of material, which was not a good conductor of heat, would lead to an inadmissible rise in temperature, unless considerable subdivision and good ventilation were effected. On the other hand, if the power-factor were one-half, the heat would only be half and would be very much more within practical limits. The author had made no mention of the saving in capital costs of mains and the improvement in the working of alternating-current generators, by the use of condensers in practice.

Mr. James Swinburne (communicated) said that his firm, as it then was, made condensers about 1891 to take up the wattless or idle current of "hedgehog" transformers. Those condensers were made of oiled paper, which was first dried for some days, then further dried under vacuum, and finally treated with paraffin. The paraffin was to keep it dry, not to insulate; in fact, it reduced the insulation resistance. They made some specimen condensers that kept their charge for three weeks without perceptibly falling off, but the commercial condensers were not so good. They tried mica, waxed paper, glass, and other dielectrics. However, they found that glass heated; and that trouble was present, he believed, in all dielectrics whose inductive capacity was abnormal with reference to their index of refraction. As an alternative to condensers, over-excited motors were discussed. The idea was to uncouple one or two generators from their engines and let them run light and over-excited. That was published about 1891, but people had tried to patent it several times since. The uses of leading currents were more numerous than generally supposed. A leading current could be used for exciting a dynamo by armature reaction, or increasing its excitation. That was the cause of the phenomenon known as the Ferranti effect in the Deptford mains. He remembered reading a Paper before the Physical Society pointing out that the ordinary resonance theory of self-induction and capacity would not explain the phenomenon, and that the armature reaction theory would. The leading current could be used to alter the ratio of transformation of a transformer by making the inductive drop act in the opposite direction. How far it would pay to use condensers to prevent arcing at switches he did not know. Of course, the President's application to the surface contact system was a very special case, and yet it would have occurred to very few people to have tried such a solution. A new form of electro-dynamic condenser was brought before the Society in 1902. He had since found out that M. Leblanc was the real inventor of that or something very like it, and he would like to take the opportunity of calling attention to that point.

Mr. W. M. Mordey, in reply, said he was interested to hear that the metal was not vapourised; but he had a recollection of magnified photographs which Mr. Mansbridge had showed them of the faults that did occur, and they had the appearance of a small amount of metal vapourised round a small hole. As to the temperature of the test, that was normal, being the ordinary temperature of the workshop. He thought that the C^2R losses in the conductor of the condenser were, perhaps, less important than Mr. Mansbridge supposed. In the 10 microfarad condenser shown—which at 500 volts 50 ∿ had an apparent power of 785 v.a., or more than 1 h.p.—the total loss was only $4\frac{1}{2}$ watts, and a large portion of that loss was dielectric hysteresis, so that the possible reduction in the total loss due to any increase in the cross-section of the conductor must be small. He looked rather to cheapening these condensers than to further reduction in their losses. His object in reading the Paper was a very humble one. He merely wished to act as a sign-post to direct attention to a field that it might pay them, as engineers, to explore.

ON THE NATURE OF ELECTROLYTIC CONDUCTORS.

Ever since the discovery that water could be decomposed into hydrogen and oxygen by the electric current the question as to the nature of the substances that suffer chemical decomposition by the passage of an electric current has received careful experimental investigation. In this work the effort has naturally always been to ascertain what other peculiar chemical or physical properties were associated with this conductivity, and to which this property might be ascribed.

Researches on this subject were made by Faraday, who was able to divide substances into electrolytes and non-electrolytes, and who discoverd a famous law that forms the basis of all electrolytic work. Hittorf, Arrhenius and Van't Hoff have all advanced theories as to the true nature of electrolytes, but the fact must be calmly faced that no single physical or chemical property, so far as we know, affords any basis whatsoever of a correct view as to the nature of electrolytes as contrasted with non-electrolytes. Nevertheless, the various views presented have all been useful in that they have stimulated experimental inquiry which has brought out a vast quantity of new facts, though the latter have in all cases shown that the views entertained as to the nature of electrolytic conductors are quite untenable, being founded upon by far too narrow a field of induction.

Whether an electrolyte or a non-electrolyte results from a compound of a conducting with a non-conducting substance depends on the relative amounts of each present in the combination, while the temperature is also a factor of consequence. As an example, the compounds of tin with chlorine may be taken. Stannous chloride is quite a good electrolyte when in a fused condition, while stannic chloride is an insulator over a very wide range of temperature. Its non-electrolytic character is, therefore, not merely a question of state, but rather one of composition. In general, it may be said that every element tends to preserve its properties as it enters a com-

* Abstract of a Paper read before the American Electrochemical Society. "The Transactions," Vol. XIII.

pound, so far as the other ingredients in the compound will permit it to do so. In such properties as mass, specific heat, refractive power and specific volume, which are known to be additive or approximately so, the elements exhibit in a large measure the properties in the combined state which they had in the free state. In the case of properties like the optical rotatory power and electrolytic conductivity which are not additive in character, the elements, or groups of elements, retain their original properties to a much less degree, though it would be quite incorrect to assert that they lose them entirely.

On the basis of the above considerations it would seem easy enough to see why some substances containing metals should be electrolytes, and why others, which also contain metals, do not conduct. A great difficulty, however, arises in explaining why certain substances and solutions which contain no metals at all conduct electrolytically and others do not. In the face of the fact that in general compounds of metals with moderate amounts of non-metals form electrolytes, whereas there are also known compounds and notably solutions which conduct electrolytically and yet do not contain metals, one might well hold that the electrolytes which do not contain metals have yet a property which is characteristic of compounds containing metals. In this category we have notably acids and salts of non-metallic bases. The hydrogen of acids has always been considered as having metallic characteristics, and the fact that liquid hydrogen has after all been found to be a non-conducting, colourless liquid, and solid hydrogen a colourless, transparent solid, has been somewhat disappointing to many chemists.

In so far as many non-metallic salts do possess the power to conduct electrolytically, they are akin to metallic salts. Indeed, in consideration of the fact above mentioned, that metallic salts are very commonly electrolytes, one might almost incline to the view that, since the non-metallic electrolytic salts really have one of the very pronounced characteristics of metallic salts—namely, the power to conduct electricity—they represent a step toward the synthesis of the metals themselves. It must not be overlooked that very many salts do not conduct electricity. So, for example, the chlorides of carbon, silicon, sulphur and titanium, the oleates, palmitates and stearates of the heavy metals, and in general all alkyl halides and esters of various kinds are insulators. And it must also be kept in mind that many compounds rich in content of heavy metal like zinc ethyl, mercury ethyl and other organic metallic compounds are yet non-conductors.

It is relatively easy to understand why the conductivity of a metal should be reduced by union with a non-metal commonly forming an electrolyte or an insulator; but it is not so easily comprehended why in certain cases the union of the two very poor conductors should result in a very good electrolyte. Cases where two or more good insulators unite to form a good conductor of the first class are not known. Cases where excellent first-class conductors are transformed to either electrolytic conductors or insulators by chemical union with non-conductors are common; but we also have an abundance of cases where two insulators, or at any rate very poor conductors, yield a good electrolyte when combined with each other. As a typical example of the latter class, acetic acid and water may be cited. Both of these are very poor conductors indeed, whereas by combining the two the solution conducts well. All efforts to explain such cases have thus far failed. These efforts, of course, have been directed toward finding some other physical or chemical property of the solvent or solute, or both, to which the peculiar electrolytic conductance of the resulting combination, the solution, could be ascribed. Thus, the specific inductive capacity and the state of polymerisation of the solvent have been invoked but without avail. The supposed relation between the so-called osmotic pressure, vapour tension or freezing and boiling points of solutions, on the one hand, and their electrolytic conductivity and chemical activity on the other, has also repeatedly been shown to be quite untenable. Moreover, the comparison of the so-called molecular conductivity of solutions at different dilutions really involves a comparison of conductors of different cross-sections, and so cannot legitimately be used as a basis for further conclusions as to the nature of electrolytes, as is frequently done at present. The power of two non-conductors to unite to form a solution, or a compound in the narrower sense of the term, which is an electrolyte, is not confined to certain elements nor to certain peculiar combinations of elements. It must be admitted, of course, that all our notions as to the chemical constitution, so-called, of a compound are derived from the mode of building up or tearing down the compound and its behaviour toward re-agents. Our efforts to trace the power to conduct electrolytically to the chemical constitution of a compound are, therefore, simply efforts to find a relationship between electrolytic conductivity, on the one hand, and the behaviour of the substance in question toward other chemical re-agents on the other. And it is really not surprising at all that we should not be able to find any simple relationship to exist here. We do not know why a piece of silver conducts and a piece of sulphur does not, though the experimental fact in question has been known for a long time; and we are really much more in the dark as to why some compounds conduct electrolytically, others do not conduct at all, and still others conduct without decomposition. A frank acknowledgment of the actual situation seems very desirable, for it is bound to stimulate inquiry that will lead to a better comprehension of the phenomena of conduction. The few experiments which have been made thus far with induced currents in electrolytes show that when no electrodes are used electrolytes conduct the same as the metals themselves. The presence of electrodes seems, consequently, essential in order that electrolysis may take place. The statement of Faraday that the electrodes are the doors at which the electrolytic products are eliminated by the electric current, which acts as an axis of force, is as adequate as ever in summing up the situation. The concentration changes which occur at the electrodes in solutions may be regarded as secondary phenomena produced by the chemical changes taking place at the surface of the plates. Experimental facts show that the viscosity is really quite a minor factor in determining the conductance of electrolytes. In the case of all liquid electrolytes, Faraday's law has been found to hold at room temperatures and also at high temperatures. Recently tests in this laboratory have shown that it is also valid at quite low temperatures. In the cases of gases, it is well known that Faraday's law generally does not hold. The study of radio-active phenomena and the power which various emanations have to make an air-gap conduct has rightfully aroused much interest, and experimentation and also speculation as to the nature of electricity and matter and their inter-relations. Much more intelligent experimentation must be made upon the subject of electrical conduction in general and electrolytic phenomena in particular before we can hope for a real improvement of our theories of the inter-relation of electricity and matter and our views of the process of electrolysis and the nature of electrolytic conductors.

A NEW FORM OF STANDARD RESISTANCE.*

BY E. B. ROSA.

Summary.—A description is here given of the new standard resistances which have been designed and made at the Bureau of Standards, Washington. These resistance coils are sealed and are unaffected by changes in atmospheric humidity. The measurements made show a remarkable constancy in the value of the resistance, the variations being only in the neighbourhood of 1 part in 100,000.

In a previous article† an account was given of an investigation of the effect of atmospheric humidity upon the resistance of coils of manganin wire. The resistance always increased by an appreciable amount when the humidity of the atmosphere surrounding the coil increased, owing to the swelling of the shellac, the wire embedded in the shellac being stretched by an amount depending on the relative humidity of the air and the length of time the coil was exposed. It was found that keeping the coils submerged in pure high-grade petroleum oil, as is usually done in precision resistance measurements, did not prevent this change, although it largely retarded it. Such oil in a damp atmosphere absorbs moisture and passes it on to the shellac, and in a drier atmosphere gives it up again. The effect is increased by stirring the oil to secure uniformity of temperature.

Dr. Lindeck‡ and Mr. F. E. Smith§ have confirmed these results. Dr. Lindeck found two methods of reducing the change produced by humidity. The first was to use a heavy paraffin oil, which absorbs and transmits moisture to a less degree than the petroleum oil commonly used. The second was to use a very thin tube on which to wind the resistances, and to cut slits in it, so that the tube yields readily to external pressure. The objection to the first method is that the heavy paraffin oil is less mobile and does not equalise the temperature of the bath as readily as the lighter oil, and is less convenient in use. The second method does not permit as substantial a construction as the usual form of coil, and would not seem to be a satisfactory solution, even if it prevented the change to a greater degree than it does. As, however, neither method, according to Lindeck, prevents the coils entirely from changing, some other method must be employed. The methods which have been employed at the Bureau of Standards are here described.

The design which was adopted more than a year ago, and which experience has since shown to be perfectly satisfactory, is shown in

* Abstracted from the "Bulletin of the Bureau of Standards."

† THE ELECTRICIAN, Vol. LX., p. 162.

‡ THE ELECTRICIAN, Vol. LIX., p. 626.

§ THE ELECTRICIAN, Vol. LXII., p. 222.

Fig. 1. The coil is wound in the usual manner on a brass cylinder 30 mm. in diameter and 70 mm. long, and is contained within a cylinder 40 mm. in diameter and 12·5 cm. high. The coil is shellacked, dried and annealed in the usual manner, as originally specified by the Reichsanstalt. The coil is supported, as shown, by a small

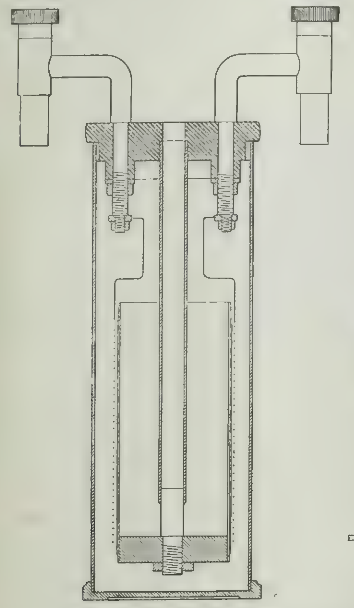


FIG. 1.—SECTION OF SEALED RESISTANCE STANDARD.

tube (closed at the bottom) which serves as a thermometer tube. The hard-rubber top through which the leads pass is threaded, and screws into the outer brass cylinder which forms the case. When the coil is finally adjusted the case is nearly filled with pure oil that has been freed from moisture, and the top screwed firmly into place. To make the joint perfectly tight, shellac is usually put into the threads before screwing up. Shellac is also put into the joints in the top, where the leads and thermometer tube pass through the ebonite. The terminals dip into mercury cups, but the upper potential terminals may ordinarily be used as current terminals. Only in low-resistance coils (1 ohm and less) is the difference in resistance appreciable.

Sealing the standards in this way possesses several distinct advantages. First and most important, of course, is the protection against the changes in resistance due to the absorption of moisture

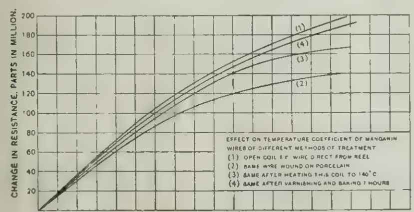


FIG. 2.

by the shellac (or varnish or other protective covering). In the second place, it protects the coils from dirt or mechanical injury, to which they are liable if open. And, finally, if any bare spots exist, due to shellac coming off or being imperfectly applied, the oxidising effect of moisture in the oil bath and of the atmosphere is far greater than it can be when the coil is sealed air tight in very pure dry oil. Hence the resistances are not only protected from the serious fluctuations from day to day, and the still greater seasonal changes due to moisture, but also from slower changes due to oxidation of the manganin and the possible sudden changes due to accident.

The new form of resistance standard is much smaller than the Reichsanstalt type, so long and so favourably known throughout the world as a standard of resistance. It weighs only about 400 grammes filled, and measures only 7·5 cm. across the terminals, instead of 16 cm. For measurements up to an accuracy of 0·001 per cent. it is measured as it stands, its current capacity being ample when using reasonably sensitive galvanometers, and the small thermometer in the central tube giving its temperature with all needed accuracy. The temperature coefficient is generally not greater than 0·002 per cent. per degree, so that a quarter of 1 deg. uncertainty in the temperature would cause an error less than that allowed.

When used as standards of the highest precision, and measured to one part in 1,000,000 or closer, it is necessary to know the temperature of the coil very accurately. The standards are then submerged in an oil bath which can be stirred and kept at constant temperature and the precaution taken not to use current enough to make the temperature of the wire uncertain. The standards when properly prepared and aged are remarkably constant in value, and in measuring them to test their constancy the author has been obliged to take extreme precautions in order not to have their slight variations exaggerated by errors of measurement. The temperature coefficients of the coils vary through wide limits, the average value

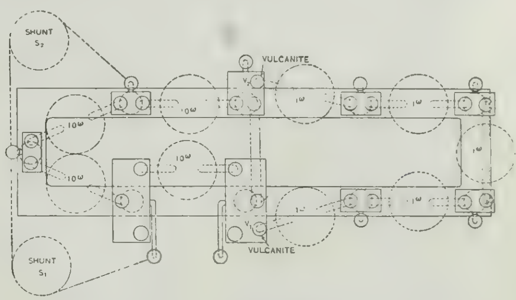


FIG. 3.—PLAN OF BRIDGE.

between 15°C. and 30°C. generally falling between 4 and 20 parts in a million per degree, but sometimes exceeding 20. Different specimens of manganin wire vary greatly as to temperature coefficient, and hence it must be carefully selected if the coils are to have coefficients as small as these.

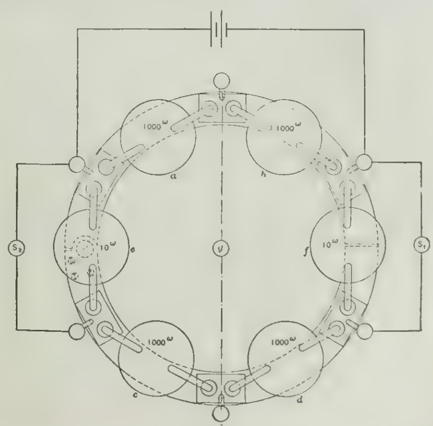


FIG. 4.

Particulars of measurements on a number of samples of wire are given in the "Bulletin." The resistance curves are seen to be substantially parabolas, and the temperature coefficients vary greatly through the range 15 deg. to 25 deg. The curves serve as a warning to anyone anxious to make good resistance standards not to use manganin wire without first testing it for temperature coefficient. Fig. 2 herewith shows the effect on the temperature coefficient of different methods of treatment.

The apparatus employed in comparing the coils of any denomination with one another consist of a Wheatstone bridge with the coils arranged in a circle (*see* Fig. 4), having two extra coils inserted, on

which shunts may be applied for balancing the bridge instead of shunting directly the ratio coils. Or these two openings may be closed by heavy links and the shunts applied directly to the ratio coils. The circular frame is so hinged that it may be opened far enough to admit a larger coil; as, for example, one of the Reichsanstalt form. The apparatus is very convenient, is compact, requires a relatively small oil bath, or may be used without an oil bath except in comparisons of extreme precision, and will accommodate any kind of a resistance standard that is provided with terminals for dipping into mercury cups.

For stepping up from one denomination to another the author has designed the form of bridge shown in Fig. 3. This is a very compact and convenient apparatus for comparing the sum of five coils of one denomination with two coils in parallel of the next higher denomination.

Observations, particulars of which are given in the "Bulletin," show a remarkable constancy in the resistance of the coils. While they are not all constant, there is only one coil of the 28 under observation that has changed as much as two parts in 100,000 during the past 12 months. This coil is regarded as defective. Of the other 27 coils, more than half have changed less than one part in 100,000.

Measurements have also been made on 13 1-ohm coils during the past three months. In seven coils the average deviation is less than one part in a million, and for the entire 13 the mean of the average deviations is exactly one part in a million. These comparisons were made at temperatures ranging between 15°C. and 28°C., some of them thus involving considerable temperature corrections, and the small variations are no more than the probable errors of the measurements. On the other hand, open 1 ohm coils exposed to atmospheric influences sometimes change appreciably in a single day, or even in a few hours; and although the average values of the 1 ohm standards at the Reichsanstalt have undoubtedly remained very constant for some years, Dr. Lindeck has recently found a difference of about 13 parts in a million in his 1 ohm coil between April and October. His coils of larger denomination—of 10, 100, 1,000 and 10,000 ohms—changed in the same time from 28 to 75 parts in a million. Moreover, these changes occurred in the favourable climate of Berlin, whereas in London or Washington the change could be expected to be much greater.

The reference standards of the Reichsanstalt are now being kept in an atmosphere of constant humidity in order to avoid these changes, and at the National Physical Laboratory the reference standards are about to be sealed for the same reason.

A further study of these resistances is, of course, necessary, but the author thinks it not improbable that if three or four national laboratories were each supplied with a dozen sealed standards of the Bureau of Standards type, and they were occasionally intercompared by means of a number of travelling coils of the same type, that a mean international ohm could thus be maintained constant to within one or two parts in a million, and a reference to primary mercury ohms would need to be made only at relatively infrequent intervals.

Reference is then made to the comparison of standard resistances at Washington, London and Berlin. These showed that the values assigned to the coils in Washington differed from the values found at the Reichsanstalt by about one part in 100,000 on the average. This shows excellent agreement in the stepping up at the two institutions.

Such intercomparisons of resistances between the several standardising institutions should be made from time to time, and a mean value of the international ohm derived therefrom, which would be used by all countries. Now that resistance standards are available that can be depended upon to within a few parts in a million, probably for long intervals of time a concrete international ohm can be maintained that can be used in all countries, and the value of a resistance standard will then be the same from whatever source it is derived. It only remains to have established some permanent official body as an international electrical commisssion, which may cause the necessary intercomparisons of the several mercury standards to be made, and deduce therefrom the value of the common international ohm. In the same way intercomparisons of other concrete standards, as standard cells, inductance coils, &c., will fix the values concretely of the various international units, and so promote uniformity in standards and advance the precision of electrical measurements.

Particulars are finally given of a special form of Wheatstone bridge which is termed an Anderson bridge, employed for measuring inductances, and two special precision rheostats. The bridge is used with alternating currents, employing tuned galvanometers, and to increase its current-carrying capacity, in order to give a high sensibility, the bridge has a metal case which is filled with petroleum.

CENTRIFUGAL FORCE.

BY H. LUCKIN.

On looking into most text and pocket-books for the formula for centrifugal force one usually finds the following

$$F=\frac{WV^2}{gR},$$

when W=weight in pounds, V=velocity in feet per second g=32·2 and R=radius in feet, while in those which go into details something after the following will appear:—

When a particle of W lb. moves in a circle of R ft. radius, with a velocity of V ft. per second, it must be pulled or pushed towards the centre of the circle by a force, F, whose magnitude in pounds $=\frac{WV^2}{gR}$, $g=32{\cdot}2$.

This, as far as it goes, is, of course, quite correct, as from this formula all other centrifugal force formulæ are derived, but where it is in frequent use, as it is in most electrical drawing offices, for calculating the centrifugal forces acting on the various parts of the armatures, windings, commutators, &c., it is found to be rather a tedius formula.

Let us take this formula $F=\frac{WV^2}{gR}$, and from it deduce a simpler one. Now, W in pounds we cannot very well simplify, but V=velocity in feet per second armature speed are, however, given at so many revolutions per minute, so for V we may read $\frac{2R\times\pi\times N}{60}$ if N=the number of revolutions per minute. Again, R is in feet, but it is usually found in calculations much easier to work with R in inches, as this saves converting such dimensions as $5\frac{7}{8}$ in. into the decimal part of a foot. Therefore let us take R in inches, and so for R we must read R/12. Then, by making use of these values in place of V and R respectively, the formula will read

$$F=\frac{W\times 4R^2\times\pi^2\times N^2}{32{\cdot}2\times R\times 60^2\times 12}=0{\cdot}0000283WRN^2;\text{ or }\frac{WRN^2}{35{,}340}.$$

The second of these two is, perhaps, the better, as it does away with the objectionable 0·000s which is apt to lead to confusion when calculating with a slide rule. Of course, if it is found more desirable to work with R in feet multiply the above formulæ by 12; they will then read $F=0{\cdot}000341WRN^2$ and $WRN^2/2{,}941$ respectively.

I think the formula $F=\frac{WRN^2}{35{,}340}$ when once tried will always afterwards be used, as it lessens the chance of error somewhat, eliminating, as it does, converting revolutions per minute into velocity in feet per second, and inches and fractions of same into the decimal part of a foot. For those constantly engaged in centrifugal force calculations the following table will, however, be found to be still more useful.

The table gives the centrifugal force in foot pounds for 1 lb. at 1 in. radius for any number of revolutions per minute from 10 to 990, advancing by tens, and can, of course, be used for 1,000 to 9,900 revs. per min. (advancing by hundreds) by moving the decimal point two places to the right. To use the table multiply the figure in the table by the weight in pounds and by the radius of gyration in inches. Thus centrifugal force due to 23 lb. being rotated at 900 revs. per min., the radius of gyration being $4\frac{3}{4}$ in. $=C\times 4{\cdot}75\times 23$, and as for 900 revs. per min. C=23, then $F=23\times 4{\cdot}75\times 23=2{,}512$ lb.

R.P.M.		10	20	30	40	50	60	70	80	90
.	C	0·00283	0·0114	0·0256	0·0455	0·0711	0·102	0·139	0·182	0·230
100...	0·283	0·344	0·409	0·480	0·557	0·639	0·728	0·821	0·921	1·03
200...	1·14	1·25	1·38	1·50	1·64	1·78	1·92	2·07	2·23	2·39
300...	2·56	2·73	2·91	3·10	3·29	3·48	3·68	3·89	4·10	4·32
400..	4·55	4·78	5·01	5·25	5·50	5·76	6·01	6·29	6·55	6·82
500...	7·11	7·39	7·68	7·98	8·29	8·60	8·91	9·23	9·56	9·89
600..	10·2	10·6	10·9	11·3	11·6	12·0	12·4	12·8	13·1	13·5
700..	13·9	14·3	14·7	15·2	15·6	16·0	16·4	16·9	17·3	17·7
800...	18·2	18·7	19·1	19·6	20·1	20·5	21·0	21·5	22·0	22·5
900...	23·0	23·5	24·1	24·6	25·1	25·6	26·2	26·7	27·3	27·9

AN ECCLESIASTICAL ASPECT OF ELECTRIC FANS.

In this enlightened country the climate does not allow us to take fans in what is really a serious manner, or even to think of them without a shudder for the greater part of the year, though the lovely weather that we have been lately enjoying has no doubt had the effect of putting a number of these apparatus, and we hope electrically driven ones, into more or less extended use. In more sultry climates the matter is altogether different, and the employment of fans is very wide. This is particularly the case in India, where the large white population, who are by nature unfitted to withstand the great heat, makes some sort of artificial ventilation an absolute necessity in practically all the buildings. Man-driven punkahs have been used since the very earliest days, but these are now being gradually superseded by electrically-driven fans.

And this is as it should be. Further, perhaps no other firm have more aided the development of electric fans in India than have Messrs. Crompton & Co.; in fact, we have from time to time in these columns called attention to the many interesting details of the installations which they have erected in India. One of the latest buildings in that country to which Crompton fans have been supplied is of an ecclesiastical nature, St. Thomas's Cathedral, Bombay. The ventilation of churches, even in this country, is often not all that can be desired, and the soporific results are well known. To remove these difficulties a number of Crompton fans have been installed in this cathedral, and their method of installation is shown in the accompanying illustration. Each pillar supports four handsome wrought-iron brackets, from each of which is suspended a standard Crompton ceiling fan, whose details, both electrical and mechanical, are well known to our readers. The work has been carried out by Messrs. Greaves, Cotton & Co., and certainly reflects great credit upon them. Even in India the ventilation provided by these fans should be ample, and there should be no excuse for drowsiness among the congregation, at this church at any rate.

CROMPTON FANS IN ST. THOMAS'S CATHEDRAL, BOMBAY. (Installation by Greaves, Cotton & Co.)

ELECTRIC TRACTION ON RAILWAYS.*
XIV.—PRACTICAL CONSIDERATION OF OVERHEAD CONDUCTORS.

BY PHILIP DAWSON.

(*Continued from page 173.*)

Summary.—In this article the author first considers the many objections which have been raised against the use of the third rail for main line railway electrification, and then proceeds to discuss the use of overhead conductors, dividing the latter system into those where two overhead conductors per track are necessary and those where only one conductor per track is required. The construction of the overhead work is also considered in detail.

Having now described some of the most important examples of overhead construction adopted in connection with high-tension single-phase railways, with suburban and country lines, we will consider more carefully some of the many details which have to be used in connection with such construction. Fig. 26 illustrates the construction adopted by the Westinghouse Company for the single catenary bracket arm type of suspension. It will be seen that the droppers or hangers which support the trolley wire from the catenary are malleable castings, or drop forgings, and that corrugated porcelain insulators are fixed over the bracket arm. Two types of insulators are shown, one suitable for pipe arms and the other suitable for arms of T-iron construction, single insulators being resorted to. At the same time it will be noticed that every pull or push off device required the insertion of at least one additional insulator, in other words that the form of insulators is in many ways comparable to the construction which has so long been adopted for trolley lines for tramways. Fig. 26

illustrates the different points in such detail, and their uses are so self-evident and so clearly shown in the illustration that no further detailed description is needful here. The earthed loop shown in the illustration is fixed to the main bracket insulator, serving to earth the catenary in case of breakages, and also serves to protect the insulator from mechanical damage, in the case when ordinary trolleys are used which might come off at an insulator, and, flying against it, cause a fracture.

When span wire construction is used the bracket arm insulator already described is fitted on to a piece of pipe having a loop at each end and this is fixed by means of a span wire attached to each end of it to the two cross poles supporting the span. Fig. 27, from a photograph, gives details of the section insulator used, which consists of an armoured wooden strip about 5 ft. long, supported as shown. Fig. 28 shows an entirely different form of sectional insulator construction as used on one portion of the Swedish State Railways experimental line.

Experience has proven that moulded insulators, while quite satisfactory for low voltages, are not entirely satisfactory for high voltages. Porcelain has proved to be the best all-round insulating material that has yet been developed. The trouble in the past has been that while porcelain has good mechanical strength in pure compression, its strength cannot be relied on in tension or in bending strains, although, as previously shown, very good results have been obtained with properly designed and manufactured porcelain insulators.

In the insulator shown in Fig. 29, the portion of the porcelain carrying the load is so disposed that it is impossible for any but compression strains to reach the porcelain. It will be noticed in the cut that a good sized mass of porcelain placed between two parallel surfaces carries the load. The head of the insulator which carries the load is enveloped in a split malleable iron case, the joint of which is packed to keep out moisture. The insulation of the head is further protected by a moulded mica cap cemented on with an insulating cement. This ensures the head of the porcelain against moisture and dirt.

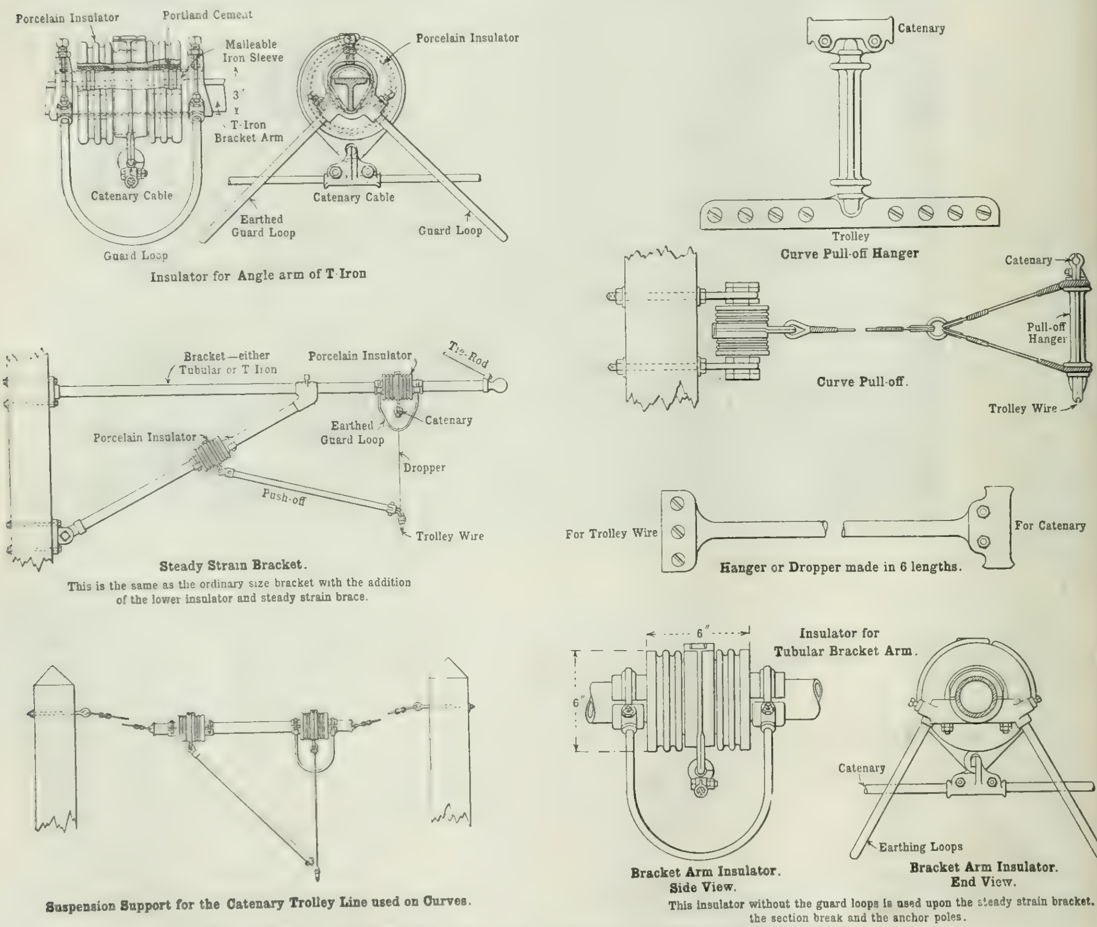


Fig. 26.—Details of Westinghouse Single Catenary, Bracket Arm Construction.

Other features claimed for the insulator are (*a*) the head of the bolts passing through the porcelains are larger than the opening in the shell, so the line can never get away should the porcelain be broken into small pieces and drop out. (*b*) The portion of the porcelain having the greatest electrical strain is free from mechanical strain. (*c*) In case

the porcelain neck becomes cracked, the resulting arc will not burn the cable and cause it to break.

The essentials of the anchorage scheme illustrated in Fig. 30 consists of anchoring catenary and trolley to a bracket arm and anchoring the bracket arm to the adjacent pole on either side. The catenary is supported on the regular insulator whose stud passes through the bracket arm and an "anchor plate" on the bottom of the bracket arm. The catenary and trolley wire are anchored to this plate by means of a strain insulator, spreader, clamp ear, and cable clamp as shown. This brings all parts of the same vertical plane with the catenary and trolley wire so that when ordinary trolleys are used, as is usual on American interurban routes, the trolley wheel cannot strike them if it comes off the wire. The plate also affords protection for the insulator against the trolley pole.

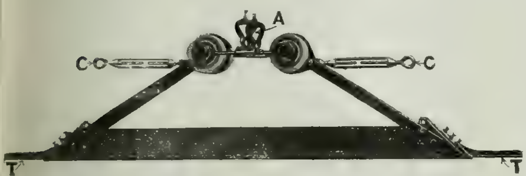


FIG. 27.—WESTINGHOUSE SINGLE-PHASE SECTION INSULATOR.
A—Clips through which T of bracket arm passes. C=Catenary. T=Trolley wire.

This scheme of two-point anchor avoids pulling the trolley wire away from the centre line of the track, as is the case when the anchor is attached at the middle of a span. It also allows flexibility at the anchor point, and by means of the spreader avoids "cupping" the trolley wire by applying the strains on catenary and trolley wire in parallel directions.

It will be noted that in this construction also provision is made for the use of an ordinary trolley and trolley wheel, which is quite suitable in connection with interurban American railway practice, but which could not be tolerated under the working conditions obtaining with main line

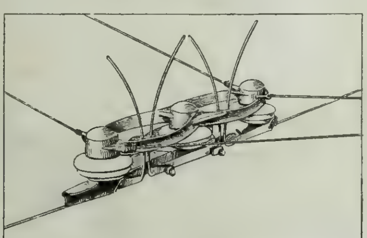


FIG. 28.—SECTION INSULATOR, AS USED ON THE SWEDISH STATE RAILWAYS.

railway working, where, of course, it must be out of the question for a current collector to ever get off the overhead conductor.

Some further American construction details as regards the practice of the General Electric Co., of America, will now be considered in connection with the Toledo and Chicago interurban single-phase railway which was equipped by them. The trolley line consists essentially of a grooved copper wire and a steel catenary cable, also called "messenger" in America. The former is of No. 000 hard-drawn copper and the latter is composed of seven strands of No. 77 B. & S. steel wire. The diameter of the catenary cable is $\frac{3}{8}$ in. and is made of a special grade of steel having a tensile strength of 70,000 lb. per square inch. The trolley is suspended every 50 ft. from the catenary cable by means of mechanical clips, of which two forms are used. One of these (illustrated in Fig. 25) supports the trolley midway between the poles, at the point where the amount of catenary sag is a maximum and is attached to the catenary

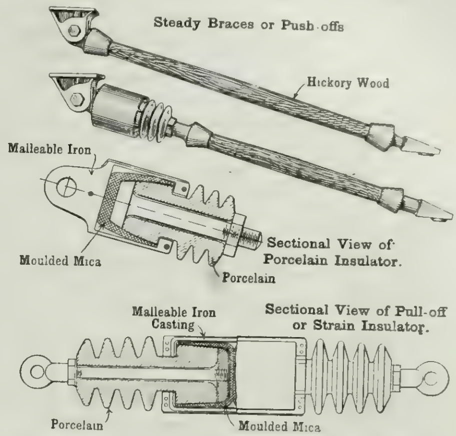
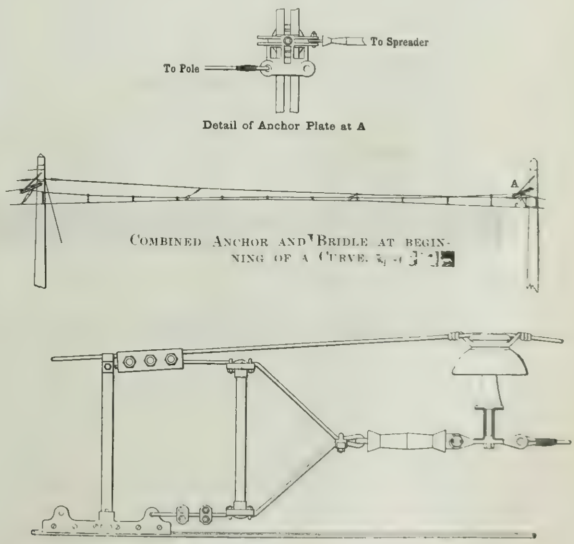


FIG. 29.—PUSH AND PULL-OFFS JOHNS-MANVILLE TYPE.

by means of the sister hooks seen. The one shown in the figure is used at other points and is suspended from the catenary by means of flexible steel wire or rigid distance pieces.



ANCHOR SPREADER.

FIG. 30.—DETAILS OF JOHN MANVILLE SINGLE CATENARY CONSTRUCTION.

The bracket arms are made of $2\frac{3}{8}$ in. external diameter structural steel piping. They are fastened to the poles by means of a flange and two lag screws and are supported by a $\frac{5}{8}$ in. guy rod. In Fig. 31 all the essential details of the bracket construction are clearly shown, whilst Fig. 32 gives details of attachments. The trolley is supported 20 ft. above the track. The type of insulator used to support

the catenary is shown in Fig. 33, and is of porcelain, 5 in. in diameter and $3\frac{7}{8}$ in. in height and has a surface distance of $7\frac{1}{2}$ in. These insulators weigh 3 lb. each and were tested to withstand 40,000 volts pressure. They are attached to the malleable iron pins by means of cement.

We will now consider a little more in detail the overhead section switches adopted in connection with this form of construction. There are two forms of aerial switches generally used: one in which the whole switch is mounted

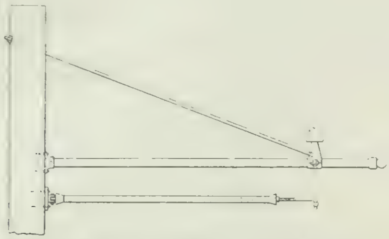
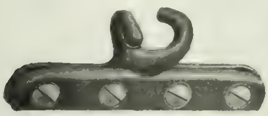


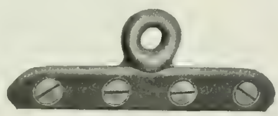
Fig. 31. Bracket and Steady Brace Now Used

on porcelain insulators which are fixed and in which the ring is operated by itself to open and close a circuit, a counterweight usually being provided in order to make closing and opening (as the case may be) certain. This type, as used on the Swedish State Railways, is shown in Fig. 34, and is operated by means of an insulated rope fixed in a locked box at the bottom of the pole, as seen in the illustration. This type has not proved satisfactory, as it has been found that, owing to the counterweight that is required, it is liable to go to pieces.

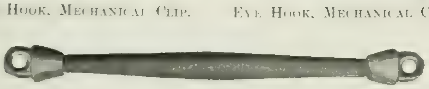
Another type which was evolved by the Swedish State Railways themselves is shown in Fig. 35. It was made by slightly altering a Siemens lightning arrester. As will be seen, in this type the insulators themselves form part of



Sister Hook, Mechanical Clip.



Eye Hook, Mechanical Clip.



Hickory Strain Insulator.

Fig. 32.—Constructive Details, General Electric Co., Toledo and Chicago Interurban Railway.

the moving switch contacts, being connected to one end of a right angle lever, hinged at the centre, and at the other end of which the counterweight is attached.

Another form of this arrangement as installed by the Siemens-Schuckertwerke on the Hamburg-Blankenese line is shown in Fig. 36. This illustration also clearly shows the bending in wires from the overhead feeder to the contact wire.

A most careful investigation of everything that has been done either in Europe or America was made by the writer before he eventually decided on the overhead construction adopted on the South London line of the L.B. & S.C. Railway. As a complete description of this installation will be given later on, reference will not be made to it here. The design of overhead construction requires the most careful investigation and attention, before being definitely laid out and settled upon. Large scale and accurate p'ans of the tracks are necessary, but it is essential to verify the whole lay out on the site, and the greatest care must be exercised in selecting the position for the supports, so as to render them not only as little objectionable as possible from a railway point of view, but also so as to locate them in positions in which there is little or no likelihood of their being disturbed.

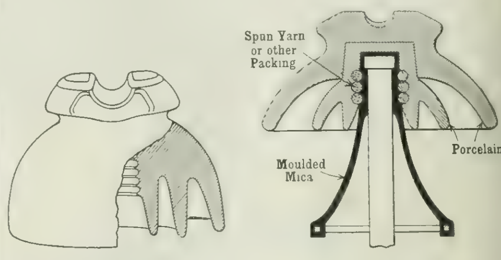


Fig. 33.—Catenary Insulator used on the Toledo and Chicago Interurban Railway, as made by the General Electric Co.

The following are a few of the points which must be borne in mind when laying out a system, and it is important to recollect that the overhead construction for one of our main line railways must, under no circumstances, be considered as a sort of glorified tramway construction.

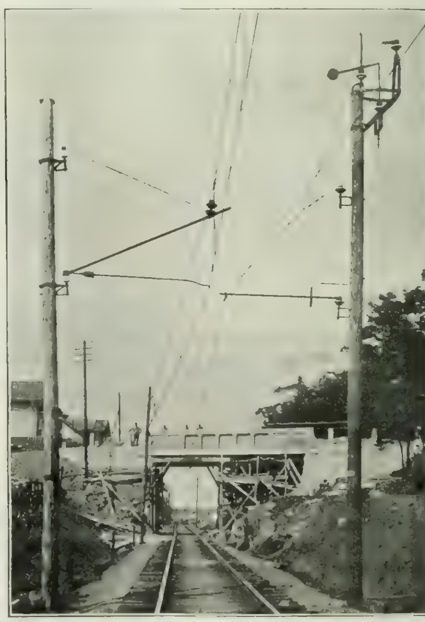


Fig. 34. Overhead Switch, Old Type, Not Recommended. Swedish State Railways.

It should be designed on the same basis as that on which all railway work is designed and constructed, and that is, as far as such a result is possible, with a view of, or practical impossibility of, mechanical breakages occurring. In America, with but few exceptions, such as the New York. New Haven and Hartford, the single-phase high tension system has been used on long interurban roads, and not for

main line railway working, and hence the overhead construction, as will have been seen, by what has been said, in this chapter, in many cases resembles a sort of glorified tramway construction. This may be all very well from a point of view of securing cheap construction, and on lines where, if a trolley wire were to break, no very great harm would be done. Totally different conditions apply when

Fig. 35.—Form of Ordinary Siemens Lightning Arrester, Converted into Switch. Swedish State Railways,

considering the problem of electrification of one of our main line railways, and it is in this connection that a few of the very many points which require attention have been set forth below :—

Some Maxims and Rules to be Borne in Mind when Laying Out and Designing Overhead Construction for Railway Work.

1. The number of insulators should be as small as possible, the fewer the points of insulation, the less the danger spots

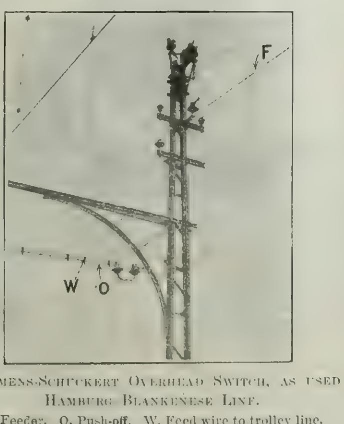


Fig. 36.—Siemens-Schuckert Overhead Switch, as used on the Hamburg Blankenese Line.

F Feeder. O, Push-off. W, Feed wire to trolley line.

2. The mechanical and electrical strength of the insulator adopted should be so great as to render the likelihood of a breakdown, under the worst conditions, very remote.

3. No pull off wires should be used if it is possible to avoid them, and for pull or push off points actual supports should be utilised, as well as the principal insulators already installed for supporting the catenaries and conductor wires.

4. Remember never to use porcelain, except in direct compression, and to see that the bearing surface taken on the insulator surface is large, and that as far as possible uniform pressure is exerted on it.

5. A soft material such as leather fibre or lead, according to circumstances, should be inserted between the insulator and the clip that surrounds it, where bolted clips of any description are used.

6. If little caps are fixed to the top of insulators these should be very firmly attached to the insulator by means of proper cement, which is non-hygroscopic, and which does not expand in setting, and which is not effected by heat or by vibration. For this purpose a mixture of red lead and glycerine has frequently been used.

7. All fixtures of insulators should be such as to render them easily and rapidly removable under the most adverse circumstances of light and weather ; no special tools should be required, no nuts or screws of bolts should require unfastening in order to replace the principal insulator.

8. Nothing but the very best form, from the manufacturing point of view, and quality of insulator should be used, and in this connection special attention is called to the remarks on porcelain insulators made in a previous part of this article.

9. Precautions must be taken so as to render it absolutely certain that when men are at work on the line it is not only cut off from current supply, but also earthed.

10. Great care and forethought must be exercised in deciding upon the sectionalising of the line, so as to meet the railway requirements.

11. All clearances between the live wires and standards should be as great as circumstances permit.

(To be continued.)

INTERPOLE DESIGN.

We give below a short account of the discussion which took place at a meeting of the Glasgow Local Section of the Institution of Electrical Engineers, when Mr. W. B. Hird read his Paper on the above subject. An abstract of this Paper appeared in our last issue.

The Chairman (Mr. W. W. Lackie) said the subject was of increasing importance and of great moment to manufacturers. His first experience of inter-pole design was not very happy. The characteristic of a shunt machine with interpoles resembled that of a compound-wound machine, and the result was that in running in parallel the interpole machine endeavoured to do all the work, sending, in the case of a short-circuit, a reverse current through the shunt-wound machines and operating the reverse-current cutouts. Several methods of overcoming this had been suggested, one being to insert a resistance between the interpoles and the switchboard, so as to cause a drop in pressure when a heavy load was on. The method now adopted was to put one or two reverse series windings on the field of the machine. The other trouble with interpole machines was that if the brushes were moved or required to be moved beyond the zone of the interpole the difference of potential per segment of commutator was high and flashing over took place. The author had referred to forced ventilation, but he, the speaker, thought it had been found that fixing fan blades on the spider was not always so economical as a separate fan.

Mr. H. A. Mavor thought the points raised were of very great importance. For a long time he was sceptical of interpoles, because of the methods necessary in getting rid of the troubles introduced. That was true before reactance voltage was so fully understood. It was about 25 years since Prof. Ryan, of Bristol, first suggested interpoles. It was remarkable how the invention lay dormant for many years. Possibly increasing the diameter of machines, decreasing the cost of materials, and increasing the output by keeping the reactance down would be better than having smaller diameters and using interpoles. The difficulty referred to by Mr. Lackie would also not arise, but they were face to face with the difficulty that large diameters were unsuitable for coupling to turbines, and such a device as suggested must be adopted for running in parallel.

Mr. McWhirter mentioned that at one time it was the sparking limit which governed the output, but now it was the heating limit. If the cost

was kept down, as it appeared to be by interpoles, there was no doubt the other advantages were great, and led to the absence of sparking. He asked for a simpler explanation of the reactance voltage formula given by the author, the expression "20 lines per inch length of core" appearing strange. Did it mean length parallel to the spindle ?

Mr. Hird : Yes.

Mr. McWhirter also said he considered Mr. Lackie's suggestion of an external fan was a good one.

Dr. John S. Nicholson thought that if the output was limited by heating they should try and eliminate the heating without the use of a fan. The better the iron and other materials used the less would be the heating, and a great advance on those lines was being taken.

Mr. C. McMillan mentioned that he was an understudy of Mr. Hird's predecessor, and approved of his methods. (This referred to Sayer's special armature windings.) Progress, in his opinion, must be obtained without such refinements as extra forced ventilation. The lines indicated by Mr. Hird should be followed as closely as possible by designers. He would like to know what success attended the attempts at forced ventilation for railway motors. The results were not very accessible. He also asked if the curves shown applied to experience gained, and so represented the commercial facts of the case, or whether they applied to a limited range. Minor facts, such as increase in strength of shaft to deal with the large weight of armature, were added, and they began to vitiate the simplicity of the laws indicated by the graphical results.

Mr. H. A. Mavor, interposing, said Mr. McMillan's remarks suggested a note of warning to young engineers in dealing with such problems. Wages, material and other things did fluctuate, and for estimates of cost of machinery one must not expect to get within 10 per cent. of the true price.

Mr. E. G. Tidd thought Mr. Hird seemed to have discovered a conspiracy against interpole design. Interpoles were now recognised as a commercial success. The most compact motor sold more readily than any long inartistic looking arrangement.

Mr. J. R. Barr considered that interpoles were only justified in the case of special machines.

Mr. T. G. Pearson asked if water cooling had not been tried. It might be simpler than air.

Mr. Hird replied briefly.

LANGDON-DAVIES MOTORS.

In the simplicity of their control alternating-current induction motors possess a feature which will always make them popular with power users, and the limit of simplicity, particularly as regards design, is probably reached in those of the squirrel-cage pattern. A name which has always been intimately connected with this type of

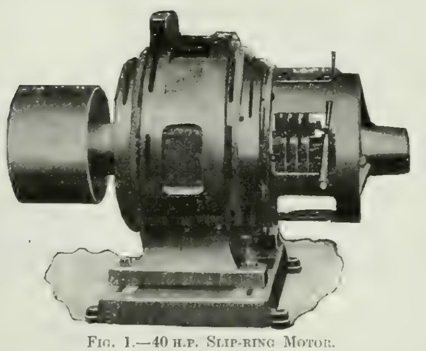


Fig. 1.—40 h.p. Slip-ring Motor.

motor is that of "Langdon-Davies," and an inspection of the motors now being supplied by the Langdon-Davies Motor Co. shows the great developments that have taken place in the design of squirrel-cage motors since the latter were first introduced.

It must not be thought, however, that the Langdon-Davies motors are only of the squirrel-cage type, as motors of all sizes with wound rotors are continually being manufactured by the company, and an interesting arrangement of a slip-ring motor is seen in Fig. 1.

It will be remembered that in its early form the squirrel-cage rotor consisted of a number of copper rods inserted in holes in the iron core and soldered to a copper ring at each end, the holes being placed close to the periphery of the rotor so as to avoid magnetic leakage. This design was liable to cause trouble due to the conductors not being quite symmetrically placed in regard to the magnetic field. When the open-slot type was next evolved, this difficulty, of course, was practically surmounted, and open slots have now become standard construction.

Round wires were for many years employed for the winding inserted in the slots, but flat strip is now adopted and possesses many advantages. Of these we may mention the fact that the slots become much narrower—indeed, they may simply be regarded as saw-cuts in the body of the rotor—with consequent greater economy in iron, and also improved efficiency. The method of fixing the conductors is as follows : The iron sheets forming the rotor are clamped between two gunmetal end plates ; after the saw-cuts have been made in these plates and the conductors inserted, the surface of the gunmetal is milled, this process resulting in the conductors being securely held in the slots. The ends of the copper

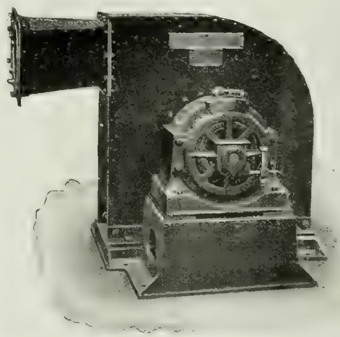


Fig. 2.—Squirrel-cage Motor driving High-pressure Centrifugal Fan.

strips are bent over flat against the end plates of the rotor, the ends of every third or fourth strip, however, are left unbent, and, forming a blade, thereby promote the ventilation of the motor.

In the original type of rotor, in which the holes or slots were parallel with the shaft, the turning moment was uneven ; it was soon found, however, that an improvement resulted if the slots were cut at an angle to the axis of the rotor, and that form of construction is now always adopted, the amount of slant being made slightly greater than the pitch of the slots so as to allow a little overlap.

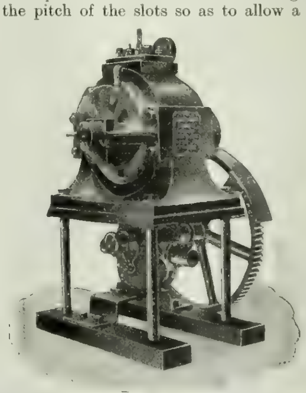


Fig. 3.—Small Single-phase Motor with Starting Switch.

With this design an absolutely even turning moment results and the starting of the motor is facilitated.

An important factor in determining the efficiency of an alternating-current motor is the air-gap. This has to be made very small if the magnetising current is to be kept within small limits, and the accurate centring of the rotor is therefore an important detail in the construction of these motors, whilst the wear of the bearings has also to be carefully taken into consideration. The method adopted at the Langdon-Davies works certainly seems to admit of little improvement. The process is as follows :—

The brackets on the sides of the motor containing the bearings are completely finished, as is also the cast-iron body, these being all fitted together. The stampings of the stator are then mounted on a dummy shaft, and whilst thus supported are fixed into the stator frame, the dummy shaft passing through the bearings. Perfect centralisation is thus secured, and any risk due to errors of machining are completely prevented. The rotor stampings are all made with a

central hole exactly fitting the shaft in the smaller motors and the spider in larger machines. After being fixed in position they are then trued up. As the rotor stampings are the pieces which are stamped out of the stator plates, this method of construction provides the minimum possible air-gap. The bearings are made with very long surfaces, resulting in an exceedingly long life before the wear allows the rotor to touch the stator.

The importance of accurately centring the rotor cannot be too strongly emphasised, and the results are seen in the quiet and vibrationless running of Langdon-Davies motors, as proof of which it is no uncommon occurrence for the prime mover driving the turning shop to be quite overlooked by engineers when passing through the works. The motor in question, which is of 10 H.P., has now been running for over 10 years and the bearings have never required attention beyond the addition of oil. This is, indeed, a unique record

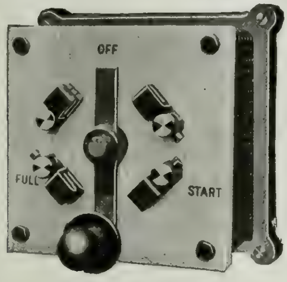


FIG. 4.—ORDINARY TYPE STARTER.

and speaks well for the smooth running of the rotor. The bearings now usually adopted consist of phosphor bronze, as the original type of cast-iron bearing, although giving such excellent results when receiving proper attention, was not very popular in inexperienced hands. A typical motor is shown in Fig. 2, direct coupled to a centrifugal fan.

A few central station engineers regard squirrel-cage motors with some disfavour, urging the supposed large starting currents as an objection, and oppose the installation of all save the smallest sizes. In view of the desirability of encouraging the use of motors, and the cheapness of the squirrel-cage type, this policy cannot be always

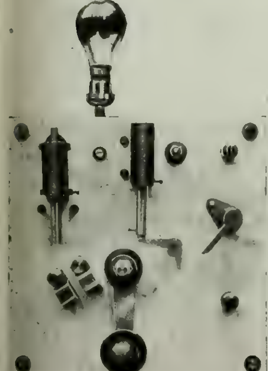


FIG. 5.—LATEST TYPE OF STARTING SWITCH FOR SQUIRREL-CAGE MOTORS.

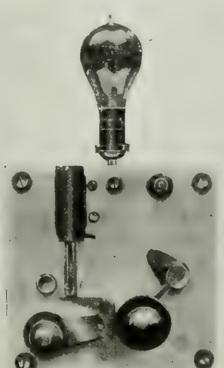


FIG. 6. AUTOMATIC CUT-OUT.

defended, more particularly when it is remembered that the starting current of a squirrel-cage motor can be fixed by the design, whilst if motors with slip rings and starting resistance are employed the maximum starting current is controlled by the method of handling the starting switch and may be greater than where the simpler type of motor is installed. Langdon-Davies squirrel-cage motors of all outputs are in regular use, and have given entire satisfaction for many years. A loose pulley can, in the great majority of cases, be fixed to allow the motor to run up to speed with only the load of its own belt before the working load is thrown on.

We noticed recently, when visiting the works of the Langdon-Davies Motor Co., a number of three-phase motors direct-coupled to "Sirocco" fans, which are being supplied to the Admiralty for wireless telegraph stations. These motors, which had been subjected by the Admiralty to very severe tests, will doubtless give an excellent account of themselves.

For small motors, such as $\frac{1}{4}$ H.P., $\frac{1}{2}$ H.P., 1 H.P., 2 H.P. and 4 H.P., squirrel-cage motors are in great demand, and we noticed a very large number being completed. The attention paid to their construction is as great as in those of larger size, and their simplicity and smooth running are responsible, no doubt, for the great popularity of these small motors. They are produced for both single and polyphase working, and, in the case of single-phase motors, starting coils are wound with the usual arrangement of a "throw-over" switch having "off," "start" and "full" positions. For motors up to 1 H.P. the switch is generally fixed on the top of the machine, as shown in Fig. 3, thus forming a very compact and convenient arrangement; for larger sizes, up to about 10 H.P., a switch of the type shown in Fig. 4 is usually employed. This type has the great merit of extreme simplicity and is therefore the most lasting and reliable. It is of a very solid design and the marble slab on which the switch arm and contacts are fixed is mounted on a frame which contains the non-inductive starting resistance.

At the present time much uncertainty exists in regard to the interpretation of the new Home Office Regulations. There seems to be some doubt as to whether starting switches have to be completely enclosed, or whether a well-protected handle, such as that seen in Fig. 4, in which there is no danger of the operator's hand coming in contact with "live" metal, is sufficient. One of the most recent types of starting switch brought out by the Langdon-Davies Motor Co. is shown in Fig. 5 herewith.

It will be noticed that this type of starter is fitted with no-voltage and overload releases, which perform the same duties as those regularly used with direct-current motors. The switch arm when using the starter is moved over to the left and held in the "start" position. As soon as the motor has attained full speed, the arm is moved over to the "full" position, and is held in position by the trigger, the no-voltage solenoid core being held up by the current. Should the current be interrupted, or the motor become overloaded, the solenoid core immediately ceases to be energised, and the core falls on the end of the trigger. This releases the switch arm, which falls into the "off" position. The lamp, which is fitted on the top of the starter, forms a resistance which is in series with the no-voltage solenoid. In addition to operating in this way, it has the further useful purpose of showing when the switch, and the motor controlled by it, is in use. Fig. 6 shows an automatic cut-out also fitted with a lamp.

We are indebted to Mr. F. B. O. Hawes, managing director of the Langdon-Davies Motor Co., and Mr. F. W. Hartmann, assistant managing director, for giving us facilities for obtaining the information contained in this article; and we must also express our thanks to Mr. Davidson, the works manager, for kindly conducting us over the works and explaining the various processes connected with the construction of the motors and starting switches here described.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Proceedings of the Royal Society." Vol. LXXXII. No. A553. Series A, Mathematical and Physical Sciences. (London: Harrison & Sons.) 2s. 6d.

"Science Abstracts." April, 1909. Vol. XII. Part 4. Section A, Physics; Section B, Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d.

"The Telegraphists' and Telephonists' Note Book." (London: S. Rentell & Co.) 1s. 6d. net.

"The Commercial Engineer's Pocket Book: Electricity Supply." By Francis H. Davies. (London: H. Alabaster, Gatehouse & Co.) 1s. 6d. net.

"Munro & Jamieson's Pocket Book of Electrical Rules and Tables." Nineteenth Edition. (London: Charles Griffin & Co.) 8s. 6d.

"Jahresbericht des Physikalischen Vereins zu Frankfurt am Main für das Rechnungsjahr, 1907-1908." (Frankfort-on-Main: C. Naumann's Druckerei.)

"Elektrische Uhren." By Dr. A. Tobler. Vol. XIII., of "Elektrotechnische Bibliothek." 2nd edition. (Leipzig: A. Hartleben.) M.3.

"Fortschritte der Elektrotechnik." By Dr. Karl Strecker. 2nd number, 1908. (Berlin: Julius Springer.) M.10.

"Die Seekabel unter besonderer Berucksichtigung der Deutschen Seekabeltelegraphie." By H. Thurn. (Leipzig: S. Hirzel.) M.9.

"La Machine à Influence." By V. Schaffers. (Paris: Gauthier-Villars.) Fr.10.

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THE INSTITUTION OF ELECTRICAL ENGINEERS.

In looking over the annual report of the Council of the Institution of Electrical Engineers, an abstract of which will be found elsewhere, one of the most striking points is the small growth of the Institution during the past year. The total increase is only 29. A few years ago the growth was extremely rapid, and although the rate which then held good could scarcely be expected to last for any lengthy period, so rapid a falling off is a little surprising. Possibly the Institution has reached practically as large a percentage of the profession as will be attracted by a body of this kind, or it may be that no great increase can be expected until some material change is made; it is to be hoped that the Institution's new home, which is to be realised so very shortly, may give the necessary fillip to the increase of membership. On the other hand, it may be that the industry has settled down to a somewhat stagnant condition, and the fact that there are fewer students than there were a year ago lends some colour to this view.

When the Council decided last year, with the sanction of a special general meeting, to purchase the building of the Royal College of Physicians and the Royal College of Surgeons, many members had their misgivings as to whether the burden so taken up was not more than the Institution could bear with safety. We are glad to find that Mr. HAMMOND, the treasurer of the Institution, in presenting the balance-sheet last week, felt quite assured in regard to the future. The building is much larger than

is necessary at the present time, and the annual cost is likely to be heavy; we are, therefore, very glad to find that the Royal Colleges of Physicians and Surgeons will occupy a large part of the building for at least the next three years. This should make a material difference to the certainty of the situation. By the end of that period it is to be hoped that the membership will show a tendency to increase more rapidly than at present, and that the financial position will be perfectly sound.

Along other lines the Council continue to move with present requirements. Thus, a new edition of the Wiring Rules is in course of preparation, and will contain certain modifications to meet the new Regulations of the Home Office. Provision will also be made to sanction less expensive methods of wiring, and apparently the rules are to be extended to embrace work at very low pressures, presumably those which have been brought about by the introduction of 25-volt metal filament lamps. Another subject to which the Council are giving attention is that of professional conduct. The Institution of Civil Engineers has already done something in this direction. Years ago the Institution of Electrical Engineers took up the matter, but without any great measure of success, and a further attempt is now to be made. There are many who feel that no good in this direction will be done by what is necessarily a heterogeneous body, because the rules apply particularly to only one class, and should really be framed by that class without the influence of other interests. Yet another question is that of examination for associate membership; this is merely mentioned in the report, no scheme being submitted. It will be seen that the Council have some difficult problems before them, and we hope that no hurried decisions will be made.

In any society it is most important that the council should reflect the feeling of the general body of members. This desirable state of things has not always characterised the Institution of Electrical Engineers, and, as a result, there has been friction which at times has been acute. Fortunately, of late years, this condition has improved very materially, but nevertheless we think there is still wanting the intimate touch that should exist between the Council and the members. It is an undesirable task to criticise a body that gives much time for the common good and receives nothing in return; moreover, plain speaking does but little good, and we do not care to indulge therein except as a last resource. We will therefore content ourselves with the remark that the Institution of Electrical Engineers is primarily a body concerned with electrical engineering and with the technical applications of electricity as a profession, and this fact cannot be borne in mind too thoroughly by the Council in all their actions.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, auding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Elementary Manual on Steam and the Steam Engine. By Prof. ANDREW JAMIESON. 12th edition. (London: Charles Griffin & Co.) Pp. xiv.—355. 3s. 6d.

The first three lectures or chapters deal with the calculation of such areas, volumes and weights as are commonly met with in practice. The next sixteen lectures treat of the effect, nature, transfer and measurement of heat; of the properties of water and steam; of indicators and indicator diagrams; of eccentrics and slide valves, and of the early steam engines. The details of a compound marine engine are described in Lectures XX. to XXV. A description of various types of boilers and boiler mountings is given in the two following lectures. The last lecture is devoted to locomotive and steam turbine work. Of the four appendixes, one deals with experimental work, another consists of various examination tables and constants, whilst the remaining two are devoted to recent Board of Education examination papers.

The subject matter of the theoretical portion of the book is clear and concise, but does not cover the syllabus for Stage I. The descriptive part is well written, although there are a few inaccuracies.

Judging from the past examination papers, it appears that the ability to execute hand sketches of some of the principal details of steam plants is essential to success. An intimate knowledge of the form, service and position of the details to be sketched is necessary if satisfactory sketches are to be produced. The fact that three or four views may be required to portray accurately the shape of a detail must not be overlooked. Although it is preferred that the requisite knowledge be gained by a direct association with and handling of the actual details, yet students are often obliged to rely solely upon book illustrations for information and ideas. Considered with reference to the above, the sketches in this book are far from the ideal. A highly-shaded sketch of a piston may be artistic; a reprint from a photograph of a vessel travelling at a high speed may be beautiful; or that of a power station condensing plant may be interesting; but do they help students preparing for this examination?

Details of a triple-expansion engine (marine type) of modern design in place of the compound engine shown would increase the educational value of the book.

It would be of interest to learn how the throttle valve liner and body are machined so as to fit together in the manner shown on p. 211.

Galvanotechnik. By Engineer KRAUSE. Vol XCII. of "Bibliothek der gesamten Technik." (Hanover: Dr. Max Jänecke.) Pp. xi.—195. M.2.80.

This little book is intended for the use of students engaged in the metallurgical industry. It, therefore, contains very little theory, because, as the author states, it is intended for the practical man. He, consequently, thinks that it should be useful to those who are practically engaged in electroplating or electrotyping, and have not the time to study carefully the larger handbooks.

As the book is small the author has not thought it necessary to insert all the various receipts to be found in the literature for this or that process. He has, therefore, contented himself with giving those which he himself considers the best. We certainly agree that most books on this subject make the mistake of giving too many processes, especially as many of them are absolutely valueless.

The book commences with a description of the sources of current. Nearly all the various primary batteries are mentioned and briefly described. There is then a very short description of the dynamo, followed by an equally short sketch of accumulators. The next subject treated of is the chemicals used by the electroplaters, and here we think the author makes a mistake in trying to teach chemistry in a book of this kind. For example, what would the following convey to one who had studied no chemistry: "Of particular value are the three groups of material—acids, bases and salts. The bases are mostly metallic oxides and compounds of such with water, which then form hydroxides. . . . The acids are chiefly oxygen compounds of the non-metals, which have taken up water."

This method of teaching is too much like that which was in vogue, and to a certain extent still is, in this country, of trying to build without a foundation.

The rest of the little book has a good many quite useful "cookery" receipts, some of which will be very valuable to the experienced plater, who will be able to employ them without

first reading the chemistry (?); in fact, probably better without doing so.

Of course, we are not advocating that a plater should learn no chemistry. In fact, we consider it most essential, but the chemistry must be properly taught—half knowledge is of very little use. F. M. P.

Elektrotechnische Messkunde. By ALEX. KÖNIGSWERTHER. Vol. II. of "Grundriss der Elektrotechnik." (Hanover: Dr. Max Janecke.) Pp. 167. M 4.20.

The second volume of this series is devoted to electrotechnical measurements, and as it follows the previous volume on the "Physical Principles of Direct and Alternate-Current Technics," its object is chiefly to develop the fundamental principles of the theory and construction of direct and alternate-current instruments, and methods of testing. The first part describes the most common forms of galvanometers, dynamometers and supply meters and calls for little comment, except, perhaps, that the sources of error in the alternate-current instruments are rather glossed over. Three chapters are then devoted to the measurement of resistance, current, and P.D. respectively. The chapter on power measurement is short and clear, but the theory of the wattmeter hopelessly inadequate. Capacity, inductance and magnetic measurements receive a fair amount of attention, and the last portion, which deals with the measurement of phase and delineation of wave form, contains a very clear account of the various point to point methods, oscillographs and the ondograph. The style is throughout simple, and the figures clear; and the book, while of a somewhat elementary nature, will doubtless be of service to the students and young engineers for whom it is intended.

INSTITUTION OF ELECTRICAL ENGINEERS.

The annual general meeting was held last week on Thursday evening at the Royal Society of Arts, being followed by a Paper on "Some Tests and Uses of Condensers," by the President, Mr. W. M. Mordey. An abstract of this Paper will be found elsewhere in this issue.

The annual report of the Council was approved, as were also the statement of accounts and balance-sheet for the year ended December 31, 1908. In moving the adoption of the report, Mr. Mordey said that he hoped more Papers on telegraphic subjects would be brought forward in future; in fact, there had been no Paper of importance in telegraphy since the one by Mr. Sidney Brown on "Automatic Relay Translation for Long Submarine Cables," seven years ago. In connection with the list of members of the British Electrotechnical Committee given in the report, Mr. Mordey mentioned that since the report was printed Mr. Alex. Siemens had been elected chairman of the committee in place of Sir John Gavey, who had resigned, but who would continue to serve on the committee. Although the statement was not included in the report, Mr. Mordey was pleased to be able to state that the Council of the Institution had that day sanctioned a pension scheme for the whole of the staff by means of insurance. For this purpose the premiums will be met partly by the staff, the remainder being contributed by the Institution. He referred to the Building Fund, and hoped that there would soon be a very large increase in the number of regular annual subscribers. He believed members of all classes would wish to contribute in this way, and he suggested that a large number of small contributions—from half a guinea to a guinea or two—would be a very satisfactory form of support by the members to the arrangement to which the Council had devoted so much attention. In conclusion, Mr. Mordey mentioned that, as no nominations had been received other than those made by the Council, the Council nominees were duly elected. The members of the new Council are, therefore, as given in our issue of April 23rd.

Mr. Hammond, in seconding the report, dealt with the statement of accounts for the past year. In taking over the new building next month he felt quite certain that they would be able to make both ends meet, and at the same time put aside the necessary sums for the redemption of the debt. In making such an estimate he did not rely on any increase of membership, although, doubtless, such increase would result when the Institution became established in a home of its own.

The meeting terminated with the usual votes of thanks to the Institution of Civil Engineers, the Royal Society of Arts, and the officers of the Institution.

An abstract of the report of the Council is given below.

Growth of the Institution.—Since the date of the last annual general meeting, 421 proposals for election have been considered, and there have been elected 14 members, 165 associate members, 17 associates, and 201 students. To the class of members there have been transferred 35 associate members and 8 associates, to the class of associate members there have been transferred 25 associates and 115 students, and to the class of associates there has been transferred 1 student. The total roll is now 6,097, compared with 6,068 in the previous year, and is composed of 7 honorary members, 1,136 members, 2,375 associate members, 1,036 associates, 1,438 students and 105 foreign members.

Mr. Oliver Heaviside, F.R.S., and the Hon. Charles A. Parsons, C.B., F.R.S., have been elected as honorary members. Honours have been conferred upon several members of the Institution. Sir H. H. Cunynghame has been created a Knight Commander of the Order of the Bath, and Knighthoods have been conferred on Sir Robert Hadfield (who has also been elected a Fellow of the Royal Society), and Prof. Sir J. J. Thomson, F.R.S.

Reference is made to the deaths of Prof. W. E. Ayrton, F.R.S., the Rt. Hon. Lord Blythswood, F.R.S., Mr. E. J. Bristow (hon. solicitor), Monsieur Mascart (honorary member), Herr Emil Naglo and Mr. C. H. Reynolds.

Meetings and Papers.—During the past session 16 general meetings, 20 council meetings and 112 committee meetings have been held. There have been 45 meetings of Local sections, namely, at Birmingham 7, at Dublin 7, at Glasgow 7, at Leeds 6, at Manchester 11, and at Newcastle 7. A complete list of Papers and original communications, with the places where read, is given in the report.

The council hope that members will avail themselves of the "Journal" to a greater extent than in the past as a medium for the publication of short notes or communications—not necessarily for reading or discussion at meetings—on new discoveries, methods of testing, and similar matters.

Scholarships.—The council have awarded a Salomons Scholarship, value £50, to Mr. J. Mould, of the Finsbury Technical College, and a David Hughes Scholarship, value £50, to Mr. H. M. Browne, of King's College.

Annual Premiums.—The premiums for Papers and communications have been awarded as follows: The Institution Premium, value £25, to M. J. H. Rider for his Paper on "The Electrical System of the London County Council Tramways"; the Paris Electrical Exhibition Premium, value £10, to Messrs. L. Andrews and R. Porter for their Paper on "The Use of Large Gas Engines for Generating Power"; an extra Premium, value £10, to Messrs. W. Cramp and B. Hoyle for their Paper on "The Electric Discharge and Production of Nitric Acid"; an Extra Premium, value £10, to Mr. T. Swinden, for his Paper "Researches on the Magnetic Properties of a Series of Carbon Tungsten Steels"; an Extra Premium, value £10, to Mr. E. A. Watson for his Paper on "The Dielectric Strength of Compressed Air"; an Extra Premium, value £5, to Mr. H. S. Hallo, for his Paper on "The Theory and Application of Motor Converters"; an Extra Premium, value £5, to Messrs. J. C. Macfarlane and H. Burge, for their Paper on "Output and Economy Limits of Dynamo Electric Machinery"; an Extra Premium, value £5, to Mr. J. S. Peck for his Paper "Fly Wheel Load Equaliser"; and an Original Communication Premium, value £10, to Messrs. C. C. Paterson and E. H. Rayner for their communication "Non-inductive, Water-cooled Standard Resistances for precision Alternating-Current Measurements." Students' premiums have been awarded to Messrs. B. E. Stott, J. Hargrove, L. H. A. Carr, P. C. Jones, W. S. Lonsdale and C. S. Richards. In conjunction with the Institution of Mechanical Engineers, a gold medal has been designed for presentation to those recipients of the Willans premium who may prefer to receive the award in this form. Bronze replicas have been presented to Mr. Mark Robinson and to Mr. P. V. McMahon, to whom the Council awarded the Willans premium in 1897 and in 1904 respectively.

Students' Section.—At the opening meeting of their session an address to the students was delivered by Mr. J. S. Highfield on the subject of "The Responsibility of the Engineer." Ten meetings altogether have been held in the Library of the Institution, at which nine Papers have been read and discussed. The Students' Committee organised a visit to Newcastle-on-Tyne in the summer of 1908. The Glasgow and Manchester branches of the Students' Section have also completed a successful session, having held eight meetings and nine meetings respectively. The students' committees and their honorary secretaries are to be congratulated on the success of the meetings and visits.

Secretaryship.—Reference is made to the resignation, last November, of the secretaryship by Mr. G. C. Lloyd and to the appointment of Mr. P. F. Rowell as his successor.

The Institution Building.—The Council have entered into an agreement to complete the purchase by June 1, 1909. For the present, the Institution will occupy the whole of the ground floor and a large portion of the first floor, which will form a library, of nearly 3,000 sq. ft., facing the river. It is proposed to enlarge and improve the entrance hall and the lecture theatre. The remaining portion of the building has been let for three years to the present owners, the Royal Colleges of Physicians

and Surgeons. It is expected that the Institution will be transferred to the new building in the autumn, and that the enlarged theatre will be available early in 1910.

The British Electrotechnical Committee.—The names of the members of this committee are given in the report. The list of terms with explanations under preparation by the sub-committee on Nomenclature has now been completed as far as the letter E, and it will shortly be circulated to the various committees abroad. The British Committee have forwarded to the Central Offices a proposal with regard to an International Unit of Light, and the matter is now before the several Electrotechnical Committees.

Wiring Rules.—A new edition of the wiring rules is in course of preparation. This will contain certain modifications to meet the new Regulations of the Home Office, and provision will be made to sanction certain less expensive methods of wiring and to extend the Rules for work at very low pressures. It is hoped to issue this revised edition before the end of the year.

Professional Conduct.—The Council have under consideration the issue of a statement on the subject of professional conduct, a matter which has recently engaged the attention of the Institution of Civil Engineers.

Examinations for Associate Membership.—The Council are considering the question of requiring candidates for associate membership to pass a qualifying examination.

Building Fund.—The attention of members generally is called to this fund. The Council express the hope that there will be a large increase in the number of contributions, and they wish to point out the importance, in the aggregate, of even small annual subscriptions.

Benevolent Fund.—The committee of management report that the Benevolent Fund of the Institution shows a satisfactory increase for the past year. On Dec. 31, 1908, the capital account of the Fund stood at £3,000, as compared with £2,735. 9s. 11d. at the end of 1907. The donations to the Fund in 1908 include one of £105 from Mr. W. B. Esson and another of £75 from the committee of the Electrical Engineers' Ball. The Wilde Benevolent Trust Fund stands at £1,744. 16s. Grants in aid have been made from the income of both Funds during 1908.

Annual Accounts.—The report of Mr. R. Hammond, the hon. treasurer, shows that the balance carried to the general fund at the end of 1908, being excess of income over expenditure, was £3,253. 9s. 3d., as compared with £3,678. 9s. 2d. for 1907, showing a decrease of £424. 19s. 11d. The transfers to the Building Fund during the year 1908 included a transfer of dividends amounting to £446. 8s. The balance sheet sets out the total investments other than the investments of the trust funds. It is seen that the total asests amount to £51,552. 11s. 1d., against which are to be set liabilities amounting to £1,064. 19s. 5d., leaving as the net assets of the Institution £50,487. 11s. 8d.

The Building Fund has increased during 1908 by the amount of £1,219. 11s. 2d., the increase being due to revenue from property, subscriptions, dividends on investments, and sundry other items.

The General Fund has increased to the extent of £3,253. 9s. 3d., and, after deducting the transfer to Building Fund, now stands at £6,852.6s.9d.

Museum.—Several interesting pieces of apparatus have been added during the year. The Institution is under a deep obligation to the Postmaster-General, who has kindly arranged that, in future, duplicates of specimens of telegraphic and telephonic apparatus selected for the Post Office Museum shall be sent to the Institution Museum. The attention of members is called to the desirability of reporting to the Institution the existence of any objects of historical interest connected with electrical science and industry which may appear suitable for inclusion in the Museum.

Library.—Early in 1908 the Council, under the advice of the honorary solicitors, considered the steps that should be taken for the appointment of new trustees for the Ronalds Library. At a meeting of the surviving trustees, Mr. J. C. Carter and Mr. J. M. Fletcher, who continue to act, the following new trustees were appointed: Col. R. E. Crompton, C.B., Dr. R. T. Glazebrook, F.R.S., Sir John Gavey, C.B., Mr. W. Duddell, F.R.S., Mr. B. Ronalds, and Mr. R. Carter. The Council have now acquired 1,418 out of the 1,623 works which were reported to be wanting to complete the Institution's collection of electrotechnical literature. In addition to these the number of new books purchased since May 15, 1908, is 120, and 346 books and pamphlets have been presented by members, publishers, and kindred societies. The number of members who consult the library continues to increase, the total number of readers during the past 12 months having been 850, of whom 34 were non-members.

An appendix to the report contains a list of transactions, proceedings, &c., received by the Institution.

SOME CONTACT RECTIFIERS OF ELECTRIC CURRENTS.*

BY L. W. AUSTIN.

It is not generally known that there is a large number of solid conductors of electricity, metallic and non-metallic, in which, when brought together so as to form a contact of not too low resistance, electricity appears to pass more easily in one direction than in the other. Most cases of this kind are too uncertain and capricious in their action to allow definite study. But silicon in contact with almost any of the ordinary metals, carbon steel, and tellurium-aluminium all show a well-marked and fairly regular unilateral conductivity.

In the investigation of these contacts I have used two main methods of experiment. In the first a direct E.M.F. was applied to the contact, first in one direction and then in the other, and the resulting currents measured on a galvanometer or ammeter having resistances small in comparison with that of the contact. In the second method a known alternating current at 60 cycles was sent through a fall of potential wire and the required voltages taken from sliding contacts and applied to the rectifying contact, which was in series with the direct-current meter.

Silicon.—The fact that a piece of silicon when properly brought in contact with brass or copper, or, in fact, almost any of the common metals, is capable of acting as a detector for electrical oscillations without the use of external E.M.F. was first announced by G. W. Pickard who ascribed the phenomenon to thermoelectric action.

A table in the Paper shows the unilateral conductivity of a silicon-steel contact for direct currents at 0·014 to 2·5 volts. The difference in the values of the current from silicon to steel and from steel to silicon increases from 0·3 to 19,000 micro-amperes as the voltage is raised. It is also seen that the resistance for currents in the direction steel to silicon drops rapidly with increasing voltage. A second table contains the rectified currents for various alternating voltages, the contact being adjusted for maximum rectification with the smaller voltages. It is noticed that these rectified currents up to about 1·0 volt correspond approximately with the differences in the direct currents in the previous table. Below 0·2 volt the phenomenon is extremely reproducible, and contacts may be set and remain constant in their action for weeks at a time, unless violently jarred or exposed to too high voltages. Within this range the rectified currents are approximately proportional to the square of the alternating voltage. Hence a silicon rectifier with a galvanometer is a useful instrument for all kinds of high frequency work with small currents.

For the determination of the absolute sensitiveness of the silicon rectifier at high frequencies, a rectifier of rather low sensibility was compared with an extremely sensitive thermoelement at a frequency of 140,000. They were connected, in turn, in series with a 1 microfarad paper condenser for stopping the direct current, and with an inductance of 0·0331 microhenry coupled very loosely to a second tuned circuit in which oscillations were excited. The discrepancy of 4 per cent. was less than the average deviation from the mean (5·2 per cent). The experiment shows that there is no change in sensitiveness with frequency within the limits of accuracy of the observations.

While in general the rectified current with silicon rectifiers flows from steel to silicon, an exception has been found in a certain sample which is probably somewhat less pure in its composition than the rest of the silicon specimens used. From this sample, rectifiers of exceptional sensitiveness have been made, but, curiously enough, the rectified current flows from silicon to steel, or in the opposite direction to that usually observed. Still more curiously, however, it is found that the thermoelectric E.M.F. at the contact is also reversed, still remaining in opposition to the rectification. That this effect is really a property of this sample is shown by the fact that the reversals persist in the case of other pieces broken from the larger sample and also with freshly broken surfaces. As might be expected, when a contact is made between two specimens of silicon with the opposite rectifying qualities, a rectifier of remarkable sensitiveness is produced.

Carbon Steel.—Another substance capable of forming rectifying contacts is carbon. It gives the most satisfactory results when used with steel. The polished surface of an ordinary steel sewing needle in contact with arc light carbon * giving excellent results. By varying the pressure it is possible to produce rectifiers of widely varying resistance. For high resistance rectifiers particularly good results were obtained by making the contact on the soft centre of a cored carbon. The high resistance contacts, while showing regular rectification for alternating currents, do not, so far as the author has observed, show regular and satisfactory unilateral conductivity for direct currents.

A comparison of the observations given in the Paper with the silicon observations shows that for the higher voltages the carbon rectification is much less perfect, but as the carbon sensibility curve drops more slowly the difference for very small voltages is less. It is also to be noted that in the case of carbon the effect becomes too irregular for observation at a much lower voltage.

Tellurium.—In addition to the rectifying effect of tellurium-aluminium contacts,† which appears to be thermoelectric, or at least in the same direction as the thermoelectric action and which

* Abstract from the "Bulletin of the Bureau of Standards."

* Graphite seems to be distinctly inferior.

† Described in the "Physical Review," No. 24, p. 508, 1907.

becomes irregular above low voltages, there is a second rectifying effect in opposition to the first. This in general becomes prominent only at the higher voltages. There is a middle region in the vicinity of 0·5 volt where the two effects appear to be in conflict. This second effect seems entirely analogous to the rectification of silicon and is of the same order of magnitude. For quantitative observations the tellurium-aluminium is somewhat inferior in point of constancy.

Conclusions.—In all the cases noticed, the contact has a resistance of several ohms as though there were a resisting film between the conductors. In all the cases, too, there is a comparatively poor conductor in contact with a good conductor, but the rectification in the cases of carbon-steel and of silicon-steel is from the good to the poor, while in tellurium-aluminium it is in the opposite direction (except for very low voltages where another phenomenon, perhaps thermoelectric, predominates). It may be worth noting that the first effect is in the same direction as the rectified current in the aluminium electrolytic rectifier. Another peculiar fact is that in the three cases studied the rectified current flows in opposition to the thermoelectric current produced by heating the contact, except in the case of tellurium-aluminium at low voltages, as noted above.

It is clear that we are dealing with a contact phenomenon, depending as it does vitally upon the pressure and area of the contact surfaces. When these surfaces are sufficiently large and the contact sufficiently close the rectification entirely disappears. It may be that there is something of the nature of polarisation and a counter E.M.F. at the contact, but if this exists no evidence of it has thus far been found. Of course it is possible that we are here dealing with the still obscure question of the escape of electrons from a conductor, and that our rectifying contacts furnish us with conditions under which the electrons pass more readily in one direction than in the other, that is, that it is a case of direct and not secondary rectification. The rectified currents described have been small, but it seems probable that by a proper arrangement of contacts, perhaps in parallel, considerably larger currents could be rectified.

CORRESPONDENCE.

OIL ENGINES FOR USE IN SUB-STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your leading article on the question of Diesel oil engines for sub-stations will, I feel sure, meet with the assent of the majority of central station engineers who have to run a central station in conjunction with sub-stations.

The proposals put forward are really too radical in their nature to cause them to be looked upon with favour. It is quite too alarming to think of the tremendous changes that would be involved by decentralising the main station and breaking the links between the sub-stations and the main station. If the oil engine is as economical as claimed, let it, by all means, be put in at the central station, but don't break the links between the main station and the sub-stations.

It has hitherto been an accepted principle the world over, that the greater the amount of plant that can be centralised in one station the lower will be the fixed charges for wages and supervision. When to this is added the lower capital cost per kilowatt of the larger generating plant, a further advantage is obtained.

It is also a fact that the smaller the proportion which the cost of fuel bears to the other charges making up the cost at the sub-station, the greater does the saving become that is effected by centralisation under the above two items.

The cost of the sub-station plant is so low, by comparison with the main plant, that it can be thrown in, with still a considerable advantage in favour of centralisation. This sub-station plant, moreover, being all operated from the sub-station switchboard, attendance on same is reduced to a minimum, and wages charges are correspondingly low, even in sub-stations very much smaller than Mr. Pfeiffer has considered.

Then again, the cost of the high-tension feeders between the main station and the sub-stations will, in most large towns, be found to be only of the order of £2 per kilowatt instead of the £[illegible] taken by Mr. Pfeiffer.

If accumulators are introduced in the sub-stations, several further advantages are gained: (1) The generating plant at the sub-station can be used to give 30 to 40 per cent. more output; (2) the wages and other fixed charges consequent upon not putting down that extra plant are in a large measure saved; (3) a stand-by, instantaneously available for the generating station and for each of the sub-stations, is provided.

When these advantages are tacked on to those of centralisation it will be seen how much we are asked to give up by the employment of oil engines in sub-stations, let alone the poor overload capacity of the oil engine, which is a most serious disadvantage when used under such conditions.—I am, &c.,

King's Heath, May 23. A. M. TAYLOR.

DIESEL OIL ENGINES IN SMALL GENERATING STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read with amusement the letter of Mr. H Leslie Dixon with respect to my claim for "being a pioneer in advising Diesel engines." I can assure Mr. Leslie Dixon such was not my claim.

If he will carefully read my Paper he will notice the following: "In the works I designed for the city of Chichester . . . the generating plant is interesting as one of the first (if not the first) depending upon its supply when employing engines of the Diesel type for prime movers." I think Mr. Dixon will find that all the companies he mentions have steam plant and also accumulators; at Chichester we have neither, but, as correctly stated in my Paper, the supply depends upon the Diesel engines—whereas in the companies he names, they have installed, it is true, engines along with their steam plant and battery plant.

However, it is a small matter, and by all means let Mr. Dixon have any honour he may get out of Diesel engines—for I am certainly not envious of any such claim; at the same time Mr. Dixon, if he finds time to reply, will, no doubt, give me the names of the towns where no steam, accumulators or other plant are used (for lighting stations), save only Diesel oil engines, nor any other plant as stand-by.

I am pleased Mr. Dixon's figures confirm my own with respect to the costs per unit which are possible with Diesel oil engines.—I am, &c., HORACE BOOT,

Consulting Engineer to the Tonbridge Corporation and the Chichester Electric Light & Power Co.

Westminster, S.W., May 22.

[The claim made by Mr. Boot apparently is based on the words "depending upon its supply when" in the above quotation. If this is so, we are, no doubt, responsible for the misunderstanding which has arisen, for in preparing our abstract we removed the words in question; we must admit, however, that we did not, and do not even now, follow their connection with the remainder of the sentence.—ED. *E.*]

INSULATING MATERIALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On p. 221 of your last issue you publish an abstract of a Paper by Mr. G. H. Fletcher on "Some Notes on Insulating Material." In this Paper the author states that "on removing the varnished covering from a wire, the copper is sometimes found to be coated with a green oxide," and apparently makes the usual tacit assumption that this green colour is a fatal defect. I have so many times seen in print similar statements that it seems worth while to attempt to show how very misleading they are.

In the first place, though no chemist, I have good reason to believe that the only known oxides of copper are red or black. The substance in question must, therefore, be some other salt of copper. Nitrate formed by electric discharge, and chloride from the bleaching material in the cotton or linen have been suggested. To obtain the observed density of colour, either of these salts would have to be present in sufficient quantity to more than cover the whole mass with easily observable crystals. In addition, the green substance gives none of the reactions of a chloride or nitrate. As a matter of fact, I have had a considerable quantity tested by a professor of chemistry, and we were both astonished to find that we could not even obtain the reactions for copper, easily detected though it is. The green matter is thus seen to be some obscure organic salt of copper, so exceptionally deep in tint that a quantity suffi-

cient to stain some feet of tape a vivid green was not enough to respond to the delicate ferrocyanide test.

From a practical point of view, the substance, though alarming in appearance, seems to do little real harm. I believe I have detected a reduction of the breakdown voltage in specimens tested in a hot state, but never in a cold.—I am, &c.,

Manchester, May 24. J. S. S. COOPER, M.A., B.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may be of profit, as the current session of the Institution of Electrical Engineers is now drawing to a close, to take some stock of the position in the light of a review of the proceedings at the general meetings now terminated.

We have had many good Papers, but I venture to question whether we have complemented the value of those contributions by bringing to bear upon them the best criticism which the knowledge and experience of the general body of members renders potentially available? Are there not "ungotten minerals" which a means ought to be found of extracting for the further enrichment of our discussions? With this object in view I submit a few suggestions in the direction of some alteration in the method of conducting these discussions.

1. Might not all members desiring to take part in a discussion be required, when sending in their names, to submit a very brief summary of, or at least the heads of, their proposed contribution? The president, having a list before him of the points which will be dealt with by each speaker, can "edit" the debate with due regard to the relative importance of the matter contributed rather than to his estimate of the importance of the matter which the speaker is capable of contributing. Thus interesting, but digressive, discourse may be curtailed; and time found for valuable contributions, some of which though tendered remained "ungotten" (to my knowledge) during the last session. Of course these contributions can always be sent to the "Journal," but there is not the same point in swelling the minutes of proceedings with matter which did not form part of those proceedings, and the inducement is often an insufficient incentive to excite the effort.

2. Instead of the author's reply being relegated to a few breathless minutes at or after closing time, might not an opportunity be given to him of replying at reasonable length to all the points of criticism which lend themselves to verbal treatment? The meeting wants to hear the author's defence. Debate has lost its best characteristic when criticism is not met with prompt reply.

3. When Papers lend themselves to such a treatment, might not the discussion of them be taken "by compartments"? The author or the editing committee could settle the divisions and the president would introduce them to the meeting in the order of their importance. With such an arrangement much confusion would be avoided, and, when time pressed, the points of relative unimportance would be crowded out instead of persons of relative unimportance. A progressive change.

There would also be a great advantage from a "debate" point of view if at least a few minutes were reserved for general discussion, as distinct from the contributions of those who have sent in their names and if the author was given an opportunity of replying on each point before the next one was presented for discussion.

The above suggestions are not made in any spirit of criticism, but purely with a view to a possible improvement of what is already good.—I am, &c.,

4, Queen Victoria-street, E.C., May 25. EDW. W. COWAN.

ENGLISH TECHNICAL EDUCATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It must be gratifying to those who are devoting their lives to the training of engineers, and to those who are bearing the expense, to have Mr. C. H. Wright's assurance that evening technical classes are doing useful work among engineering apprentices.

As to some of the lectures being given by men engaged in actual engineering practice, the real objection to this is that it is well-nigh impossible to find men engaged in engineering business who are capable of expressing their ideas in such a way as to be understood by engineering apprentices. Moreover, the majority of such men cannot devote time to the preparation of lecture notes and experiments, or to the correction of students' exercises and notes.

If Mr. Wright has had any experience in technical education he must know that it is customary for members of the staff to be "on duty" not more than 30 hours per week and that probably not more than one-third of the time is devoted to lecturing. Hence Mr. Wright's statement that evening work is certainly a burden to members of the permanent staff is absurd. In one case the lecturer is prepared for his work, and in the other too often is he tired in consequence of a hard day's work in the shops or drawing office. The bulk of the serious evening work which is being done in our engineering colleges is due to the efforts of the permanent staff.

In order that a lecturer can keep up-to-date in his ideas he should be allowed by the governing body for every three years' service to spend a year in the shops, or in inspecting important work, or in private practice or research, and it is the duty of the Government to insist upon it.—I am, &c.,

Brighton, May 24. H. H. BROUGHTON.

MOTOR CONTROL APPARATUS.

The question of the control of electrical apparatus is not without its difficulties, and probably for this reason much attention has been given to the subject by those engaged in engineering work. And the result is certainly not unsuccessful. The increasing application of the electric motor to heavy work, such as driving rolling mills, has also increased the difficulty of this problem, especially as regards speed control, and has made it a necessity for the starting and controlling resistance to be generously designed.

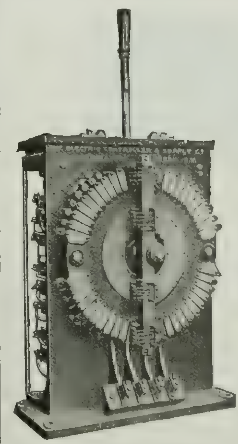


FIG. 1. V TYPE "DINKEY" CONTROLLER.

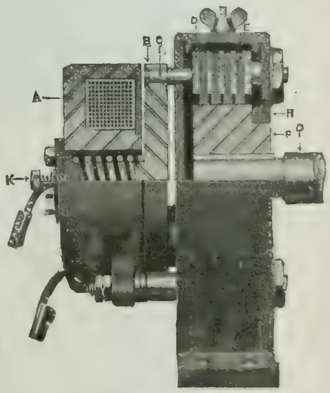


FIG. 2. WELLMAN BRAKE.

Among the firms who have made it their business to deal with these problems is Messrs. Wellman-Seaver & Head, of London, who have now on the market several types of controllers suitable for use in different kinds of work. Perhaps the most interesting of these is the "Dinkey" type V controller, illustrated in Fig. 1. It has been designed for use under the most arduous working conditions, and, in consequence, the construction is most substantial, both electrically and mechanically, while, it is claimed, the necessity for simplicity, ease of operation, compactness and accessibility, have not been forgotten. There are, in fact, only four connections to make—a remark which sums up succinctly the claims made above. This controller is being largely used for controlling live rolls and screwing down gear in steel works; and is exclusively employed for these purposes in some of the largest steel works on the Continent, over 100 having been supplied to one works alone. The reason for the adoption of the "Dinkey" controller, in spite of its higher first cost, is said to depend on the fact that the contact fingers can be renewed while the controller is working the live rolls without interfering with the output. This condition is a necessity, when, as in this particular case, the mill runs 24 hours a day the

whole year round, the motors being started and reversed 25,000 times a day—not a bad day's work.

Another type of controller, made by Messrs. Wellman-Seaver & Head, is designed for use on heavy work in confined spaces. It is an adaptation of that described above, the general arrangement being the same, though the outer appearance is rather different. The two contact faces are placed back to back above the casing holding the resistance, thus making the width of the controller about 7 in. less than in the standard type described above. The contact finger arm is in duplicate, and is worked by an insulated handle placed directly above the contact faces.

Two types of controller are made for ordinary and light crane work respectively. These possess much the same characteristics as the types described above, but have fewer contacts for the corresponding sizes. The first is made in five standard frames covering all horse-powers from 1 H.P. to 50 H.P. at 220 and 500 volts and from 1 H.P. to 25 H.P. at 110 volts. In three of these frames the contact face is carried on the side of the resistance casing, in the other two it is carried on the top. The second type of crane controller consists of a circular plate of slate on which are carried the contact segments, contact arm and resistance coils. All the working parts and terminals are fixed to the slate and can be removed with it, the iron frame simply serving as a support and protective covering for the resistance.

Type "K" controller is specially designed for use with haulage gears. Its chief features are simplicity and the quick break on every step. A sector blade engages with a copper clip and an auxiliary switch breaks the circuit on a special contact breaker; no current is broken on the clip which gives a large contact area on each side of the blade.

The grid resistances used with these controllers consists of a steel stamping, one form of which is shown in the illustration Fig. 3, with a deep corrugation. It has been designed to get over the difficulty which has been experienced with the stamped grids owing to their tendency to vibrate and sag, especially when hot. The corrugation

FIG. 3. CAST STEEL GRID USED IN "DINKEY" CONTROLLER RESISTANCE.

effectually prevents this, and allows the grid to be mounted in an ordinary resistance frame without the necessity of packing the grids with asbestos or other liners between them. Owing to its large radiating surface it has the same carrying capacity as a cast-iron grid about three times its own weight. The grid illustrated weighs 5 oz., and has a resistance of 0·03 of an ohm with 50 amperes continuous rating carrying capacity. The cast-iron grid previously used with the same capacity weighed 1¾ lb., so that the reduction in weight is considerable, while, owing to the flat surface of the ends, it makes a much better contact than a cast-iron one.

Another speciality of this firm, which comes under the head of control apparatus, is the Wellman brake, illustrated in Fig. 2. It is particularly adapted for electric cranes, hoists and all machinery subject to frequent stops and reversals. The actual braking is done by a series of metal to metal plates running in oil, and consequently the coefficient of friction is constant, while, as the pressure is applied in the direction of the axis, the brake is equally effective whichever way the motor is rotating. With the motors at rest and no current passing through the magnet coil, the armature plate, B, is pressed against the friction plates by means of a spring. This clamps the stationary friction plates to the revolving ones, and the motor shaft is prevented from turning. At the instant the current is turned on to the motor the magnet, A, is excited and at once attracts the armature plate, releasing the friction plates of all pressure and allowing the armature shaft to rotate. As the revolving discs dip into the oil bath in the friction case, the whole of the interior is kept flooded with oil, thus ensuring efficient lubrication. Also, as there is a film of oil between each pair of friction discs which takes a little time to squeeze out when the brake is applied by the cessation of the motor current, there is no jar or shock, the process of coming to rest being quick but smooth. The actual movement of the brake is very small, being only ⅛ in. in the largest size, and the wear is said to be inappreciable, while everything being enclosed damage of all kinds is practically nil.

In the control apparatus line Messrs. Wellman-Seaver & Head are also making drum-type reversing controllers of very sound design, as well as a fuse, to which we shall hope to return in a later issue.

Another speciality is the Wellman signalling apparatus for mines, consisting of a special bell push which closes both a lighting and bell circuit. When the bell push is released the bell circuit is opened, but the luminous signal circuit remains closed by an electro-magnet inside the bell push. The light thus remains on until the receiver of the signal acknowledges it by pressing a button which opens the magnet circuit. The cast-iron box containing the signalling lamps is placed in a conspicuous position either on a wall or pedestal. In mines using alternating current this apparatus can be actuated direct from the alternating-current mains by a Nodon improved rectifier, which is supplied by Messrs. Wellman-Seaver & Head, and thus the use of Leclanché cells, which are often a source of great annoyance in mines, is avoided. The whole of the signalling in the Harton Coal Co.'s mine at East Boldon, Durham, is actuated direct from their alternating-current mains by this rectifier.

NATIONAL TELEPHONE COMPANY'S STAFF DINNER.

The fifteenth annual dinner of the staff of the National Telephone Co. was held on Thursday evening last week, with Mr. ALBERT ANNS, secretary of the company, in the chair.

Besides the president of the company (Mr. George Franklin), Mr. Anns was supported by Sir H. Babington Smith, K.C.B., C.S.I. (secretary of the General Post Office), Sir Robert Hunter, Sir John Gavey, C.B., Major O'Meara, C.M.G., Mr. C. A. King, C.B., Mr. A. M. Ogilvie, Dr. Walmsley, Mr. C. S. Agnew, Mr. W. A. Smith, Mr. G. H. Robertson, Mr. S. J. Goddard, Mr. Frank Gill, Mr. G. F. Preston, &c., the gathering numbering over 300 in all.

After the loyal toasts, the CHAIRMAN proposed "The National Telephone Co." He said it was a disappointment to them that Mr. Sidney Buxton, the Postmaster-General, was unable, owing to a prior engagement, to be present, as they would have liked to have given a hearty welcome to the Postmaster-General from those who would become, or at least many of them, sooner or later, members of the department over which Mr. Buxton so ably presided. It was their pleasure that evening to make the acquaintance of the secretary of the Post Office, Sir H. Babington Smith, who was known to many of them and admired for his good work in the service of the State. The toast he was proposing invited a reference to the progress made by the National Telephone Co. during the past 12 months. This had not been so rapid as in some previous years, one of the chief reasons being the limitation of capital expenditure, a subject which had caused some public discussion. The company were face to face with the problem as to the keeping on of their constructional staff, as with the imminent transfer of the undertaking the limitation of capital expenditure was inevitable, and the discharge of the men who had executed the important work of construction on which the company had been engaged for so many years had come to be a serious question for the directors to consider. The board had hurried on the work which in the ordinary course would have been spread over a longer period so as to cause as little distress amongst the construction staff as possible, and the directors still had hope that arrangements would be made which would obviate the discharge of these highly-trained technical men. The company had opened during the year 88 new telephone exchanges, and had added 27,576 working stations, besides making good the loss of 26,180 subscribers—a loss which, strange to say, went on all the time so far as their experience went. Referring to the subject of the measured rate, the chairman said that, thanks to the firm front shown by the Postmaster-General, and to the part played by the company, the measured rate question had been settled in a way to secure the telephone as a valuable commercial asset to the nation. The value of the National Company's business to-day, ignoring the unpleasant fact that they were working under a terminable license, was at least £20,000,000. The action of the Postmaster-General with regard to the measured rate had saved the future of this great undertaking from being imperilled.

The question with which the staff of the National Telephone Co. was chiefly concerned was, What was to be their future? The 1905 agreement was a good one for the shareholders, but it was not a fair and just agreement for the staff (hear, hear). He would like to say, in this connection, that the directors and their late general manager, Mr. Gaine, fought strenuously for fair terms for the staff. They were not successful, and the staff became alarmed and formed the Staff Transfer Association. Thanks to the wisdom and moderation of the officers of that association, a fair measure of success could be recorded. While the directors and the chief officials could not take an active part in that association, it had always had their sympathy and support. He was optimistic enough to believe that when the end came they would all have fair treatment. Mr. Sidney Buxton, since his accession to the office of Postmaster-General, had shown himself most solicitous for the welfare of the great army of men and women he controlled in that important department of the State, and was in consequence held in the highest esteem by all branches of that department. Parliament, too, had always shown a disposition to see that no act of actual injustice was sanctioned, and it would be an act of injustice if any single member of the staff of the National Telephone Co. suffered from the transfer. The dinners of the

staff of the National Company were pleasant occasions for meeting together, and he could only express his regret at a presentiment he felt that this might be the last of such gatherings. In any case, they would be a pleasant memory to all who had assisted in the foundation of the great telephone industry. He coupled with the toast the name of Mr. George Franklin, their esteemed president and managing director.

Mr. GEORGE FRANKLIN, in reply, said Mr. Anns in his optimism had gone so far as to venture upon an estimate of the value of the company's property, and he (Mr. Franklin) could only feel astonishment at their chairman's modesty. With greater responsibility and less freedom, he (Mr. Franklin) hesitated to give such a figure. Before proceeding he wished to thank them for the generous hospitality which the staff had always accorded to the directors and for which they tendered their cordial appreciation. It was a great pleasure to meet once a year in this way the men who, scattered all over the country, were doing their best to further the interests of the company in somewhat difficult surroundings and circumstances. Mention had been made by their chairman of this being possibly their last annual dinner. He hoped that that would not be so. He felt sure that if the business of the National Telephone Co. should pass over to the State, and in place of their genial chairman of to-night they were to have their friend Sir Henry Babington Smith, their dinners would be none the less enjoyable. With regard to the agreement of 1905, the less said about it the better, as its meaning might have to be determined elsewhere. He would be permitted to refer to the remarkable progress of the company even under the abnormal conditions under which they were working to-day. The gross revenue for the year to March 31 last was £3,081,585, or twice as large as it was seven years ago. Out of that they had paid the Postmaster-General a royalty of no less than £283,758, which would be increased, he presumed, by the victory which the Post Office had won over the company in the House of Lords in connection with the subject of A to B lines. The total royalty paid to the Postmaster-General from the beginning was reaching £3,000,000, the total figure to date being £2,829,528, and for that royalty they had received no consideration. Thus had the National Telephone Co. presented the State with the value of two "Dreadnoughts." If the Postmaster-General, after acquiring the company, kept the telephone accounts as the company had done, he would be in a position to present a "Dreadnought" to the country at least once in five years. The National Company had now 1,555 exchanges, of which 75 was the increase on the past year. The total number of messages over the company's system had reached 1,323,000,000, or an increase of 9,500,000 over the previous year. The cost to the subscriber per message had been 0·49d., or something less than ½d. As to the conduct of that service, he wished to say how much the directors appreciated the great improvement which had taken place in London. They had made certain tests in many thousands of cases during the half-year ended December last, and had found the average time elapsing from the moment when the subscriber began to call until the operator answered with "Number, please," was only 4·70 seconds, and the time from the commencement of the call until the subscribers were connected was only 38 seconds. In the provinces the record was not greatly different. From the commencement of the call to the subscribers' obtaining communication varied from 22 to 45 seconds. This was immensely creditable to the company's staff. With regard to the complaint as to a vast number of their lines being overhead, he would like to say that 71·3 per cent. of their lines were underground, only 28·7 per cent. being above ground. This was proof that the company had not been idle in prosecuting a policy of true development. As to their exchanges, the percentage worked on the central battery system was 26·6, and six further C.B. exchanges had been opened on this system, and there were 26 more in hand. The number of stations according to the population was 1 to 78 inhabitants, compared with 1 to 137 inhabitants in 1903, an eloquent proof that the company had been keeping abreast of the demand. Mr. Anns had referred to the question of the measured rate. Events had moved rapidly since last year. The policy of the measured rate had been practically universally adopted, and he would predict that those who advocated the flat rate as against the measured rate were not only standing in the way of their own interests, but were standing in the way of the development of the telephone service. Before concluding he wished to refer to the question of the position of the staff in regard to the forthcoming transfer. There was a natural anxiety prevailing as to the rumours of negotiations with the Postmaster-General, and the possible effect of such negotiations on the staff. He sympathised entirely with this anxiety. There were no secrets to divulge. In all discussions on the subject, while the interests of the public and those of the shareholders must be considered, the directors fully recognised the need for seeing, so far as was within their power, that no injustice should fall upon any individual member of the staff by reason of the transfer, whenever that time might be, and the fact, as Mr. Anns had pointed out, that the Postmaster-General (Mr. Buxton) had shown himself sympathetic and get-at-able in all matters affecting his staff he thought should give them confidence and encourage the belief in his fairness. It was no mere formal expression when he, as president of the National Telephone Co., assured them that the directors warmly appreciated the continued devotion of the staff to the company's interests.

Mr. W. HART, in proposing the toast of "Our Guests," said it was a great pleasure to the staff to have the opportunity of meeting together on occasions like the present, but it gave them particular pleasure to welcome the directors and also the gentlemen who honoured them with their presence on these occasions—their guests. He particularly asked his fellow members of the staff of the National Telephone Co. to welcome those friends who represented the Post Office. They desired to congratulate Sir Henry Babington Smith on the honour conferred upon him by His Majesty during the past year.

Sir HENRY BABINGTON SMITH expressed, on behalf of himself and his fellow guests, the warmest thanks for the hospitality which the staff of the National Telephone Co. had accorded them. This was the first time he had been able to attend one of their annual gatherings, although it was not the first occasion that he had been honoured with an invitation. One of these invitations he received two years ago, when, they would remember, circumstances arose which prevented that dinner being held. He could not allow an occasion like this to pass without paying his tribute of respect and esteem to the man to whom in so high a measure the prosperity of the National Company and its great business was due. He had a message to deliver from the Postmaster-General to say how much he regretted being unable to be present and to have the opportunity of making closer acquaintance with some of that staff which sooner or later would pass under the orders of himself or his successors. On one point he felt sure—that when the National service passed into the hands of the Post Office the staff of the National Company would find a welcome in joining the staff which already formed part of the great Post Office service (cheers).

Mr. W. A. SMITH, a director, in further reply to the toast, regretted the absence of Mr. Sands, who was unfortunately unwell. He (Mr. Smith), along with Mr. Sands, were the only two living directors of the old original National Telephone Co. He remembered the first gathering of the staff of the National Telephone Co. in Glasgow 28 years ago next November, and he had always believed it to be the desire of the directors to cultivate with their staff the most friendly and cordial relations.

Mr. FRANK GILL next proposed the toast of "Engineering." He said the toast was of a very wide nature, and he was glad of this, as they had the privilege of having as their guests that evening other engineers than those connected with the company. He was travelling north on one occasion when a fellow passenger in conversation asked him what he did for his living, and when he informed him that he was engineer to a telephone company his inquirer, a well-known public man, asked "What engineering is there in telephone work?" Well, he could assure them there was quite a lot of engineering in telephone work, and they even ventured to call themselves electrical engineers. There was one danger they had to face, and that was of forgetting that much of their work concerned engineering that was not electrical. Many of their problems were mechanical. In their telephone construction work engineering problems had to be met, and in their building work they had to meet mechanical problems. Much of their work was rather in the nature of civil than electrical engineering, but when they came to the electrical side this was undoubtedly their most interesting work. At the present moment their chief work lay in the study of the problems of transmission. In their work they required special apparatus and special methods of carrying it on, and he was glad to be able to say that the results of their research work had been fruitful, and telephone circuits to-day were designed with nearly as much precision as electric lighting, traction or any other electrical form of circuit. There was, however, one thing that telephone engineers could not do, and that was to supply current for speech at 1d. per unit, or at a price that would compare in any way with electric lighting supply. His colleague, Mr. Cohen, had worked this matter out for him, and he was sure they would like to know that electrical energy for telephone operations worked out at about £16,400 per unit. They had to get to the consumer an amount of energy such as would require 16,000,000 similar conversations set up at the same time to equal the energy consumed under similar conditions by an ordinary 16 c.p. incandescent lamp. It was a somewhat difficult problem to measure with accuracy a quantity of such very small degree. In this work they were greatly aided by the beautiful apparatus designed by one of their guests that evening, Mr. Duddell. He had tried, but not very successfully, he feared, to ascertain the number and value of the world's telephones. He believed, however, he was not far wrong in saying that there are in the world at the present time about 10,000,000 telephones, and that the capital invested was about £350,000,000. With regard to the special application of engineering to the National Telephone Co.'s service, he was glad to be able to say they had been favoured by the directors with a clear-sighted policy on engineering matters. If engineering plant was laid out well the industry with which it was associated was almost bound to be a success. On the other hand, if it was laid out badly, it was difficult to rescue the industry from failure. Which went to show that the engineering people were very necessary in an enterprise of this character. He coupled the toast with the name of Mr. W. M. Mordey, president of the Institution of Electrical Engineers, and an exponent of all that is best in British electrical engineering.

Mr. W. M. MORDEY said, in reply, that he had missed two feasts—the dinner and the previous speeches; but duty had called him to preside over the Institution of Electrical Engineers that evening. Although he could not claim to be a professional telephone engineer, he had had a fairly early connection with that branch. He had made a telephone from a description cabled over to this country in the early seventies, and in 1877 he had the honour of assisting Mr. Graham Bell in his lectures and demonstrations in this country. He was glad that his friend Mr. Gill had said that there was a full recognition among telephone engineers that the entire science and profession of electrical engineering was one and indivisible, that it was not possible to divide the industry, the science or the practice of electrical engineering into watertight compartments. He was sure telephone engineers owed something to the heavier departments of electrical engineering. He described some tests he had been engaged upon in connection with the improvement of iron for magnetic purposes, and particularly in connection with the commercial development and improvement of iron, an invention of Sir Robert Hadfield's, and he thought he was divulging no secrets when he said that, although that iron had been developed for heavy engineering work, it

gave a very distinct improvement in telephoning. He was satisfied that, for the first time, there had been produced an iron which, without any change whatever in the telephone, gave distinctly better results under any given conditions. He thanked them very heartily for the cordial manner in which the toast had been received.

Mr. W. HOWE proposed the toast of "The Chairman," and said the services which Mr. Anns had rendered to the company had been referred to, and on such an occasion as the present it was the pleasure of the staff to refer to the services which Mr. Anns had rendered to them. Their chairman had many sterling qualities which endeared him to the staff. They regarded him as always having been their friend as well as their colleague, and they hoped he would occupy the chair at many more of their gatherings.

Mr. ANNS thanked Mr. Howe and all his colleagues for the way the toast had been received. They had, he said, always been loyal colleagues to him.

During the evening an excellent programme of music was presented, and the arrangements for the large gathering were admirably carried out.

LEGAL INTELLIGENCE.

Arc Lamp Patents.

In re Geo. Braulik's Application to revoke Bremer's Letters Patent No. 18,786, 1902.

On 21st inst. Mr. Justice Parker resumed the hearing of this appeal from a decision of the Comptroller-General of Patents revoking the above patents which was adjourned from March last for further evidence. The case was fully reported in THE ELECTRICIAN for March 12 and 19.

Mr. WALTER, K.C., representing the appellants (the British Westinghouse Co., as owners of the Bremer patent) submitted that that was really a claim by British manufacturers against Messrs. Körting & Mathiesen, who held the licence from the Westinghouse Co., and were represented in this country by the Union Electric Co. Though saddled with a considerable disadvantage, the British Westinghouse Co. continued to manufacture under the present arrangement. In 1905 they made 145 lamps, in 1906 106, in 1907 527, and in 1908 530 up to Nov. 2, and they had at that time in stock 274 lamps. The company was saddled not only with the opposition of their licensees, but they had also to deal with numerous infringers. After the licence was granted Körting & Mathiesen, through the Union Electric Co., imported in 1906 2,467 lamps.

Mr. BOUSFIELD, K.C., for the applicant, said only part of those were lamps manufactured under the patent, and he proposed by technical evidence to show that that was so.

Mr. WALTER said that they were lamps manufactured under the licence.

Mr. BOUSFIELD said that his instructions were that only a part were constructed under the letters patent in question.

Mr. WALTER, continuing, said that in 1907 3,612 lamps were sold by the Union Co, and in 1908 2,777 lamps. As regards infringement in this country, there were steps taken by the Westinghouse Co. In 1906 they issued a writ against a company, particulars of objection were put in, and plaintiffs, feeling that perhaps their claim was too weak, on Sept. 25, 1907, obtained leave to amend. The patent was amended and a fresh writ issued against the company. In the meantime that said company went into liquidation, and the receiver and liquidator consented to a perpetual injunction. A fresh action was then commenced against Braulik, the respondent to the present appeal. The date of the writ in the action against Braulik was Jan. 2, 1908, the statement of claim was delivered on July 2; on Nov. 12, 1908, a defence was put in. The petition for revocation was lodged on Oct. 20. The response to the action for infringement was to lodge a petition for revocation. Under all the circumstances, he submitted that this was not a case that the Act of 1907 was intended to deal with, and he asked his Lordship to hold that there was not such want of adequate manufacture in this country within the meaning of the act as to bring this patent within the penal clauses of the statute.

At the conclusion of the evidence, Mr. BOUSFIELD, K.C., on behalf of the petitioner, submitted that respondents had not complied with the section, and that the agreement which the British Westinghouse Co. had entered into with Messrs. Korting & Mathiesen showed that the Westinghouse Co. did not intend to seriously undertake the manufacture of the arc lamps in this country. It was consistent with the British Westinghouse Co.'s view to let these lamps be sent from abroad, so that they could get their money in royalties in that way. He contended that the company had no right to make a business arrangement of that kind to the prejudice of a British industry. Patentees in a sense had, having regard to the fact that a patent was granted to them, a British industry in partnership with them, and they were bound to do what they could to encourage a British industry. He quite agreed that from the appellants' point of view it was very good business that the German firm could go on sending into this country thousands of lamps a year and paying a royalty upon them.

His LORDSHIP: At the date of this agreement they had spent a lot of money in trying to establish an industry and failed. They then found a man who could do it. They either had to fight him or come to some terms with him. What is there unfair to the British industry in those terms?

Mr. BOUSFIELD replied that it might have been a reasonable bargain to make so far as the parties to it were concerned; but asked whether any result could have been expected from the licence except the result that had flown from it. In 1906 the British Westinghouse Co. were practically manufacturing no lamps at all in this country in accordance with the patent, and in March of that year a licence to manufacture was granted by the British Westinghouse Co. to Messrs. Körting & Mathiesen, and under that licence the German Co. paid a royalty upon every lamp made under the patent and imported by them.

His LORDSHIP said that the case for the appellants was that nobody was willing to take a licence but Körting & Mathiesen.

Mr. BOUSFIELD said the obvious intention of the agreement was that the British Westinghouse Co. meant to get their profits out of the royalties.

His LORDSHIP could not understand what other course the British Westinghouse Co. could have pursued under the circumstances.

Mr. BOUSFIELD replied that to his mind the question was what course his Lordship ought to pursue. The first question was, Had the patented article been manufactured to an adequate extent here, and, if not, had there been a satisfactory reason given? In a former judgment upon the act his Lordship had already dealt with what was "adequate extent" and "satisfactory reason," and he (counsel) was satisfied with what his lordship said in that judgment about that. The word "adequate" was a word which connoted means to an end. The act was aimed at patents being used for developing industries abroad at the expense of home industries. He submitted that when one had to define what "adequate extent" meant you had to look at the mischief the statute was aimed at.

His LORDSHIP: You do not want to penalise a man who has done his best.

Mr. BOUSFIELD: Have these people done their best?

His LORDSHIP: The question might have been different if the patent had not been in dispute.

Mr. BOUSFIELD said that they must assume for the purpose of the case that the patent was valid. If it was invalid, there was an end of the petition for revocation. The British Westinghouse Co. must have known that as a result of what they did they would only be able to put on the market 200 or 300 lamps made in this country. He submitted that upon the evidence his Lordship was bound to find as a fact that the lamps had not been adequately manufactured in the United Kingdom, and that the British Westinghouse Co. had offered no satisfactory reason why they had not.

Mr. SARGEANT addressed his Lordship on behalf of the Board of Trade.

JUDGMENT.

In delivering judgment on Tuesday his LORDSHIP said that the appeals were from two decisions of the Comptroller under sec. 27 of the Patents and Designs Act, 1907, by one of which (dated Feb. 9, 1909) he revoked letters patent No. 18,786, 1902, belonging to the British Westinghouse Electric & Mfg. Co., and by the other (dated Feb. 18, 1909) he revoked letters patent No. 23,606, 1908, belonging to the Körting & Mathiesen A-G., a German company, whom he will hereafter refer to as Körting & Mathiesen. The two cases were closely associated, and could, in his opinion, in the circumstances which were peculiar and not likely to recur, be dealt with separately. He agreed with the Comptroller (and, indeed, it was not really disputed before him) that in each case the patented article was manufactured mainly outside the United Kingdom, so that in the one case the company, and in the other Körting & Mathiesen, had to prove that the patented article was manufactured to an adequate extent within the United Kingdom, or give satisfactory reasons why it was not so manufactured. In order to discharge that onus they must at least show, with regard to their respective letters patent that they had not by any exercise of their patent rights given any preference to foreign over British industry, or otherwise done anything inconsistent with the obligations arising under the act. In Nov., 1901, the Westinghouse Co. acquired from one Bremer a number of patents granted in this country for improvements in connection with arc lamps, together with the benefit of any further improvements to be made by him within the period limited by the contract of purchase. Bremer subsequently obtained letters patent No. 18,786, 1902, for further improvements, being the letters patent the subject of the first of these appeals, and in due course (pursuant to contract) he assigned same to the company. The latter had not, prior to their acquisition of the Bremer patents, made or dealt in arc lamps, and they acquired the patents with a view to establishing an industry in arc lamps at their works at Trafford Park, England. Immediately after they commenced manufacturing lamps under the patents, and, with the object of forthwith creating a trade in this country, bought from Bremer a number of lamps already made by him abroad. The lamps supplied by Bremer, as also the lamps first manufactured by the company, proved defective, and, in consequence, the company acquired a bad reputation in that kind of goods. They continued, however, at considerable expense, to make experiments in order to overcome their initial difficulties in the manufacture, and remedy the defects which they discovered in the articles as supplied by Bremer and as made by themselves, utilising for that purpose the improvements which were the subject of letters patent No. 18,786, of 1902. Shortly after Bremer's application for his 1902 patent (on Oct. 29, 1902) one, Högner, an engineer in the employment of Körting & Mathiesen, applied for, and subsequently obtained, letters patent for practically the same invention (23,606, of 1902, the subject of the second of these appeals). Körting & Mathiesen, who acquired these letters patent from Högner, in 1903 began to import into this country lamps made under Högner's patent, which were admittedly an infringement of Bremer's 1902 patent, if such patent be valid. That was done through the Union Electric Co., who acted as their agents in this country. In 1903 26 such lamps were imported, in

1904 398, and in 1905 as many as 2,348. It did not appear when the Westinghouse Co. first became aware of that importation of infringing lamps. Up to the beginning of 1906 they were still busy experimenting and trying to obviate the difficulties they had encountered in manufacturing under the Bremer patents. At the beginning of 1906 they had, as they thought, obviated all such difficulties, and were then, at any rate, fully aware of the importation of infringing articles by the Union Electric Co. as agents of Körting & Mathiesen. Questions seemed, however, to have arisen as to the validity of their 1902 patent, one objection suggested being based on disconformity. Under these circumstances they had two courses open to them : either they could commence proceedings for infringement, at the possible risk of having their 1902 patent declared invalid, and perhaps, incidentally, setting up Högner's patent, or they could endeavour to come to terms with Körting & Mathiesen. They chose the latter course, and entered into negotiations with Körting & Mathiesen and the Union Electric Co., which resulted in an agreement under which they granted to Körting & Mathiesen a licence under the Bremer patents for 10 years from Jan. 1, 1906, determinable as the end of the first five years by six months' notice given by either party, and subject to a royalty of so much per lamp sold in the United Kingdom or the Isle of Man, and they obtained from Körting & Mathiesen a free licence under the Högner patent of 1902 for the same period and determinable in the same manner.

Having come to that agreement, the company proceeded to put their goods on the market in competition with the lamps of Körting & Mathiesen. In 1906 they made under the Bremer 1902 patent, and sold between 100 and 200 such lamps, in 1907 527, and in 1908, up to Nov. 2, 530 such, and they had 274 made by them still in stock. On the other hand, in 1906 Körting & Mathiesen imported into this country 3,467 similar lamps, in 1907 3,612, and in 1908 2,777. The company had not as yet been very successful in competing with Körting & Mathiesen, but they accounted for that by the fact that they had only recently started the manufacture of arc lamps, and had, unfortunately, acquired a bad reputation for their goods from the first. A number of cheap infringements of their patent were also being imported into or made and sold in this country, and they had instituted proceedings to stop such infringements, which proceedings were still pending. Their hope was that, as they were now manufacturing a really good lamp, that when that became better known and infringement had been stopped, they would be able to compete successfully with Körting & Mathiesen in this country, if not in foreign markets. Respondent (who was also a defendant in one of the actions for infringement) said that by neglecting to establish infringement proceedings between 1903 and 1906 in respect of Körting & Mathiesen's imported lamps, by entering into the agreement of March 12, 1906, and by bungling efforts to put competing lamps on the market, they had, in effect, destroyed all chance of establishing an industry in this country in the article protected by Bremer's 1902 patent, and that such patent ought, therefore, to be revoked under sec. 27 of the Act of 1907. It was even suggested that, whatever may have been their intentions at first, they must have given up any bona fide intention of starting such an industry when they entered into the agreement with Körting & Mathiesen. He had given the matter a good deal of consideration, and he had come to the conclusion that the company had been, and were still, making a bona fide attempt to establish in this country an industry in arc lamps. They acquired the Bremer patents (including the patent of 1902) for that purpose, and they had expended large sums with that end in view, beyond what they paid to Bremer. It was by no means an easy task to establish an industry for the first time. Both managers and workmen must buy their experience, and the attempt became the more difficult if it must be made in the teeth of the competition of a firm who had already acquired a great reputation for the quality of their own goods and had access to English markets. If, however, the person who attempted to establish such an industry had patent rights in this country, such patent rights were, of course, of great value, for they would enable him to exclude, or limit, the competition which otherwise might prove fatal ; but even such patent rights might be of little use if the competitor was in a position to put goods on the market which he could sell by virtue of his reputation, even if they did not contain the latest improvements. In the present case it was obviously the right policy of the company to use their 1902 patent to limit, or exclude, competition from Körting & Mathiesen. Possibly, they might have succeeded in stopping altogether the importation of goods made by the latter under the Högner patent. They came to the conclusion, however (and he was not in a position to say it was a wrong conclusion), not to attempt that, but to use their 1902 patent to limit the competition they feared. By the agreement of March 12, 1906, they handicap Körting & Mathiesen to the extent of the royalty imposed on them, and obtained a free licence themselves in respect of the Högner patent, thus using their patent rights to increase and not to diminish, the chance of being able to establish an industry in arc lamps in this country. It was true they limited their own power of granting licences at royalties below the fixed minimum, but he could not see that that fixed minimum was unfair, and, if it were, it did not prevent anyone applying for and obtaining a compulsory licence. It was true, also, that they limited their power of under-selling Körting & Mathiesen in the British market, but it was still open to them to compete with Körting & Mathiesen by putting as good or a better article on the market at the same price. If they succeeded in establishing their patent rights, and could obtain a reputation for their goods before Jan. 1, 1911, they could determine the agreement of March 12, 1906, and altogether exclude foreign goods made under their 1902 patent for the remainder of the term for which the patent was granted. He was satisfied that it was to their interest to manufacture, under their patent, to as large an extent as possible in the United Kingdom, for, leaving out of account the money expended in purchasing and experimenting with their patents, their profit on each lamp now made and sold by them was greater than the royalty they received on each lamp imported and sold by Körting & Mathiesen. He could find nothing in the company's conduct inconsistent with a bona fide intention to manufacture the patented article to as large an extent as possible in this country, and the agreement of March 12, 1906, was conducive to that end. With regard to the delay between 1903, when Körting & Mathiesen first began to import lamps made under the Högner patent, and the date of the agreement, it was, of course, true that, had the agreement been arrived at earlier, the company would have gained in royalties, but as they were not in a position to put their lamps on the market before 1906, that would not have prevented Körting & Mathiesen from being the first to establish a business in the patented article in the United Kingdom. In his opinion, the company had throughout used, and still were using, their best endeavours to fulfil the obligation arising under the Act of 1907 by establishing in this country an industry in the article, the subject of their 1902 patent, and they had further proved, to his satisfaction, that their want of success up to the present time had been due to circumstances beyond their own control, and not to the manner in which they had exercised the rights conferred upon them by the patent in question. The Act of 1907 was never meant to penalise want of success when the patentee had done his best, and he could not, therefore, come to the conclusion that the company's patent ought to be revoked.

With regard to Högner's patent, Körting & Mathiesen had not so strong a case for resisting its revocation as the company had for resisting the revocation of Bremer's patent of 1902. Körting & Mathiesen had made no attempt to work Högner's patent in this country otherwise than through the company, and it was largely due to the competition of lamps made by them abroad that the company had been able to manufacture and sell so few lamps in this country. On the other hand, they might fairly say that they had not only granted a free licence to a company which intended and was presumably qualified to work the patent in this country, but had precluded themselves from importing and selling competing lamps without paying a substantial royalty. Further, such patent, so far as he could see, could be valid only if Bremer's 1902 patent be invalid, and then only if such invalidity be due to the objection based on disconformity. If it be ultimately decided that Bremer's 1902 patent was invalid, and Högner's patent valid, and Körting & Mathiesen did not then forthwith take steps for working Högner's patent, or ensuring that it be worked to an adequate extent in this country, he thought they would have great difficulty in resisting its revocation. He had, however, come to the conclusion that, under present circumstances, he might fairly accept the reasons given by them for the small extent to which the patent was worked in this country as satisfactory, and he came to that conclusion the more readily beause the revocation of this patent might make things even more difficult for the company, who were, as he had said, doing their best to create an industry in the patented article in the United Kingdom.

He proposed, therefore, in each case, to reverse the Comptroller's decision so far as it revoked the patent in question ; but not to disturb his directions as to the costs of the proceedings before him. He should allow no costs of the appeals, except the Attorney-General's costs, which he directed to be borne and paid in the one case by Mr. Braulik and the company in equal shares, and in the other case by Mr. Braulik and Körting & Mathiesen in equal shares. His decision to allow further evidence on the appeals must not, however, be taken as a precedent governing other cases.

Consolidated Nickel, Tin & Copper Mines v. Crompton & Co.

Continuing the hearing of this case before the Official Referee (Mr. Muir Mackenzie, K.C.), on 20th inst.,

Mr. W. J. Evans, an engineer in the employ of Messrs. Crossley Bros., said he was informed on Jan. 5 by Capt. Tonkin that there was some trouble with the self-starter, which witness took to pieces and found there was a piece of grit underneath one of the valves. He removed it and then the starter worked all right. He did not think the engine had been carefully looked after.

Mr. C. E. Sexton, engineer in charge of contract work for Messrs. Crompton & Co., said he went to Chacewater on Aug. 22, 1907. At that time the temporary plant was running. There were difficulties in starting the plant. When the motor was switched on the gas engine slowed up. He put that down to the gas plant not being run properly by the men in charge. It was not given sufficient attention. He got the impression that they did not understand the gas plant or the engine. He tried to get the rotor into a position in which it would not bind against the stator. At first he was inclined to think that the spindle was out of truth, but that turned out not to be correct. He doubted whether a small increase of the air-gap would decrease the efficiency of the motor. He considered plaintiffs' were ordinary unskilled men. When the difficulties of starting the motor cropped up witness certainly came to the conclusion it was desirable to have some one more skilful on the spot than plaintiffs' men. He did say to his principals that there was nothing wrong with the motor. There was no difficulty about starting, and there was no trouble with the gas engine ; the whole trouble was that the men were incompetent and ignorant.

Mr. James Studer, principal armature winder for alternating-current machines at Messrs. Crompton's works at Chelmsford, said that he wound the stator of the motor in question in this action in accordance with instructions from the winding office. It was properly and efficiently done. When the machine was

returned to the works in September witness took it to pieces and examined it. He found that the three outside coils of the stator were burnt and the copper wire exposed. The bars of the rotor had been fastened with solder and rivets, but the solder had melted away. The solder had run owing to a heavy current. The melting point of solder was over 300° F. or 400° F. He could tell by examining the windings of the stator if a breakdown was due to defective workmanship or bad material, and the breakdown in question did not arise from defective workmanship. He would not be able to say from what he saw what amount of current had been going through the motor. When he re-wound the stator he did not use any thicker wire, but wound it exactly as he had done in the first place. When the breakdown in November occurred witness went down to the mine to again re-wind the stator. This time the motor was totally burnt out. There was no insulation left on the stator, and the rotor was devoid of any solder. That must have been due to heavy current in the machine. Witness repaired it as before.

Mr. P. W. Freudemacher, estimating engineer for Messrs. Crompton, said that in October, 1906, he had an interview with Mr. Williamson, director of the Consolidated Co. with a view to giving an estimate for a pumping installation at the mine. He obtained quotations for a pump capable of delivering "1,000 gallons of water per minute against a head of 120 ft." In his opinion a pump specified for in those words meant a pump capable of delivering 1,000 gallons a minute against a 120 ft. head which was made up of the height due to the suction and delivery and also the pipe friction. Mr. Williamson did not tell him that he wanted a pump to unwater a mine 120 ft. deep. Had he done so witness would not have specified in the way he did to the firms who quoted. He would have first questioned Mr. Williamson as to the length and diameter of the pipe through which the water had to be delivered, and any curves there might be. He knew nothing of letters which afterwards passed between the parties raising the question of the necessity for more power on account of friction.

Mr. W. P. Miller, a member of the London staff of defendants, stated that he went down to the mine on Oct. 5, 1907, to superintend the starting of the pumping plant. He found the motor coupling was out of centre with the pump coupling by about $\frac{12}{1000}$th of an inch. It was a flexible coupling, and therefore that did not in any way affect the running of the pump. They put it right, however, and the job took them a day, together with erecting the pump. They commenced pumping on the afternoon of the 9th, and the voltage before they put the switch in was about 550. Immediately it was put in it dropped to 270 or 300 with a starting current of 150 amperes. When the plant had got into its stride the running current was about 50 amperes and the volts 530 to 550. When they started the motor and machinery ran very satisfactorily indeed, but during the first night they had to shut down because the engine backed out altogether through bad gas. That was undoubtedly from want of attention to the gas producer. At the time witness was at the engine end of the room near the switchboard. He pulled out the rotor switch because the engine was slowing down, the short circuit current was about 150 to 170 amperes and the voltage had dropped to between 230 and 300. Under such conditions, of course, it would not have taken many minutes to burn out the machine. After witness had taken out the switch he went to the other end of the room and saw a man who had been lying down jump up and rush to his gas valve at the top end of the engine room, but, of course, that was no good. Witness then went into the producer house and found the gas scrubbers were very hot, showing that they had not had sufficient water supply. The water cock was not full on, and, in addition, was blocked a little. He reported to defendants that "with the exception of the gas falling off owing to driver's inattention, the plant had worked well." All through the following day the engine ran very well, but there was trouble again in the night. Witness did not stand by the plant that night again, but when he came down in the morning he found on examination of the plant that the lighting supply had all been stopped and the lamps blown to pieces. The supply, witness explained, was run direct off the alternator supply. When they pulled out the main switch in taking the load off the alternator, the pressure went up to about 750, which, of course, was far too high for any lamp circuit. Therefore, when he saw the lamps had been blown, he knew they had had a "shut down" of some kind. The driver, when witness first came down, told him they had had no trouble during the night, but it was afterwards admitted that something had gone wrong. Witness could only give one solution, viz., bad gas through inattention to the engine. During the rest of the time witness was there they did not have much trouble with the plant. In his opinion, the motor was allowed too frequently to get out of step, owing primarily to bad gas. Belt-slip, too, might have had something to do with it. The plant was not having fair treatment. He told his principals that the only thing that was wanted was that the men who were running the plant should be got rid of and proper men engaged.

Mr. J. B. Gall, F.I.C., in the employ of Callenders Cable & Construction Co., said he had analysed a sample of the water taken from Wheal Busy mine in November, 1907. He found it contained silica, iron oxide, lime, magnesia, soda, copper oxide, nickel and zinc oxide, sulphuric anhydride and chlorine. Free sulphuric acid was present to the amount of 4·67 grains per gallon, and that would affect the metal of the pump, setting up chemical action on the cast iron and the bronze. In addition, electrolytic action would also be set up. The chemical action meant corrosion and rusting, whilst the electrolytic action would tend to remove the metal by solution, and thus increase the clearance of the pump. Witness had detected the presence of copper sulphate in the water which would have a corrosive effect upon both the iron and bronze of the pump. The presence of phosphorous in the bronze used for making parts of the pump made it all the more susceptible to attack by dilute sulphuric acid. The phosphorous would be present in the form of metal phosphides, which were readily decomposed by contact with dilute acids. From experiments he had carried out, he had arrived at the conclusion that there would be a difference in potential set up in the pump of 0·6 of a volt approximately when the pump was full of the acid liquor. The effect of that would be to cause a passage of electricity with concurrent corrosion of the cast-iron surface. As the results of his experiments he found that the amount of corrosion from chemical action amounted to one-sixth of an ounce over 1 sq. ft. of surface area after 68 days' immersion, whilst through electrolysis for the cast iron the loss in weight amounted to one-third of 1 ounce per square foot after 67 days' immersion. Those were the results of his experiments, but in the mine itself he should say the loss would be heavier. If they had had a sample of the water sent to them in the first place they would have supplied a very different kind of cable to that which his firm did supply for the plant in question. Under such conditions vulcanised bitumen cable was far better than rubber insulation. He agreed that cable put into the shaft to supply the current from the generator to the motor was not the right sort. The cable did not actually touch the water.

Mr. H. Winwood, advisory engineer to Messrs. Tangye, said that the word "head" meant the total amount of work done by the pumping from the surface of the water to the top of the delivery including all friction in the pipes through which the water might be transmitted. Corrosion was rather common in mining all the world over, and in metalliferous mines it was very general. He had seen a sample of water from the plaintiffs' mine, and, in his opinion, it was an acidulous water which would have a very considerable effect on the pump. It was not usual when specifying for pumps to inquire the nature of the water. If the water was bad, customers generally called attention to it. Suction gas plants were very generally used for driving electric pumps.

Mr. Jas. Atkinson, engineer to Messrs. Crossley Bros., said that it was under his direction that most of the gas engines were made. That particular type of engine was a single cylinder Otto cycle gas engine working on suction gas. The cylinder was 17 in. diameter and 24 in. stroke and arranged to run at 200 revs. per min. The rims of the flywheels together weighed 2·2 tons. The flywheels had a stored-up energy in them of 185 ft.-tons when they were running at 200 revolutions. The current was taken from the generator to the motor and the motor would reproduce, as it were, the variations in speed of the generator. That variation would not affect the working of a pump of that kind. The flywheels were sufficient for driving the pump. If the flywheels had been 9 tons they could not have constructed the engine in the way it had been constructed. Irregularity due to bad gas would affect the motor in the way that the engine would run slower. Mr. Rosenbusch had suggested that the shaft was bent, but he maintained that in all probability that was not so. The fact that they had made so many engines with the same strength of shaft was fairly conclusive that the shaft was not bent with the strain. He thought it was probably due to neglect to keep the bearings properly adjusted, which would leave a little slackness in the bearings and at every explosion it would jump. From what he could gather the engine had been shamefully neglected. It required a man of a certain amount of training to work that kind of engine. Those engines were used for almost every purpose for which power was required. The reason why they were not used for electric lighting was that they had not sufficient regularity for that purpose. To build that particular type of engine for electric lighting work they would have to increase the size of the flywheel.

Mr. J. N. Boot, an engineer of the Worthington Pump Co., said he had been shown an analysis of the water taken from the Wheal Busy mine, and certain acids in it would in time tend to eat away the metal of the pump and that would to a certain extent decrease the efficiency of the pump. The water contained quantities of ochre which would have a deleterious effect on the pump. If he were supplying a pump to the order of a mining company, and if he had any doubt about it, he would make inquiries as to the chemical composition of the water to be pumped. So far as he knew, Messrs. Crompton did not give them information as to there being acid in the water. They supplied the pump on the assumption that the water which it had to pump would contain acid, at any rate to any such extent as to affect the pump.

Mr. J. C. Macfarlane, M.I.E.E., who was in charge of the main shop at Messrs. Crompton's works at Chelmsford, said that he remembered the motor supplied to plaintiffs. It was a verticle spindle totally enclosed three-phase induction motor, with an output of 55 b.h.p. when running at a speed of 1,450 revs. per min. on a 550 volt 50 cycle circuit. Messrs. Cromptons manufactured a very large number of motors of the same style and strength every year and they supplied a good many of them for pumping in mines. Before the motor left the works it was tested. The resistances of the windings were taken, the power factor and efficiencies were tested and the motor was run on light load for some considerable time to test the bearings. The usual tests were applied with regard to the soundness of the insulation. It was the practice of the company to test a motor at its full load for four or six hours before despatch; but in the present case that was not done because the motor would have to have waited for two or three days to get the power. As originally arranged, there were three bearings upon the shaft supporting the rotor portion of the motor. As originally designed, the distance between the bearings was about 27 in., which, in his opinion, was right. The distance was fairly short in this case, due to the design of the rotor. At the end of August the motor was sent to the Redruth Foundry, and the air-gap was increased from $\frac{3}{100}$ths to $\frac{5}{100}$ths of an inch. He had made calculations in respect of that and was of opinion that it would not decrease the power factor more than 1 per cent. The probability was that it was about half of 1 per cent. decrease in the power factor. On Sept. 13

the main bearing of the motor seized and on Sept. 20 it was returned to Chelmsford. He found then that several of the stator coils were entirely burnt out—that was to say, the insulation was burnt right off the wires. He thought at the time the trouble was entirely due to starting up the plant. He noticed that the solder connecting the rotor bars to the end rings was thrown out of the joints. The melting point of this solder was between 350 deg. and 400 deg. A starting current of 150 amperes, if allowed to continue, produced tremendous heat. In fact, the heat lost in the copper—the heat wasted in the copper—was proportionate to the square of the current—that was to say, if you doubled the current you would have four times the loss of heat in the copper. In this case 150 amperes was three times the full load current and the copper heating must have been nine times as great as under normal full load conditions. It would not be safe to have a starting current of 150 amperes running through it for more than six or seven minutes at the outside. If the current were allowed to continue for a longer period there would be a total burn out, the solder would be entirely melted out of the joints in the rotor and the insulation would be burnt off of the stator coils—a state of things which he found in the present case. If the motor should fall out of step the engineer, to remedy that state of things, should draw out the switch, which would open the circuit. Before he did that, he might try and remedy it by increasing the current through the field of the alternator—that was to say, he could increase the excitation of the alternator and thereby increase the magnetism, thereby increasing its volts—that was to say, the E.M.F. generated, and he might be able to stop it in that way. There was no difficulty in doing that if you knew anything at all about driving these engines. He did not think that what had happened was due to any defect in the motor itself. In his opinion, the cause of the burning out was either due to the starting current being left on too long or to the fact that the motor got out of step. He thought the exciter voltage in that case was exactly suited to the work. The reason that a starting switch was used was to cut down the voltage impressed on the motor in order to cut down the starting current. That was done in that case by allowing the alternator to supply an automatically reduced voltage when the motor was starting up. In witness's opinion, if the motor were worked with its full current of 55 amperes it would pump at the rate of 1,000 gallons per minute instead of about 600, which was its capacity at about 45 amperes. There was no necessity to have an ammeter recording more than 100 amperes. The 150 amperes was only required at starting and there was no necessity for a meter to record that amount. If the plant had been started up properly the amperes would have come down within half a minute to the normal working amperes of 50 or 60. Anyone who understood his business would know that if the amperemeter showed up to 100 amperes that there was danger and that he ought to stop the plant at once. Totally enclosed motors would not stand a great deal of continuous running on an overload because of heating. But, of course, that was a statement which was subject to qualifications. What happened was that there was a certain quantity of heat generated inside the motor, and when the rate of generation of that heat was equal to the rate of dissipation then the temperature remained constant. A totally enclosed motor was usually rated about 25 to 50 per cent. lower than an open or ventilated motor, according to the size of the machine ; with medium sized motors it was 25 per cent. He disagreed that a ventilated motor of the same size as a 55 H.P. totally enclosed machine would be rated at 100 H.P. The motor supplied to plaintiffs was constructed with a large number of raidating gills, and motors of this type, if ventilated, would not give more than 25 per cent. increased power.

Mr. ALAN WILLIAMS, electrical engineer, employed at Messrs. Crompton & Co.'s works, said that the motor in question was rated to do 55 H.P. at a speed of about 1,450 revs. per min., and it could do that continuously, and, further, it could do 25 per cent. overload for two hours and larger overloads for shorter periods. The type of enigne was perfectly suitable for driving pumps of that kind. The variations in speed between explosions would not make any difference to the running of the motor and pump. The men who worked plant of that kind required a certain amount of training. The motor, for the position in which the pump was situated, was practically the only type of motor for that purpose.

The hearing had not concluded when we went to press.

Gould v. Lehwess.

The hearing of this case was resumed before Mr. Justice Phillimore on Friday, when further evidence was given for the defence.

At the close of defendant's evidence,

Mr. W. M. MORDEY gave evidence to the effect that plaintiff could not possibly have fulfilled the tests prescribed for his batteries in the contract, as there was no battery manufactured that could meet such tests.

On Tuesday defendant's counsel (Mr. Gore-Browne) gave an account of defendant's share holding in the London Electrobus Co.

Mr. JACOB ATHERTON said he was a director of the London Electrobus Co. from the 15th April, 1908, until the end of that year. In May, 1908, when the question of batteries generally was discussed by the board, he was appointed to inquire into the matter, in conjunction with a Mr. Roberts, who, however, did not attend, and the whole thing was practically left in witness's hands. Dr. Lehwess talked to him about both the Gould and the Tudor batteries, and bothered him several times about making a test of the Gould batteries. Witness said they could not stop the business of the company in order to make tests. The company, he said, was not interested in tests so long as they ran the 'buses at 2d. a mile, the cost set out in the prospectus. The tests did not interest him. They had a contract to have their 'buses run at 2d. a mile for battery power, and that was what interested him.

Mr. Justice PHILLIMORE : How did you become a director of the Electrobus Co. ? Who put you there ?—I was asked to go there. I think the firm of accountants that acted for the company. I was asked at the same time as Sir Henry Dering.

Did you take any shares, or were they found for you ?—We took our qualification. He left the Board because he thought the directors were running things on too lavish a scale. He retired voluntarily.

Mr. GORE-BROWNE : Did Dr. Lehwess control the Board ?—No, certainly not. If he had tried to control it there would have been some trouble. Dr. Lehwess did not control the board, but he knew that he had been a promoter of the company. The only question before the board on the date of his (witness's) appointment was one relating to the Tudor batteries.

His LORDSHIP pointed out that there was nothing in witness's report showing that he had gone into the question of the Gould batteries at all.

Mr. ATHERTON replied that the Gould batteries not being satisfactory, he had not to consider them. His qualifying shares were acquired from Dr. Lehwess. He did not pay for them. Not in actual cash, but he had an arrangement with Lehwess to transfer to him (witness) 200 shares at a nominal consideration, to pay for in cash at a later date. He did not, in fact, pay him. Dr. Lehwess and he had a row, and when he ceased to be a director he handed the shares back to Dr. Lehwess. As to the tests, the company's 'buses ran from 6 in the morning to 12 at night, so that the seven or eight hours required for a test of the batteries would have interfered with the working.

At this stage, Dr. Lehwess was recalled.

His LORDSHIP : You told us that when the English Gould Electric Storage Co. was formed the shares, other than the 4,000 previously mentioned in this case, the 100 taken by Capt. Locock, and the seven signatory shares, were all taken by the Asiatic Banking Corpn. ?—They were all taken as fully paid.

But you were the Asiatic Banking Corpn. ?—As I explained to your Lordship, I was.

This is a serious matter. You did not write to Mr. Gould to tell him that you were the Asiatic Banking Corpn. ?—I did not tell him anything at all about it.

After counsel had delivered their addresses,

Mr. Justice PHILLIMORE, in giving judgment, said the facts were plain. Plaintiff supplied the storage batteries under a contract with defendant, who said he was not liable to pay for them because they had not passed the stipulated test. His Lordship came to the conclusion that the reason why the tests were not carried out was because defendant prevented that being done. He, therefore, held that plaintiff was entitled to a judgment for £2,528. 15s. the amount of the claim, less the present estimated value of the batteries.

A stay of execution was granted.

Bergtheil & Young v. Argus Printing Co.

In the City of London Court on Tuesday, plaintiffs sought to recover £14. 0s. 9d. for electrical work done. It was stated that in October last plaintiffs put in certain flame arc lamps on approval at defendants' printing works in London. Complaints were made that the lamps were not working properly. To this complaint plaintiffs alleged that the resistances had been tampered with and that there was evidence of rough treatment on the part of defendants' men. The lamps were kept for six months, and then defendants wanted to return them. The custom was that such goods should be returned within a month or be paid for.

After hearing the evidence, Judge LUMLEY-SMITH, K.C., said it was not a question of goods on sale or return, but of defendants allowing plaintiffs to put the lamps on their premises. Plaintiffs were not entitled to be paid for the lamps, but defendants must pay £1. 7s. 6d. for work which they had ordered. Judgment would be entered for £1. 0s. 6d. for plaintiffs beyond the £2. 15s. 3d. which had been paid into Court in respect of items for carbons, &c.

Wilkinson Feed Water Heater Patents.—The Comptroller of Patents has given his decision in the matter of an opposition to the grant of a patent to Mr. George Wilkinson, of Harrogate, for improvements in the "Wilkinson" feed water heater. There are a series of patents for this heater, but the present application (No. 1,777, 1908) relates to means for regulating the amount of heat transferred from the steam to the feed water, it being recognised that there is a limit to the number of heat units which can economically be transferred from the steam in a boiler to the feed water brought into contact therewith. The grant of the patent was opposed by Messrs. Hamilton & McMasters, of Belfast, on the ground that the invention had been patented under their prior patent, No. 21,070, 1900, and also upon the ground that the manner in which Mr. Wilkinson's invention was to be performed was not sufficiently or fairly described and ascertained in his complete specification.

The comptroller dismissed the opposition, with seven guineas costs.

Tariff Reform and the Electrical Engineering Industry.—It is, of course, well known to our readers that Mr. C. A. Pearson, the head of the "Daily Express" newspaper, is a leading member of the Tariff Reform League, and his energetic work has done much to keep that movement in the foreground. In the "Daily Express" for May 20 an article on the question of Tariff Reform as it affects the electrical industry appeared, and we think it right to refer our readers to this article. We understand that a postcard indicating a desire to receive a copy of the "Daily Express" of the date mentioned will secure this being forwarded free of charge.

PARLIAMENTARY INTELLIGENCE.

FOLKESTONE, SANDGATE AND HYTHE TRAMWAYS BILL.

Lord Radnor gave evidence last week on this bill before the House of Commons Committee presided over by Mr. Ashton. He said there was about half-a-mile of Sandgate Hill on which he desired the conduit system to be adopted. If that should cost £7,000 more than the overhead system, that did not seem a serious matter for the company.

Mr. Freeman, K.C. (for Lord Radnor), said his lordship did not consider Folkestone a suitable place for tramways, but he subordinated his own wishes to those of the municipal authority when they wished to construct tramways themselves, and he gave them land worth about £2,000. They had handed this over to a private company, but to save the appearance of the town they stipulated for the Dolter system for the whole of Folkestone and Sandgate. The company now appealed to be relieved of their obligations, without giving Lord Radnor anything in return. He wanted to make it compulsory to construct the Cheriton-road line and the half-mile on Sandgate Hill on the conduit system at the same time as the other portions of the tramways.

On Tuesday, Mr. Coward, K.C., for the promoters, said that the National Electric Construction Co. had spent £30,000 in trying to perfect the Dolter system, but, unhappily, they had made a mistake. The company proposed to spend £5,000 in addition to what the 1906 scheme would have cost although they were now getting 3 route miles of line less. The Lorain system was an afterthought of the local authorities, and was only mentioned after the promoters had put all their cards on the table. The patentees of the Lorain system would not guarantee it, and it had been suggested that the promoters should put down the Lorain system without a guarantee. The promoters wished to repeal the section of their act which said the question of the system to be used must go to arbitration.

After consultation, the Chairman announced that the Committee's decision was that only so much of the preamble was proved as related to the extension of time, which would be fixed at two years.

Royal Assent. On Tuesday last Royal assent was given to the Anglo-Argentine Tramway and the North Metropolitan Electric Power Supply Companies' Acts.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governors of the Heriot-Watt College, Edinburgh, invite applications for the position of assistant lecturer in electrical engineering as from Sept. 6 next. Salary £130 per annum. Further information from Prof. Baily at the College. Applications must be lodged by June 21. See also an advertisement.

The Aron Electricity Meter (Ltd.), 80A, Salusbury-road, Kilburn, require a test room assistant. See advertisement.

West Ham Corporation invite applications for the position of electrical engineer and manager of their electricity undertaking. Candidates must have had considerable experience in important electricity undertakings, and have a sound knowledge of the commercial management of electricity supply. Application forms, &c., from the town clerk, Mr. Fred. E. Hilleary, Town Hall, West Ham, to whom applications must be sent by 5 p.m. June 1.

The managers of the Technical College, Dundee, invite applications for the position of lecturer in electrical and mechanical engineering. The person appointed will have full charge of the electrical department, and must be competent to take the senior branches of mechanical engineering. Salary £350. Applications to the Director of Studies, Technical Institute, Dundee, by June 15.

The appointment of lecturer in the physics and electrical engineering departments at the Sunderland Technical College is now vacant. Salary £150 per annum. Applications to the Secretary, Mr. T. W. Bryers, 15, John-street, Sunderland, before May 31.

A cookery demonstrator, capable of using electrical cooking apparatus in an effective manner, is required for the Borough of Accrington electrical exhibition from Aug. 30 to Sept. 7 next. Particulars from the Borough Electrical Engineer.

Croydon Education committee invite applications for the post of principal of the polytechnics. Salary £300, rising to £350. Forms from the Clerk, Catherine-street, Croydon. Applications by June 26.

Teachers of electrical engineering and wiremen's work are wanted to evening classes at Tottenham Polytechnic. Fee 12s. 6d. per evening. Applications by June 7 to Mr. J. W. Tomlinson at the [illegible].

A full time assistant for the electrical engineering department is required for Leicester Municipal Technical School. Commencing salary £160. Applications to the secretary, Mr. T. Groves, by June 16.

An additional lecturer in mathematics is required at West Ham Municipal Technical Institute. Salary £200. Applications to the [illegible].

Mr. E. C. Jennings, at present with the British Thomson-Houston Co., has been appointed assistant to the mains engineer of the Birmingham Corporation electricity department.

Mr. J. H. Cardew has been appointed as the Government's electrical inspector at Madras.

EDUCATIONAL NOTICES.

East London College.—A special lecture on "The Technical Aspect of the G.B. System of Electric Traction" will be delivered by Prof. J. T. Morris on June 7 at 8 p.m., and a course of three lectures on "The Electrification of Main Lines" will be delivered by Mr. L. Murphy on June 2, 9 and 16.

University of Sheffield.—The council of this university recently decided to purchase a Kjellin electric furnace for experimental purposes in the applied science department. Sir Joseph Jonas, vice-chairman of the department has generously given £500 towards the cost of the furnace.

Amalgamated Association of Tramway and Vehicle Workers.—The nineteenth annual conference of this Association was opened at Bradford on Wednesday. About 70 delegates, representing a membership of 14,833, attended. In the evening the Lord Mayor entertained the delegates to dinner in the Council Chamber.

Ashton-under-Lyne.—Sanction to a loan of £48,424 for extensions of the electricity undertaking has been applied for by the Council.

Bedford.—58 gas lamps are to be superseded by electric lamps at a cost of £630. The annual charge will be £150. 15s., an increase of £17. 15s., but the total candle power of the electric lamps will be 3,840, against 928 from the gas lamps.

Bray (Ireland.)—An inquiry was held here last week into the Council's application for sanction to borrow £2,600 for extensions of the electricity works.

Cookstown (Ireland).—Mr. Pegg (of Messrs. Miller, Wilson & Pegg) has been asked by the Council to prepare a report on the question of electricity supply for the district.

Country House Lighting.—Mr. G. H. Simpson-Hayward, the well-known Worcestershire cricketer, has for some time past been restoring and repairing his residence—"The Place," Icomb, which is one of the oldest, if not the oldest, country residence in Gloucestershire. With a view to further improvements and safety from fire, Mr. Simpson-Hayward has now decided to instal the electric light throughout the house and stables, and Messrs. Sanders & Co., of Clarence-street, Cheltenham, have secured the contract for the work, which will consist of a complete generating plant, including oil engine, dynamo, storage battery, underground cable, and the necessary wiring, fittings and lamps.

Dewsbury.—The order made by the L.G. Board for the extension of the boundaries of Dewsbury include clauses which transfer the Ravensthorpe electricity undertaking to the Borough Council, extend the electricity powers of Dewsbury to Ravensthorpe, and provide that nothing in the Order shall prejudicially affect the powers of the Yorkshire Electric Power Co.

Droylsden.—Manchester Electricity committee have decided to take steps to give a supply of electricity in this district.

Egham.—The Council have assented to the inclusion of a clause in the Egham provisional order to enable the Company to give a supply of electric current to small consumers from dusk to dawn at a uniform rate of 10s. per lamp, per annum.

Electric v. Gas Lighting.—At the meeting of Burton-on-Trent Council last week, in the course of a discussion on the annual accounts, Councillor King gave a striking instance of economy effected by the substitution of electric for gas lighting.

Some time ago the churchwardens of St. Peter's Church, Stapenhill, substituted electric for gas lighting. The electric light had cost £3.10s.8d. against £13. 7s. 7d. for gas for the same quarters in the previous year Mr. King, commenting on these figures, urged those who had the charge of public buildings in the town to apply to the borough electrical engineer (Mr. P. J. Pringle) for a supply of electricity.

The church referred to was previously lit by 12 coronals of fish-flame burners, each coronal having 24 burners; but the whole of these burners were not in use. The lighting is now effected by 75 osram lamps of 25 c.p. each. The bill for electric lighting for two quarters amounted to £3. 10s. 8d., against £13. 7s. 7d. for gas for the corresponding quarters in the previous year. Apart from the great economy effected, there are other advantages in favour of electric lighting—viz., increased illumination and the decided improvement in the atmosphere. We are informed that the registration of the electricity meter has been checked, and that a test meter was inserted some time ago to double check the consumption, and there is no question whatever that the economy shown has been obtained.

Electrical Exhibition.—An exhibition is to be held in the Town Hall, Accrington, under the auspices of the municipal electricity

department, from Aug. 30 to Sept. 7 next, and free space, power, &c., within reasonable limits, will be provided for exhibits.

Gillingham.—The Council have applied for sanction to a loan of £3,000 for additional generating plant, including a Diesel oil engine set. Low voltage transformers are to be hired out to consumers at 1s. per quarter up to a capacity of 500 watts, and 1s. 6d. from 500 to 1,000 watts.

Hastings.—130 further gas lamps are to be converted to electric lamps at an estimated cost of £500.

Hereford.—An inquiry was held last week into the application of the Council for sanction to a loan of £8,000, for extensions of the electricity undertaking.

The Inspector (Major C. E. Norton, R.E.) referred to the practice of lumping all the loans together and charging the capital expenditure to the general total instead of allocating it to each of the separate items.

The city electrical engineer (Mr. W. T. Kerr) explained that the system was adopted by his predecessors, and the chairman of the Electricity committee (Mr. Moore) said they would take care that future loans were kept separate. He and Mr. Kerr had been endeavouring to get the accounts into something like ship shape.

There was no opposition.

Islington.—The Great Northern & City Railway Co. have offered to supply electricity in bulk to the Council, and the matter has been referred to the Lighting committee for report.

The Borough Council have now agreed to the proposal to widen the Ball's Pond-road, at an estimated cost of about £54,000, for the purpose of laying a double line of tramways. The Islington Council's portion of the cost will be one-third of £22,775, the total cost of the widening in Islington, the remainder of the £54,000 being required for the widening of the Hackney portion of the road.

Leeds.—The extension of the city tramways from Horsforth to Guiseley was opened for traffic on Wednesday.

London (Canada.)—The London Electric Co. have offered to dispose of their generating plant and undertaking to the City Council for $400,000 in order that they may not find themselves in competition with the municipality in the business of electricity supply.

London County Council.—On Tuesday it was agreed to install electric light at the western engine house at the Deptford pumping station.

Anchoring of Track Rails.—A recommendation of the Highways committee to expend £7,000 on the anchoring of track rails was postponed.

Capital Account of Tramways.—In connection with the annual estimates (which have previously appeared), the Highways committee presented a statement showing that the total capital expenditure for tramways up to March 31, 1908, had amounted to £8,415,000, while a further amount had still to be expended for the completion of the work of electrification and the construction of authorised lines, making the total capital outlay about £12,750,000. The expenditure to March 31, 1909, was £9,484,000, exclusive of the cost of acquiring part of the London United Tramways Co.'s undertaking, and for the construction of new tramways for which Parliamentary powers are being sought this year. The annual estimates now before the Council provided for expenditure for tramways in the year 1909-10 of £1,800,000.

Lea Bridge-road Tramways.—The same committee recommended an expenditure of £1,690 for the construction of a tramway in the Lea Bridge-road on the overhead trolley system, and that the work should be carried out by Messrs. Dick, Kerr & Co. When constructed the tramway will be worked by Leyton Council, who will pay as an annual rent (*a*) $\frac{1}{37}$th part of the cost incurred in respect of the execution of the street widenings on the route, (*b*) $\frac{1}{25}$th part of the total cost of construction and equipment of the tramways, (*c*) $3\frac{3}{4}$ per cent. on the total cost of the street widenings and the construction of the tramways for the time being unpaid by the Leyton U.D.C., and (*d*) 1 per cent. of the total cost of the street widening and the construction of the tramways.

Blackfriars Bridge.—The Highways committee were authorised to arrange for Messrs. Dick, Kerr & Co. to lay pipes for the cables across Blackfriars Bridge for the tramways at a cost of £1,200.

Sand Crushing Apparatus.—An expenditure of £2,690 was authorised for the provision of additional sand crushing apparatus, &c.

Estimates.—On the recommendation of the Finance committee, the following estimates were agreed for the Highways committee: £1,800,000 on capital account, and on revenue acconnts (electric traction) £1,103,570, and (for horse traction) £173,750.

Marylebone (London).—The Electricity Supply committee report that the results of the conversion of the street lamps in Harley-street to electric lighting has been very satisfactory, and that the cost of the whole conversion of 1,964 street lamps would be under £7,000 against the previous estimate of £8,000.

The newly-appointed borough electrical engineer (Mr. A. H. Seabrook) has been permitted to act as consulting engineer to West Ham for one year, in order to dispose of several pending matters in that district.

Municipal Telephony.—On Monday Ald. Brown, chairman of Hull Telephone committee, presented the annual report of the telephone undertaking to March 31.

The total receipts were £10,592, an increase of £1,025, gross profit £4,443, increase £472, and £1,786 was transferred to loan repayment account, an increase of £506, making the total amount carried to loan repayment account £4,405, to temporary sinking fund £1,217, and to reserve £2,311, total (including the year's surplus of £1,040) £8,973, after deducting the cost of changing over the system. The Government royalty for the year was £1,082, and the total to March 31, 1909, £3,778. Capital expended is £57,858, increase of £3,111, which has been expended on extending the plant under the main headings of underground, overhead, exchange and instrument construction. The total conduits laid now reach 35 miles 1,647 yds., and the underground mileage equals 3,639 miles 848 yds. metallic circuit, or 7,278 miles of single wire. The total overhead mileage is now 575 miles 1,425 yds. of metallic circuit, or 1,151 miles of single wire. The cost per station now stands at £21·42, compared with £22·36 last year.

The Chairman claimed the report showed that the undertaking was in a happy condition. They had paid £5,067. 11s. 2d. for maintenance, £1,786. 9s. 9d. to sinking fund and £1,616. 9s. 2d. in interest, and were left with a profit of £2,122. 9s. 8d. Out of that they had to pay the Postmaster-General in royalties £1,082, or 51 per cent. of the net profits, and 10 per cent. of the whole turnover. The fact that they had met all charges and paid to sinking fund £500 more than hitherto was sufficient proof that municipal telephones could be made to pay, and ample vindication of the policy adopted by the Corporation. During the past year they had had 255 new subscribers.

New Submarine Cable.—"The Times" publishes some further interesting particulars concerning the proposed new submarine telegraph cable, between Europe and Argentina:—

The Argentine Government has at present under consideration a scheme which was originated by the Western Telegraph Co. for giving the country direct cable communication with Europe, instead of via Uruguay and Brazil on one side, and through Chile and other West Coast Republics on the other. As things stand at present the Argentine Republic might at any time find herself cut off from telegraphic communication with Europe, should the outbreak of a war, revolution, or other cause determine the suspension of cable messages in any of the countries through which the lines at present pass. The proposed new cable would join up with existing cables at Ascension, and one of the conditions of the concession is that the line should have a greater carrying capacity than any of the existing cables of the same length. The report of the Posts and Telegraphs Department on the scheme has been very favourable, and the Executive, it is believed, will endeavour to get the necessary Bill through Congress as soon as the Chambers meet next month, in order that no time may be lost in putting the work in hand. There is no doubt that the proposition is a favourable one for the country, as no special privilege nor subvention is asked for, the only stipulation being the exemption from taxation for a term of 25 years, which is not much in exchange for the benefits offered, and the reduction of 50 per cent. to be allowed from existing rates for official despatches. A rebate from the present tariff of 15 cents per word for private messages is also stipulated for, which would reduce the cost per word to Great Britain from 104 cents (4s. 2d.), the present charge, to 89 cents gold (3s. 6¾d.), and be of enormous advantage to the commercial community and the trade of the country in general.

When this cable is laid it will be the second largest cable in the world (3,250 nautical miles), and will have the heaviest core.

Personal.—Mr. C. S. Thomson, formerly superintending engineer to the Brush Co., and for the last six years connected with the export business of the British Westinghouse Co. in London, has severed his connection with the latter, and has taken up the position of London representative of Messrs. Vickers, Sons & Maxim, announced in another column.

Scottish Tramway Officials' Association.—The summer meeting of this Association was held at Aberdeen on Friday and Saturday last.

Mr. R. S. Pilcher (Aberdeen) was elected president for the year, and gave an address on "Current Consumption as applied to Aberdeen," describing the system which had been introduced in Aberdeen three years ago and had effected a substantial saving.

At the dinner in the Palace Hotel Mr. Shepherd, general manager at Edinburgh, proposed "The Chairman and Members of the Aberdeen Tramways Committee," which was replied to by Mr. Coutts.

Tramcar Disinfection.—Liverpool Tramways committee have inaugurated a system by which their tramcars are disinfected daily. Hitherto all cars have been disinfected during the night at the sheds, but during the summer season all cars are also to be disinfected during the day.

Watford.—The Electricity committee have decided to introduce a system of bonuses to the staff at the electricity works for economy in coal consumption.

Westhoughton (Lancs.)—The Westhoughton Electric Lighting Order of 1902 has been formally transferred to the Lancashire Electric Power Co., who will at once put into operation the powers conferred by the Order.

Wireless Telegraph Notes.—It is announced that the U.S. Navy Department have invited further tenders for the construction of a tower 600 ft. in height for wireless telegraph work at Washington, with a guaranteed radius of 3,000 miles. The base will be 50 ft. in diameter, and the tower will taper to 8 ft. at the top. It is calculated, according to the reports published, that communication will be

possible with Gibraltar eastward and San Francisco westward. The cost of this part of the work is given as £60,000. It will be remembered that tenders were recently accepted for a station of 3,000 miles range. Special particulars of the tenders were published in our columns.

The new wireless telegraph station at Ipswich, which is being built and equipped for the Admiralty, is approaching completion. The station occupies four acres.

An Ordinance has been issued by the Gibraltar authorities regulating the working of wireless telegraph apparatus installed on merchant ships, whether British or foreign, while in the territorial waters of Gibraltar. It is provided that no such apparatus shall be worked or used whilst such ship is in any of the harbours of Gibraltar, except with the special or general permission in writing of the Governor. Such apparatus is to be worked in such a way as not to interfere with naval signalling or the working of any wireless telegraph station lawfully established in Gibraltar or the territorial waters thereof, and, in particular, must not interfere with the transmission of any messages between wireless telegraph stations established on land and on ships at sea. The rules are not applicable to the use of wireless telegraphy for the purpose of making or answering signals of distress.

Workhouse Lighting.—An L.G. Board inquiry was recently held into the application of the Guardians of North Dublin Union for sanction to a loan of £2,000 for the electric lighting of the workhouse and north city dispensaries.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Birmingham.—In presenting the report of the Electricity committee on Tuesday the chairman (Mr. ELLAWAY) said that a prominent feature was the rapid growth in output during the past year.

The units sold for private lighting and power had gone up to 3,000,000, an increase of 31 per cent. on the previous year. The output for traction was up by 500,000 units. The most satisfactory point about the statistics was the increase in the number of consumers. There was an increase of 25,000 16 c.p. lamps, and, more satisfactory still, motor connections had gone up from 7,084 kw. to 10,716 kw., representing an increase of more than 50 per cent. The total cost of production, distribution and management was £72,984, which represented a saving of over £5,000 on the year. That was largely due to the fact that they had shut down the Dale End station and were working more from Summer-lane. An item of special expenditure was £6,347 which had been spent in the reconstruction of the Dale End offices. The £11,071 for plant abandoned in Dale End and Water-street cleared off the amount for that purpose. Their gross profit was £85,000. They proposed to carry £7,000 to renewals fund to provide a sufficient sum of money each year to make up the difference between the actual life of the plant and the period for which they had obtained the loan. The average price per unit had gone down in the last nine years from 4·37d. to 1·73d., and, therefore, they proposed to provide a sum each year to enable them to renew plant which became worn out during the period of the loan, and to provide against any risk of the plant becoming obsolete. The reserve fund was not applicable for the purpose, because it was a fund to meet unforeseen and unexpected expenditure. Renewal of plant was not an unforeseen or unexpected circumstance. They were also obliged to invest their reserve fund from time to time in securities, and that made it difficult to draw upon it for renewal purposes. The surplus for the year was £10,007, which, for the first time, they proposed to pay to the improvement rate.

In presenting the accounts of the Tramways department,

Mr. HARRISON BARROW said the amount spent during the year was £72,000, of which £30,000 had been spent on permanent way and about £19,000 on cars. In the coming year only a small amount of capital would be spent, and the bulk would be for the extension of the permanent way department at Miller-street. Revenue had risen from £356,686 to £365,611, an increase of £8,925. Of that amount £4,143 was expended outside and £4,782 inside the city. The net revenue inside the city was £291,036, against £286,255. The smallness of the increase was undoubtedly due to bad trade. The average takings per car-mile were 11·13d., compared with 11·42d. in 1907-8. The amount spent on electric current was about £2,500 more than last year. Wages had increased about £9,000, chiefly caused by increased services, reduction in hours of employés, increase of car mileage and automatic increase in wages. Rent, rates and taxes showed a considerable increase, due largely to increased income tax. Great credit was due to the motormen for the great freedom from accidents during the year. Under general repairs and maintenance there was a considerable increase in the amount spent on permanent way, and a heavy increase in the cost of rolling stock. The net result was a gross profit of £105,403, compared with £121,112, and the net profit was £51,039, compared with £72,000. £21,550 was carried to reserve, and a balance of £29,489 would be handed over to relief of the rates. The number of passengers carried showed an increase of about 2,000,000. The average fare was the same, but the percentage of working expenses had increased to 64 compared with 58.

The accounts were approved.

Burton-on-Trent.—The accounts of the Electricity Supply and Tramways departments (an abstract of which appeared in our last issue) were presented to and approved by the Council last week.

Croydon.—The accounts of the electricity department for the past year show a balance of £9,443. 5s. 1d., and of this amount £3,500 has been appropriated for street lighting and distribution renewals, and £5,943. 5s. 1d. carried forward. From June 30 next the flat rate for current is to be reduced from 4½d. to 4d. per unit, and the charge for arc lamps will be reduced from £16 to £15 each per annum.

Exeter.—For the year ended March the receipts of the tramways department were £15,873 against £15,420 in 1908.

The traffic expenses were £4,329, against £4,106. The general expenses were £1,365, against £1,303, and repairs, maintenance, &c., £1,035, against £1,136. The cost of current was £4,958 against £3,909. 3,891,000 passengers were carried against 3,754,000. The department has contributed £821 to the rates and £2,000 has been placed to reserve.

Norwich.—The chairman of the Electricity committee (Mr. Wild) stated at the meeting of the Corporation last week that the report of the electricity department for the year ended March was satisfactory.

They had (Mr. WILD said) passed through a year of depression, but the output for 1907-8 exceeded that of the previous year by 800,000 units, and that for 1908-9 that of the previous year by 400,000 units. There were a number of empty houses (nearly 2,000), and the capital of the committee, in the shape of meters and wiring, was lying idle in many of those houses. There was an extension of metallic filament lamps, and although the output was 4,066,000 units, against 3,361,000 last year, the coal bill was less. The cost of coal per unit last year was 0·43d., this year 0·39d. per unit. Three per cent. of the decrease was due to a reduction in the price of coal, and 7 per cent. to economy in the management, &c. The whole cost per unit last year was 1·06d., against 2·16d., and the price realised was 2·2d., against 2·33d. They would probably have to ask the Council for powers to obtain another loan to still further extend the business in the autumn. The sale of current this year realised £35,331, against £33,851; and meter rents £1,258, against £1,323. The whole income of the year was £37,188, against £35,612. Working expenses were £8,892, against £8,618; repairs and maintenance £4,915 (£5,244); rates, taxes and insurance £1,621 (£1,475), and management expenses £3,615 (£3,529). Totol expenditure was £19,046, against £18,868, and the balance was £18,142. After paying interest and sinking fund (£14,706), the net profit (£3,700) was carried to appropriation account, making that £3,800. £850 had been written off for depreciation, and a balance of £1,200 was voted in relief of the rates. There were 29,000 houses in Norwich, and at least 20,000 of these were capable of taking electricity, yet only 4,400 did so. If only the 20,000 would co-operate with the committee what could they not do? They might by their co-operation have the best supply of electricity in the kingdom, and at the same time remove the city from the reproach of being said to be the highest rated city in the kingdom. He urged ratepayers to co-operate with the committee, and not let selfish motives keep them from using electricity for lighting and power. He would like to say one word of appreciation of the staff under Mr. F. M. Long, who had worked well and successfully.

Stepney (London.)—The accounts of the electricity supply undertaking for the 12 months ended March 31 were submitted to and approved by the Council at their meeting last week.

The total income was £46,934. 3s. 2d., including £37,852. 3s. 10d. received from private consumers for power and heating and £6,012.18s.6d from public lighting. The expenses were £28,746. 5s. 3d., leaving a gross profit of £18,185. 17s. 11d. After paying interest and providing for repayment of debt, &c., the net balance was £1,808. 2s. 8d. The total capital outlay to date is £324,034. 4s. 10d. 7,760,301 units were generated, an increase of 1,321,709. 3,088,177 units were sold for private lighting, an increase of 295,091; 2,558,585 for power and heat, an increase of 725,455; 1,129,772 for public lighting, an increase of 43,244, and 57,391 for bulk supply, making a total of 6,833,865 units sold, an increase of 1,121,181. The average works cost was 0·692d. per unit sold (against 0·701d.) and the total cost was 1·505d. against 1·539d. The average revenue per unit sold was 1·54d.

In his report, the engineer and manager (Mr. W. C. P. Tapper) states that the figures for the past year show the undertaking in a better position than in any previous year. The net surplus is slightly lower than in previous years, owing to the heavy charges incurred in connection with the opposition to the various power bills in the 1908 session and to increased interest and sinking fund charges. The gross profit represents 6·05 per cent. on the capital outlay, but it is anticipated that the capital expenditure on the Blyth's Wharf scheme will be unproductive during the first few years and, consequently, will lower the percentage of profit. The equivalent 8 c.p. lamps connected during the year aggregate 65,550, making the total 311,131 8 c.p. The total connections were greater than in any previous year, but the increase had been almost entirely confined to power, the net increase in the connections for private lighting being only 2,155 8 c.p. The actual connections were, however, considerably in excess of this figure for private lighting, because during the year an exceptionally large number of existing consumers replaced carbon filament by metallic filament lamps, thus reducing the number of 30 watt lamp equivalents connected to their installations. Of the 126,578 lamps connected for private lighting, 13,093 represent consumers who have taken advantage of the restricted supply. The average revenue per unit (1·54d.) was lower than last year, and still constitutes a record for London.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

SALFORD Electricity committee invite tenders for the supply, delivery and erection at the Corporation electricity station, Frederick-street, Pendleton, of a battery booster and switchgear. Specification and form of tender may be obtained from the borough electrical engineer, Mr. Victor A. H. McCowen, M.I.E.E., and tenders, addressed to the Chairman of the Electricity committee, must be delivered at the offices of the Borough Electrical Engineer by noon of Monday, June 14. See also an advertisement.

TUNBRIDGE WELLS Corporation invite tenders from manufacturers for supply and delivery of l.t. cables during the ensuing 12 months. Specifications, &c., from the consulting engineer, Mr. Horace Boot, at the Electricity Works, Tunbridge Wells. Tenders to the town clerk, Mr. W. C. Cripps, Town Hall, Tunbridge Wells, by 10 a.m., June 12. See also an advertisement.

The Visiting committee of the NORTH WALES Counties Asylum invite tenders for fitting up the asylum with telephones, fire alarms, night recording clocks and entrance bells. Particulars at the Asylum or from Mr. Wm. Barker, Denbigh. See also an advertisement,

Tenders are invited for eight sections of common battery switchboard and subscribers' apparatus for Hawthorn Exchange for the Postmaster-General's Department, VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 50 coin attachments (suitable for coins of different values) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited for the supply of a branching multiple magneto switchboard to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specification may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of 150 relays (non-polar) to the Postmaster-General's Department in the State of NEW SOUTH WALES. Tender forms and general conditions may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of one photometer, &c., to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specification from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Electricity committee of STEPNEY (London) Borough Council, invite tenders for the supply during the period ending June 30, 1911, of ampere-hour meters, demand indicators and time switches, and arc lamps. Specifications, forms of tender, &c., may be obtained from the borough electrical engineer and manager, Mr. W. C. P. Tapper, 27, Osborn-street, Whitechapel, E., where tenders must be delivered by noon June 14.

SOUTHAMPTON Corporation invite tenders for the supply of sundry heavy cables for l.t. trunk mains required by the electricity department, in accordance with the specification, particulars and conditions which may be obtained from the borough electrical engineer, Mr. H. F. Street. Tenders to the town clerk, Mr. R. R. Linthorne.

GRIMSBY Corporation invite tenders for supply, delivery and erection of two superheaters for two Stirling boilers, and the renewal of dripping bars in existing cooling towers. Specification, &c., from the borough electrical engineer (Mr. W. A. Vignoles). Tenders by first post June 7.

LONDON County Council require tenders by 11 a.m. June 22 for the supply and fixing at Greenwich generating station of steam, exhaust, feed and drain piping, valves, &c., and cast-iron condenser water piping, valves, &c. Forms from the Clerk of the Council, Spring-gardens, S.W.

Penrikyber Navigation Colliery Co., PENRHIWCEIBER, Glam., want tenders by June 5 for 12 months' supply of electrical fittings, iron and steel castings, ironmongery, tools, paints, &c. Forms from the Secretary.

SCULCOATES Guardians want tenders by 10 a.m. June 9 for supply and erection of 15 kw. dynamo driven by steam turbine or high-speed engine. Specification from Mr. W. J. Coles (Maxted, Knott & Coles), Burnett-avenue, Hull.

PORTSMOUTH Corporation want tenders by 10 a.m. June 16 for one or two years' supply (10,000 to 12,000 tons per annum) of coal for the electricity department.

ILFORD District Council want tenders by June 7 for construction and alteration of tramways permanent way. Specification, &c., from Mr. H. A, Shaw, Town Hall, Ilford.

MANCHESTER Guardians want tenders by noon June 16 for an electric light installation for their offices. Specifications, &c., from the Clerk.

DUDLEY Corporation want tenders by noon June 10 for supply and erection of a traction battery and automatic booster with switchgear. Specification, &c., from the Borough Electrical Engineer.

PLYMOUTH Corporation want tenders by June 7 for supply of steam coal for the electricity department. Specifications, &c., from the Borough Electrical Engineer.

Tenders are wanted by June 28 for the construction of an electric tramway at Ploesti (Roumania), for the Municipality. Tenders must be accompanied by a deposit of £1,000 and local representation is desirable.

TENDERS RECEIVED AND ACCEPTED.

Marylebone (London) Council have accepted the tender of H. Harrison for 1,906 twin lamp lanterns, and 23 triple lamp lanterns, and for the conversion of street lamps to electric lighting as follows: Fittings for twin lamp lanterns, 12s. 3d. each, fixing on site 3s. 6d., fittings for triple lamp lanterns 16s. each, fixing 4s., wooden rods for turning on and off, 1s. each, spare parts complete switch in chamber 5s. 6d., sealing chambers 1s. 9d., reflectors, 2-light 3s. 9d., 3-light 6s. 6d., enclosed fuse carriers 4d. each.

Hastings Corporation have accepted the tender of the General Electric Co. for Osram lamps at £47. 10s.; W. Lucy & Co. for lamp brackets, lanterns, &c., at £158. 17s. 6d.; W. T. Glover & Co. for concentric cable at £71. 10s.; Doulton & Co. for rectangular troughing, bricks and insulators at £41. 1s. 1d.; Cowans (Ltd.) for joint boxes.

London County Council have entered into a contract with Messrs. Reid Bros. for laying stone ware ducts in connection with the electrification of further portions of the Victoria Embankment tramways at £3,500, and the offer of Geo. Skey & Co. for the supply o- 15,000 stoneware cable ducts at £9 per 1,000 has also been acceptedf

Wm. Geipel & Co. have secured the contract for the supply to the L. & N.W. Railway Co. of the whole of the carbons required during the year ending June 30, 1910, including open and enclosed type and flame carbons of Henrion make. We are informed that the contract is for 1,170,000 carbons.

Southend Council have accepted the tender of Hadfield's Steel Foundry Co. for 24 steel tramcar tyres, at 22s. 6d. each, and that of Callender's Co. for cables.

Gillingham (Dorset) Fire Brigade committee have accepted the tender of Mr. Martin for supply and erection of electric fire calls.

Hull Telephone committee have accepted the tender of the British Insulated & Helsby Cables for £253 worth of new telephone cable.

Siemens Bros. Dynamo Works have obtained a contract for the supply of Tantalum lamps to the L. & N.W. Railway Co.

Bennis Stoker Contracts.—Messrs. Ed. Bennis & Co, have recently secured a number of important contracts for Bennis stokers, including some installations of the company's high-duty smokeless coking stoker. It is claimed that this new stoker overcomes all the recognised disadvantages of cokers hitherto placed on the market, and combines the best features of the sprinkling and coking types. Following are some of the recent contracts booked by the company:—

Ruston, Proctor & Co., four Bennis stokers and self-cleaning compressed air furnaces for two Lancashire boilers (repeat order); A. M. Peebles & Son, two 1909 high-duty smokeless coking stokers for an 8ft. 6in. boiler; Keyes' Daren Flour Mills, two 1909 high-duty smokeless coking stokers for a 7 ft. 6 in. Lancashire boiler; Leeds Industrial Co-operative Society, two stokers and self-cleaning c.a.f. for an 8 ft. Lancashire boiler (repeat); C. Brown & Co., two high-duty smokeless coking stokers for an 8 ft. Lancashire boiler; Greenall, Whitley & Co., stoker and c.a.f. for a brewing copper, and four stokers and self-cleaning c.a.f. for 6 ft. 6 in. Lancashire boilers and one independent coal elevator for Wilderspool brewery; Rd. Thackray & Sons, two stokers and self-cleaning c.a.f. for an 8 ft. Lancashire boiler; R. Brearley & Sons, two stokers and self-cleaning c.a.f. for an 8ft. 6in. Lancashire boiler (repeat); S. Courtauld & Co, six stokers and self-cleaning c.a.f. for 8 ft. Lancashire boilers, with independent coal elevators to each boiler (repeat); J. R. & A. Smith, two stokers and self-cleaning c.a.f. for an 8 ft. Lancashire boiler; Blackburn & Bray, two stokers and camel or natural draught furnace for an 8 ft. Lancashire boiler; Gamble & Smith, four self-cleaning c.a f. for 7 ft. 6 in. Lancashire boilers (repeat); W. & J. E. Crossley, two stokers and self-cleaning c.a.f. for an 8 ft. Lancashire boiler (repeat); D. Dixon & Sons, two stokers and self-cleaning c.a.f. for an 8 ft. 6 in. Lancashire boiler; Bowyer & Priestley, two stokers and self-cleaning c.a.f. for a new 7 ft. 6 in. diameter boiler; and J. Ockleston & Son, stoker and c.a.f. for Cornish boiler for burning spent tan mixed with coal (repeat).

Rolling Stock Contracts.—Messrs. Mountain & Gibson & Thornewill (Ltd.) have recently secured important contracts for rolling stock, and their other manufactures from the Admiralty and a number of municipal and company owned undertakings at home and abroad, including Bradford, Llandudno, Colwyn Bay, Costa Rica, La Plata Tramways, London Brighton & S. Coast Railway, the Dock Works of Canada, Oporto (Portugal), and South Africa. Messrs. Mountain & Gibson & Thornewill (Ltd.) are now making a public issue of capital, some particulars of which appeared in the last issue of THE ELECTRICIAN.

BUSINESS NOTICES.

Messrs. Vickers, Sons & Maxim inform us that in view of the growth of their electrical business, and for the greater convenience of their customers in London, they have appointed a representative at 28, Victoria-street, S.W. This branch of the business will be under the management of Mr. C. S. Thomson, M.Sc., M.I.E.E., who will deal with the large range of electrical machinery made at the Sheffield Works, and also the smaller motors and generators manufactured by the Electric & Ordnance Accessories Co., at Birmingham, under the control of the Vickers Co.

The partnership between C. Remington, W. Ramsbottom, and J. H. Bennett (trading as Remington, Ramsbottom & Bennett), electrical engineers, Manchester, has been dissolved so far as regards C. Remington.

The partnership between A. John, A. S. Lloyd, and W. G. Everingham (trading as the Electro-Medical Co.), Wigmore-street, London, W., has been dissolved so far as regards W. G. Everingham.

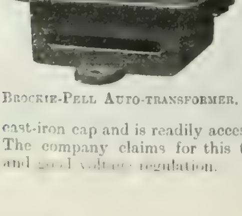
Sale by Auction.—Messrs. Fortt, Hatt & Billings have received instructions to sell by auction, on Tuesday, June 15, upon the premises at Locksbrook Engineering Works, Bath, the lease, goodwill, patents, patterns, drawings, working plant and stock of Kramos Limited. Catalogues are in course of preparation and may be obtained from Messrs. Ham, Denneky & Co., C.A., Quiet-street, Bath, or of the Auctioneers, 3, Burton-street, Bath. See also an advertisement.

Plant for Sale.—Messrs. G. Elliott & Co., 186-188, Long-lane Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

A charging set for electric car (dynamo, alternating current motor and accessories) is advertised for sale on another column.

An advertisement contains particulars of some electrical engineering plant (including two 110 H.P. d.c. Siemens motors, with starter, &c., one 105 H.P. single-phase motor, two 4 H.P. electric capstans, one 2-ton electric derrick crane and one 5 H.P. electric locomotive) which is for sale.

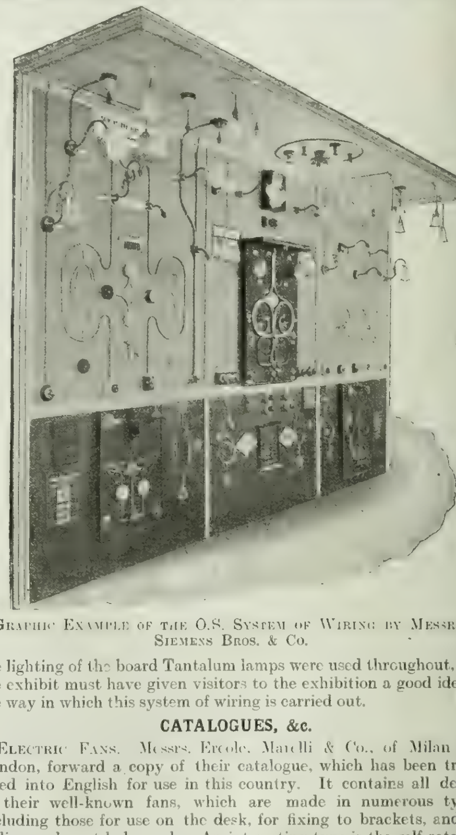
Whitsuntide Holidays.—We have received from the London & South Western Railway Co. a programme of the holiday arrangements made for Whitsuntide, and from this we find that the company are providing amply for those who are seeking health and recreation in the country, at the seaside in England, or at the several popular and interesting places on the Continent for which the company's fleet of steamers provide facilities. The South Western arrangements for those visiting the Channel Islands are of the most complete character, and we have the best of reasons for knowing that the islands are very charming just now. It only remains for us to advise intending holiday seekers to write for a copy of the Whitsun excursion list, which can be obtained at all the company's ticket issuing offices and agencies, at the company's stations, or direct from headquarters at Waterloo. It is worth reminding those wishing to avail themselves of such facilities that tickets can be obtained at these agencies, offices, &c., beforehand if desired.



BROCKIE-PELL AUTO-TRANSFORMER.

Auto-Transformers.—The Brockie-Pell Arc Lamp Co., of Wimbledon, are putting on the market a new type of auto-transformer for use with metallic filament lamps. We show the exterior of this transformer in the accompanying illustration. The connections are made in a porcelain chamber, which is protected at the top by cast-iron cap and is readily accessible by the removal of two screws. The company claims for this transformer a very high efficiency and good voltage regulation.

O.S. Wiring System.—As mentioned in our last week's issue, one of the principal exhibitors at the Electricity Exhibition organised by Hornsey Borough electricity department, were Messrs. Siemens Bros. & Co., who showed a large board (15 ft. long by 9 ft. high) wired in order to demonstrate the various applications of the O.S. system to economical wiring, whilst it also showed clearly the bending qualities of the Stannos wires. As the matter is of considerable interest to wiring contractors we give an illustration of this exhibit which, as will be seen, was mounted on a large three-panel board, complete with fuse boxes, switches, brackets, lamps and fittings. For



GRAPHIC EXAMPLE OF THE O.S. SYSTEM OF WIRING BY MESSRS. SIEMENS BROS. & CO.

the lighting of the board Tantalum lamps were used throughout, and the exhibit must have given visitors to the exhibition a good idea of the way in which this system of wiring is carried out.

CATALOGUES, &c.

ELECTRIC FANS. Messrs. Ercole, Marelli & Co., of Milan and London, forward a copy of their catalogue, which has been translated into English for use in this country. It contains all details of their well-known fans, which are made in numerous types, including those for use on the desk, for fixing to brackets, and for ceiling and port-hole work. An interesting type is the self-rotating ceiling fan, which is supplied with a 20 in. rod and which, it is claimed, is a most beneficial piece of apparatus. Small electric motors and electroliers combined with ceiling fans are among other specialities of this firm dealt with in the catalogue.

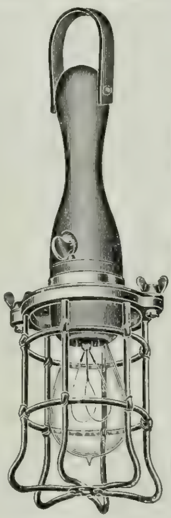
THE SUN EVAPORATOR.—The Sun Patent Evaporator Co., of Liverpool, have sent us a pamphlet dealing with their new evaporator, designed to secure the condition that the gases are utilised at the highest available temperature. The basic idea is that a thin metal plate is a far more efficient heat conductor than a thick one. The steam drawn from the boiler is superheated and is passed through a shell boiler into a series of nests of tubes placed in the water space and is then returned at the temperature of saturated steam into a secondary superheater, where it is dried, slightly superheated, and led into the steam mains. By the use of this device, it is claimed, the coal bill is reduced, the steam capacity is increased, and the boiler's life is prolonged.

ELECTRIC REVOLUTION INDICATOR.—Messrs. Siemens Bros. & Co. have just issued a pamphlet dealing with the Siemens electric revolution indicator. This apparatus is designed for indicating the speed of an engine or other shaft at positions some distance away. It is claimed that it is specially suitable in ship work for indicating the speed of a vessel on the bridge. The necessary transmission is effected by an alternating current which is supplied by a special form of generator driven by chain gearing from the engine shaft. The indicators are practically voltmeters of the well-known Ferraris type.

Simplex Electric Fittings.—The Simplex Co. have ready two pamphlets, one of which deals with electric fittings. These are divided into two classes, cheap brass brackets, pendants and electroliers and candle fittings. The second pamphlet deals with "spookie" shades, claimed to give all the decorative effect of stained glass with an added richness and softness.

Willans Vacuum Turbines.—We have received from Messrs. Willans & Robinson a pamphlet dealing with their exhaust steam turbines. The brochure contains an exhaustive commentary on the possibility of installing Willans vacuum turbines for working in conjunction with either condensing or non-condensing reciprocating engines, the various advantages accruing when this course is adopted being put forward with great clearness. We are not able to do more than note this interesting pamphlet at the moment, but we shall return to the subject, which is one of great and immediate importance, in more detail in our next issue.

Hand Lamps.—Messrs. Ward & Goldstone, have issued a pamphlet dealing with their "Guardian" hand lamp, which is specially interesting from the fact that the new Factory and Workshop Electricity Regulations come into force on the 1st of next month. Messrs. Ward & Goldstone's lamp, which we illustrate herewith, is patented and is claimed to be the only hand lamp with a switch lampholder, and complies with the Board of Trade regulations. The guard is made of No. 10 galvanised wire.



"Guardian" Hand Lamp.

Oil Engines.—Messrs. H. & C. Grayson, of Liverpool, have ready a small catalogue dealing with their petrol or paraffin engines for stationary and marine work which operate on either the two or four cycle system. Great attention is paid to the general design, and the result, it is claimed, is most satisfactory. The engines are specially designed for direct coupling to electrical generators, and they certainly form a neat and handy set.

Electric Motor-Control Apparatus.—We have received from Messrs. Wellman,-Seaver & Head, Victoria-street, London, S.W., a copy of their catalogue dealing with this subject. It contains details of controllers, motor starters and electric brakes. Some of the firm's specialities are more fully described and illustrated on another page of our presentissue.

"Installation News."—The *pièce de résistance* of the April issue of this publication is a leading article entitled "Flexible Chaos," dealing with the numerous flexible systems of wiring at present in vogue.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of Middleton & Co., electrical engineers, &c., Dover, the gross liabilities are returned at £789. 10s. 9d. and £771. 14s. 7d. is expected to rank. Assets nil.

The Official Receiver, in his observations, states that one of the debtors (J. R. W. Middleton) had been established as an electrical engineer for between four and five years, and two years ago he was joined by Alfred Daniels and Francis Balch in co-partnership, the arrangement being that Daniels and Balch should each pay into the business £200 as their share of the capital. The firm traded as Middleton & Co., and the debtor Middleton stated that at that time he had a considerable amount of work on hand, and considered his share in the partnership was worth more than the others, and it was arranged that he should have 13 per cent. of the gross profits, and that the balance should be equally divided between the three partners: meantime Middleton should draw £3, Daniels £2. 15s. and Balch £2. 5s. per week. Balch retired from the partnership in August last, and Middleton and Daniels continued the business, arranging to pay Balch £250 as his share by weekly payments of £1. 10s. Apparently, there was now owing to Balch about £226. Debtors admitted that no proper balance-sheets were made out, and that they discovered in September last that they were unable to discharge their accounts, pay wages, &c. They were financed by a gentleman to the extent of over £350, and on Dec. 8, 1908, assigned their business, including stock in trade, goodwill, &c., to him in consideration. The business was still being continued by the purchaser in the name of Middleton & Co., on the same premises, and debtors remained in his employ at a salary of £2 a week each.

The first meeting of creditors of J. G. S. Cunnington and H. P. Allison, trading as Laing, Wharton & Cunnington, electrical engineers and contractors, Great Newport-street, London, W.C., took place on Tuesday.

Mr. D. Williams, assistant O.R., reported that the debtor, Mr. Cunnington, had been examined, and had stated that he began business in 1894. He traded alone until 1902, when he took in a partner, who brought into the business capital and stock to the value of £3,000, together with the goodwill of Laing, Wharton & Down (Ltd.). The partners traded under the style of Laing, Wharton & Cunnington until 1903, when the partnership was dissolved, Mr. Cunnington taking over the liabilities and assets. He then continued alone until 1907, when he entered into partnership with the debtor, Mr. Allison, and traded down to the date of the receiving order. The liabilities were £6,541. 11s. 8d., net assets £3,785. 17s. 9d., and the failure was attributed to an adverse judgment for £4,000, for which debtors stated they had received no consideration. Resolutions for an adjudication in bankruptcy were passed, and Mr. A. Page, C.A., was appointed trustee.

The following are the creditors over £20 in this failure:—

	£	s.	d.
H. J. Snowdon and H. Muff	£4,027	7	6
Standard Cable Mfg. Co.	199	9	9
Callenders Cable Co.	52	16	5
Evered & Co.	24	10	0
Atkins & Dott	26	1	4
Cons. Pneumatic Tool Co.	96	18	4
British Insulated & Helsby Cables	27	18	1
D. P. Battery Co.	35	0	0
Electrical Co.	£59	5	4
Fulham Elec. Mfg. Co.	20	13	4
Galsworthy Ltd.	24	17	5
General Elec. Co.	47	3	11
Hornsby & Sons	78	3	0
Marples, Leach & Co.	51	16	0
R. Pope & Co.	21	0	0
J. Pinson & Co.	44	1	0
J. Stringwith	62	15	0
A. T. Snell	21	19	6

At Bradford County Court last week, Judge Graham, K.C., conditionally granted the discharge of Wm. T. Garnett, late cable manufacturer.

Charlotte Rix, "a person or one of the persons trading as Bridgewater & Wright," electrical engineer, York-road, King's Cross, London, N., has been adjudicated bankrupt.

Voluntary Liquidation.— A meeting of the creditors of the General Electric Sign & Engineering Co. (Ltd.) (in liquidation) will be held at Messrs. Hayes & Co.'s offices, 28, Basinghall-street, E.C., at 2 p.m. on June 10. The liquidator is Mr. E. Hayes.

COMPANIES' MEETINGS AND REPORTS.

Callender's Cable & Construction Co. (Ltd.)

The annual general meeting was held yesterday, under the presidency of Mr. Henry Drake, who commented briefly upon the report of the directors (an abstract of which appeared in our last issue, p. 241), and in regard to the item of shares, investments and interests in other companies, remarked that the amount of this item had been so greatly increased because some items from the general debtors' account had been transferred and put under this head as being the more correct. Last year they placed £10,000 to suspense account. This amount still remained in that account, and their profit for the year might be said to be practically the same as in the previous years.

Mr. T. O. CALLENDER (Managing Director) said he thought 1908 would be remembered as an exceedingly bad year, especially by those in the engineering and allied trades. Not only had there been strikes of the utmost importance, all of which affected their business, but the year had been marked by great financial stringency. There had been plenty of money, but none for operations of the kind in which the company were interested. Their business had also been injured by the complete stoppage of all work in London pending some decision as to the future of London electricity supply. For two years practically no new work was carried out in London, but the bill which was passed last autumn had lifted that cloud, and already they had received orders to the extent of many thousands of pounds for mains of extensions, and for linking up in London. The advent of the metallic filament lamp had also been a very sore trial to them. Mains which they had hoped the companies would extend each year had been more than sufficient to meet the demand last year; but the directors did not look forward with any misgiving, and he thought that although they might suffer a little just now, there would presently be a large extension in the use of electric lighting due to these lamps. The management of the company were thankful to see the back of 1908, which had been the most trying year they had had. Recently there had been a very distinct and satisfactory improvement. The demands from old customers were increasing, and there was a decided movement towards extension elsewhere. On the Continent, where they had carried out much work during the past few years, things had been, if possible, worse. During the last part of 1908 there was a bitter warfare between the different makers of electric plant, but even there things were improving, and this warfare seemed to be dying out. They had recently secured some very good orders. Unfortunately, there was not much margin of profit, but nevertheless, they were useful adjuncts to their business at Erith and Leigh. With all the complaints as to keen competition and as to prices, they had managed to make a fair profit. They had been assisted by the excellent results from the Anchor Company, which was profit-earning and helping towards the dividend. The St. Helens Co. had not yet got into that position, but they were working it up, and he hoped at no distant date would give them equally good results. There was a considerable sum in the balance sheet for new plant, and machinery. The engineers of municipalities, the Government and others were constantly adding to the burden put upon them in their specifications, and whereas a few years ago they thought they were clever in making a cable to stand 10,000 volts, they had now to make cables for ten times that pressure, and it was necessary to put down plant to meet these conditions.

The report and accounts were then adopted.

BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)—Mr. J. A. Bryce stated at the meeting on Monday that the falling off in the trading profit was due to the universal depression in business. Not only was the volume of orders smaller, but the severe competition for such as there were necessitated a further reduction in prices. Dealing with the various items in the accounts, he said that shares in other companies (£287,092) showed a large reduction in consequence of the transfer of shares of the Traction & Power Securities Co. The largest portion of the item was now represented by shares of the Clyde Valley Electrical Power Co., whose business was now rapidly increasing. The balance was in shares of the Traction & Power Securities Co., and small items in other companies. The steel foundry was closed in the early months of 1908, the directors fearing that to continue operations would result in a serious loss owing to the restricted volume of business then offering. A careful study of comparative figures for the four years beginning 1905 led the directors to the conclusion that the many changes and improvements that had been made during the past three years had resulted in a marked increase in efficiency, and, notwithstanding the heavy handicap of a large plant, restricted volume of business and severe cutting of prices, the accounts showed that the percentage of gross profit returned on the apparatus manufactured had been satisfactory. Among the more important economies that had been effected was that of factory expenses, which had been reduced by 30 per cent., with a resulting saving of £70,000 per annum. Other expenses showed a decrease at the rate of £10,000 per annum, and that saving had been accompanied by a marked increase in efficiency of manufacture. Under that combination of economy and improved efficiency the percentage of gross profits had more than doubled. The directors had carefully considered the possibility of a further reduction of staff with a view to economy until better times arrived. During the past year they had secured several important contracts. The future seemed to depend mainly upon the volume of business which could be secured. For the moment no great help was to be looked for on the side of export business owing to the general depression all over the world, resulting from the American financial crisis of 1907, and, with a reduced demand, the competition for orders abroad had been almost as severe as at home. There were, however, signs that the wave of depression was passing away, and it might be hoped that, after the turn of the year, the outlook might be brighter. It may be doubted, however, whether the position of the electrical industry in this country could become permanently sound until British purchasers realise, as they had done in Germany and America, that the standardisation of manufacture was in their interest as much as in that of the manufacturer. To that having been realised in Germany was due the fact that, though the electrical manufacturing capacity of that country was far larger than that of Great Britain, it was occupied to an immensely greater extent by the supply of the demand in Germany itself, where, owing to the cheapness of manufacture resulting from standardisation, the application of electrical apparatus was infinitely more extensive in every industry, and that relative cheapness, aided by the enterprise of the large industrial banks—numerous in Germany, but non-existent here—enabled the German manufacturer to compete on favourable terms for his surplus product, which was much less in volume than that of this country, in the foreign and colonial markets which naturally belonged to us. When consumers have had brought home to them the elementary axiom that the manufacture of an article to 10 patterns only was immensely cheaper than the manufacture of it to 100 patterns, demand would begin to overhaul supply. There were already faint signs that that fact was beginning to dawn upon the British consumer.

ELECTRIC TRACTION CO. OF HONG KONG (LTD.)—The traffic receipts for the year ended Dec. 31 showed an increase over those of 1907, but owing to the decline in the value of the dollar the total amount is less. The expenses also show a decrease. The loss sustained in respect of subsidiary coinage during the year was £4,070. After providing for working expenses and payment of interest there is a profit of £3,756, added to amount brought forward, making £4,286, of which £4,000 has been allocated for depreciation and renewals, the balance (£286) being carried forward. Mr. J. J. Stodart Kennedy, late manager of the electric tramway in Bangkok, has been appointed manager in succession to Mr. J. Gray Scott.

ELMORE'S GERMAN & AUSTRO-HUNGARIAN METAL CO. (LTD.)—At the meeting last week, Mr. J. MacFarlan said the company had been effected by the severe trade depression which existed in Germany and practically throughout the world during the year. Their sales were extending, and there was a substantial increase to date. The trading for the first four months of this year was unsatisfactory.

GALLOWAYS LIMITED.—At the adjourned meeting on Friday, Mr. E. N. Galloway presided. The meeting was private, but it was stated that after a long discussion the directors' report was passed, and Mr. A. Hewlett, jun., and Mr. C. Price were elected directors to fill vacancies caused by the retirement (by rotation) of Mr. A. W. Galloway and Mr. Wm. Bayliss. Mr. R. F. Reddick and Mr. L. Agnew have joined the board.

MIRLEES, BICKERTON & DAY (LTD.)—At the first annual meeting last week the directors' report for the period from Dec., 1907, to March 31, 1909, recommended that £1,645 should be written off formation expenses, and the balance profit (£1,567) be carried forward. The chairman (Mr. A. F. Baird) stated that their works had been erected to the plans of Mr. Chas. Day at a cost (including plant and tools) of £45,100, and workmen were rapidly becoming familiarised with the special requirements of the Diesel engine. The directors had been in negotiation for agencies abroad, and some had been completed. He had found that on the Continent the manufacture of Diesel engines was going forward by leaps and bounds.

PARA ELECTRIC RAILWAYS & LIGHTING CO. (LTD.)—At the meeting on Wednesday, Sir Wm. Evans-Gordon said that it was only in June, 1908, that the last of the mule-drawn cars disappeared, and the full effect of electric traction could not be judged by the accounts to Nov. 30 last. The gross receipts of the tramways were £139,509, compared with £137,098, and of the lighting department £65,802, compared with £67,485, a total of £205,311, compared with £204,583. The expenses were £152,637, compared with £162,951, leaving a profit of £52,674, against £41,632. Net returns were better by £11,000, which might be regarded as very satisfactory. When their lighting cables had been put underground a very material saving of costs would be effected. During four months ended February economies were effected representing a saving at the rate of over £18,000 per annum, and without any sacrifice in efficiency. The returns which had come to hand since the commencement of this year had more than confirmed the estimate he had formed of the company's prospects.

PERTH (W. AUSTRALIA) ELECTRIC TRAMWAYS (LTD.)—The gross receipts for 1908 were £73,338. 12s., compared with £75,041. 17s. 10d. for 1907, and the profit was £28,720. 12s. 2d., against £31,176. 19s. 11d. The decreased profit was due to diminished traffic receipts, to increased facilities and increased mileage necessary to give better service on certain lines, partly to increased wages, and partly to increased expenditure on renewals of track, rolling stock, &c. The company were pressed to build extensions into North Perth, South Perth, Maylands and Bayswater and West Leederville. For dealing with these extensions a company called the Perth Traction & Development Co. (Ltd.) is being formed to act as auxiliary to the company. After payment of interest and sinking fund on the first and second debenture issues and trustees' fees, the balance at credit of profit and loss account is £11,153. 17s. 9d. After adding balance brought forward (£945. 18s. 2d.) and deducting £6,000 for preference dividend, the balance is sufficient to pay a dividend of 5 per cent. on the ordinary shares. The directors have decided to put aside £2,500 from this year's profits to reserve, and can only recommend a dividend of 2½ per cent. on the ordinary shares, leaving £1,099. 15s. 11d. to be carried forward.

REUTER'S TELEGRAM CO. (LTD.)—At the meeting on Wednesday Admiral Sir John C. Dalrymple Hay said that the outstanding feature of their operations during the past year had been the incessant and growing demands of the news department. In India they were taking steps to place their service upon a satisfactory footing, and they continued to pay special attention to their business in China. The greatest journalistic coup of the year was the news received at Melbourne by wireless telegraphy from Suva (Fiji) of the progress of the American battleships when 1,200 miles away from Fiji.

NEW COMPANIES.

BASTIAN ELECTRIC HEATING SYND. (LTD.) (103,083.)—Reg. May 19, capital £10,000 in £1 shares, to adopt an agreement with C. O. Bastian and to carry on the business of manufacturers of and dealers in electric heaters and cookers and kindred appliances, founders, electricians, &c. First directors A. C. Newman, H. G. M. Smith, and P. Vandervell.

PIRELLI LIMITED. (103,068.)—Reg. May 18, capital £8,000 in £1 shares, to carry on the business of manufacturers of and dealers in indiarubber, gutta-percha and asbestic articles, insulating materials, insulated wires and cables for use for telegraphic, telephonic and other purposes, electric lighting, &c., and to adopt an agreement with Pirelli & Co., of Milan, Italy. Private company.

PREMIER LIGHTING & ENGINEERING CO. (LTD.) (103,093.)—Reg. May 19, capital £3,000 in 2,999 ordinary shares of £1 each and 15 deferred shares of 1s. 4d. each, to adopt an agreement between W. C. Sharpe, W. C. Sharpe, jun., and H. C. Robottom, and to carry on the business of engine builders in accordance with the patents referred to in the said agreement, electricians, engineers, machinists, &c. Private company. First directors, H. C. Robottom (chairman) and W. C. Sharpe. Reg. office, 4, Lloyd's-avenue, London, E.C.

CITY NOTES.

MEMORANDA (May 27).—Bank rate 2½ per cent. (since April 1, 1909). Price of silver, 24¼d. per oz. Consols 85—85¼ for money and account. Consols Pay Days, June 1 and July 1; Stock and Shares Continuation Days, June 9 and 23; Ticket Days, June 10 and 24; Pay Days, June 11 and 25; Mining Shares Carry Over Day, June 8.

PRICES OF METALS (London).—*Copper*, cash, $61\frac{1}{16}$; three months $61\frac{13}{16}$. *Lead*, English, 13⅜—13¾; foreign, cash, $13\frac{5}{16}$; three months, 13½; *Spelter*, cash, 22—22⅛; three months, 22¼—22⅜. *Tin*, English, 131½—133½; foreign, cash, 132⅝, three months, 133⅛—133⅝. *Iron*, Cleveland, cash, 48/9, and three months, 49/5. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

ARON ELECTRICITY METER (LTD.)—The transfer books and register of members will be closed from June 1 to 19 inclusive.

BRUNNER, MOND & CO. (LTD.)—The net profit for the year ended March 31 was £760,130, and a final dividend at the rate of 30 per cent. is proposed on the ordinary shares, making 27½ per cent. for the year, adding £100,000 to suspense account, writing £2,500 off patents and carrying forward £37,033, subject to directors' fees.

MOUNTAIN & GIBSON & THORNEWILL (LTD.)—The list of subscriptions for the issue at par of 60,000 shares of £1 each and 808 5 per cent. debentures of £50 each of this company will close to-day (Friday).

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Amount.	Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 19	1,215	− 112	51	69,568	− 175
Airdrie	,, 14	223	− 3	19	4,076	− 76
Anglo-Argentine	,, 20	38,787	− 2,496	20	783,433	+ 41,212
Ayr Corporation	,, 23	274	− 19	1	274	− 19
Baker St. & Waterloo Ry.	,, 22	3,030	+ 505	20	66,790	+ 5,565
Barnsley	,, 14	169	− 10	19	3,131	− 80
Barrow	,, 14	213	− 13	19	3,929	− 289
Bath Electric Trams, Ltd.	,, 19	1,000	+ 235	20	13,264	+ 719
Birmingham Corporation	,, 22	6,479	+ 34	8	49,011	+ 489
Birmingham & Mid.	,, 7	797	+ 21	18	14,404	+ 103
Blackburn Corporation	,, 19	1,032	− 96	8	9,169	+ 64
Blackpool and Fleetwood	,, 23	383	+ 31	...	...	...
Bolton Corporation	,, 23	2,369	+ 25	8	18,512	+ 34
Bombay	April 22	R33,610	+ R1,450	16	R617,016	+ R44,295
Bournemouth Corporation	May 19	1,493	+ 27	7	11,890	+ 154
Bradford Corporation	,, 23	4,831	+ 10	8	36,107	+ 719
Brighton Corporation	,, 23	895	+ 53	8	6,913	+ 630
Bristol Trams & Carriage	,, 21	5,437	+ 598	16	129,561	+ 11,377
Burnley Corporation	,, 22	1,231	− 32	8	10,334	+ 309
Burton Corporation	,, 23	261	+ 5	8	1,977	− 20
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	,, 22	R17,572	+ R3,352	20	R295,350	+ R35,880
Camborne-Redruth	,, 23	115	− 4	21	2,389	− 93
Cardiff Corporation	...	...	...	...	...	...
Cavehill	,, 14	103	+ 18	19	1,290	− 147
Central London Railway	,, 22	5,766	− 753	20	101,910	− 10,707
Charing C., Euston & H'stead	,, 22	3,835	+ 515	20	77,015	+ 13,000
Chatham & Dist. Lt. Rys.	,, 20	751	− 109	20	14,692	+ 1,184
City & South London Rly.	,, 23	2,978	+ 176	20	65,277	+ 599
City of Birmingham	,, 11	2,789	− 17	19	51,031	− 410
Colchester Corporation	,, 19	194	− 35	...	...	...
Cork Electric Trams Co.	,, 20	314	− 139	20	7,412	− 852
Croydon Corporation	,, 21	1,416	− 158	[illegible]	10,869	+ 449
Devonport & Dist. Trams	,, 14	306	− 93	19	6,961	− 423
Dover Corporation	...	...	...	...	...	...
Dublin & Lucan Railway	...	...	...	...	...	...
Dublin United	,, 21	5,246	− 229	20	99,860	+ 869
Dudley-Stourbridge	,, 14	775	− 1	19	14,036	− 212
Dundee Corporation	...	...	...	...	...	...
East Ham Council	,, 22	1,037	+ 147	§7	7,554	+ 1,313
Exeter Corporation	,, 21	306	+ 3	8	2,313	+ 102
Gateshead & Dist. Trams	,, 14	988	+ 6	19	18,538	− 97
Glasgow Corporation	,, 22	18,315	+ 98	51	866,787	− 16,333
Glossop Trams	...	...	...	...	...	...
Gravesend—Northfleet	,, 14	136	− 8	19	3,496	− 130
Great Northern & City Rly.	,, 22	1,337	− 160	20	30,657	− 3,696
Gt. Northern, Piccadilly, &c	,, 22	5,670	+ 319	20	115,760	+ 7,430
Greenock & Port Glasgow	,, 14	598	+ 78	19	9,118	− 14
Hartlepool Tramways	,, 14	215	+ 5	19	3,816	− 111
Hastings Elec. Trams Co.	,, 20	898	− 50	20	16,379	− 415
Hong Kong	,, 22	$7,538	− $157	20	$164,482	+ $11,299
Huddersfield Corpn.	,, 22	1,603	+ 17	7	12,437	+ 485
Hull Corporation	,, 22	2,330	− 40	7	18,141	− 36
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 19	119	− 28	7	901	− 86
Ipswich Corporation	,, 22	370	− 19	8	2,718	+ 85
Isle of Thanet Co.	,, 22	474	+ 30	§25	10,232	+ 338
Jarrow	,, 14	117	+ 11	19	2,033	+ 190
Keighley Corporation	,, 20	133	+ 5	7	1,141	+ 43
Kidderminster & District	,, 14	97	+ 3	19	1,623	− 51
Kilmarnock Corporation	,, 22	157	− 4	1	157	− 4
Lanarkshire Trams Co.	,, 20	1,281	− 18	20	21,017	− 1,531
Lancashire United	,, 19	1,273	− 91	20	24,835	+ 242
Leamington	,, 14	167	+ 25	19	2,829	+ 205
Leeds Corporation	,, 22	6,639	+ 79	8	49,782	+ 2,3[illegible]9
Leicester Corporation	,, 22	2,262	− 51	...	...	...
Leith Corporation	...	...	...	...	...	...
Lincoln Corporation	,, 22	125	+ 12	8	983	+ 46
Liverpool Corporation	,, 15	10,631	− 156	‖19	201,061	− 9[illegible]6
Liverpool Overhead Rly.	,, 23	1,324	− 15	21	27,230	− 2,00[illegible]
Llandudno & Colwyn Bay Ry	...	...	...	...	...	...
*London County Council	,, 15	35,199	+ 834	§3	229,853	+ 13,813
London United	,, 23	6,802	− 889	‖23	109,148	− 6,314
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 22	178	− 18	7	1,331	− 64
Manchester Corporation	,, 22	14,973	− 670	8	112,254	+ 1,963
Mersey Railway	,, 22	1,907	+ 62	20	39,271	+ 1,034
Merthyr	,, 14	203	+ 7	19	3,863	+ 4
Metropolitan Dist. Railway	,, 22	10,011	+ 1,131	20	195,137	+ 17,571
Metropolitan Elec. Trams	,, 14	6,258	+ 435	19	106,844	+ 12,103
Middleton	,, 14	357	− 13	19	5,893	− 253
Nelson Corporation	,, 22	131	− 6	†8	1,062	− 21
Newcastle-on-Tyne Corp.	,, 22	3,790	+ 147	8	29,061	+ 140
Newport (Mon.)	,, 22	639	+ 4	8	5,163	+ 34
Northampton Corporation	,, 21	452	+ 3	§8	3,468	+ 252
Oldham, Ashton & Hyde	,, 14	576	− 27	19	10,238	− 637
Oldham Corporation	,, 23	1,960	− 101	8	16,527	− 742
Perth (N.B.) Corporation	...	...	...	...	...	...
Perth (W.A.) Elec. Trams	,, 21	1,369	− 38	21	29,283	+ 21
Peterborough	,, 14	108	− 17	19	1,918	− 121
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 14	1,767	− 36	19	33,116	− 1,15[illegible]
Preston Corporation	,, 19	665	− 61	7	5,108	+ 95
Rotherham Corporation	,, 20	587	− 33	7	4,326	− 76
Rothesay	,, 14	105	+ 3	19	1,476	− 11
Salford Corporation	,, 21	4,553	− 64	‡8	35,129	− 430
Sheerness	,, 14	45	− 8	19	832	− 115
Sheffield Corporation	,, 23	5,627	− 67	§8	47,033	− 536
Singapore Trams	,, 22	$9,101	+ $109	20	$202,701	+ $1,558
South Metropolitan	,, 14	786	− 3	19	13,395	+ 355
South Staffs	,, 14	812	− 35	19	15,437	− 836
Southend Corporation	...	...	...	...	...	...
Southport Tramways	,, 14	285	+ 8	19	4,359	+ 121
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 22	741	− 40	§7	5,868	− 43
Sunderland Corporation	,, 23	1,103	− 8	8	8,337	− 300
Sunderland District	,, 19	411	− 48	29	12,783	− 348
Swansea Trams	,, 14	961	+ 80	19	16,836	+ 430
Swindon Corporation	,, 19	115	− 22	...	...	...
Taunton	,, 14	35	− 4	19	653	− 65
Tynemouth and District	,, 14	177	− 4	19	2,758	− 83
Tyneside Trams Co.	,, 19	395	+ 6	20	7,971	+ 581
Wallasey District Council	,, 22	903	+ 17	§7	6,982	+ 148
Walsall Corpn.	,, 23	487	− 54	20	9,989	− 801
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	,, 13	2,310	+ 133	6	14,518	+ 1,403
Weston-super-Mare	,, 14	103	+ 23	13	912	+ 127
Wolverhampton Co.	,, 14	401	− 28	19	7,514	− 831
Wolverhampton Corpn.	,, 19	721	− 83	20	14,013	− 998
Worcester	,, 12	274	+ 6	19	4,615	+ 6
Wrexham	,, 14	95	− 7	19	1,762	− 55
Yorkshire W.R. Trams	,, 23	1,119	− 61	21	23,689	...
Yorkshire Woollen District	,, 14	910	− 27	19	16,231	− 497

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share.	Last Dividend	Name.	Price Wed. May 26.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to May 26: Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½–10	6 [illegible] 0	Mar, Sept		–
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾–10¼	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼–10¾	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101–105	4 5 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½–4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93–96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	5½–[illegible]	[illegible] 11 0	March....	[illegible]	..
5	3/6	Do. 7 per Cent. Pref.	8–8½	4 2 [illegible]	Mar, Sept	–	–
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	99–102	3 18 6	June, Dec	..	–
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾–4¼	[illegible]	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¾–5	4 12 0	Feb, Aug	–	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99–101	3 19 0	Jan, July	..	–
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	[illegible]	4 [illegible] 0	..	[illegible]	[illegible]
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾–4¼	5 [illegible] 6	Jan, July	4[illegible]	..
5	2/6	Chelsea Electric Supply Ord.	3½–4	[illegible]	March ..	..	.
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102–105	4 7 6	June, Dec	.	..
10	7/0	City of London Electric Lighting Ord.	[illegible]	[illegible]	Feb, Aug	[illegible]	16[illegible]
10	6/0	Do. 6 per Cent. Cum. Pref.	[illegible]	4 1[illegible] 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121–123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101–104	4 [illegible] 6	Jan, July	..	..
5	..	County of Durham Elec. P.D. Ord.	1¾–2¼		April, Oct	–	..
5	5%	Do. 5 per Cent. non Cum. Pref.	[illegible]	[illegible] 11 [illegible]	April, Oct	..	.
10	6/0	County of London Elec. Supply Ord.	8½–8¾	5 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾–11¼	5 6 6	Mar, Sept	10⅞	..
St.	4½%	Do. 4½% Deb. Stock (red.)	106–109	4 [illegible] 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100–103	4 7 6	May, Nov	[illegible]	[illegible]
5	3/6	Folkestone Electricity Supply Co. Ord.	4½–5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97–100	4 10 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7½–7¾	5 10 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7⅝–7⅞	5 5 0	Feb, Aug	..	–
5	6%	Do. 6 per Cent. 1st Pref.	5⅝–5⅞	4 14 6	Jan, July	..	–
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94–97	4 3 0	..	–	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98–101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85–89	6 1 0	Jan, July	.	..
3	1/9⅜	London Electric Supply Ord.	1⅞–2¼	3 6 8	Mar, Sept	2[illegible]	..
5	3/0	Do. 6 per Cent. Pref.	5⅛–5¼	5 11 6	Mar, Sept	5	5⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92–96	4 3 6	Jan, July	–	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅜–[illegible]	5 13 0	April, Oct	4[illegible]	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾–5⅛	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107–110	4 2 0	June, Dec	–	–
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	86–88	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95–98	4 12 0	June, Dec	..	–
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4¾–5	4 2 1	Feb, Aug	..	–
100	4½%	Do. 4½ per Cent. Deb.	88–90	5 0 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅞–5	2 19 7	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5–5¼	4 17 6	Feb, Aug	–	–
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	98–100	4 0 10	Jan, July	–	–
100	50/	North Metro. Elec. Power Sup. 5 Morts	99–101	4 19 0	..	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	–
100	4½%	Do. 4½ per Cent. Deb.	91–93	4 17 10	Jan, July	–	..
10	8/0	Notting Hill Electric Ord.	11½–12½	5 13 0	March ..	–	..
5	4/6	Oxford Electric Ord.	6–6½	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94–97	4 2 6	Jan, July	..	–
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅞–9⅜	5 7 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7–7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85–90	3 18 0	Jan, July	..	–
[illegible]	..	Smithfield Markets Electric Sup. Ord.	⅝–⅞	..	Feb	..	..
[illegible]	4/0	South London Electric Supply Ord.	2¼–3¼	6 8 0	April	3	..
St.	..	Do. 5% 1st Mort. Stk. Red.	[illegible]	..	–	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	[illegible]	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	[illegible]	5 7 0	Feb, Aug	..	–
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100–103	4 7 6	April, Oct	..	–
5	2/6	Urban Electric Supply Ord.	⅞–1	–	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2–[illegible]	10 0 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80–84	5 7 3	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9⅛–9⅜	5 4 0	Mar, Sept	9½	9¼
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛–[illegible]	4 11 0	Jan, July	5	5[illegible]
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	97–99	4 1 0	Jan, July	98½	97¾
1	..	Bath Elec. Trams Pref. Ord.	[illegible]	..	April	¼	.
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜–¾	6 13 0	Jan, July	..	–
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88–92	4 18 0	April, Oct	.	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89–93	4 13 6	Jan, July	91	..
10	6%	Bristol Tramways & Carriage Ord.	8¾–9¼	6 9 9	Feb, Aug	..	–
10	4%	Do. Cum. Pref. (fully paid)	8½–9	4 9 0	..	..	–
St.	4%	Do. 4 per Cent. Debs.	99½–100½	3 19 7	Feb, Aug	..	–
10	..	British Electric Traction Ord.	⅞–1¼	..	June, Dec	1	..
10	8/0	Do. 6 per Cent. Cum. Pref.	2¾–3¼	9 13 0	Feb, Aug	3⅛	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	89–93	5 7 0	April, Oct	89	8[illegible]
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68–72	6 5 0	May, Nov	70	6[illegible]
St.	2½%	Central London Ordinary Stock	68–70	5 0 0	Feb, Aug	70	6[illegible]
St.	4%	Do. 4 per Cent. Pref. Stock	85–87	5 12 0	Feb, Aug	8[illegible]	..
St.	2½%	Do. Deferred Stock	52–54	4 11 6	Feb	52¾	52
100	4%	Do. 4 per Cent. Debs.	102–104	3 16 6	Jan, July	103⅛	[illegible]
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92–94	4 5 0	Jan, July	[illegible]	[illegible]
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾–5¼	4 15 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97–101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	[illegible]	4 12 0	Feb, Aug	[illegible]	31¾
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110–112	4 9 0	Feb, Aug	..	..
St.	5%	Do. (1896)	103–105	4 12 0	Feb, Aug	–	..
St.	5%	Do. (1901)	[illegible]	4 15 0	Feb, Aug	.	–
St.	5%	Do. (1903)	93–95	5 4 0	Feb, Aug	[illegible]	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99–101	3 19 0	May, Nov	[illegible]	–
10	6/0	Dublin United Trams. Ord	—	4 15 0	Feb, Aug	..	–
10	6/0	Do. 6 per Cent. Pref.	13–14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	½–¾	..	Feb, Aug	..	–
10	..	G. Northern, Picc. & Brompton 4% G.Pf.	8½–[illegible]	–	Feb, Aug	.	.
St.	4%	Do. 4 per Cent. Deb. Stock	94–95	4 3 6	Jan, July	95	[illegible]
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2–2½	..	Mar, Sept	..	–
St.	4½%	Do. 4½ Db. St.	82–87	5 3 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	6½–8	8 [illegible] 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6¾–7¼	7 13 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	87–89	5 1 11	Jan, July	..	–
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅛	..	Mar, Sept	..	–
St.	4%	Do. 4 per Cent. Deb. Stock	[illegible]	6 13 0	Jan, July		–
10	6/0	Lanarkshire Tramways	[illegible]	5 17 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91–93	5 7 6	Jan, July	.	..
10	..	Liverpool Overhead Railway Ord.	[illegible]–1	..	Feb, Aug	..	–
10	5%	Do. 5 per Cent. Pref.	[illegible]–6	[illegible]	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82–84	4 15 3	Jan, July	–	..
10	2/6	London United Trams. 5% Cum. Pref.	2½–3¼	[illegible] 10 [illegible]	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	[illegible]–74	5 8 [illegible]	Jan, July	..	..
St.	—	Mersey Con. Ord. Stock	1–2	–	Feb, Aug.	–	–
1	10¼	Metropolitan Elec. Tramways Ord.	[illegible]	–	..	..	..
1	–	Do. Deferred	[illegible]	..	April..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97–99	4 11 0	Jan, July	98	97¾
St.	½%	Metropolitan Railway Consolidated	39–39½	1 5 0	Feb, Aug	39⅞	[illegible]
St.	3%	Do. Surplus Lands Stocks	70–72	4 3 0	Feb, Aug	70¼	70
St.	3½%	Do. 3½ per Cent. Preference	89–91	3 17 0	Feb, Aug	91	89
St.	3½%	Do. 3½ per Cent. "A" Preference	82–84	4 8 6	Feb, Aug	83¾	83¼
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82–84	4 3 6	Feb, Aug	[illegible]	[illegible]
St.	3½%	Do. 3½ per Cent. Debenture Stock	93–95	3 13 3	Jan, July	[illegible]	94⅛

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ment of accumulator-driven cranes, especially when a cheap supply of power is available for charging purposes, possesses many advantages. Their radius of action, though small, is generally quite extended enough for ordinary industrial purposes, while this type of crane possesses the advantage that its sphere of usefulness is not hampered by the absence, or presence, of the trolley wire, and that it can practically go anywhere where there are rails. Its adoption for use in railway yards should, therefore, be assured, when the prejudice at present existing in favour of the "potato-engine" arrangement now so often employed for loading goods into trucks is a thing of the past.

The day of the accumulator then, even when it is of the lead type, is by no means past; and there is no reason to suppose that it will not be still further extended. We lay no claim to the gift of prophecy; but there seems no harm in saying that if a secondary battery is invented, and the "if" should certainly be in large capitals, which is lighter and perhaps more efficient than the present existing types, it will help towards the solution of such problems as the provision of suitable conveyances in districts where there is but a scattered population.

This latter problem is already receiving some attention, and the system known as the "trackless trolley" has been proposed as a solution. There can be no doubt, however, that the use of accumulators would be in many ways more advantageous; each running unit would be self-contained and the erection of a double overhead trolley wire would become unnecessary.

Oil Switches.

GREAT interest is being taken in the design of switchgear at the present time, and for this reason some descriptive particulars of their latest designs in oil switches sent us by Messrs. Cowans are of peculiar

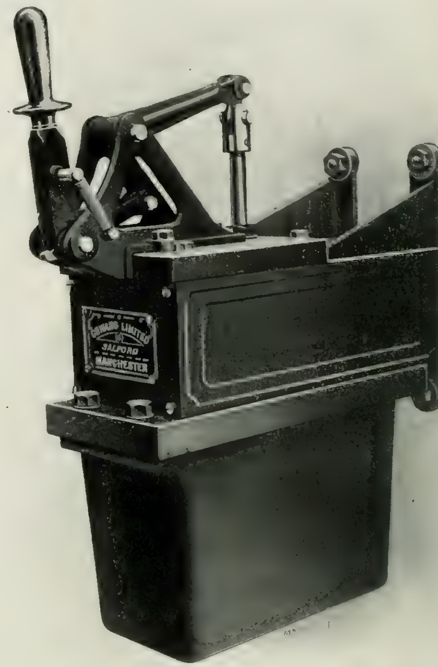


Fig. 1.—Single-pole Switch for Pressures up to 3,000 volts.

interest. The firm call special attention to the fact that an oil-immersed contact has always a higher specific conductivity than a contact in air, the ratio of efficiency of contact

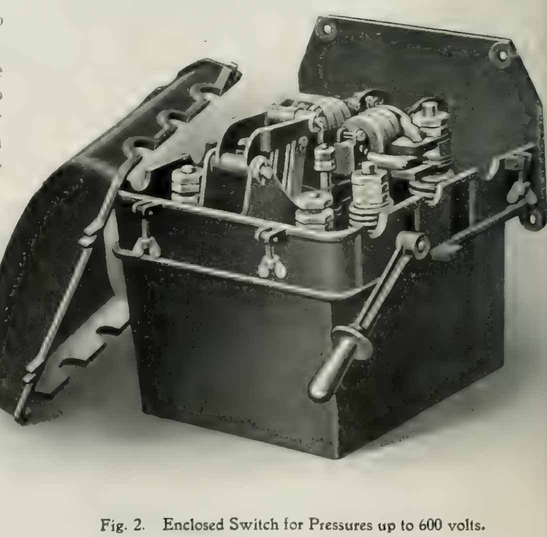


Fig. 2. Enclosed Switch for Pressures up to 600 volts.

being at least 2 to 1 in favour of the oil-immersed contact. Further, the conductivity is maintained at a high efficiency, whereas, in the case of dry contacts, the efficiency rapidly deteriorates. This deterioration is, of course, due to oxidation.

Messrs. Cowans recommend the extension of the use of oil switches for continuous-current circuits under certain conditions. The break is too sudden for circuits of high inductance, but in the case of motors, where there is a "cushioning" resistance or its equivalent, they have been used with complete success. A powerful magnetic blow-out has much the same effect as a break under oil. Prof. Bertram Hopkinson made some experiments many years ago which demonstrated that the rise of pressure accompanying the opening of the strong blow-out circuit breakers then in general use was considerable. Under oil there is, with continuous currents, always a flash at break, and this flash is Nature's safety valve and relieves the pressure considerably. The presence of this flash necessitates that certain special precautions should be taken in the design of the switches to prevent trouble arising from the carbonisation of the oil.

The switch which we illustrate in Fig. 1 is of the single-pole type, without any automatic gear, and is designed for pressures up to 3,000 volts. Its chief merits are its simplicity and substantiality. All "live" parts are protected against accidental contact. This switch is made for two, three and four-pole circuits, and can be fitted with excess current automatic trip with or without time lag arrangement, or with reverse-current automatic release gear.

Fig. 2 shows a similar switch, but completely enclosed and adapted for pressures not exceeding 600 volts. It has been designed for mine and workshop use.

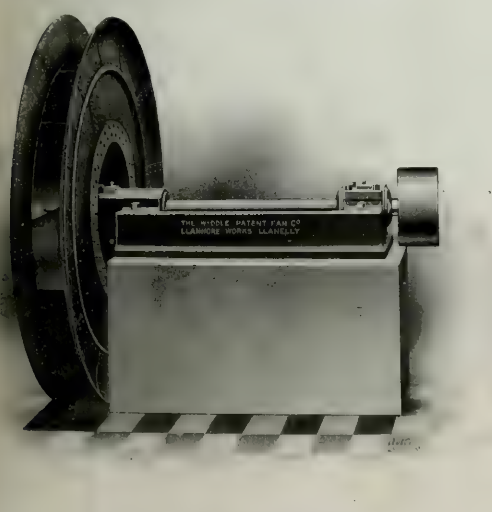
Waddle Fans.

To those to whom questions of the depreciation of plant and machinery appeal with some force it will be of interest to know that the very first fan erected by the Waddle Patent Fan & Engineering Co., of Llanelly, is still in full working order. This fan, though of primitive construction, and, of course, not fitted with the electric drive, is still going strong, and seems good for another 40 years.

The reason for this satisfactory result is said to be found in the construction of the Waddle fan and its principle of working, which is common to both the first and latest types. The Waddle fan may, in fact, be considered as a light hollow disc, the two sides of which are braced together by the blades, which are riveted to them. The periphery is open all round, and the air is, it is claimed, discharged equally from every part of it. The load on every blade, and on every part of it, is therefore steady and unvarying, while there is said to be a complete absence of that vibration which is an annoying feature of some enclosed fans. In an enclosed fan each blade is doing a maximum amount of work when nearest the outlet, and this load is suddenly thrown off as soon as the blade has passed this point.

The Waddle fan is of the single-inlet type, an arrangement which is said to possess certain well-defined advantages, and the air on leaving the blade tips enters a diffuser, and is finally discharged into the atmosphere at a greatly reduced velocity. Direct driving is advocated wherever possible, but fans designed for belt driving are also made, one of which is shown in the accompanying illustration. The Waddle electrically-driven fans are made in nine sizes, varying from 3 ft. to 18 ft. in diameter, and capable of dealing with volumes of air between 25,000 and 400,000 cubic ft. per minute.

This wide range allows them to be used for a variety of purposes, while their sound engineering details also tend to this end.



"Waddle" Fan for Belt Driving.

Siemens' Circuit-Breakers.

SPECIAL attention has recently been directed by Messrs. Siemens Bros. Dynamo Works, Ltd. to the subject of automatic circuit-breakers, and they have now placed on the market two improved designs, known as classes S.K.B. and S.K.A. respectively, the former for dealing with currents ranging up to 1,000 amperes and the latter for larger currents

These circuit-breakers—of either the single, double or triple-pole types—are designed for direct or remote operation on continuous or alternating-current circuits. All current-carrying parts are of copper, the main brushes being built up of copper laminations, which press firmly against the main contacts when the circuit-breaker is

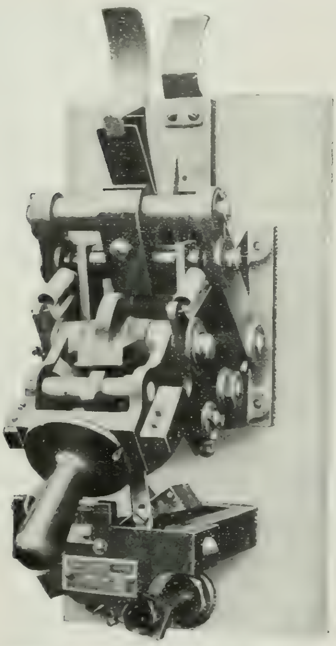


Fig. 1.—Siemens' Class S.K.B. Circuit-Breaker. Maximum and Reverse Type.

closed. The arc at break can only take place between auxiliary contacts specially designed for the purpose, which are provided with a pair of metal horns; the danger of spoiling the main contact surface is thereby entirely avoided.

Automatic releases can be fitted to the S.K.B. type (Fig. 1) to suit any of the following conditions—viz., maximum, maximum and reverse, minimum or no-voltage. The maximum-current circuit-breakers are held in their closed position by a magnetically controlled catch, which, when the current rises to a predetermined value, is released, thereby causing the circuit-breaker to open. It is then impossible to close the circuit-breaker while the overload or short-circuit persists. The maximum-current release can be set for any value between normal and about three times normal. Maximum-current circuit-breakers for high voltages (above 750 volts) consist of two switches in series, arranged to break the circuit at two places.

In the case of class S.K.A. (Fig. 2) circuit-breakers the operating and tripping mechanism is made in one size only, and forms a self-contained unit. This, together with the switch part (which varies in size according to the capacity), forms a complete non-automatic circuit-breaker, which can be readily arranged as an automatic circuit-breaker of any desired type by fitting the necessary releases. In this manner it can be arranged as either a maximum, reverse, minimum or no-voltage circuit-breaker, or combinations of these. The releases form independent, direct-acting, self-contained, detachable units which can be readily fitted to an existing S.K.A. circuit-breaker. Multiple brushes are employed, each of which is built up of interchangeable unit brushes, the number of the latter varying according to

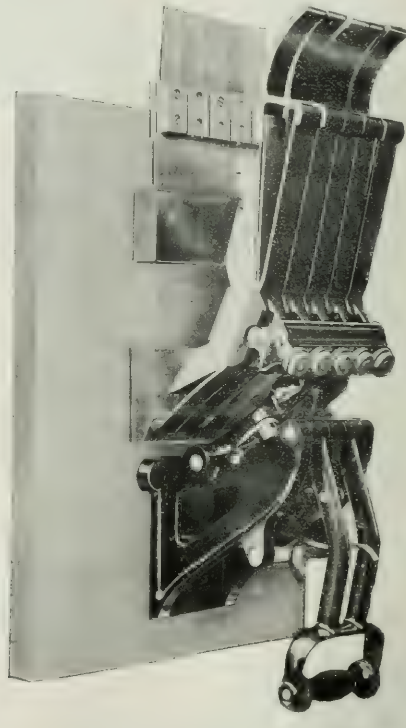


Fig. 2.—Siemens' Class S K.A. Circuit-Breaker.

the capacity of the circuit-breaker. The brushes are carried on pivots which tend to equalise the pressure and reduce the contact resistance. Each complete brush can be removed or replaced by the withdrawal of a single bolt.

All parts, with the exception of the main contacts and brush carrier, are the same for all sizes and readily interchangeable. Complete sets of parts are always in stock, thus ensuring prompt delivery. Both types of circuit-breaker can be fitted with a time-limit attachment to delay the action of the releases.

In the foregoing notes it will be seen that Messrs. Siemens have spent a good deal of time and trouble on the design of their circuit-breakers. A great point seems to be that the main current carrying parts are unaffected by the break, which is made between auxiliary and easily renewable contacts. Such an arrangement obviously greatly prolongs the life and improves the operation of the switch.

Induction Instruments.

THE advantage for switchboard purposes of instruments of the ordinary external dimensions, but arranged with a long scale must be obvious to everyone. This desirable state of things can only be arrived

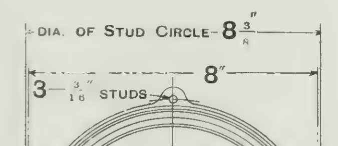


Fig. 1.—Ferranti Induction Instrument.

at by arranging for the movement to swing over an arc of the order of 300 deg. The induction type instrument not only lends itself admirably to this purpose, but also allows the scale to be made open or closed at any one part of the arc as may be desired. In Fig. 1 the external diameter of the instrument illustrated is 8 in., while the length of the scale is $15\frac{1}{2}$ in. To obtain the same length of scale in a round type instrument of similar construction, in which the movement would have to be restricted to an angle of 75 deg., the external diameter would require to be of the order of 20 in.

The induction type instrument, as introduced by Messrs. Ferranti Limited, of Hollinwood, Lancs., is of exceedingly simple construction. The moving portion consists of a pivoted aluminium disc having a contour of spiral form. The edge of the disc swings within the gap of a shaded-pole electromagnet; the electromagnet being energised

Fig. 2.—Ferranti Induction Ammeter.

by the main current in the case of ammeters and by a pressure winding in the case of voltmeters. The shaded-pole electromagnet is built up of stampings in the ordinary way, and one-half of the front and the corresponding half of the back pole is surrounded by a copper shroud, which causes the flux emanating from these portions of the pole to be retarded in phase behind the flux due to the unshrouded portions of the pole.

The currents induced in the disc by the shrouded portions occupy a position under the unshrouded portion, and *vice versa;* and, owing to the phase displacement, there is a current component induced in the disc under each portion of the pole in phase with the magnetic flux emanating from that portion of the pole, resulting in a torque in one direction. The value of the torque depends upon the flux-density, phase displacement and quantity of material in the disc acted upon. Since, however, the disc has, as

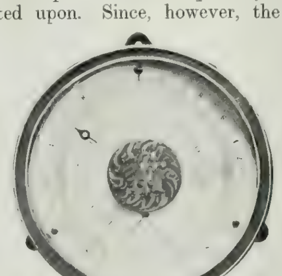


Fig. 3.—Long Scale Power Factor Indicator.

already explained, a spiral form, the quantity of material acted upon by the pole varies as the movement is deflected; and by suitably shaping the disc it is evident that any form of scale, whether uniform or not, can be arrived at. The disc is controlled by a system of hair springs in the usual manner.

The torque exerted upon the movement in this class of instrument is very considerable, a torque of 2·5 gramme-centimetres being easily obtainable. This is naturally of considerable importance, since with a large torque slight variations of pivot friction do not produce perceptible errors in the accuracy of the instrument.

The instruments, as manufactured by Messrs. Ferranti, are compensated for frequency, wave form and temperature changes. This compensation is effected in the case of ammeters by a suitable shunt connected across the main winding. The shunt is non-inductive, and will, therefore, shunt a larger proportion of the whole current with an increase of frequency. Other conditions remaining the same, the torque upon the disc increases with frequency; consequently, by arranging to shunt a larger proportion of the current when the frequency increases, the necessary correction is obtained. The shunt, again, has a somewhat different temperature coefficient to that of the main

Fig. 4.—Long Scale Induction Indicating Wattmeter.

winding, and consequently the amount of current shunted depends also upon temperature. The shunt, therefore, at the same time is arranged to provide the necessary temperature compensation. In the case of the voltmeters, the compensation for frequency and wave form is also partly due to a non-inductive series resistance inserted in the voltmeter circuit.

Figs. 2, 3 and 4 illustrate other types of Ferranti instruments, such as power-factor indicators, which are designed in harmony with the foregoing criteria.

British Westinghouse Electric Fans.

THE British Westinghouse Mfg. Co.'s 1909 electric desk fans, although containing several new features, show a considerable reduction in price. They are made both for direct and alternating currents, the former having blades from $7\frac{1}{2}$ in. to 16 in. in diameter. The blades of the alternating-current fans vary from 9 in. to 16 in.

The 12 in., 14 in. and 16 in. type of direct-current fan is quite a special production, beautifully made and artistically finished in black enamel with gold lines. The blades are of lacquered brass and are highly polished. They are a combination of the desk and bracket type, and being quite portable and having complete universal movements, can be converted from desk to bracket use merely by operating a thumb screw. They are also provided with a swivel and trunnion, so that all the movements required can be obtained without the aid of a screwdriver.

The new fan regulators for 50 per cent. speed regulation have been specially designed for use with direct-current ceiling fans and small motors. The cover is efficiently ventilated and is insect-proof, which is absolutely essential in tropical countries. It is thoroughly insulated and has no exposed parts. The resistances are of the Westinghouse patent unit type, and in case of a burn-out can be easily and quickly replaced after removing the cover. It is artistic in design, the cover being of antique hammered copper.

Though the ceiling fans have undergone no radical change of design, various improvements have been effected. They have four wooden blades with a sweep of 57 in. The motors are controlled by a conveniently located switch, and give

Westinghouse Fan Regulator.

three speeds of 100, 150 and 200 revs. per min. The rotating element is mounted on ball bearings with an effective system of automatic lubrication and practically noiseless working. The direct-current ceiling fans have similar speeds, the consumption of energy depending on the speed, which is controlled by a regulating resistance cut in and out of the circuit by means of the switch mounted on the under side of the fan. The commutator gives sparkless commutation.

The new type of direct-current box-blade fans are of very powerful make. They are in 10 sizes, with speeds ranging from 250 to 1,000 revs. per min. They can be worked horizontally or vertically without any alteration or adjustment, and are smartly finished, the frame in green and the blades in red.

2,000 H.P. Blower Motor.

THE recent introduction of the electric drive into iron and steel works has had the result that the blowing machines are now usually actuated by this means. A motor installed at the Peiner works by the Felten & Guilleaume-Lahmeyerwerke A.G., of Frankfort-on-Main, for this purpose is interesting for several reasons. It is claimed to be one of the largest continuous-current motors that has been built up to the present time, and as far as is known it is the first that has been applied to driving blowing machinery in steel works. Such machines as blowers provide only an intermittent load, but when it is necessary to blow a charge they must be instantly ready. Further, it is necessary that their speed should be capable of regulation between wide limits in order that the pressure of the air blown through the furnaces may be maintained at any desired value. It was, in fact, this last condition that determined the Felten & Guilleaume-Lahmeyerwerke Co. to use a continuous-current motor.

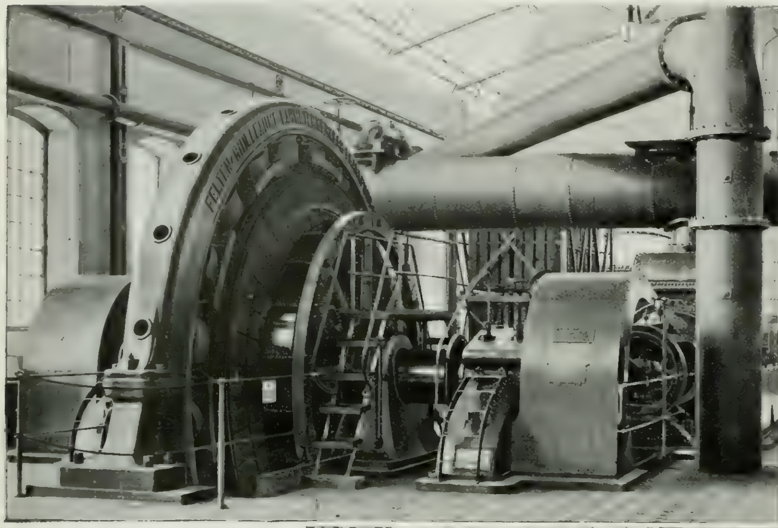


Fig. 1.—2,000 H.P. D.C. Blower Motor.

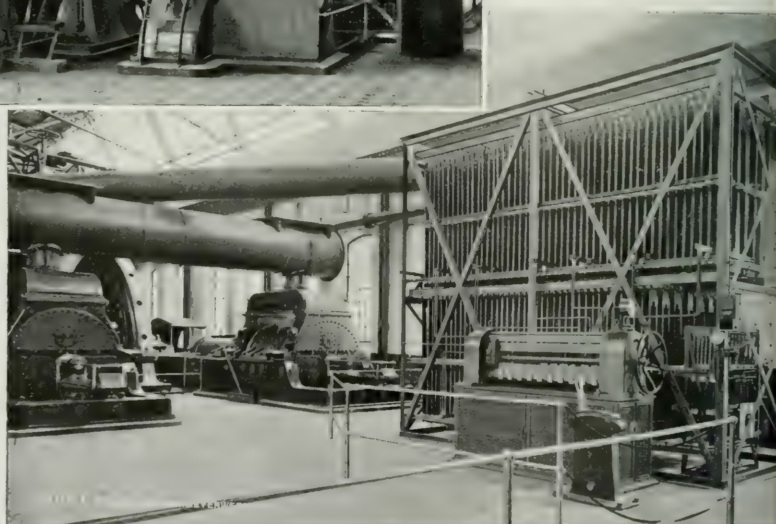


Fig. 2.—Regulating and Starting Gear for 2,000 H.P. Motor.

This motor, which is of the shunt type, is illustrated in Fig. 1. It is supplied with current at 500 volts, and is capable of developing 2,000 H.P. when running at any speed between 50 and 80 revs. per min. At a speed of 40 revs. it is designed to give 1,500 H.P., and at least 600 H.P. when running at 22 revs. It will thus be seen that a large range of power can be obtained with great ease. The field system is made up of 20 poles of circular section and 18½ in. in diameter, between which are placed the same number of auxiliary poles, with the idea of avoiding sparking at the brushes whatever the load may be. The armature core is built up of soft iron stampings 12 in. wide and has a diameter of 15 ft. and a breadth of 3 ft. It is keyed on to a shaft of diameter 2 ft. 6 in., and is carried on two bearings. Current is conveyed to the armature by 20 brush bars, each containing seven brushes. The commutator is 12 ft. in diameter, and has 11 in. of useful breadth. The brush-holder is fixed to the frame of the machine by a special support, by the use of which, it is claimed, all chance of any oil reaching the current-carrying parts is avoided.

The motor is fitted with a shunt regulator and with a starting rheostat, by which also the speed is controlled between 22 and 40 revs. per min. It is, therefore, constructed with extra generous dimensions. In practice, however, it is expected that this regulation will scarcely ever be employed. The starting resistance is divided into nine sections, made up of sheet iron and carried on porcelain insulators. The starter brushes, which are fixed on a movable nut running on a square threaded screw, which is fitted with a hand wheel, slide on the faces of contacts connected to these resistances. When the motor is started, as each main brush leaves the starter contact, the auxiliary brushes put the following contact in circuit with a rod of copper connected to an electrode which is immersed in a special liquid resistance. The object of this is to prevent the sudden alteration in current which would result from the fact that the number of sections on the starter is small. This electrode is carried on a spindle keyed to the screw so that its position at any instant corresponds exactly with that of the brush. As it becomes more and more immersed the resistance of the liquid becomes less until as the starter reaches the last contact it is cut out altogether.

The fitting which supports the screw and the contacts is

divided into two separate compartments. One of these contains the liquid resistance, while in the other is fixed a double-pole automatic circuit-breaker. An indicating arrangement worked by the screw shows at any instant the position of the brushes on the starter. The automatic circuit-breaker is interlocked with this arrangement, and cannot be switched in until the starter brushes are brought back to their initial position. Further, a bell which works in connection with this indicating arrangement prevents the principal starter brushes from being stopped between two of the starter contacts, in which case all the current would be passed continuously through the liquid resistance. The small wheel, which can be seen below that of the starter in Fig. 2, works the shunt regulator through a chain and gear wheels, so that the speed of the motor can be altered between 40 and 80 revs. per min. without any great expenditure of energy. The man in charge of this set is made aware of the working conditions of the blower by the readings of a pressure gauge, which shows the pressure in the exhaust pipe, and by a voltmeter and ammeter, which read up to 500 volts and 5,000 amperes respectively. Further, he is in communication with the furnace room by means of a bell system which is shortly to be replaced by an optical telegraph. This apparatus, by means of a number of incandescent lamps, allows a whole series of signals to be accurately and clearly transmitted.

This interesting motor was put into operation in January last, and as the result of tests made at that period it would seem that it is capable of fulfilling all the conditions likely to be imposed upon it. By closing the exhaust valve from the blower the load on the motor was raised to as much as 2,630 H.P., corresponding to a current of 4,100 amperes, without any heating of the brushes. As under ordinary conditions the current will not exceed 2,800 to 3,900 amperes, it would seem that the sparkless operation at all loads is fully assured. The blowing of the charge takes about 13 minutes on an average, and there is an interval of 18 and 20 minutes between two blowings, during which the motor runs light at a speed of 40 revs. per min. This method of working has been adopted under normal conditions as it permits the motor to be taken advantage of at any instant, and is not more costly than stopping the motor between the blowing, as the energy only costs about ½d. per unit; besides, it allows economy as regards labour, as one man can look after the whole installation. Further, frequent startings of such a set as this would be very inconvenient and would cause a large expenditure of energy. Tests on this machine have shown that its use instead of the steam blowing apparatus formerly employed has given rise to an increased production, owing to the greater speed at which the charges can be blown.

Veritys Fans.

AT this time of year, with the hot weather in the offing, our thoughts turn towards fans and the cooling breezes produced by their use. Among fan makers who have a useful range of electric fans are Messrs. Veritys, and an interesting fan made by them is shown in Fig. 1. This is known as the "Delhi" desk fan and is intended for alternating-current work. It is of special interest, as Messrs. Veritys consider that it is one of the few of its kind made in this country, most alternating-current fans being of foreign make. The problem of the proper design of these fans is more difficult than would be thought at first sight. They are made for two standard voltages, from 100 to 125 and 200 to 250 volts respectively, and for four frequencies consumption varying from 55 to 70 watts. These fans have a blade diameter of 12 in. The "Delhi" desk fan is fitted with a self-starting induction motor and no fibre whatever is used in its construction. Three speeds are obtainable. The bearings of this fan, and also of the "Typhoon" desk fan, which we describe below, are made of solid cast-iron in which the spindle runs. These bearings are of ample length, and by dispensing with the usual gun-metal liners perfect alignment can be secured.

Fig. 1.

The next fan on the list is the "Typhoon" combined table and bracket fan, which we illustrate in Fig. 2. This is provided with a very neat arrangement by which the fan and trunnion can be taken out of the pedestal stand and placed in another socket also provided on the pedestal, so that the desk fan is transformed into one of the bracket type. This fan is made in three sizes, having blade diameters of 9 in., 12 in. and 16 in. respectively, two

Fig. 2.

speeds being available in each size. The motors provided with these fans are made for pressures of 24, 65, 100 to 110, 200 to 220, and 230 to 260 volts respectively. The blades are of polished brass and are protected by a substantial brass guard strongly supported by corrugated straps. The motor is of the "Aston" type and is specially designed for silent and sparkless running. The regulator provided gives two speeds with an "off" position.

An "Aston" ventilating fan suitable for more serious ventilating work is also made by Messrs. Veritys.

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Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Electrical Production of Iron and Steel. In quite the early days of the electrical industry William Siemens succeeded in employing the electric current for the production of steel, and one of the sights of the Paris Exhibition of 1881 was a small ingot of metal made in an electric furnace. Like many other inventions, however, this furnace was somewhat before its time, and it was not until quite recent years that electrical methods of producing iron and steel became economically possible. Since its second birth, however, the advances in this direction have been very rapid and its position in the iron and steel world may be rightly gauged by the prominence given to such Papers on the subject as have recently been read before the Iron and Steel Institute. Nor is the application of electricity in metallurgy confined to iron and steel, for it is common knowledge that one very widely-used metal, aluminium, would scarcely be more than a chemical curiosity without its aid. To make the various electrical processes an industrial success, cheap power is an absolute necessity; and it is interesting to know that where this is available, such methods are economically advantageous. For instance, according to Mr. Pring, in California, commercial pig iron made by electrical methods can be obtained on the San Francisco market at half the price of the imported material. The advantages of producing iron from the ore by electrical means are not so pronounced as those obtained when the same methods are applied to steel manufacture. An exceedingly economical cycle of operations seems to be made up of the following sections: The production of iron in the ordinary blast furnace, the heating of the iron in either an ordinary or electric furnace, and its final purification in the electric furnace. It is found that a much better quality of steel is obtained in this way than by the ordinary methods; doubtless owing to the easier manipulation which is possible, especially in the induction or conducting hearth type of furnace. In such an installation blast furnace gas used in connection with suitable engines would, of course, be employed, and cheap power thus obtained. At the present time in this country, unless something of this kind is done, the outlook for the electric furnace is not very bright; for coke is cheap, and it has been shown that the costs of the blast and electric furnaces are equal when coke is 25s. per ton and electricity £2 per horse-power-year, or 0·073d. per unit. In countries where the conditions are reversed, and plenty of cheap water power is available, much development may be made in the near future along the lines of electric production of iron from its ores. As regards steel refining, on the other hand, electrical prospects are even more rosy, as the difference in the costs of heating are not so great. Besides, as mentioned above, the metal obtained is of a higher quality, a factor which should be by no means overlooked in considering this question. To the supply engineer, perhaps, the matter is not one of extreme importance, but to electrical engineers in general it will be helpful to know the progress which is being made in what was only a few years ago quite a virgin field.

The Advantages of Oil-immersed Switch Contacts. The primary idea of the designer of the first oil switch was to provide a method of breaking an electrical circuit without an accompaniment of destructive arcing. As is so often the case, however, this idea was the cause of improved operation in quite other directions to those first thought of by the inventor, for it has since been found that while oil-immersed switches are excellent from the point of view of preventing arcing, they have a further advantage in that they increase the conductivity of the actual contacts—*i.e.*, the conductivity of such switches at the point of contact has been found to be considerably greater than in the case of dry contacts, for a given area and a given pressure between the contacts. Mr. Browning, who carried out some experiments on this subject, at Manchester in 1906, showed that the ratio of the conductivities of oil-immersed and dry contacts was as 130 to 34 in favour of the former with a mechanical pressure of 15 lb. per square inch. At a pressure of 35 lb. per square inch, at which pressure the highest conductivity was obtained, the ratio was decreased to 130 to 68. The actual condition of the contacts, as would naturally be expected from the above figures, was much better when they were kept under oil. The explanation of this improved efficiency is probably a double one. In the first place oxidation cannot take place, and as copper oxide is a bad conductor its absence cannot but help to lower the contact resistance of the switch. The other reason put forward is that, the space between the actual points of contact being filled with a thin film of oil instead of air, the conductivity of the whole area is improved in such proportion as an oil is a better conductor than air. This is certainly an interesting point, for it is evident that the actual contact between two parts of a switch at the so-called point of contact is very poor, and that a thin layer of air is always present. This, in the case of the oil switch, is replaced by a layer of oil of higher conductivity than the air, with the improved results stated above. It would be interesting to know the effect of the

ordinary steam-laden atmosphere of a central station on the conductivity of the switch contacts. At first sight it would seem that a layer of damp air would increase the conductivity, but any such increase in this direction is probably more than counteracted by the oxidising effect of the air. Such an increase in conductivity as that mentioned above should lead to a substantial reduction in the heating losses and, though small, may none the less be worth considering from an economical point of view. At the present time oil-switches are generally used on alternating-current circuits, but their employment on continuous currents as well presents no unsurmountable difficulties. This particular question is one which falls within the scope of what may be called theoretical engineering. It is perhaps not so economically important as some of the problems now exercising the minds of engineers; though this side should not be neglected, and it is interesting in that it gives an insight into the "how" of engineering work.

The Electric Lighting of Motor Cars.

The motor car can certainly be no longer considered merely as a thing of pleasure. It is now used for business purposes to a very large extent, and is also finding an increasing application in the transport of both humans and goods. This being so, it is not surprising to find that care is being taken so to equip cars that they are capable of use at all hours of the day and night. To fulfil such a condition some method of artificial lighting of the interior of the car becomes necessary, while the headlights also have to be illuminated by some means or other. Following the example of the bicycle, oil and acetylene are both used for these purposes, but the claims of electricity as the best lighting agent have not gone unconsidered. For the electrical lighting of cars, accumulators, which are also employed for supplying the ignition, are often used. This method has certain obvious disadvantages, especially when the car has to cover a large mileage regularly every day, as in the case of motor omnibuses. Under such conditions the battery would have to be of large capacity, and therefore heavy, to supply the necessary current for an extended period without failure. The dead-weight of the car would, as a consequence, be considerably increased. The problem confronting motor engineers has already been successfully attacked on our railways with the result that various methods have been proposed in which a dynamo driven from the axle mainly supplies lighting, but is re-inforced by a battery when the train is standing still. A similar principle has been applied to motor omnibuses, for we understand that 22 steam cars belonging to the Metropolitan Steam Omnibus Co., which have been fitted with the well-known Leitner system, have successfully run upwards of half-a-million car-miles. The provision of such a portable "central station" has the advantage that, barring extraordinary accidents, the good operation of both the ignition and lighting is safeguarded. Good ignition can, it is true, be arranged by fitting both a magneto and battery, but to our mind the portable central station is a better method, while it possesses the further distinction of being also able to provide an adequate illumination by the various car-lights, both interior and exterior, at night.

A New Compound Voltmeter.

In the great majority of cases where electrical energy is transmitted to a distance from the generating station it is very necessary to know at the switchboard the voltage at the feeding point, which voltage, of course, varies with the station voltage and with the load on the feeder. To do this, pilot wires running alongside the cable are generally used, and by this means it is possible, by using a sufficiently high resistance voltmeter, to obtain in the station a measure of voltage at the distributing point.

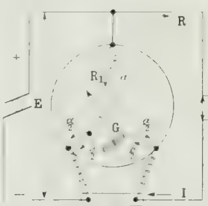


Fig. 1.

This arrangement, which is always costly, is often by no means safe, for the fine pilot wire employed deteriorates rapidly, and its use is often the cause of bad insulation. On the other hand, if the pilot wires are kept quite separate from the others their installation and fixing means a large amount of extra labour.

Means have, therefore, been sought to obtain a voltmeter, which, while connected to the feeder at the point of departure from the generating station, gives readings which depend on the current in such a way that they are inversely proportional to the load on the feeder. The first apparatus designed for this purpose consisted of a solenoidal galvanometer. This had two windings in opposite directions, one of thick and the other of thin wire. The fine winding was connected across the station voltage whilst the feeder current traversed the coarser. The magnetism due to the feeder current, therefore, opposed that due to the voltmeter circuit, so that the readings of the voltmeter were decreased in proportion to the strength of the current passing along the feeder.

This voltmeter was calibrated to give the drop in volts directly. For this purpose an adjustable resistance was placed between the two current terminals, and if for any reason an alteration of the resistance of the feeder took place with a proportionate alteration in volts, it was sufficient to alter the amount of this resistance to obtain again the differential

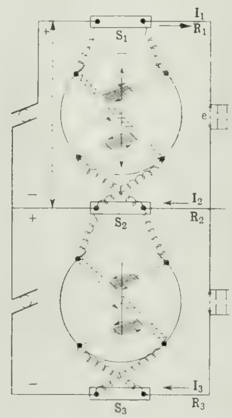


Fig. 2.

effect desired. This interesting arrangement had the disadvantage of necessitating the employment of a soft-iron galvanometer which is always exposed to hysteresis errors, and which consequently does not allow these instruments to be used for accurate readings.

The latest method for overcoming these difficulties is due to M. Pillier, of Messrs. Chauvin & Arnoux, of Paris, to which firm we are indebted for the details describing the instrument. In this method the use of highly accurate moving coil voltmeters of the d'Arsonval type is possible for continuous current. For alternating current, voltmeters of the hot wire type are necessary.

Fig. 1 shows the general arrangement of the apparatus. As will be seen, the moving coil G is connected to one pole of the circuit through a resistance, R_1, which is called the circuit resistance. It is also connected across the terminals of the shunt S, through a resistance equal to its own. The current due to the voltage tends to divide into two equal parts through the resistance and the coil. In the same way a current due to the main current flows through

the coil and resistance. This, as shown by the arrows, opposes the "voltage" current in the instrument and is added to it in the resistance. By determining these two currents it is found that the current passing through the

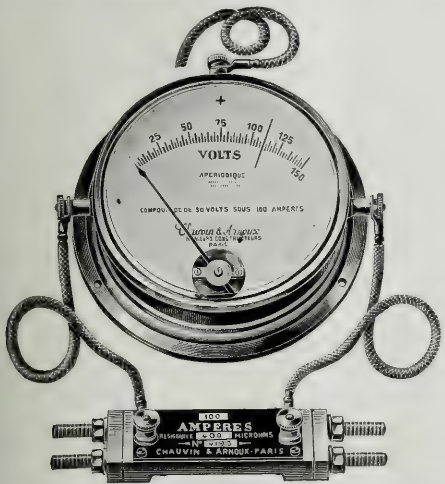


Fig. 3.—Chauvin & Arnoux Compound Voltmeter.

coil depends on the generator voltage and on the current in the feeder, so that the deflection is in proportion to the voltage to be measured.

A similar arrangement can be used on 3-wire circuits, but the connections are necessarily more complex. The voltmeter in this case is of the differential type and has two moving coils mounted on the one spindle and deflecting in the field of one electro-magnet. The requirements in this case are of course to obtain a deflection of the needle, which will be equal to the algebraic sum of the deflections of both the moving coils taken separately. The additional shunt, which is connected in the middle wire, as shown, renders it possible to obtain accurate readings on both instruments, even when the out balance current is considerable. Fig. 2 shows the diagram of connections when such a voltmeter is connected to a three-wire system, while in Fig. 3 is shown a general view of a compound voltmeter of the moving coil type with shunt complete.

This interesting instrument is supplied in this country by Messrs. Wm. Geipel & Co., of London.

Shop Lighting Fittings.

THE design of suitable fittings for lighting shop windows has recently received much attention, while the introduction of metallic filament lamps has rendered certain modifications in the details of these fittings necessary. Among the firms who have had this question under consideration are the Reason Manufacturing Co. of Brighton, who have, as a result, been led to design a line of fittings specially for use with these lamps, so that full advantage may be taken of a cheap and efficient method of lighting. Without touching upon a delicate subject, we may say that there can be no doubt that such an arrangement as that proposed by the Reason Co. offers certain well-defined advantages over any system of gas lighting.

The fittings illustrated herewith are not intended to take the place of ordinary or flame arc lamps either for outdoor or indoor work; but they possess an advantage in the way of small capital outlay and there are besides many interior

Fig. 1.—Reason Shop Fitting for Exterior Work.

show rooms and show cases where the light of even a miniature arc lamp is more than is either necessary or desirable. It is to meet such cases that these fittings are particularly applicable.

A "Reason" shop reflector for outside work is shown in Fig. 1. It is claimed for it that it is cheap and efficient, and can be fixed in a very short time by any workman. The special point about this fitting is the silvered glass reflector which is placed at the back of the lamp and which

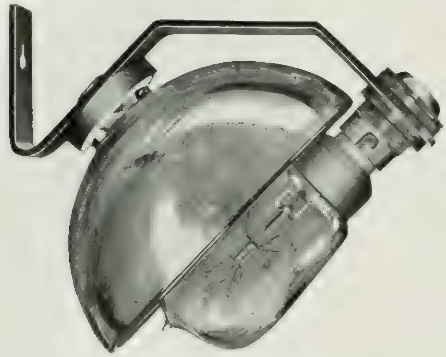
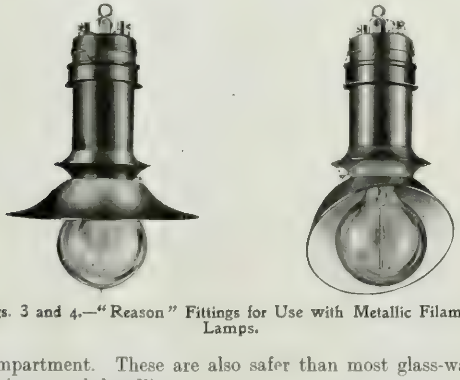


Fig. 2.—"Reason" Shop Reflector for Inside Work.

enormously increases the effective candle-power in the direction where it is most required. The light is also diffused satisfactorily, a point of some importance where the actual source of light is as concentrated as in a metallic filament lamp. The globe is attached to a strong cast-iron ring and can readily be removed for cleaning and renewal. This fitting can be made more ornamental, if desired, by the addition of scroll work or other design in accordance with the existing decoration.

A strong window fitting for interior work is shown in Fig. 2; a somewhat similar fitting fixed at the end of a bracket arm is also supplied. The reflectors used are of a patent silvered glass type in which the silvering is protected by two walls of glass, being thereby sealed up, so that it is contained in an air-tight and dust-proof



Figs. 3 and 4.—"Reason" Fittings for Use with Metallic Filament Lamps.

compartment. These are also safer than most glass-ware against rough handling

Two fittings designed for use with high candle power incandescent lamps are illustrated in Figs. 3 and 4. As will be seen, these fittings are similar in outward appearance to miniature arc lamps. They are supplied in four types; two of these being intended for outdoor and two for indoor work. They are fitted with ordinary bayonet fittings and when used with a 300 c.p. lamp the likeness to a miniature arc lamp is fairly close. Those intended for indoor work are highly finished off and make a most artistic fitting.

The Latest in Desk Fans.

WE are pleased to put before our readers the latest production of the General Electric Co. in desk fans.

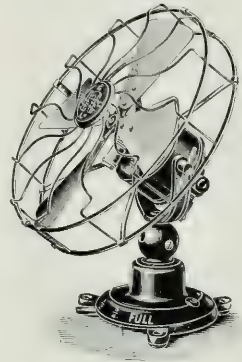


Fig. 1.—G.E.C. Table Fan, Vertical Type.

It is interesting to note that although much better material has been used in the construction of these fans, the cost of production has, it is claimed, been considerably reduced, while at the same time a much lighter and neater article,

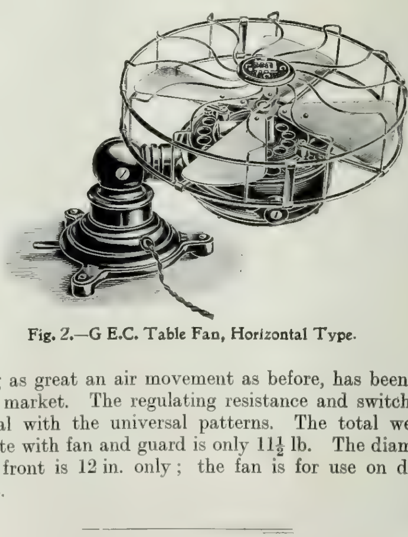


Fig. 2.—G E.C. Table Fan, Horizontal Type.

causing as great an air movement as before, has been put on the market. The regulating resistance and switch are identical with the universal patterns. The total weight complete with fan and guard is only $11\frac{1}{2}$ lb. The diameter of the front is 12 in. only; the fan is for use on direct current.

Electric Washer.

ELECTRICITY is already used to some extent in the laundry, and the latest step forward in this direction is the "Thor Electric" washing machine recently introduced by the Hurley Machine Company of Chicago. It consists of a small motor connected by a belt to the wash-tub, the current being obtained from an ordinary lamp socket. The wringer is also specially adapted for use with a motor, and can be started and stopped by merely pressing a button. All that is necessary to start the work is to fill, partially, the machine with soapsuds, place the clothes in it and turn on the current.

Roots' Blowers.

THE machinery used in engineering work for the purpose of delivering air under pressure may be conveniently divided into three classes. In the first of these are placed such fans as deliver comparatively large volumes of air at a pressure slightly above that of the atmosphere. Centrifugal fans are examples of this class of machine. In the next class are placed blowing engines, or compressors, which deliver comparatively small volumes of air at pressures above that of the atmosphere. Intermediate between these two classes is the third in which are machines delivering moderate volumes of air at higher pressures than are those of the first class, but at the same time also delivering larger volumes than those of the second class at lower pressures. Such a machine is the Roots' blower, manufactured by Messrs. Thwaites Bros., of Bradford.

This blower was first introduced in this country in 1876 and was then fitted with wooden revolvers covered with plastic composition. In the modern machines, however, machined iron is now generally employed. These

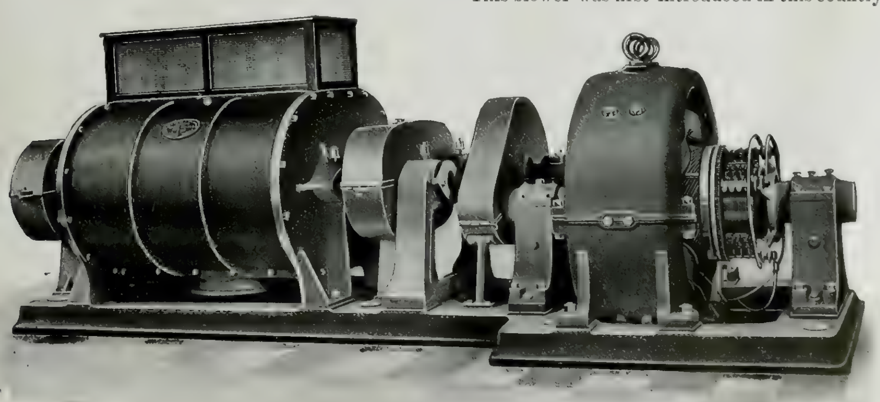


Fig. 1.—Electrically-driven Roots' Blowers.

revolvers, which are cast in one piece from a special mixture of cast iron, are accurately machined all over to gauge, and are then carefully balanced. This latter operation, combined with the arrangement employed for centring the revolvers, ensures, it is claimed, both great regularity in running and absence of knocking. The form of revolver adopted is the result of 30 years' experience and experiment, and gives, it is said, the best results under actual practical conditions. While there is no actual contact between revolvers and case the backward leakage of the blast is a minimum, so that a high overall efficiency of the blower can be obtained, and volumes of air up to pressures of about 3 lb. per square inch obtained with ease

The case in which the revolvers operate is carefully machined throughout, its semi-cylindrical sides being accurately bored, while the end plates, which carry the shaft journals, are planed and the journals bored simultaneously on a duplex boring machine. The type of journal adopted is also the result of much experiment, the final result of which is the employment of a special conical adjustable journal. These journals allow no leakage of the air, while any blowing out of the lubricant is quite a remote contingency. The gear wheels are preferably moulded from a machine-cut pattern, as the makers consider that this ensures a better accuracy of pitch and form of teeth, while the wheels themselves are more durable than those of the machine-cut type.

Such blowers as these, which are made in sizes varying from that capable of delivering 20 cubic ft. of air per minute to that capable of delivering 25,000 cubic ft. of air per minute, are, of course, eminently suited for use with the electric drive. An example of a Roots' blower direct-coupled to a 60 H.P. electric motor is shown in Fig. 1. In this arrangement the armature shaft carries a pinion of either gunmetal or compressed raw hide, which gears into a spur-wheel carried on an extension of one of the blower shafts. Both spur-wheels and pinions have machine-cut teeth, and are enclosed in an iron case. By means of a suitable regulation of the motor varying speeds of the blower can be obtained and the amount of air delivered thus adjusted to any desired amount—an arrangement which possesses certain obvious advantages. Fig. 2 illustrates another side of Messrs. Thwaites Bros.' work, showing two electrically-driven fans which have recently been constructed.

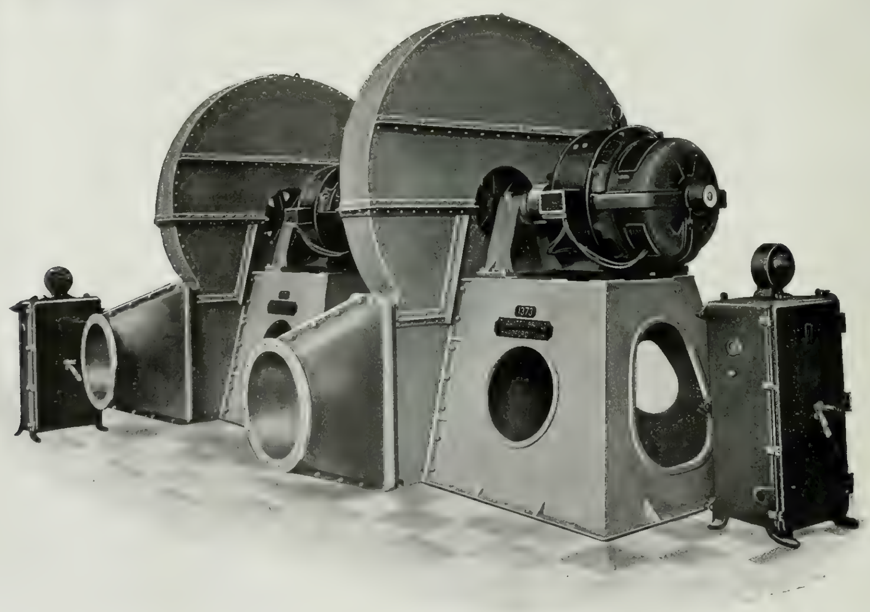


Fig. 2.—Thwaites' Fans coupled direct to Motor.

"Ulster" Fans.

IT seems a perfectly obvious fact that a piece of engineering apparatus which has been developed as the result of wide experience and after many years' close study of the conditions under which it is required to work is likely to be more efficient than one which is put on the market straightaway in what *may* prove a perfect form. Other things being equal, the best apparatus is admittedly turned out by the oldest-established firms. Among these, at any rate as regards fan matters, may certainly be placed

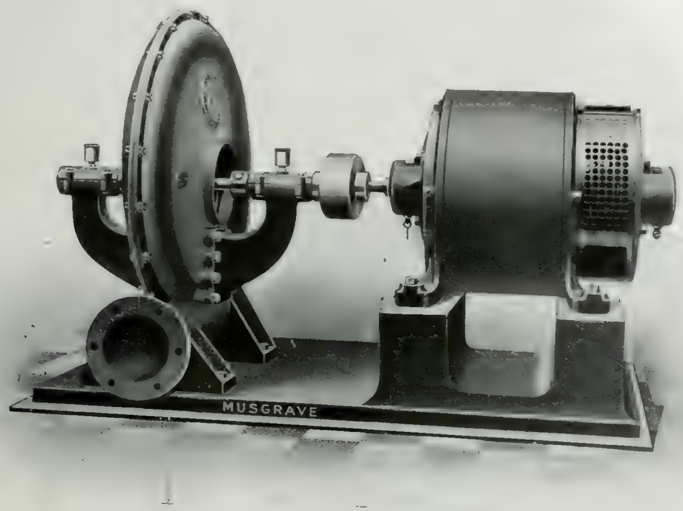


Fig. 1.—High-pressure Electrically-driven Blower.

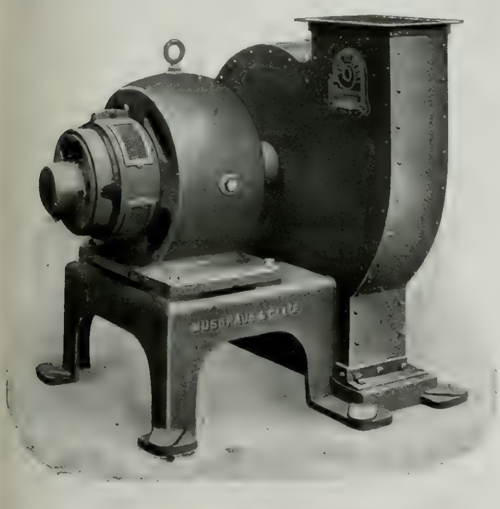


Fig. 2.—"Ulster" Fan for Induced Draught Work.

Messrs. Musgrave & Co., of Belfast, whose "Ulster" fans embody, it is claimed, the results of long practical experience, gained in designing and applying this class of equipment to various industries. Large numbers of these fans have been supplied, and are in daily use in ventilating installations of various kinds, as well as for generating and inducing draught in boiler houses ashore and afloat and for removing dust or shavings from machinery and workshops.

The casings and wheels of "Ulster" fans are so proportioned that they will pass the largest possible volume of air or gas with a minimum of friction. At the same time they are capable of maintaining either a high pressure or suction without there being any necessity to use excessive speeds. Great care is taken to balance the fan wheels correctly, so that they may be relied upon to run without vibration. The bearings are of ample length and are of the self-oiling swivelling type. For high temperatures they can be fitted with a water-cooling device. The component parts of the "Ulster" fans are constructed strictly to gauge and are all readily interchangeable.

Fig. 1 illustrates Messrs. Musgrave's high-pressure type of blower. It is made specially suitable for high pressures and small volumes of air such as would be required in connection with cupolas or gas plants working on pressures up to 20 in. water gauge. The fan casings of these blowers are strongly constructed of cast iron, while the wheels and shafts are made of steel throughout. The fans are supplied with pulleys for separate drive by belt, or they can be direct-coupled to a motor, as shown in our illustration.

Fig. 2 shows an "Ulster" fan applied to mechanical draught purposes. This type is intended for use in producing forced draught for boilers, smith's forges and other similar work. It is specially adapted to the motor drive, and the fan and motor together make up a convenient and also, it is claimed, a very economical combination. "Ulster" fans are also made in medium and high-pressure types, types which are suitable for air pressures beyond the limits attainable by standard "Ulster" or steel-plate fans. The medium-pressure type is used for forced draught for steam boilers, forge fires and dust collecting installations where pressures up to about 10 in. water gauge with a moderate volume of air are necessary.

The question of induced draught, as we endeavoured to show in our last issue, is intimately bound up with economy in the boiler house, and by the use of such apparatus as the "Ulster" fan a large increase in efficiency can be obtained in this part of the station.

An Electrically-driven Wood-working Plant for Northern India.

THE application of the electric drive to such operations as generally take place in sawmills is well illustrated by some recent examples of wood-working plant that have been built by Messrs. J. P. Pickles & Co., of Hebden Bridge, for use in an extensive new sawmill and joinery works in Northern India. The full equipment consists of vertical log frames for dealing with logs up to 3 ft. in diameter. These frames carry as many as 45 saws at once. Travelling table rack saw benches for re-sawing and edging operations, as well as roller and drag-feed saw-benches, cross-cut saws and band saws, have also been installed. A feature of the installation is a number of four-cutter planing and moulding machines, while some interesting and modern joinery machinery, by which such operations as tenoning, mortising and boring, as well as turning and mitreing, can be effected, have also been erected.

All the machinery in this mill is driven by alternating current motors from a high-tension supply working at a pressure of 2,200 volts. Some of the machines are direct driven by separate motors, an arrangement which possesses the great advantage of requiring no shafting or belting, while at the same time the equipment can be so arranged in the mill that consecutive operations of the material with a minimum of handling is obtained.

Fig. 1 shows an electrically-operated vertical log-sawing frame with a roller feed, direct driven by a motor through machine-cut spur and raw-hide gearing, and having the starting switch in the handiest position for operation. This machine is made by Messrs. Pickles & Co. in various sizes to take logs of diameters from 18 in. to 48 in. It is of massive construction throughout, and is arranged to carry the maximum number of saws. This type of log frame is, it is claimed, suitable for erection in almost any locality; as, being top-driven and self-contained on a heavy base bed, it can be fixed either on or slightly below the floor level. The feed motion is variable and is effected by a roller feed with bogies and rails as shown. If hard irregular logs have to be dealt with, however, it is found that a rack feed with screw clips, rollers and stands is preferable.

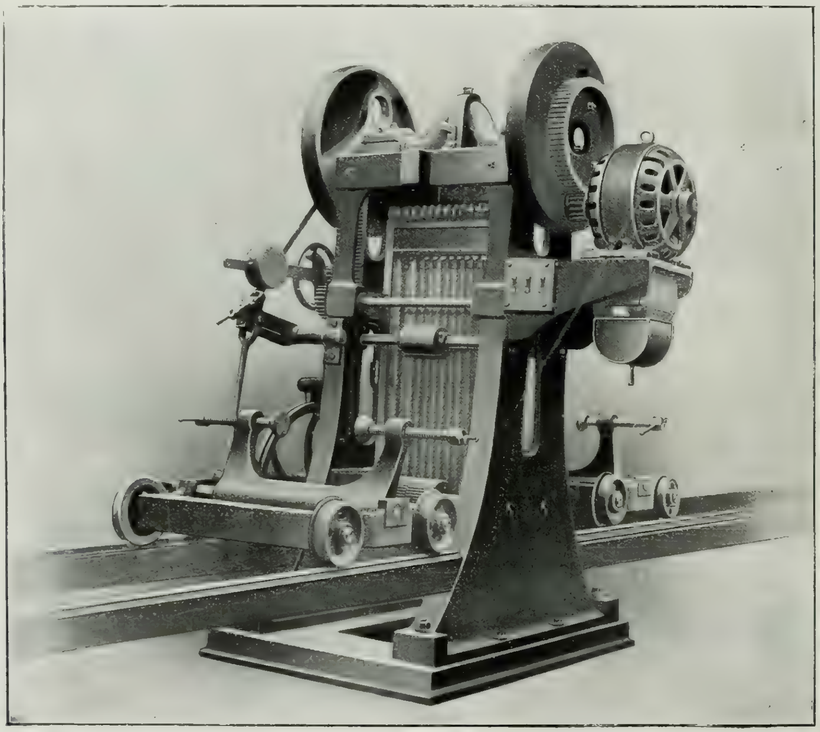


Fig. 1.—Vertical Log-sawing Machine.

Fig. 2 shows the standard type crab of a 10-ton electric three-motor crane, specially designed with extra strong gear and electrical equipment to stand the rough usage of sawmills or timber yards. The travelling wheels of the crab, and also of the cranes themselves, are fitted with closed roller bearings, so that the friction is a minimum, and consequently very little power is required, especially at starting with heavy loads. The controllers for each motor are mounted in the crab itself, which is covered in to protect the gear from the weather, and carries the operator, who is located immediately above the lifting hook. The controllers are of latest tramway type combined with suitable resistances. Both mechanical and electrical automatic brakes are provided to hold the load in any position, and it can be lowered without current.

Fig. 2.—Standard Type Crab for 10-ton Crane.

Messrs. Pickles make a speciality of supplying cranes of the type above named, or with the controller cage attached under one end, special attention being given to the design, so that highest amount of lift and minimum headroom is obtained. These cranes are made for lifts from 5 to 25 tons, and each size is of generous proportions, so that the overloads above mentioned can be tackled with ease.

"Cyclone" Fans.

AMONG those firms who have had a vast deal of experience in fan matters may be mentioned Messrs. Matthews & Yates, of Swinton, near Manchester. They have been for many years engaged in the manufacture of all types of fans, both direct-coupled and belt-driven, and these fans, which are very often used in conjunction with an electric motor, are made for every conceivable purpose for which such devices can be employed.

An apparatus of interest in connection with the application of the electric drive to fan work is a new type of two-pole motor which has lately been put on the market by Messrs. Matthews & Yates. The armature of this motor is former wound, the end windings being carried by a strong cast-iron plate, which, it is claimed, enables the armature to be accurately balanced, and gives a neat, finished appearance to the whole. Special attention is given to the insulation, and the complete motors are subjected to severe breakdown tests before leaving the works. Two automatic oil rings are fitted to all motors whose output exceeds 1 H.P. The standard two-pole protected type motor of the 1 H.P. size is illustrated in Fig. 1. The same type of machine is used on standard fans, and is found to give very satisfactory results, both as regards silent running—a special feature of this firm's motors—and efficiency. It is claimed for "Cyclone" fans that they have a minimum current consumption for a maximum of air moved. They are standardised in all sizes from 9 in. to 72 in. diameter for working on direct current, and also on alternating current either single, two or three-phase. All parts are jigged throughout and interchangeable, and the fans may be run with any kind of discharge to suit every requirement, oil ring bearings being fitted for horizontal positions and ball bearings for angular and vertical positions.

The single-phase motors (one of which fitted to a "Cyclone" fan is shown in Fig. 2) have an auxiliary starting winding, so that it is possible to start the fan up against load without any loose pulley. In connection with

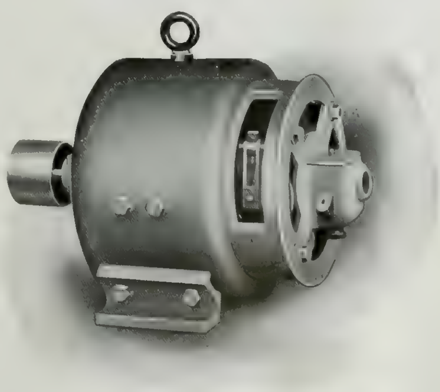


Fig. 1.—Standard Two-pole 1 H.P. Motor.

this winding, a special two-way switch is used, so arranged that it cannot be left in the starting position.

The motor is of the induction type with a squirrel-cage rotor, and is wound for frequencies between 50 and 87 for standard speeds, the speed being reduced or increased slightly from standard for other frequencies. The power factor may be taken as 0·6, for all sizes, for speeds between 225 and 900 revs. per min., and for outputs between 650 and 10,500 cubic ft. per minute. All the fan motors are wound for voltages from 100 to 200, with the exception of the smaller sizes with which a suitable transformer is supplied.

Attention should also be called to the blade construction, which, owing to its open type, does not obstruct natural ventilation, a detail which is in many cases very desirable.

Electric blowers (as shown in Fig. 3) are also standardised by this firm in sizes from 8½ in. to 40 in., and are used for ventilating work where a considerable resistance is occasioned by the use of necessary air trunks, and where higher pressures are required than can be obtained by propeller fans. The blower illustrated is a combination of a light pattern blower and exhauster (as constructed for general ventilating work, where high pressures are not required) and a semi-enclosed type continuous-current motor. It is particularly adapted for ventilating public buildings, hotels and restaurants, as it can be placed in any out-of-the-way corner and air trunks carried to it. Being a combination of blower and motor, there are no belts or other driving arrangements required beyond the necessary connections to the supply circuit. It is built for either right or left hand working and to discharge in any position—*viz.*, top or bottom horizontal discharge, vertical up or down discharge, or at any angle between—as may be required to suit any special purpose.

High-pressure electric blowers for gas producers, smiths' fires and similar work, to suit any special requirement, are manufactured by this firm, who are experts in the application of fans and blowers for all purposes. A fan of this kind, which has been specially designed to meet the growing demand for an up-to-date machine, that will give the required duty with the maximum efficiency is illustrated in Fig. 4. It is intended for all purposes where a small volume at high pressure is required. The casing is built

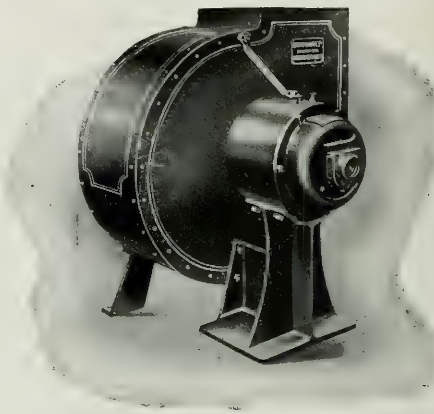


Fig. 3.—Standard Electric Blower.

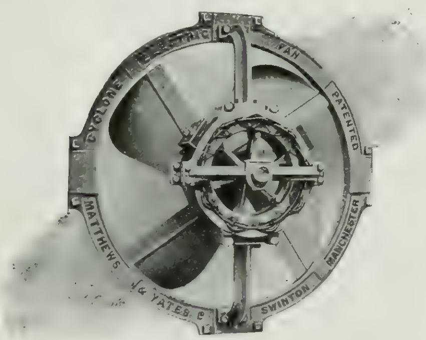


Fig. 2.—Standard "Cyclone" Fan.

entirely of mild steel, with an angle iron stiffener at the base. The bearings are well adapted for their work, being of the self-lubricating oil-ring type, and fitted with extra long gunmetal seatings. A modified arrangement of this fan is used for exhausting gas in conjunction with gas-producing

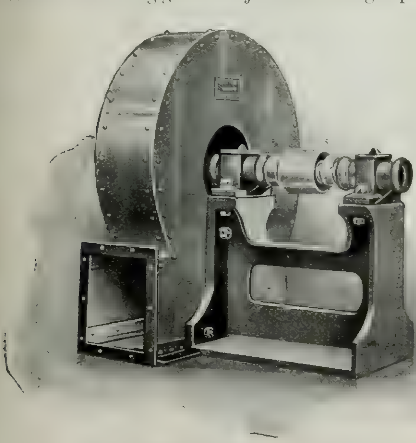


Fig. 4.—Standard High-Pressure Blower.

plants, when the inlet and outlet are fitted with drilled flanges to facilitate the attachment of gas pipes, and a gunmetal stuffing gland is fixed to the side of the casing where the shaft passes through, so as to prevent the escape of gas. They can be arranged with pulley for belt driving or be fitted with direct-coupled electric motor.

Some American and Continental Fans.

IT is always interesting to those engaged in electrical work of any kind to see or hear about what is being done in other countries in regard to their particular speciality. For this reason we give below some details of American and Continental fan practice, thus indicating the arrangements used for this purpose in countries other than our own.

One of the best-known manufacturers of fans in the United States of America are the KIMBLE ELECTRIC Co., of Chicago. These fans are of the Blackman type, and are all driven by a variable-speed single-phase alternating-current motor. Pressures between 100 and 220 volts and frequencies between 50 and 80 are considered the best to use. The motor is of the commutator type, the speed variation being obtained by altering the position of the brushes on the commutator by means of a lever. The speed can, therefore, be continuously varied between a certain maximum or minimum without the use of any rheostats or resistance coils. The fan, as shown in Fig. 1, is controlled by two pendant chains, which are attached to the levers mentioned above. In spite of the inherent noisiness of an alternating-current motor, these fans are claimed to be practically noiseless when they are running at full speed. Kimble fans are made in three sizes, 18 in., 24 in. and 30 in. in diameter respectively, and deliver 2,500, 6,000 and 12,800 cubic ft. of air per minute when working on full load.

Another firm who make fans a speciality are the ILG ELECTRIC VENTILATING Co., of New York, a section of one of whose fans we show in Fig. 2. As will be noticed, besides actually drawing the air into the fan and delivering it, the motor itself is fitted with a vent pipe. The motor is of the enclosed type and its ventilation is effected by the

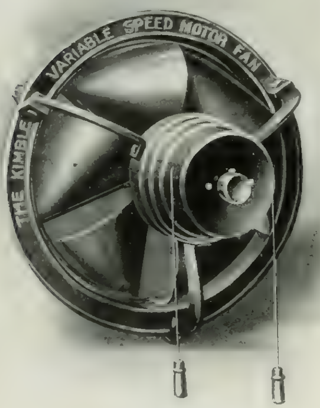


Fig. 1.—Kimble Variable Speed Fan.

vacuum created in front of the fan axis drawing air from the outside through this pipe which is connected with the hood. The latter completely encloses the motor on all sides but the front. After ventilating the motor the air is carried away with the general exhaust. This fan can be fitted with either continuous or alternating current motors, and is made in 13 sizes, delivering from 2,530 to 40,000 cubic ft. of air per minute.

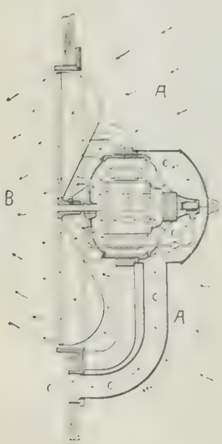


Fig. 2.
Ilg Electric Fan.

The SPRAGUE ELECTRIC Co., of New York, are another firm of fan specialists, the well-known Lundell fan being one of their specialities. These fans are made in all conceivable types, including those for use on ceilings, walls and tables as well as oscillating and exhaust fans. A standard 16 in. oscillating table fan for direct current is shown in Fig. 3. It is fitted with a single field coil, and the worm-gear mech-

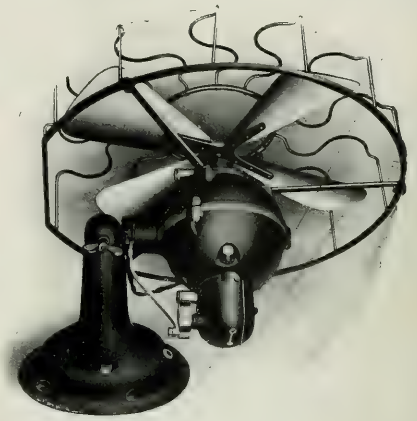


Fig. 3.—Sprague Table Fan.

anism, which is entirely enclosed within a dust-proof enamelled iron casing, is constructed with generous proportions so that the wear is very small. The oscillating movement may be put into or out of action by a small lever

Fig. 4.—A Swiss Electric Fan.

fixed to the gear casing. The arc through which the fan oscillates is practically 100 deg. in the case of a bracket fan and 25 deg. in the case of the desk fan. These fans are made in two sizes, 12 in. and 16 in. in diameter, and for the standard pressures of 115 and 230 volts; three speeds are

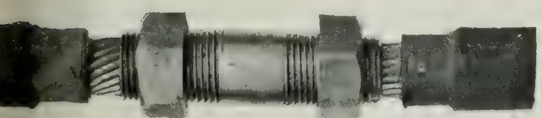
available in each type. A rather interesting fan which is made by this firm, but is not seen much in this country, is the column fan standing on the floor. In general appearance it is like a ceiling fan turned upside down.

A Continental firm which has had a good deal of experience in fan work is the Societe Anonyme pour Constructions Electriques, of Biasca. We illustrate one of their fans in Fig. 4. In this fan the motor is entirely enclosed, the rotor being fixed on a steel spindle. Concave blades are used and are protected by a solid guard. These parts are nickel-plated, the rest of the fan being finished in black enamel. Two speeds are available and the fan is said to be very silent in working.

"Alpha" Cable Connector.

One of the first practical jobs which is set the electrical student on his entry into a technical college is to joint two wires together. The result is generally not successful, but the patience and application which must be expended on the work are, we are told, desirable from a disciplinary point of view, and in this way at least fit the beginner for the problems he will have to tackle in after life. This matter of joints is really no matter to the student, who looks towards higher things; but even the experienced wireman finds some difficulty in making a successful electrical connection with large wires when he has to rely on twisting and soldering iron alone.

Many methods of overcoming these difficulties have been



"Alpha" Cable Connector.

proposed, and among the most successful of them may be noted the "Alpha" patent cable connector made by Messrs. How, Partington & Co., of Taff's Well, and supplied by Messrs. Haslam & Schontheil, of Cardiff. The connector shown in the illustration is intended for making a straight through joint on two cables, though other types suitable for all classes of work are also supplied. The connector consists essentially of a taper split brass tube, which is tapped at each end and fitted with two nuts. When it is required to make a joint these nuts are simply slacked back, and the two cable ends inserted, the nuts being then screwed up over. It is claimed that a lad can make a joint with this connection in two minutes, but ten men cannot pull it apart. No solder is required, while no unstranding, or binding wire is needed. As regards the strength of this joint, a test was made on a 0·25 sq. in. cable fitted with one of these connectors, and it was found that the joint had a conductivity equal to that of the cable, and a weight of 2 tons was lifted by it without severing the joint.

This arrangement is, therefore, a great advance on the more usual methods of binding and soldering up, which, moreover, have the disadvantage of destroying the cable to some extent. With the "Alpha" connector, on the other hand, the wire need not be touched, while the result seems all that can be desired.

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NOTES.

Report of the Electrical Inspector of Factories.

To anyone who delights in the study of human nature we can recommend no better subject for contemplation than the Annual Report of the Chief Inspector of Factories and Workshops. The subjects dealt with are varied; and there is no lack of humour in its pages. Not the least interesting portion of the volume is that in which the Electrical Inspector of Factories, Mr. G. Scott Ram, reports on his work of supervising the electrical installations in such places as are factories under the Act, a term which includes generating stations and sub-stations. This report will be found, in abstract, on another page of this issue. As usual, it begins with a tabular summary of the accidents at electric generating stations which have occurred during the year, and this does not, unfortunately, make very pleasant reading. The number of accidents shows a slight increase over that of the previous year; this increase, however, is partly due to the fact that accidents which have occurred in generating stations and sub-stations belonging to certain electric railways are now included for the first time. And it cannot be overlooked that the great majority of the accidents, whether fatal or non-fatal, that took place during the year were quite preventable. Mr. Ram gives short details of the way in which each accident occurred, and without much reading between the lines it may easily be discovered that practically all the accidents were due either to want of forethought on the part of the employer, carelessness on the part of the employé, or bad design of the apparatus; or combinations of any or all of these.

During the years that Mr. Ram has produced his annual reports he has presented many useful suggestions to the electrical engineering world at large. Last year he proposed a hand lamp of safe design, by the use of which many accidents could be prevented. In parenthesis, and as an interesting commentary on this, it may be mentioned that one of the fatal electrical accidents during the year was due to such a type of lamp as drew down adverse criticism from Mr. Ram last year. This year Mr. Ram suggests an arrangement whereby commutators can be safely cleaned while running; also a method whereby the wire entanglements often met with in the neighbourhood of motors may be avoided, and details of a new and safe design of plug for portable equipment. What we have said above with regard to bad design in apparatus is confirmed by reading Mr. Ram's account of the accidents that have happened in factories other than electrical generating stations. The accidents due to arcing of switches were mostly due to faulty construction of the apparatus. Often there was no switch by means of which the current could be cut off before the fuses were replaced. Portable apparatus accounts for a considerable number of injuries, some due to badly designed hand lamps, but more to badly designed plugs. This is a question to which Mr. Ram considers manufacturers should give their attention. Want of forethought on the part of the employer and carelessness on the part of the employé are generally the cause of accidents in test rooms. Too often an apprentice is employed on this work; and he has no adequate appreciation of the dangers present. Another frequent cause of accidents, as rendered evident in this year's report, is the insufficient earthing of apparatus. In explaining the question, Mr. Ram goes fully into the pros and cons of the systems, or lack of systems, that are at present used. Owing to pressure on our space, we are not able to reprint this part of the report in full (a portion is certainly only intended for non-technical readers), but as a short essay on

the subject it is quite admirable. In these days of depression any encouragement is worth a great deal, and for this reason we are pleased to see that Mr. RAM, who may be certainly classed as an independent critic, is of the opinion that the exhibits shown at the recent Manchester Exhibition indicate that steady progress is being made in the design of electrical apparatus. This is certainly something to be thankful for. The report this year is of more than passing interest owing to the fact that the new regulations come into force on the first of next month: "a consummation devoutly to be wished," in Mr. RAM's opinion. Better control, he considers, will be possible under these regulations; and in agreeing with him we may again express an opinion that we have expressed before, that if administered in a liberal fashion and with a proper appreciation of the needs of a growing industry, they will do a great deal of good; but if administered in any other way, they will be very harmful.

Railway Electrification.

THAT the future of the electrical industry is bound up in no small degree with the electrification of our railways will be readily admitted, but the converse proposition is not so easily proved. In this connection too much stress cannot be laid upon the opinions formed by engineers with practical experience of the matter. Thus, Mr. J. A. F. ASPINALL, in his recent Presidential Address to the Institution of Mechanical Engineers, remarked that, in his opinion, "there are a number of suburban lines around our great cities, and especially near London, which can be electrified with advantage to the public and to the railway companies." In view of Mr. ASPINALL's position as manager of the Lancashire & Yorkshire Railway Co., this opinion, which is the result of experience with the electrical line between Liverpool and Southport, is encouraging. Similar views have also been recently expressed by Mr. W. S. MURRAY, electrical engineer of the New York, New Haven & Hartford Railroad, in a Paper read before the New York Railroad Club. The author, after uttering a warning as to standardisation at the present time, expressed his strong belief in the single-phase system. The single-phase system is young in comparison with the direct-current system, but it has possibilities which are beyond the sphere of the latter. As the result of his experience Mr. MURRAY says conclusively that on lines having the same features as those of the New Haven road he would certainly be in favour of alternating current. It is interesting to note that he prefers generation at, say, 2,200 volts and the use of step-up transformers, rather than generating direct at 6,000 volts. The costs per kilowatt are practically the same in either case, but the interposition of transformers provides a cushioning effect on the occasion of short circuits, which is very desirable, and is lacking in the case of the high-voltage generator station. As is well known, copper wire was first installed on this railway for the trolley line, but gave trouble on account of kinks being produced at the hanger points. This was subsequently supplemented by an auxiliary steel wire, the copper wire being used merely for transmission. After six months' operation this steel wire was found to have worn only to the extent of 1 per cent. of its vertical diameter, so that a long life may be expected. With regard to the relative advantages of steam and electric locomotives, Mr. MURRAY found that the latter are able to perform a greater mileage per day; so much so that 64 electric locomotives would do the work of 100 steam locomotives.

ON another page will be found an account of the discussion which followed the reading of Mr. MURRAY's Paper before the American Institute of Electrical Engineers on the subject of the New Haven electrification. This is interesting on account of the particulars given in regard to various single-phase lines, and also because further results are now given of the performance of the single-phase motors. These appear to be giving no trouble. Disturbances from short-circuits have disappeared, and the mileage of the motors has become in some instances as high as 70,000 miles. The commutators appear to wear as well as on continuous-current motors. In a discussion of this kind there was naturally some comparison between single-phase and continuous-current systems, such a comparison being prompted by the fact that, on the one hand, there is the New Haven line working with 11,000 volts single phase and, on the other hand, the New York Central line working with 600 volts continuous current. There is nothing easier, however, than to draw misleading comparisons. At first sight it would seem that the continuous-current locomotives weigh somewhat less than the single-phase locomotives, and are capable of drawing about double the load. Any such comparison, however, is vitiated by the fact that the New York Central service is of a local character, a few trains running 12 or 13 miles, and the remainder only about 6 miles. The distance being short and the service intermittent, the locomotives are able to work at a load far in excess of the one-hour rating without overheating. The New Haven service is of a very different character. Since part of the New Haven line is operated by continuous current, a further comparison is possible, and Mr. MURRAY stated that the operating costs, *per se*, on the continuous-current zone were just 40 per cent. greater than with alternating current. Something was made of the fact that delays on the New Haven line were much greater than on the New York Central, but it appears that these have been reduced to 13½ per cent. of the figure given some time ago. Thus it may be concluded that any comparisons of this kind are apt to be very misleading unless carried out with the greatest attention to all the facts of each case.

Wiring Rules.

WITH the exception of the Wiring Rules of the Institution of Electrical Engineers, the Phœnix Fire Office rules for electric light and electric power installations are probably the most widely adopted in this country. From a hasty glance through the thirty-eighth edition of these rules, which has just been issued, we notice that they have been mostly rewritten. In general it may be said that particular attention has been paid to rendering the rules applicable to modern wiring systems and metal filament lamps. Recent developments have rendered certain alterations necessary, not only in these rules but also in those of the Institution; and a new edition of these also is to be issued next session. A multiplicity of rules is, of course, to be deplored, but as the Institution rules are not universally adopted, it is worth noting that the Phœnix rules are accepted by many Fire

Offices as a basis for their own, though it is to be hoped that one set of regulations will ultimately result. In our glance through the new rules we notice two which are of interest—viz. (1) that all joints in tubing should be treated with aluminium paint, and (2) that flexible cords not provided with an efficient flame-proof outer covering must not be used in shop windows containing inflammable goods. In our next issue we hope to deal with further points in detail.

Electrical Marine Propulsion.—An interesting lecture was recently delivered by Mr. W. P. Durtnall at the Queen's Hall, Chatham, to a large company of engineer officers of the Royal Navy. The lecturer considered the effect of economy in fuel and machinery on the design and fighting capacity of ships of war, and showed that by taking advantage of modern developments of electrical machinery and adopting electrical power transmission, the steam turbine would prove as economical at sea as it is on land. Mr. Durtnall believed that a polyphase system was the only one to meet all requirements, and in this connection he described the "Paragon" system of main marine propulsion, which is well known to our readers.

Electric Traction in Berlin.—According to "The Times," the Gesellschaft für Elektrische Hoch und Untergrundbahnen has recently opened two new lines in Berlin. On the one hand the line has been extended into the outlying suburbs in the west, and on the other from the Leipzigerplatz to the Spittelmarkt, which lies in the centre of the city. Although no useful facilities previously existed in Berlin for travelling quickly from one part of the city to the other, the new extension has not been appreciated by the public to the extent that was expected. There is reason to believe, however, that traffic will increase in the future, and further extensions are contemplated. In spite of the general depression, the company has been able to declare, as in the previous year, a dividend of 5 per cent.

The "Electron."—The current issue of this now well-known journal is particularly healthy looking. From time to time we have called attention to the complaints of its editor of lack of copy, but this want now seems to be amply satisfied; and we are pleased to note that the editor is of the opinion that further demands on the literary capabilities of his readers will be no longer necessary. The articles this month include one on "Rolling Mills" by Mr. C. A. Ablett, on "Engineering and the Gyrostat" by Mr. J. K. Catterson-Smith, and on "The Cableship 'Faraday'" by Mr. F. Allinson. Quite a considerable portion of the paper is, as usual, taken up with Siemens doings; and the various clubs and societies established in Stafford seem to be in a very flourishing condition, a condition which is doubtless not a little due to the publicity given to their doings in the columns of the "Electron."

Boiler Efficiency Calculator.—We have recently seen a novel type of slide rule designed to facilitate comparison of actual figures of water evaporated per pound of coal, when the feed water and also the steam are at temperatures other than 212°F. The percentage overall working efficiency of boiler and furnace can also be ascertained. There are four logarithmically graduated scales, and the method of operation is as follows: The known feed-water temperature is set opposite the actual evaporation per pound of coal burnt; this allows the equivalent evaporation—from water at 212°F. at a boiler pressure of 150 lb., and also from water at 212°F. at atmospheric pressure—to be read off from two pointers. If the rule is then turned over, the thermal units transmitted to the water and steam for each pound of coal burnt and the percentage efficiency (with coal of 14,000 B.Th.U.) are indicated on the scales at the back. Corrections are provided for differences of boiler pressure, for superheat or wetness of the steam, and for coal of other quality.

Cable Interruptions.	Date of Interruption.
Jamaica—Colon	May 6, 1909
Dakar—Conakry	May 13, 1909
Tangier—Cadiz	May 19, 1909

The Illuminating Engineering Society.—It will be remembered that at an inaugural dinner held on February 9th last it was decided to form an Illuminating Engineering Society. A committee was formed to consider the matter and reported to the supporters of the society at a meeting held on May 25th. A number of gentlemen are to be invited to act as officers or on the council of the society. Anyone interested in the objects of the society and desiring to become a member is invited to communicate with the hon. secretary, Mr. L. Gaster, 32, Victoria-street, London, S.W.

Institution of Mining Electrical Engineers.—A general meeting of members and prospective members of the newly-formed Institution of Mining Electrical Engineers was held recently at Sheffield, under the chairmanship of Mr. William Maurice, president of the Institution. In opening the proceedings the president explained the lines on which it was proposed to develop the Institution. He suggested that branches should be formed in every mining centre, and that each branch should be separately organised. All Papers submitted to be read at branch meetings would be first approved by the general council, and then read, so far as practicable, simultaneously at all the branches. The general council would be mainly an organising and administrative body drawn from representatives of local councils. It would hold quarterly meetings and arrange for an annual general meeting in various mining centres.

A meeting of the Institution was held on May 22nd at the University College, Cardiff, at 6 p.m., at which Mr. S. F. Walker presided, and the following gentlemen were nominated for local officers: President, Mr. Sydney F. Walker; vice-presidents, Messrs. E. M. Hann, G. F. Flanders and Llewellyn; and local secretary, Mr. E. Ivor Davies. It was decided to hold meetings alternately at Cardiff and Swansea in order to give members the opportunity of having meetings locally as far as possible. There was some discussion upon the question of membership, and several members expressed the opinion that only mining electrical engineers should be elected as members. It was, however, explained that for the present the membership would be open to all those interested in mining electrical work in a responsible capacity, and that later on a separate class of membership would be opened for those who wished to undergo an examination and gain a certificate of competency which it is proposed that the Institution should issue. The membership of the Institution has now reached nearly 100.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 4th (to-day).

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Researches in Radiotelegraphy," by Prof. J. A. Fleming, F.R.S.

THURSDAY, June 10th.

ROYAL INSTITUTION.

3 p.m. Meeting at Albemarle-street, Piccadilly, W. Lecture on "A Modern Railway Problem": "Steam *v.* Electricity," by Prof. W. E. Dalby. (Lecture II.)

FRIDAY, June 11th.

PHYSICAL SOCIETY.

8 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: "The Arthur Wright Electrical Device for Evaluating and Solving Equations," by Dr. A. Russell and Mr. A. Wright; "The Echelon Spectroscope, its Secondary Action and the Structure of the Green Hg Line," by Mr. H. Stansfield; "The Proposed International Unit of Candle-power," by Mr. C. C. Paterson; "Inductance and Resistance in Telephone and other Circuits," by Dr. J. W. Nicholson; "Note on Terrestrial Magnetism," by Mr. G. W. Walker, and "On the Form of Pulses constituting White Light," by Mr. A. Eagle.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Problems of Helium and Radium," by Sir James Dewar, F.R.S.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, June 7th, "A" Company ...... } Officers' drill cup competition at 7 o'clock.
Tuesday, June 8th, "B" Company ...... }

THE NEW HAVEN RAILROAD ELECTRIFICATION.

In our issue of January 8th last we gave an abstract of the Paper read by Mr. W. S. Murray before the American Institute of Electrical Engineers, in which the author described his experience with the overhead single-phase system on the New Haven Railroad. In view of the importance of this subject at the present time, the following account of part of the discussion (from the "Proceedings") which followed the reading of the Paper should prove of interest to our readers.

Mr. C. Townley noted that the author had omitted the customary conclusions usually drawn from the facts furnished in a Paper. Those which seemed to stand forth were: (1) The system was put in without any previous similar installation to pattern after. (2) Several of its fundamental features were either entirely new or had so new an application that their previous use was not much of a guide. (3) Sundry and various defects developed as the installation progressed, resulting in interruptions to the service. (4) These defects had practically all been remedied, certain other improvements had been made, and (5) Five months after the complete substitution of electricity for steam the system had been demonstrated to be successful, and well adapted to the service for which it was designed. At the present time the electric service was less subject to interruption than was the steam service which it replaced. In the speaker's opinion what was really at the bottom of the major part of the difficulties encountered was that the electrification was not begun soon enough. The keystone of the system was the locomotive. A study of the list of changes that were made in the locomotive originally furnished disclosed the interesting fact that while there were a number of electrical difficulties, a very large per cent. of the changes made were mechanical. With the principal elements of the locomotive design—namely, the large gearless 25 cycle motors—there had been practically no trouble. Their performance as to torque, commutation and capacity had been most gratifying. A feature of locomotive design of the greatest importance was the flexible drive, whereby the armature of the gearless motor was wholly supported on and exerted its driving power through a set of spirally concentric springs. The method of mounting the armatures obtaining the cushioned effect, exerting the full driving power of the motors and compensating for the so-called varying torque thereof, had been successfully accomplished in a way never before tried. The results in improved track maintenance could not fail to be of far-reaching consequence.

Mr. B. G. Lamme said there were two parts of the total equipment to which he had given a great deal of personal attention—namely, the design of the alternating-current generators in the power house and the main motors on the locomotives. In the motors there were two points that were generally looked upon as sources of weakness—namely, the commutation and the use of preventive leads (or so-called "resistance leads"), between the armature winding proper and the commutator. As to the record on these points: With a mileage of 30,000 to 50,000, the commutators of the motors were all in excellent condition, having a good polish and showing but relatively little wear. At the present rate of wear on these commutators they appeared to have 15 to 20 years' life. It was correctly considered that an injury to the armature of a motor is a much more serious condition than an injury to the field or the connections. The records of the New Haven installation showed that the injuries to the armature represented only a small percentage of the total injuries. In fact, the few damages to the armatures had been largely from external causes. In such cases as he had been able to make a thorough examination into the condition of the winding on the armatures they showed no dangerous overheating from the heavy loads that had been carried, and also that the preventive leads gave no more evidence of heating than the main windings. Only two instances had been found where there was a breakdown in the preventive leads. The time, he thought, had now arrived when the "preventive" leads should stand on their own merits, for no amount of criticism could belittle the record which they had made in the New Haven service. As to the generators, no defect had developed in them which was not, to a certain extent, foreseen and apparently provided for. The first and most pronounced source of trouble was heating, not in the winding, but in the field or rotor structure, due to the pulsating reaction of the armature winding when carrying a heavy load in single-phase current. When the first rotor was built the structure was laminated as completely as mechanical conditions would permit. Upon testing the first machine it was found that there was local heating, with heavy load, sufficient to create hot spots in the core; and in a comparatively short time in turn these spots damaged the insulation on the coils from the outside, thus causing earths on the winding. It was decided, after considerable work had been done, to attempt to eliminate all pulsating reactions from the armature by putting a short-circuited winding on the rotor, of such value that a very large current could flow in it with but very little loss. It was the idea to damp out the field in very much the same way that the armature of a polyphase alternator demagnetises, or kills, its magnetic field if the armature terminals are all short-circuited together. A complete cage winding was placed on one of the rotors of the New Haven generators. This rotor had not been designed originally for this purpose, and it was, therefore, difficult to adopt the most suitable proportions in this winding, but what was put on immediately showed in practice that a practicable remedy had been applied for this trouble. Meanwhile, the new rotors designed for the application of heavy cage windings were under construction, and upon the installation of these the field or rotor trouble all disappeared. It is interesting to note that the fourth machine installed, which has a 4,260 kv.-ampere single-phase rating, has a solid steel core, in the surface of which the copper cage winding is embedded. As this winding completely eliminated the pulsating armature reaction, there was no further occasion for laminating the field as a protection from magnetic pulsations. The generators in the power house at first suffered from the tremendous shocks which accompanied short-circuits on the line. The considerable stray fields at the ends tended to exert a bending or distorting effect on the end windings, and bracing not proving sufficient, an unsaturated choke coil, or impedance coil, was placed on the trolley side of each machine to reduce the short-circuit current to six times full-load current. This coil took up a comparatively small voltage under normal operation, but in case of a short-circuit the E.M.F. generated in it was sufficient to limit the current rush to less than half the value it would attain without this coil. The shocks on the machines were very greatly reduced, so reduced that future trouble from this source was not feared. An interesting point in connection with the use of the cage windings on the generators was that the apparent regulation of the system had been improved. This was anticipated, but the actual result in practice was more pronounced than was expected.

Mr. L. B. Stillwell considered the engineering world was fortunate in the fact that the New York Central Railroad and the New Haven Railroad had not adopted the same electric system. Such an opportunity to compare the possibilities and limitations of the direct-current system and the single-phase alternating-current system was unprecedented, and, except in America, would be impossible. Whatever they might think of the wisdom, from an economic standpoint, of investing millions to learn from experience, the answers to questions which by German methods, for example, might be answered at much less cost (and there was much to be said on both sides of this question), they as engineers were in no position to complain of lack of opportunity to subject their ideas to the test of practice. With reference to the plan adopted to improve the overhead trolley construction which converted this to a catenary construction with secondary suspension cable, he observed in Hamburg recently that the single-phase system in use in that city employed this method of supporting the trolley wire.

Mr. H. P. Davis said that in the operation of a railroad one condition stood ahead of all others—namely, the trains must be kept running and the schedule maintained at almost any cost. In this connection the author had presented a condition of vital difference between electric and steam operation of a railroad. The answer to the question: What was the best way to distribute current at high potential to a trolley wire over a busy railroad, with four or more parallel tracks, increased in places to several times this number, and connected at intervals to busy sidings and shifting yards, was yet to be forthcoming. In practice, the failure of the line to operate as laid out was for a considerable time extremely puzzling. The destructive action of short-circuits on the circuit-breaking apparatus, on the generator windings, on the insulation of the line, and the failure of the circuit-breakers to be selective, could not be explained by any previous experience. To protect the generators choke coils were placed in the trolley phase of each generator, and designed to cut down the maximum short-circuit current values to about 40 per cent., and the resulting mechanical shock to about 16 per cent. To limit the current to be opened in the distribution system, and to make the selective action possible, ohmic resistances were placed in each of the three feeder leads going to the distributing system. These resistances were normally short-circuited by circuit-breakers controlled by a single underload and overload master relay, so installed that the entire station single-phase output passed through it. The automatic tripping coils of the circuit-breakers on the overhead feeder and trolley systems were normally cut out. In the event of a short-circuit or overload on the system exceeding a certain predetermined current, the master relay above referred to operated, causing the circuit-breakers short-circuiting the resistances to open. The power-house resistance was proportioned so that it allowed sufficient current to flow to trip the two circuit-breakers in the trouble section, and yet limited the amount of current to less than enough to trip any of those in parallel in the remainder of the system. If one or both of the circuit-breakers at the ends of a trolley section failed for any reason to operate, it was arranged that the main circuit-breakers at the power house operated and opened the entire circuit. To accomplish this, the main power-house circuit-breakers were provided with time relays of the constant-time type, set so that they did not act until a sufficient period had elapsed for the trolley and feeder current breakers to open.

Mr. C. P. Steinmetz believed that when the time arrived to electrify the transcontinental railways it would be done by means of the alternating-current motor. In the immediate railway problems, the decision whether one or the other type of motor should be used had shifted from the electrical engineer to the railway engineer or the railway manager. This decision would be determined by the economic question whether higher weight efficiency—*i.e.*, higher draw-bar pull per pound of motor weight and reliability of service—should be sacrificed because of the possibility, at some future time, when the electrification of railroads for long distances was proposed, of being able to extend the same system of operation over other parts of the road.

Mr. A. H. Armstrong thought, in view of the fact that the alternating-current trolley construction as installed on the New Haven line apparently cost 80 per cent. more than a 600 volt third rail, and the alternating-current locomotives cost at least double for the same service performed, it was instructive to compare the operating results secured with the two

systems. The locomotive weights given included pony trucks on both locomotives.

	600 volt d.c.		New Haven 11,000 volt a.c. 600 volt d.c.
Weight total	94·5 tons	......	102 tons
Weight on driver	68·5 ,,	......	77 ,,
Number of motors	4	......	4
Total H.P., 1 hr. rating......	2,200	......	1,000
Guaranteed trailing load...	400 tons	......	200 tons

Having approximately the same total weight, a single New York Central locomotive unit had a capacity equal to two New Haven units, although the motors of the latter were cooled by forced ventilation. The reliability of the direct-current and alternating-current systems was illustrated by the train-minutes delay for the months of July to October, 1908, inclusive. The alternating-current figures, taken from Mr. Murray's Paper, were 5,695 minutes, and the direct-current figures from the New York Central operation were 160 minutes.

Mr. N. W. STORER, in connection with the remarks of the last speaker, said it was well known, and had been announced in the technical Press, that all the New York Central locomotives were to be reconstructed by changing the two-wheel trucks to four-wheel trucks, and that the weight of the modified locomotive was between 115 and 120 tons. Mr. Armstrong had also stated that the guaranteed trailing load of the New York Central locomotive was 400 tons, and that of the New Haven was 200 tons. The trailing loads of these two locomotives should, of course, be compared in the same kind of service. The New York Central guarantee was based on express service with long lay-overs. The New Haven locomotive was guaranteed to handle a 200 ton trailing load in continuous local service. In express service, which was the class of service on which the New York Central guarantee was based, the New Haven locomotive handled easily a load of 300 tons. No one was more anxious than the speaker to give the New York Central locomotive full credit. He believed that it was doing most excellent service; but that service was simply switching. There were a few trains that had to be hauled a distance of about 12 or 13 miles. The remainder of the trains were hauled for a distance of only about 6 miles. This was anything but trunk-line service. The distance was so short, and the service necessarily so intermittent, that the locomotives should be able to work at a load far in excess of the one-hour rating without over-heating. It was a noteworthy fact that since the wreck of the Brewster express these locomotives had never been run double-headed. It was also noteworthy that after that date the limiting speed on the New York Central electric zone was 45 miles per hour until recently, when it had been raised to 50 miles per hour. Under these circumstances, it was impossible to make comparisons between them and the New Haven locomotives, which were operating in all classes of service, running most of the time at very high speeds. It must be borne in mind that the electric locomotive of the future would be designed so as to have good riding qualities, and to secure them the mechanical parts would form a much larger part of the total weight than was thought necessary or desirable two or three years ago. This feature in itself would bring the weights of the single-phase and direct-current locomotives much nearer together.

Mr. M. M. DAVIS (communicated) thought the author's remarks about the effect of single-phase currents upon telegraph and telephone wires might be misunderstood. Transformers were by no means completely corrective, although to some extent they were beneficial. His understanding was that the transformers on the New Haven road were applied only to single-wire operation, and that they did not neutralise the disturbing effects of the single-phase electric current sufficiently to permit the operation of duplexes, quadruplexes and printer circuits upon the wires to which the author referred. This meant that one-half or two-thirds or even a larger proportion of the carrying capacity of the telegraph wires was destroyed, notwithstanding these transformers. To apply these transformers, several otherwise idle wires must be carried upon the poles, and these wires and transformers were objectionable.

Mr. H. F. PARSHALL (communicated) thought it must be conceded by all that the alternating-current train equipment, *per se*, was inferior as regards cost and maintenance to a direct-current train equipment, and that it gave no tractive advantage. The advantage, then, must be external to the train, and confined to the system of transmission, or more properly the collector system, since the transmission system would naturally be the same either with direct current or alternating current. It had been found that the cost of a high-tension overhead system properly installed was greatly in excess of that of a third-rail system, and having regard to the exceedingly numerous difficulties as put in evidence by the Paper, it could not be contended that the action of an overhead high-tension system was anything like as satisfactory as the third-rail system. The absolute lack of commercial data as regards the cost of the installation, cost of operation and cost of maintenance vitiated any conclusion that might be drawn other than that the system, when compared with such a system as had been installed by the New York Central, was entirely unjustified by the practical results. In his opinion, many of the troubles experienced would have been avoided had the alternating-current system been installed in accordance with accepted alternating-current practice, with a high-tension system of transmission, say, from 20,000 to 30,000 volts with sub-stations at the different sections and a trolley voltage not exceeding 5,000. The cost need not have been greater, and the system would have been far and away safer, in that the different sections could be independently controlled. Further, the volume of stray current in the earth causing electrolysis and induction troubles would be greatly lessened. In conclusion, he said he was responsible for the electric traction installation of the Central London Railway. While this was one of the first systems to employ multiphase transmission with synchronous converters and a direct-current collector system, none of the troubles instanced by the author had been experienced, and since the installation opened there had never been, all told, an hour's delay caused by any electrical failure. He had not found a problem to which the single-phase system was properly applicable. He had recently pretty thoroughly investigated railway matters in the United States, and, considering the inherent properties of the different classes of apparatus, his conclusion was that the direct-current system of electric traction was superior to all others, and was likely to remain so for many years to come.

Mr. O. S. LYFORD (communicated) gave particulars of the operation of the electrified section of the Erie Railroad Company. It commenced its work on a moderate scale on a branch line with 34 miles of track and six motor cars. The line was operated with 11,000 volt single-phase trolley, and had been in operation 18 months with the following results: *Safety.*—One man lost his life during the first few days of operation by coming in contact with the trolley wire. There had been no other personal injuries to employés or to the public due to the electrical equipment. *Reliability.*—In October, 1908, there were no detentions chargeable to the electrical equipment. In November there were four detentions of this character, one due to control trouble, two due to hot motor bearings, one due to breakage of air-compressor crank shaft. Three of these detentions were of a character preventable by more rigid inspection. In December there had been no detentions up to the date of the meeting. This good record, however, was obtained only after the equipment had been in process of "tuning up" for many months. In the 12 months ended October 31, 1908, there were 120 detentions chargeable to the electrical equipment, which detentions totalled 4,800 minutes. These included a number of serious detentions due to the 90 mile 60,000 volt transmission line over which power was received from Niagara Falls for the operation of the road. The record was much better than that of the steam equipment replaced. *Maintenance.*—There had been no transformer troubles, either on the cars or in the sub-stations. Motor troubles had been very few. No mechanical troubles with the contact wire. The wear on this wire up to August, 1908, was from 0·004 in. to 0·009 in., at which rate it would be between 20 and 30 years before the wire would be worn back to the supporting clips. Stretch of the copper wire and abnormal wear at hard spots would no doubt result in a life materially less than this. There had been no apparent deterioration of the galvanising of the messenger cable and other galvanised parts, but such painting as was done on the overhead work had not lasted. There had been no material troubles or expense caused by locomotive gases. The life of the pantograph shoes averaged about 15,000 miles. *Cost of Operation.*—The operating cost under the usual transportation and maintenance headings of the Interstate Commerce Commission classification, averaged during last summer about 9d. per car-mile. It was difficult to make a fair comparison with other lines. The greatly increased cost of the electrical equipment of the locomotive or motor car must necessarily involve greater cost of repair and maintenance. The savings effected in other parts of the system must carry this burden.

Mr. PHILIP DAWSON (communicated) agreed with the conclusions at which the author arrived, in which he pinned his faith for general railway electrification of urban, suburban and long-distance lines to the single-phase system. It was the very serious inconvenience possessed by the direct-current third-rail system which, he believed, had brought about the introduction of the single-phase system. Had it not been for the latter system the conditions were such that the directors and officers of the London, Brighton & South Coast Railway Co. could never have seen their way to adopt electric traction, if adopting it had involved the use of the third-rail system. The form of construction was the double catenary. The droppers were solid Sherrardised steel wire, the shorter ones having a loop at each end, the longer ones consisting of two parts looped in the middle. This arrangement gave great flexibility in the vertical plane, whilst ensuring great stability in the horizontal plane for the trolley wire. The catenaries were of galvanised steel wire cable ⅜ in. in diameter. Each catenary was independently fixed by means of a turn buckle and insulator, and supported from a saddle piece resting on the top of the main insulator. The sag in the catenary was calculated so as to produce absolute balancing at the supports. The principal insulator had to bear a dead weight which amounted to 850 lb. All of the insulators were of the best quality porcelain, and the principal ones were tested to 65,000 volts, and the secondary ones to 25,000 volts for 30 minutes; 10 per cent. of the insulators were tested mechanically. The whole construction of the catenaries, girder bridges, insulators, &c., was calculated so as to result in a factor of safety of 10. The trolley wire itself was round, with sharp grooves at the sides, into which mechanical clips fixed, and its area was 0·197 sq. in., its tensile strength being in all cases above 22 tons per square inch. In order to prevent the hammer blows from which the New Haven line had suffered, the whole construction had been designed so as to make the clips and the droppers from which the clips were supported as light as possible in comparison with the weight of the trolley wire itself. Three years ago, at the time the London, Brighton & South Coast Railway installation was planned, he made the most careful investigation, and decided on the flexible system instead of the rigid one originally adopted by the New Haven line. The greatest span so far was 195ft. The vertical projection of the sag of the catenary wire at 50°F. for this span corresponded to 6 ft. Contrary to Continental practice, the trolley wire was drawn up and anchored at both ends with due regard for the lowest temperature to which it might be subjected, so that in the coldest weather the elastic limit should not be exceeded in the wire. He

had provided for the wire being staggered 18 in. altogether, or 9 in. on either side of the centre line of the track, although there were occasions when he had diverted it so as to go as far as 13 in. from the centre line. The normal height of the wire would be between 16 ft. and 17 ft., whilst in the two terminal stations the height was 21 ft. At some of the lowest bridges the wire descended to a height of 13 ft. 10 in., or only 4 in. above loading gauge. The train service which would operate over the line at present was of a purely local character, and it was not likely that at the outset a speed of 45 miles an hour would be exceeded. Careful consideration had led him not to adopt the pantograph type of collector, but to adopt a type of trailing bow collector. This collector consisted of a tubular frame, the top of which was fitted with two bows, one forming the rigid portion of the frame itself, whilst the other was hinged and sprung from it. It was believed that this method would ensure sparkless running and operating with a pressure of from 12 lb. to 15 lb. between the collector strip and the contact wire. There were two bows, one for operating in each direction. On the top of the collector bows were fixed renewable grooved aluminium strips, as it was believed that by this means the wear of the wire would be localised on the contact strip, virtually no wear of the trolley wire taking place. Furthermore, owing to the form of strip, and to the low pressure exercised by it against the trolley wire, the cost of the strip itself would not be a very large item in the working expenses.

Mr. Ivan Ofverholm (communicated) gave some particulars of the tests of single-phase equipment in Sweden. The conditions in the power station were somewhat different from those in the Cos Cob station. They had four-pole generators running at 750 revs. per min. and driven by steam turbines. In this case the flywheel effect of the steam turbine with its gearing (reduction 8,500 to 750) was about three times as big as the flywheel effect of the generator; therefore, when a short-circuit came on, the stresses on the generator axles were so severe that the axles were twisted. For this reason the coupling between generator and turbine had to be made so weak that it would break when severe short-circuits came on. It was also proposed to make a kind of spring coupling that would allow the generator to slow down when the momentary stress of a short-circuit came on; but as the cost of such a contrivance was considerable, they preferred to make a coupling that did break, but was eaily replaced. In the power station there were two generators but only one circuit-breaker, which at the same time kept the generators in parallel and connected to the line. With this circuit-breaker they had not had the least trouble. In the beginning there was much trouble with the windings of the generators. They were often short-circuited. At first it was thought this was due to high potential stresses, and protective devices were installed. As these did not seem to work at all, they studied the conditions more closely, and found that the coils of the windings were bent in many places. They therefore got the idea that the short-circuits were partly due to mechanical stresses. Mechanically stronger insulation was then used in some places where weak points were found. Since then there had been no short-circuits in the generators, although there had been several very severe external short-circuits. He was interested to hear that the author thought the single catenary contact line was just as good, or even better, than the double catenary. In Sweden they thought that a contact line without any catenary was the best, provided the mechanical stress in the contact wire was kept constant at different temperatures, and the bow pressure so adjusted that the resultant stress in the contact wire (the sum of the normal stress in the contact wire and the bending stress resulting from the bow pressure) never exceeded the elastic limit. At present it was not so with ordinary trolley lines. In nearly all the cases considered they found that the elastic limit was exceeded; the fact that the trolley lines did not come down more often was due to the fact that copper wire could stand bending above the elastic limit to a remarkable degree. For steel wire the elastic limit was sufficiently high, and, according to their researches, such a wire could keep the internal stresses sufficiently constant at varying temperature without being readjusted. For this reason he thought it was a good idea to put up a steel wire as contact wire on the New Haven road; but he wondered if it could stand the smoke from the locomotives. They had had very bad experience in that respect. He knew of at least one big installation with steel catenary wires where these had had to be replaced by bronze wires. They thought they could improve the present trolley line construction without catenary very much by using automatically working tightening gear. They intended to make the distance between the suspension points 25 to 30 metres. But he did not think that they could operate locomotives at high speeds on such a line with only one bow. It was their intention to use two bows placed 6 metres or more apart. The bow had a small (30 cm. high) top bow with little inertia, supported by a pantograph. The arrangement they intended to use was an improved form of this bow. The author had spoken of hard spots in the line and the way to get rid of them. They had had the same experience, and therefore now made the line as movable as possible in a vertical direction, but had anchored it duly in a horizontal direction. They did not intend to use any deflectors on their lines. They had made many trials in order to see how to get rid of the difficulties at the points where the wires crossed each other, and had found that these difficulties could be done away with by placing the wires in the proper position at the crossing. In connection with telegraph and telephone disturbances, in the case of the New Haven Railroad the disturbances seemed to be due chiefly to electromagnetic influence, and not to the static charging effect from which the Swedish telegraph and telephone lines suffered so much. This could also be prevented, but by other means; these were mentioned in Mr. Dahlander's report about the Swedish trials.

Mr. C. E. Eveleth (communicated) had built and tested in 1904 an oil circuit-breaker, which contained less than 3 gallons of oil and opened repeatedly on a single break with a current of 20,000 to 25,000 amperes at 2,200 volts. This was equivalent to a rupturing capacity with four breaks in series, such as would ordinarily be used for a single-phase circuit of over 100,000 k.v.a. Under these conditions the circuit was ruptured without throwing oil or otherwise damaging the switch, except for some burning of the contacts. As these tests preceded by a considerable time the selection of the New Haven oil circuit-breakers, and as there were many oil circuit-breakers in service for feeders where the total generator capacity connected to the 'bus bar exceeded 50,000 kw., it was apparent that circuit-breakers capable of handling the New Haven conditions had been built and might have been selected. If they had been adopted a large proportion of the serious delays would have been obviated.

Mr. W. S. Murray, in reply*, did not think it was by any means impossible to design generators of the voltage and capacity, as installed in Cos Cob station, to withstand the shocks of short-circuits of the character that had been received by that station, yet the form of protective apparatus that had been installed to alleviate the electrical and mechanical strains incident to these short-circuits certainly suggested the wise expedient of designing a low voltage (say not greater than 2,300 volts) station, employing static transformers to secure the higher transmission voltages; and it was to be noted the increased cost due to transformer equipment would be offset by a lower price per kilowatt of generators and switchboards, due to lower voltage, and, further, that what loss might be suffered in virtue of the introduction of transformers would be greatly offset by the higher efficiency accruing from a low instead of a high-voltage generating system. He believed, in connection with single-phase electrification, this arrangement in power-house design should be effected. Four months had elapsed since Mr. Lamme's remarks were made, and the short-circuit disturbances had since disappeared, and the mileage of the motors, instead of the figures stated by Mr. Lamme, had become in some instances as high as 70,000 miles; the average mileage of all motors being probably 60,000 miles, and this with 60 per cent. of the commutators still unturned. As a matter of fact, and as Mr. Behrend had pointed out, the operation with both alternating and direct-current power was very much alike as far as sparking was concerned, and the period before turning up of the commutators was necessary was, therefore, about the same. In regard to the use of a two-phase rather than a three-phase generating plant, as applied to the New Haven conditions, power house location had much to do with the choice between the two systems. In the case of a two-phase system it was natural to suppose, in order to secure the highest copper efficiency, that the point of divergence of the two phases should take place at the power house, if the power house was on the line of the railroad. Examining the location of the power house in the case of the New Haven line, it was to be noted that about 18 miles of track lay west of the station, while about 3½ miles lay east of it. Thus it was quite clear that had the station been designed for two phases they would have been very much unbalanced, especially as the train density was heavier per mile of track on the longer section. In connection with Mr. Parshall's remarks, the London and New York subways offered about as much comparison to the New York, New Haven & Hartford Railroad conditions as a steamboat did to a flying machine. Also, the perfected alternating-current motor did not weigh 40 per cent. more than a direct-current motor of the same capacity. If the air-gap of the alternating-current motor was of a character which permitted the revolution of the armature in its bearings, and required no greater maintenance than the direct-current motor, it did not matter how much smaller it was than the direct-current motor air-gap. Higher armature speeds were a specific advantage rather than disadvantage, in view of this characteristic having excellent application to the direct-connected type of locomotive. Their experience did not prove that the cost of the high-tension overhead system properly installed was greatly in excess of a third-rail system. Even if the overhead contact construction on an alternating-current system was more expensive in first cost, it might be more economical in use. Their present operating sheets showed that the operating costs, *per se*, on the direct-current zone were just 40 per cent. greater than those with alternating current. Mr. Armstrong's remarks were inconsistent with the facts. For example, the weights of the locomotives. Again, his reference to the one-hour performance of the New Haven locomotives completely ignored the continuous capacity for which the New Haven locomotives were designed. It was interesting to note that the average for the train-minute delays during the past five months following the four months cited in the Paper was 13½ per cent. of the average during the period of operation the Paper included. Mr. Lyford's statistics in regard to wear on the contact wire were interesting, and corroborated micrometer measurements made on the steel wire during the past nine months of operation. Mr. Dawson's remarks were of much interest. It was to be noted that the spans of the L.B. & S.C. Railway were very much less than in the New Haven. The clips for supporting the contact wire might be sufficiently light to prevent kinking at the hanger points. This arrangement would be greatly fortified if, as Mr. Dawson stated, speeds of 45 miles an hour would not be exceeded. The double messenger triangular form of hanger offering a more rigid form of construction, and a greater degree of inertia at the hanger points, shortly proved itself undesirable for the speed conditions that existed upon their lines, and he felt quite sure that, even in the form of single catenary suspension, their conditions would not permit the form of construction as adopted and described by Mr. Dawson. In short, their experience with the overhead construction led to the following brief specification for an overhead contact wire: (1) One single steel stranded messenger cable with deflection corresponding to economical values fixing distance of span. (2) One horizontal solid copper conductor sup-

* Written about four months subsequent to the date of the Paper.

ported from steel messenger at intervals of 10 ft. with light tension on same. (3) One horizontal solid grooved steel (contact) wire supported by light clips (weight not greater than 9 oz.) from the solid copper wire at mid points between messenger hangers. The tension in this wire not to exceed the elastic limit of the steel at lowest temperature. This auxiliary or contact wire (3) had as much right for existence as the floor of a highway bridge. To make contact on the copper wire would be the same as running on the members of a bridge. The double-bow pantograph collector with renewable contact strips had been tried on the New Haven system. They did not get a very great deal of encouragement out of this form of collector. In answer to Mr. Ofverholm's inquiry in regard to the effect of smoke on the steel contact wire, a careful observation on the steel wire during the past nine months did not indicate that the blast from the locomotives had had much, if any, effect.

THE RADIO-TELEGRAPHIC STATION AT CULLERCOATS.*

BY AAGE. S. M. SÖRENSEN.

After referring to the early history of wireless telegraphy and describing the principles of the apparatus employed, a description of the installation at Cullercoats† is given to show the construction and working of a spark system. The building of the Cullercoats radio-telegraphic station was started in February, 1906, and the mast and house completed about June, 1906. The mast is a lattice-built pole which was completely constructed to its full length lying on the ground. After fixing the upper ends of the guys to the mast, it was lifted bodily into position by means of a derrick crane. This first installation of apparatus has been greatly altered, and is, therefore, not described here.

The mast serves to support the antennæ, which originally took the form of an inverted fan, consisting of eight wires connected at the top and about 60 ft. from the ground, spread at equal distances between two smaller masts 150 ft. apart. The wires were connected to the inlet insulators on the roof, four wires meeting at each of the two inlets. The present antennæ are made in the umbrella shape. Eight wires are suspended between the top of the pole and eight iron posts, arranged on the rocks and on land at nearly equal distances apart, in a circle round the pole. The upper 160 ft. of each wire forms part of the antennæ, and is separated by a long insulator of hard rubber from the rest of the wire, which only serves as a stay. The lower ends of the eight antennæ wires are connected by an octagonal boundary wire.

At the top of the mast four wires come together on each side, and are there joined to two copper cables, which run down to the leading-in insulators on the roof. The two half parts are suspended from the top of the mast by means of a series of porcelain insulators, and similar insulators are used to cut the guys into short lengths. The insulators are constructed so that the wires are looped into each other through the insulators, and in case an insulator breaks the wires will remain in position. The antennæ are made of seven stranded silicon-bronze wire, strand No. 20. The earth connection consists of 70 copper wires of about 2 mm. diameter, laid about 6 in. under the surface, and spreading from the centre of the cabin in all directions like spokes in a wheel. The average length of the earth wires is 130 ft. The interior of the cabin is divided into four rooms, of which three are occupied by the spark apparatus.

The engine room contains a motor-generator and necessary regulating apparatus. The town supply at 480 volts is used. The speed of the motor can be regulated by field resistance from 1,800 to 2,400 revs. per min., and the motor started automatically by a motor starter of the "Igranic" type, which is controlled from the operating room. The dynamo is a single-phase alternator, which gives 90 to 120 cycles according to the number of revolutions. By field regulation the voltage can be altered from 300 to 600 volts. To protect the dynamo from high-frequency induction, the cables pass through choking coils with spark arresters before they enter the operating room, where the telegraph key and a variable reactance are inserted in the circuit, which is completed in the third room—the spark room—through the primary winding of a dry transformer. The secondary of the transformer is connected to the spark-gap, across which is shunted a battery of Leyden jars and a self-induction helix, forming the closed oscillatory circuit; the antennæ and the earth connections are taken off from two points of the same helix, thus forming a so-called galvanic or direct coupling. As the fundamental wave-length of the antennæ (i.e. the wave-length obtained when the antennæ are connected direct to earth through the spark-gap) is 800 metres, and the normal working wave is 600 metres, the antennæ are "shortened" by an inserted small battery of Leyden jars. Over these jars the antennæ are "interrupted" by an anchor spark-gap, which ordinarily leaves the antennæ disconnected from the sender, but during sending is bridged across by a spark.

A branch of the antennæ comes into the operating room to a switch by which it can be joined through a self-inductance and a condenser to earth. This apparatus forms the receiving circuit, which can be tuned by varying the capacity and the self-inductance. The condenser consists of a set of semicircular plates, which can be turned in and out in the spaces between a set of similar fixed plates, whereby the capacity can be altered. The helix has 100 turns of thick insulated copper wire about 1 mm. in diameter, and terminals at different places arranged so that a number of turns in steps of five can be branched off. If self-inductance and capacity are arranged in series with the antennæ and earth, the receiver can be tuned to wave-lengths from 300 to 1,000 metres, and when the condenser is shunted across the inductance, to wave-lengths of between 800 and 2,500 metres.

Inductively coupled to the tuning helix is another coil, the ends of which are connected to the detector, in this case a De Forest electrolytic cell, by means of which the received energy is transformed into audible signals composed of long and short sounds in a telephone. Ordinarily the operator on duty is constantly listening in this telephone, and on 600 metres wave-length. A ship intending to communicate with the station will send a call signal with the names (in code) of the called and the calling station. To reply, the operator breaks the antennæ switch, which in its other position closes the circuit to the control relay of the motor starter, the motor starts, and in 10 seconds the transmitter is ready for making the reply. When this has been done the antennæ are switched over again, the motor stops and receiving conditions are immediately re-established.

The described arrangements could be modified in several ways. In short-distance work, for instance, a spark coil might be employed instead of motor-generator and transformer. Further, the sender could be arranged with a single open circuit or with inductive instead of galvanic coupling, and likewise the receiver, where also special hook-ups may be used for the various forms of detectors. But the systems are all able to intercommunicate, and a common feature in all of them is that the waves are damped and interrupted.

Reference is then made by the author to Duddell's and Poulsen's methods of generating high-frequency undamped oscillations. Immediately after his discovery Mr. Poulsen started experiments on radio-telegraphy, and in a short time the Poulsen system was developed so far that the construction of complete apparatus for practical use could be started. In November, 1906, a receiver of the Poulsen type was installed at the Cullercoats station, and at the first test signals were received from the Danish stations, Lyngby and Esbjerg, over distances of about 400 and 600 miles respectively. Early in 1907 an experimental arc was set up in Cullercoats, and very satisfactory results were obtained, considering the energy and the small antennæ then used. In 1908 the antennæ at Lyngby and Cullercoats were extended, and the stations equipped with generators of up-to-date design, and since then perfect working has been obtained at all times between the three stations.

It was mentioned above that the cabin at Cullercoats had four rooms, and the installations in three of them have been described. The fourth is occupied by the complete Poulsen installation, consisting of the two essential parts, sender and receiver. The sender comprises the generator, the oscillatory circuit with capacity and self-induction, antennæ and earth. As the oscillatory tension between the condenser plates is much smaller in a Poulsen arc sender than in a spark sender, it is possible to use condensers with air or oil dielectric of the design mentioned above, one advantage of which is that the capacity of the sender is readily altered, and as the distance between the plates only needs to be a few millimetres, the condensers occupy considerably less room than a battery of Leyden jars. The sending circuit or circuits can, of course, be arranged in exactly similar hook-ups to those of a spark sender, the arc taking the place of the spark-gap.

The generator is built in the following way: On an iron footplate are mounted two vertical iron cores, round which the magnetic field coils are placed. Above the coils an airtight double-walled box is placed between the cores, and horizontal pole-pieces pass through the box on each side, an air space being left between them. The arc electrodes are passed through the end walls of the box, but are insulated from it, and are placed so that the arc is burning between the magnet poles. The copper electrode is in a fixed position, while the carbon holder can be moved to and fro by a screw for adjusting the arc length, rotated by a small motor through a worm gear. Outside the box the electrodes end in metallic plates with radiators for air cooling. From a sight feeder (such as is used for oil in gas engines)

* Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers.

† A complete description of this installation appeared in THE ELECTRICIAN, December 20, 1907, p. 355.

methylated spirit is dropped into the arc, and by its decomposition generates the necessary hydrogen atmosphere.

The direct-current supply passes from the switch through a variable resistance, the magnetic field windings and two air-cored choking coils, to prevent oscillations in the mains, to the arc electrodes. The signalling is effected by letting the telegraph key short-circuit a part of the self-induction in the circuit, so that the arc is oscillating during the whole period of working, but two different waves are radiated, corresponding to marking and spacing. It will be understood that as long as the key is pressed the transmitter generates a persistent train of constant oscillations, and consequently nothing would be heard in an ordinary receiver for audible signals. To produce sound it is necessary to cut the oscillations up in groups, occurring with a frequency which can be heard. So far this cutting up could be effected in the sender or the receiver at will.

By the "ticker," a very ingenious arrangement of Mr. Poulsen's, it is possible to employ this method advantageously in the receiver. The Poulsen "ticker-telephone" receiver consists of a primary circuit (the ordinary antenna-earth circuit, with necessary self-inductance and capacity for tuning), which is in inductive and extremely loose coupling with a secondary closed circuit, composed of self-inductance and capacity. Across the secondary condenser is placed through an intermittent contact (the "ticker") a condenser of large capacity (in comparison with the condenser in the circuit), and across this condenser is placed a telephone.

The action is as follows: If the "ticker" contact is broken the secondary circuit is quite free—that is to say, no energy is taken from the circuit—and if set in oscillation from a sender through the primary, the secondary circuit will accumulate energy by integrating the impulses; after a certain time the ticker contact is closed, the circuits thrown out of resonance and the secondary gives up the energy to the "block condenser," which again discharges through the telephone; then the "ticker" closes again, and the process is repeated as long as energy is forthcoming from the sender and of the proper frequency. In this way the signal is marked in the telephone by a ticking noise, from which the apparatus is named.

It will be seen that this method allows a considerable amount of energy to be given off in the receiver at one time, although only oscillations of very small amplitude are created in the sender, while at the same time it requires and makes use of the sharpness of tuning obtained by undamped waves.

Detectors can be used without the "ticker" for printing arrangements. A specially sensitive type is the photographic printer, in which the feeble direct current obtained from the detector is passed through the fine wire in an Edelmann thread galvanometer. The wire moves in front of a slot, and through a microscope the slot is photographed, with the moving shadow of the wire, on a strip of sensitive paper. As the mass of the wire is extremely small, the speed is nearly unlimited, as long as energy enough is obtained to give a visible movement. In this way messages have been received in Lyngby from Esbjerg at a rate of 300 words a minute, and at Cullercoats from Lyngby up to 100 words a minute.

Brief reference is made in the Paper to radio-telephony, and the author finally states that a comparison between the arc and spark systems will certainly show the advantage of the arc system, which is bound in time to supersede the other method.

THE PRACTICAL STERILISATION OF WATER AND OF SEWAGE EFFLUENTS.*

BY H. C. H. SHENTON.

The author here deals with the practical sterilisation of sewage effluents and of water, as distinguished from the theoretical side of the question, which has been treated at great length by chemists and bacteriologists. Sterilisation work cannot be carried out to the best advantage without the co-operation of both the engineer and the scientist. This fact has often been overlooked in the past in sewage purification experiments and requires to be emphasised. Hitherto most people in this country have regarded the idea of sterilisation of water or of sewage effluents with disfavour, and eminent authorities have declared it to be practically impossible. This feeling of prejudice is the more remarkable when one considers that the sterilisation of sewage effluents is practised in America and [illegible] recommended by the Board of Agriculture of that country, while the sterilisation of water supplies has been adopted on an [illegible] at many places on the Continent and in America.

Various methods have at different times been proposed for sterilisation. Heat, lime, acids, ozone, copper and its compounds, chlorine and its compounds, &c., have been proposed as agents, but at the present time there is a general agreement of opinion that chlorine is the most economical sterilising agent for sewage, while for the sterilisation of water ozone has been used at the majority of places. For the sterilisation of water Dr. Rideal has pointed out that ozone is the ideal agent, since it leaves behind it only oxygen and nothing foreign to the water; but in the author's opinion there is much to be said in favour of hypochlorite of sodium, and especially for that produced by electrolytic methods. This agent is much cheaper, and unless the amount of organic matter present in the water is very large, it will have no unpleasant effect upon the liquid. It is difficult to see how ozone purification can compete with sterilisation by means of hypochlorite in the case of sewage effluents, but the ozone plant manufacturers are undertaking to do such work, and in view of further developments it is quite possible that both systems will be used.

Ozone Sterilisation.—In his Paper read before the Royal Sanitary Institute upon the purification of water by ozone, Dr. Rideal draws attention to the fact that the Paris authorities are sterilising, or have decided to sterilise, a large proportion of their water supply. From this Paper and from the discussion which followed it, it seems that about 20,000,000 gallons of water per diem are now to be sterilised by the ozone processes, as the result of experiments which have been carried on for a considerable period. This decision by the Paris authorities in favour of ozone is of great importance.

There are many patents which affect the various processes of ozone sterilisation. Particulars are given in the Paper of many ozone installations by the Lahmeyer Electrical Co., to whom the author is also indebted for the following figures:—Allowing 20 gallons per head per day for a town of 50,000 people, a supply of 1,000,000 gallons per day could be sterilised at a capital outlay of £4,000. This would include the whole of the electrical machinery, sterilising galleries and motive power (if necessary) where no local electrical supply is available. Should an electrical supply be available the annual cost of treatment would be lower. A population of 25,000, requiring 500,000 gallons per day, would entail an outlay, under the above conditions, of £3,500. The cost per 10,000 gallons of water treated would be about 5d. to 7½d., according to the local value of the kilowatt-hour, which usually ranges from 1d. to 1½d. The cost of treating 1,750,000 gallons per diem would be about £1,168 per annum. This is inclusive of labour, repairs, rates, taxes, power, depreciation of plant and sinking funds, inclusive of interest at 6 per cent. on the capital outlay of £4,500. The cost of treatment of 1,000 gallons in this case works out at ⅓d. The cost of sterilisation of sewage by ozone is estimated as follows:—

For the treatment of 600,000 gallons per day: For supplying the whole of the machinery, exclusive of erection, £3,000. For the treatment of 1,250,000 gallons per day: In accordance with the particulars given above, £4,000.

The above figures give an approximate idea of the cost of ozone sterilisation, but it is impossible to compare them exactly with the prices which follow without having further details as to the quality of the water sterilised. In the case of sewage, the figures relate to a liquid containing 3 grains per gallon of solids.

Hypochlorite Sterilisation for Water.—The sterilisation of drinking water by means of hypochlorite is obviously possible, and the cost of the treatment and of the plant itself is very much less than in the case of ozone, whilst an unpleasant taste could only result in cases where the water contained a large quantity of suspended matter and required treatment with a much larger proportion of chlorine.

Reference is next made to the Hermite plant installed at Poplar, and to particulars of its working.*

Dr. Rideal, in a Paper read recently before the Faraday Society, described the oxychlorides process in use at Guildford. Early experiments proved that if 1 part per 100,000 of available chlorine were added at the inlet of a branch pipe through which septic effluent were passing at the rate of 1,000 gallons per hour, the pipe being 40 ft. long and 2½ in. bore, the liquid would be deodorised in passing through the pipe. A large number of other experiments showed that it was possible to deodorise septic tank effluent without in any way interfering with subsequent filtration. A much more important fact was ascertained in these experiments—viz., that by the addition of hypochlorite to the tank effluent, clogging growths can be dissolved and washed speedily from filters. It was also found that an addition of strong hypochlorite would prevent the sprinkler from becoming clogged with growths, and it was also established that filters that have been thus treated quickly recover under normal conditions.

* Abstract of a Paper read before the Institution of Municipal Engineers.

* See THE ELECTRICIAN, November 8, 1907.

Investigators for the Ohio State Board appear to have no doubt that more economical results are to be obtained by the use of hypochlorite produced by electrolytic methods. A summary of the experiments is given in the Paper. Copper sulphate experiments were made before the chlorine experiments, and it was clearly established that chlorine, even in the chemical form, was very much more economical than copper sulphate. On a basis of treating daily 41,000 gallons of effluent from the primary contact filters, the initial cost of a sulphate plant would be about £14. The cost of the chemicals would be about 3s. 5d., and the cost of labour about 2s. 1d. per diem. The annual cost with copper sulphate at 3d. per lb., and labour 1s. 0½d. an hour, would be £96. 10s.; capitalised at 5 per cent. this would represent an investment of £1,930. Whilst in another case of an Ohio installation for dealing with 160,000 gallons per day the capitalised value is shown to be £4,400.

For the chlorine experiments, calcium hypochlorite or bleaching powder was selected, costing 2d. per lb., and showing on analysis 34 per cent. of available chlorine. It was found that unless special precautions were taken in dissolving the chloride of lime, many large lumps which enclosed chlorine remained, and materially reduced the efficiency of a given weight of the chemical. Experiments were carried out at the Boys' Industrial School, Lancaster, Ohio. The sand filter effluent was treated with available chlorine varying from 3·6 to 4 parts per 1,000,000, taking the daily average. Coli organisms were completely removed, and the removal of the total number of organisms was from 99·8 to 99·9 per cent. The solution was discharged into the sewage at the rate of 0·75 gallon a minute, and variations in the quantity of chlorine applied were made by changing the strength of the hypochlorite solution. The cost of constructing the plant for treating sand filter effluent in this manner may be taken at £18. 8s., and it is estimated that the annual cost of applying 4 parts to the 1,000,000 of available chlorine to a sand filter effluent flow of 160,000 gallons per diem, would be about £184. 16s, including labour. Capitalised at 5 per cent. this would represent an investment of £3,700.

Conclusions.—It is difficult to compare prices exactly owing to the varying conditions in the cases concerning which figures are to be obtained. Prices are not quoted for comparison, but merely as a matter of general interest. For instance, at Marion, Ohio, the cost of sterilisation per 1,000,000 gallons with chloride of lime appears to be about 27s. 8½d. (4 parts of available chlorine per 1,000,000), while at Boston, with 5 parts of chlorine per million, the cost is 4s. 4½d. per 1,000,000 gallons. It is stated in a Paper read before the Nova Scotia Society of Engineers that the cost of sterilising the Philadelphia water by the Vosmayer ozone process costs from 13s. to 30s. 4d. per 1,000,000 gallons. Here the water is very bad. The figures of the Lahmeyer Company, which presumably refer to a water of average quality, give a price of from 41s. 8d. to 62s. 6d. per 1,000,000 gallons, taking the cost of the electrical power at from 1d. to 1½d. per unit and allowing for many things probably omitted in other prices. Dr. Rideal gave an estimate relating to Paris, where, assuming that the cost of the electric power to be ½d. per unit (a very low figure), the cost of ozone sterilisation would be 27s. 9d. per 1,000,000 gallons.

In the Digby-Shenton Paper it was demonstrated that at London prices 1 kg. of available chlorine in the form of hypochlorite can be produced by modern electrolysers with guaranteed output for 10d., taking electrical power at 1d. per unit and salt at 1d. for 10 lb. This price does not include labour. On this basis the cost of treatment would be for 4 parts per million of chlorine 15s. 2d. per million gallons treated.

It was established by Drs. Kautbach and Rideal in the Maidenhead experiments, that 1 gramme of available chlorine would sterilise 1·21 cubic metres of settling tank effluent, or 1·5 cubic metres of filter effluent. In any good modern electrolyser 1 B.T.U. will produce from 152 to 200 grammes of available chlorine. Taking the lower figure we obtain sterilisation of an unfiltered sewage effluent at a rate of 24·95 B.T.U. per 1,000,000 gallons by hypochlorite as against the rate of 133 B.T.U. per 1,000,000 gallons by the ozone process at Paris, as described by Dr. Rideal in his ozone Paper, which process was dealing with water and not with sewage.

In the author's opinion, therefore, it is clear that hypochlorite sterilisation must be much more economical than ozone treatment, making every allowance for the price of salt.

Motor Control Apparatus.—*Correction.*—In our account last week of the motor control apparatus manufactured by Messrs. Wellman-Seaver & Head, the footline to Fig. 3 should read "Steel Stamping Grid used in 'Dinkey' Controller Resistance," instead of "Cast Steel Grid used in 'Dinkey' Controller Resistance."

ELECTRIC CRANES.*

BY H. H. BROUGHTON.

(*Continued from page 211.*)

Summary.—The author here deals with the design and construction of the mechanical equipment of cranes. The mechanism required for effecting the usual crane motions is treated in four sections. The first section relates to lifting mechanism. The article opens with a short discussion on the determination of the size of motor, and a simple expression is given suitable for most ordinary types of jib and overhead travelling cranes. Then follow notes on wire ropes, flat link-chains, the gear ratio, spur and worm gears, shafting, barrels, blocks and hooks, mechanical brakes, limit switches, and the "free-barrel" system. Lifting magnets and safety tongs are also described.

"Free-Barrel" System.—An excellent mechanical feature in the lifting mechanism of Stothert & Pitt's jib cranes is the "free-barrel" arrangement. As the system has been adopted in nearly all the harbours and docks recently constructed, comprising installations at Glasgow, Heysham, Cardiff, Bristol, Southampton, Fishguard, Sunderland,

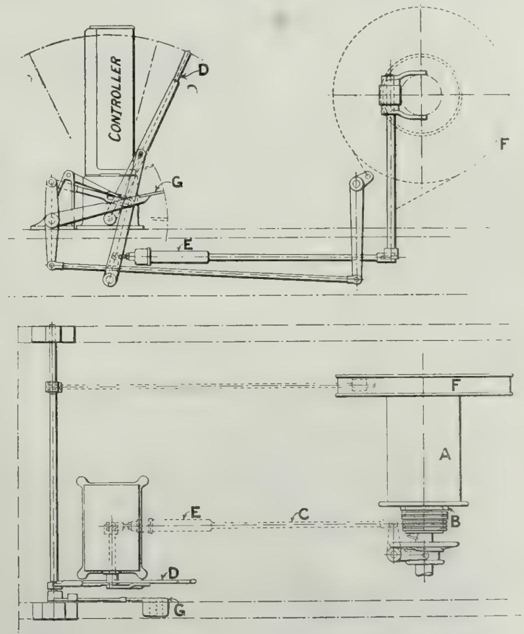


FIG. 94.—"FREE-BARREL" ARRANGEMENT BY STOTHERT & PITT.

Table Bay, East London, &c., we propose, through the courtesy of the makers, to describe the arrangement at some length.

Referring to Fig. 94, it will be seen that the hoisting drum A is not keyed directly on the shaft, but runs loosely upon it, being connected and disconnected by a coil friction-clutch B. This friction-clutch is thrown in and out of gear by the rod C which is actuated by the controller handle D. When the controller handle is in the position shown the clutch is disconnected and the motor is at rest. On moving the handle forward the motor is started, and the clutch is thrown into gear, thus locking the barrel to the shaft and lifting the load. Further motion of the handle increases the speed of the motor without altering the clutch, the motion being taken up by the spring-box E.

Lowering is performed by the mechanical brake F, which is operated by the foot-treadle G. Between the treadle

and the controller handle, an interlock, in the form of a coupling-rod, is provided, so that depressing the treadle and putting on the brake throws back the handle D, stops the motor, and disconnects the barrel, leaving the load suspended on the brake. This arrangement also prevents the motor being started until the brake is released.

The construction of the coil-clutch is shown in Fig. 95, and a clear idea of the whole lay-out will be gathered from Fig. 96.

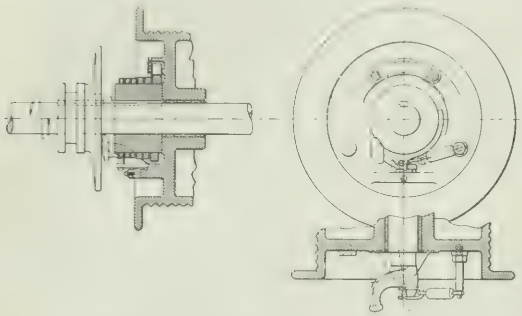


Fig. 95.—Coil-Clutch Fitted to Crane Barrel.

The advantages derived from the "free-barrel" system are briefly as follows :—

(i.) Lowering can be performed at a rapid rate without reversing the motor, thus enabling the crane to work at a very high speed.

(ii.) Lifting can be carried on without stopping until the top of the lift ; the clutch is then instantly disconnected, leaving the motor armature rotating, no time being lost in waiting for the armature to come to rest.

It will be seen that in cranes where the motor is always in gear with the lifting barrel the motion must be checked before the top of the lift to prevent overwinding, but with the system under consideration it is found that a load can be lowered the full depth before the motor has come to rest, and frequently there is a certain amount of momentum left in the armature to aid the next lift.

Lifting Magnets.—During the last few years numerous attempts have been made to use magnets for the purpose of lifting figured sections, rails, plates, ingots, and pigs.

At first sight, the problem of designing such magnets appears to be analogous to that of an ordinary tractive magnet. That such is not the case is evident from an examination of the many types which have been evolved. The designs have to be based upon experimental data and full knowledge of the conditions under which the magnets have to work and of the service for which they are intended.

Mr. A. C. Eastwood, in an article * on the subject, states

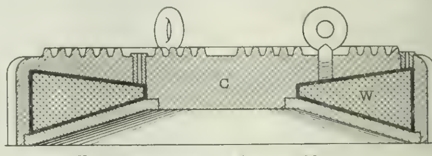


Fig. 97. Section of Lifting Magnet.

that a lifting magnet which would readily lift an ingot weighing 10,000 lb. would not lift a single pig weighing 100 lb. when lowered upon a pile of pig-iron.

A magnet which appears to be gaining ground is that manufactured by the Controller Co. A section of a pig magnet is depicted in Fig. 97. The case C is a heavy casting made from a grade of steel having low retentivity.

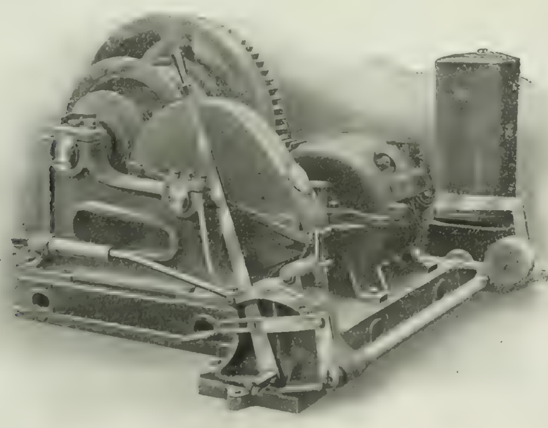


Fig. 96.—Free-Barrel Lifting Mechanism.

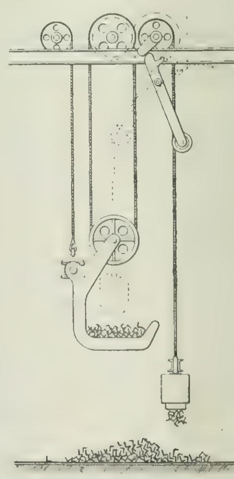


Fig. 98.—Small Magnet for Loading, together with "Tilting" Device for Unloading.

(iii.) Decrease in gearing strains, as the gear is never reversed.

(iv.) A more equal demand upon the power station, as the use of the coil clutch does away with the rush of current at starting.

(v.) Increased economy.

(vi.) From the electrical engineer's point of view, the motor is very well treated.

The magnetising coil W is former-wound ; it is impregnated with compound in a vacuum-oven, and heavily insulated so as to minimise the risks of internal short-circuits and earths. The coil is completely enclosed and protected by the case, which is ribbed to provide for rapid radiation of the heat from the coil.

Current is supplied through a suitably protected plug

* "Cassier's Magazine," December, 1906.

connection, and the plug is pulled out when it is desired to detach the magnet from the crane hook. For the reason given below a "tell tale," or preferably, a magnetic lock of some kind, should be fitted to the plug, so as to make it impossible to remove the latter while current is passing. The cable should be permanently secured to the hook block.

It is necessary to place a non-inductive resistance in parallel with the magnet winding at switching off in order to prevent the high E.M.F. of self-induction from damaging the winding. If this precaution be neglected, sooner or later the insulation will be broken down, or the operator will receive a dangerous shock, or the switch contacts will be badly damaged.

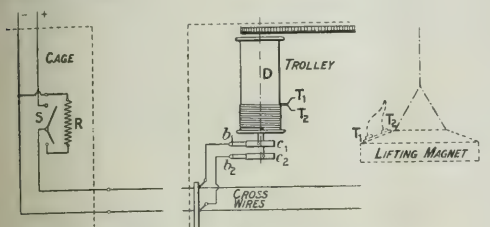


FIG. 99—WIRING DIAGRAM FOR LIFTING MAGNET CIRCUIT

The magnetic flux takes some time to die down after the magnetising force has been removed, and this "time element" characteristic of a lifting magnet is made use of when plates are being handled. A number of these can be lifted at one time, and dropped singly in any place desired by simply opening and closing the switch which controls the magnet. Resistances inserted in the circuit by means of a simple form of controller bring about the same result.

The manner in which such magnets are controlled is shown in diagrammatic form in Fig. 99. The field breaking switch S, with non-inductive resistance R, mounted behind, is fixed in the operator's cage. A drum D, geared to one of the hoist shafts, and provided with two collector rings, C_1, C_2, is mounted on the trolley. Current is conveyed to and from the magnet winding by means of a heavily insulated, twin conductor, flexible cable which is coiled on the drum, and connected to the two collector rings. The

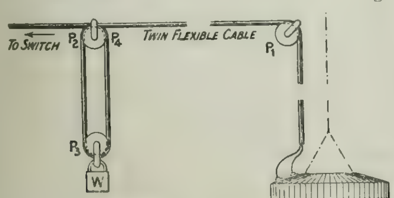


FIG. 100.—ALTERNATIVE METHOD OF WIRING FOR LIFTING MAGNET.

brushes, b_1, b_2, are connected to two cross-wires, one of which may be the common return for the whole trolley. It is desirable to connect these wires to the supply, on the "live" side of the circuit-breaker or main fuses.

An alternative method of coupling up the magnet is depicted in Fig. 100. In this case the twin conductor cable is passed over a pulley P_1, attached to the trolley; back over a pulley P_2, attached to one of the bridge girders near the operator's cage; down and under a pulley P_3, and back over a pulley P_4 (behind P_2), to the switch or controller in the cage. A weight W, is attached to the pulley, P_3, which rises and falls, to take care of the slack cable required.

The great drawback to lifting magnets is that they are not absolutely reliable and safe in operation. Makers of such magnets urge that these drawbacks are no greater in practice than faulty slinging. Accidents due to carelessness of this kind are rare, and engineers, more particularly English engineers, seem to prefer to take the risks which arise from the faulty slinging of awkward loads than pin their faith on lifting magnets.

A number of clever arrangements which possess all the advantages of the lifting magnet and none of its disadvantages have been devised by the Stuckenholz Co.

The mode of working with the arrangement shown in diagrammatic form in Fig. 101 is such that when the grippers or jaws are opened, the magnet is lowered to raise the material, in this case tubes, after which the jaws close again under the magnet, and thus prevent the material being accidentally dropped, even in the event of failure of the current supply.

It is evident that the jaws may be of such a form as to support the load. Under these conditions, the magnet is only required for lifting purposes, and consequently an appreciable saving of current is effected.

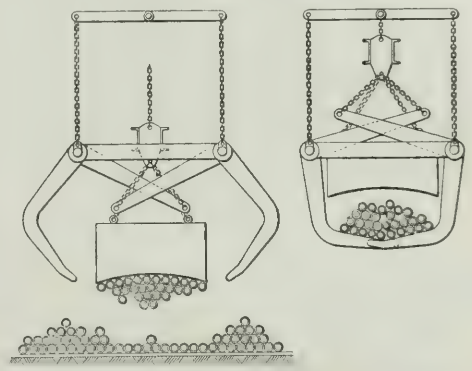


FIG. 101.—LIFTING MAGNET WITH SAFETY JAW ATTACHMENT.

Large lifting magnets, apart from their great cost, are of considerable size and weight; the latter impairs the efficiency of the lifting mechanism, and the current consumption of the magnet itself runs to a high figure.

The appliance shown in Fig. 98 has been used in order to work a crane at its full capacity and at the same time employ a comparatively small lifting magnet.

(*To be continued.*)

A NEW FORM OF FÉRY RADIATION PYROMETER.

During the last few years the methods of measuring high temperatures have been developed by the physicist, and the manufacturer has not been slow in employing in everyday life the instruments and methods so developed. Everyone who has had any experience of the temperature measurements made in the majority of works during the past 10 or 20 years must be struck with the enormous advance that has been made. A few years ago in many processes temperatures could be only gauged approximately by eye, whereas now they are stated definitely in degrees Centigrade or Fahrenheit. The improved methods have also brought with them a demand for accuracy which to the uninstructed appears entirely unnecessary. Ten years ago very few manufacturers or engineers would have thought it necessary or feasible to control a high temperature process to within 1 per cent., yet this limit, and even finer limits, are now being frequently imposed. It is difficult to say how much this desire for increased accuracy is due to the ambition of the manufacturer to produce a still finer product than that he has been in the habit of making, or the wish to go one better than his competitors. Competition is a hard mistress—the eternal struggle after the cents., and yet this same struggle does more than anything else to develop industry.

To improve the products all the methods of manufacture must be closely examined, and this brings in its train improved furnaces, with improved methods of determining the temperature of those furnaces.

The great drawback to the employment of pyrometers in furnaces whose temperatures are higher than 1,000°C. has been the destruction of the pyrometers by the intense heat, and it was not until the radiation or optical methods of measuring temperatures were evolved that this difficulty was overcome.

In radiation pyrometers the heat radiated by the hot body is measured in various ways by the heat effect it produces, such as by the electric current set up when the radiation heats one or more junctions of two dissimilar metals, the expansion produced by the heating of a compound metal strip, or the change in resistance of a fine metal ribbon. The laws governing the amount of heat or energy radiated in relation to the actual temperature of the hot body have been studied by several observers. Of the radiation pyrometers the best known is that invented by Prof. Ch. Féry, of the Ecole Municipale de Physique et de Chimie Industrielles, Paris, in which some of the heat rays from the hot body are concentrated by means of a concave mirror on to one junction of a small thermo-electric couple. This couple when heated sets up an E.M.F., which is indicated on a galvanometer, the scale of which is divided in degrees of temperature. The great disadvantage of this form of pyrometer is the fact that a galvanometer has always to be used in conjunction with it; this necessitates a comparatively level spot on which to place the galvanometer, and the employment of leads to connect the pyrometer to the galvanometer.

Realizing this drawback, Prof. Féry has designed a new pyrometer which, whilst having practically all the advantages of the old instrument, does not require a galvanometer and leads. The instrument is a complete unit in itself, and only those who have had to take the temperatures of an open hearth steel furnace or of a gas retort with the older type of instrument can fully appreciate what this means.

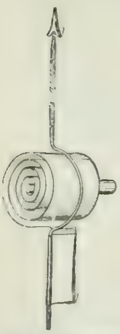


FIG. 1.—ENLARGED VIEW OF SPIRAL.

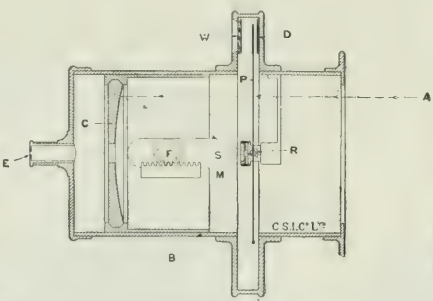


FIG. 2.—DIAGRAMMATIC SECTIONAL VIEW OF INSTRUMENT.

FIG. 3.—PYROMETER COMPLETE.

FIG. 4.—FRONT VIEW OF INSTRUMENT.

The principle and construction of this new instrument is extremely simple. Instead of the heat rays being concentrated on a thermo-electric couple as in the earlier instruments, they are focussed on a small bi-metallic strip made of two metals rolled into the form of a spiral which unrolls when heated, owing to the largely different co-efficients of expansion of the metals used.

Fig. 1 shows an enlarged view of the spiral, its centre being fixed, whilst its outer free end carried a light aluminium pointer which, as the spiral unfolds, moves in front of a scale calibrated in temperatures. The spiral is very small, actually measuring less than $\frac{1}{8}$ in. (3 mm.) diameter and $\frac{5}{64}$ in. (2 mm.) wide. It is blacked so as to absorb as large a quantity of heat as possible. Any radiation passing through its convolutions is reflected back on to it by means of a very small mirror placed behind it. (This mirror is not shown in Fig. 1.)

Fig 2 shows diagrammatically a sectional view through the instrument, A representing one of the heat rays which, coming from the furnace or hot body, strike the concave mirror C and are reflected to a focus on the small spiral S. The pointer P moves in front of the scale D, the observation being taken through the glass window W. A shutter, not shown in the illustration, is provided in front of the instrument, to screen off all radiated heat until it is desired to take a reading.

In order to eliminate errors which may arise through change in the actual temperature of the instrument, an adjustment is provided by which the centre rod supporting the spiral may be turned, and thus the needle set to the zero on the scale. It is important that this zero adjustment should be made immediately before taking any observation, the shutter in front of the pyrometer being closed whilst the setting adjustment is made by a small knob on the side of the instrument. On opening the shutter and exposing the instrument to the heat rays the pointer will be seen to rise rapidly to some point on the scale, and then to pause; this point is the temperature of the hot body. It will be noticed as the instrument as a whole gets hotter the pointer will creep up slowly, and if the pyrometer is left in position for a comparatively long while then a second zero reading must be taken, and a correction applied for the new zero reading.

Extreme scientific precision is not claimed for the new instrument, but an accuracy of between 1 and 2 per cent. is readily obtainable.

The following table shows the result of some comparative tests made by Mr. G. C. Pearson* at the Birmingham Gas Works between a standardised thermo-electric Féry radiation pyrometer, and the new spiral type of instrument:—

Féry.	Spiral.	Difference.	Féry.	Spiral.	Difference.
990	990	0	995	1,000	5
930	940	10	980	978	−2
1,000	1,005	5	1,210	1,218	8
1,020	1,020	0	1,225	1,220	−5
1,250	1,200†-1270	...	1,250	1,250	0
1,240	1,238	−2	845	840	−5
1,260	1,260	0			

These tests are of particular interest, as they were made by an observer who had practically no experience with the new instrument, and were taken in a retort house in full operation. The two pyrometers were focussed on the same point in the retort and the readings taken simultaneously.

As will be seen from Fig. 3, the instrument is portable, and is supplied with a light rigid wooden tripod. Fig. 4 shows the front view of the pyrometer with the temperature scale and pointer.

As at present constructed the instrument is made with three different scales, which it is believed will cover most commercial requirements. These scales are:—

(1) 500°C to 1,100°C. which will cover practically all annealing, hardening and case hardening temperatures.

(2) 500°C to 1,400°C., which will cover practically all the temperatures met with in gas works, the pottery trade, &c. It is on the whole the most generally useful range.

(3) 500°C. to 1,700°C. covering any temperature in a steel works.

In order to get true temperature readings with this and all types of radiation pyrometers, the condition which should be fulfilled is that the hot body sighted on should be contained within a chamber, the walls of which are at approximately the same temperature as itself. This condition is, of course, fulfilled in most practical cases, such as in taking the temperature of the inside of a gas retort, firebox, annealing, hardening, or muffle furnace, &c. The error caused by the fact of the furnace door being open when sighting is negligible, especially as the instrument is calibrated under these same conditions. If it is desired to take observations without opening the door of the furnace, or making any opening in the wall, the arrangement illustrated by

* Midland Junior Gas Engineering Association, February 13th, 1909.

† Variation due to draught, to the effect of which the new instrument would appear to be much the more sensitive.

Fig. 5 may be adopted. A cast iron or fire-clay tube is built into the furnace wall the tube being closed at the end A, which is inside the furnace and open at the other end. Since the tube takes up the temperature of the furnace for some distance along its length, it fulfils sufficiently closely the required conditions of a closed chamber with walls at the high temperature, and therefore by sighting on the blind and A we get the true temperature, without allowing any cold air to find its way into the furnace, or flame to come out.

In measuring the temperature of a crucible of molten metal, or an ingot of steel, or any body which is not inside a closed chamber with hot walls, the reading obtained will be lower than the true temperature of the body. The amount by which the reading will be low depends chiefly on the nature of the surface of the body itself; for instance, in the case of a block of carbon, it will be very small since carbon is what is known as a "black body," whilst in the case of a crucible of copper with a clean surface the reading will be perhaps a hundred degrees or more below the true temperature.

Although no definite figures can be given for this apparent error, as it depends on local conditions, yet, if the conditions remain the

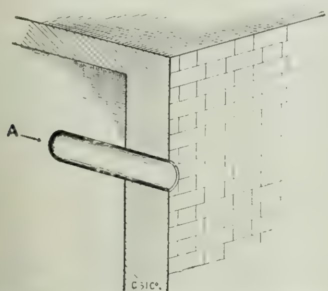


FIG. 5.—ARRANGEMENT FOR OBSERVING WITHOUT OPENING FURNACE DOOR.

same, the error will be a constant one, so that it may be determined once for all experimentally by measuring the temperature of the body first inside and then outside the furnace.

This new Féry pyrometer is being constructed in this country by the Cambridge Scientific Instrument Co.), who have also the sole manufacturing and selling rights in the Colonies and the United States.

A NEW RAIL-GRINDING MACHINE FOR TRAMWAYS.

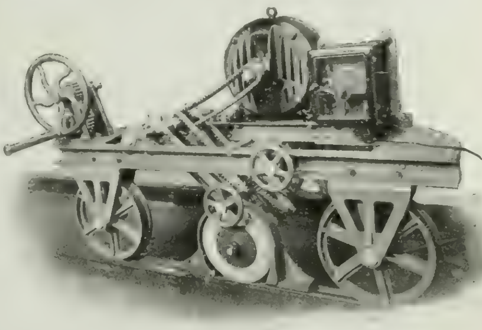
There are very few electric tramway systems which are not faced with the problem of removing corrugations from the rails. The cause of these corrugations is still a much discussed question, but, so far, no one theory has been universally accepted as correct. Nevertheless, whatever the cause underlying the formation of corrugations may be, it is very important that they should be removed without delay, otherwise the effect will soon be apparent in an increased cost for repair to rolling stock and equipments, while residents along the tramway route will have just cause for complaint of the noise made by the cars.

The usual method employed up to the present for removing corrugations has consisted in running a car fitted with blocks of carborundum or other abrasive substance to and fro over the affected portions of the track, the wavy surface being gradually ground down by the scrubbing action of the blocks, which are forced down upon the rails with considerable pressure. Not only is this method slow but it is also expensive, owing to the amount of power consumed.

Machines have also been employed in which a rotating grinding wheel is driven by a motor, the whole being carried on a little truck running on the rails. But as the grinding wheel has been supported from the track, it follows that any inequalities which the truck wheels pass over will be reproduced on the rail by the grinding wheel, which can, therefore, never entirely remove a corrugated surface.

To get over this difficulty, and to enable corrugations to be quickly and cheaply removed, a new machine, called "The Corrugation Remover," has been designed and patented by Mr. Frank Ayton, chief engineer and manager of the Ipswich Corporation electric supply and tramways departments, and Mr. L. Crosta, managing director of the Railway & General Engineering Co., of Nottingham, and made by the latter firm. The new feature embodied in this machine lies in fixing the grinding wheel in a "skate" which is only attached to the truck by two radius arms. The skate is able to move vertically, and also to some extent in a lateral direction, independently of the movement of the truck carrying the driving motor. A screw adjustment and guide are provided for feeding the grinding wheel down in the skate. As the skate slides along the rail on two perfectly flat faces, it is obvious that the crests of the corrugation waves will be ground off, and finally a perfectly flat and smooth surface reproduced on the rail head. The effect is really the same as that obtained by a carpenter truing up the wavy edge of a board with a trying plane.

The machine is also arranged so that it may be used to grind out the small grooves worn by the wheel flanges at the bottom of the grooves of open points. These grooves cause bumping of the cars entering points and are also, no doubt, the cause of many broken axles. For this purpose, the machine is provided with a second set of skate faces and a narrow grinding wheel is used.



CORRUGATION REMOVER. AYTON AND CROSTA'S PATENT.

The power required is small. When the machine is running light, that is to say, with the grinding wheel not touching the rail, the motor of the machine shown in the illustration takes 1½ kw. When grinding corrugations, the average input is 3·75 kw., and the maximum about 5 kw. The motor is rated at 5 B.H.P., and the drive is to a countershaft and thence to the skate by means of two chain belts of Hans Renold's make. Power is taken from the trolley wires by a long bamboo with contact hook at the top. The slow traverse along the track of about 5 ft. to 8 ft. per minute is obtained by winding up a small steel rope on the little winch seen at the left end of the machine. The other end of the rope is fixed to a steel stake driven between the setts or into the wood paving blocks.

SOME NOTES ON WILLANS VACUUM TURBINES.

Introduction.—This is an age of progress, also of economy: the net result being the production of a class of machinery, since this is also an age of machinery, by which a certain amount of work can be done for a less expenditure of energy than has hitherto been possible. This is particularly the case in steam-driven generating stations. First, there was the slow-speed engine, then the high-speed reciprocating engine and then the turbine; each piece of apparatus having certain and distinct advantages over its predecessors. In laying down a new station at the present time, though there have been notable exceptions, steam turbines are practically certain to be specified. There are, however, cases where the old reciprocating engines are in good working order; where their replacement by turbines would not be economical; but where some increase in the plant efficiency, and perhaps also in the output, is much to be desired.

A certain amount of energy is still available in the steam when it leaves the engine, for either the condenser or the atmosphere, and if this can be converted into work an economical problem is at once solved. To aid this solution is the purpose of the Willans vacuum turbine which can be installed in all cases where exhaust steam is available, whether the existing reciprocating engines are working condensing or non-condensing. The actual economy, which can be effected, can only be determined by a consideration of the conditions in each particular case; but some idea may be gained by taking certain empirical, but at the same time practical, figures and deducing therefrom results which may be considered as being sufficiently

near the mark for the purpose. This we shall forthwith proceed to do.

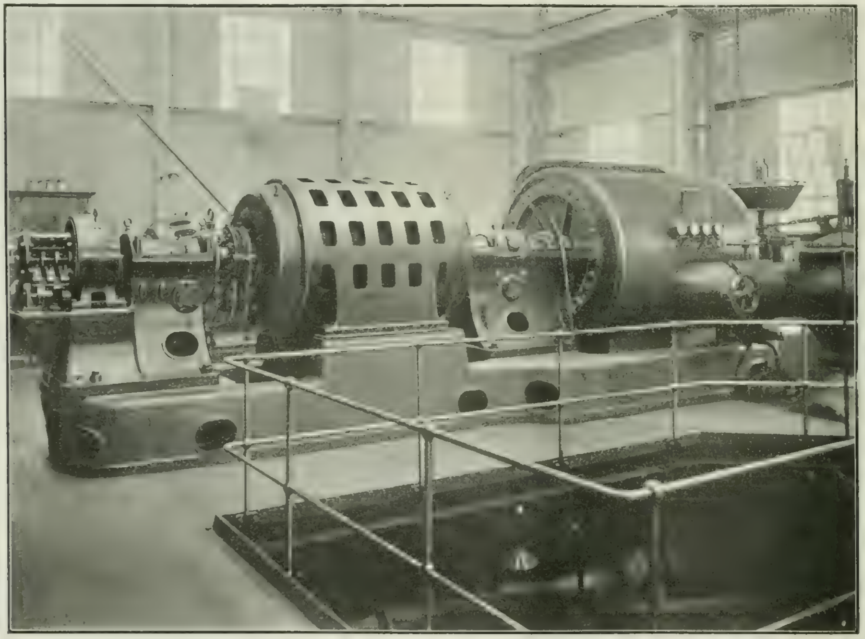
Although the greatest savings are effected with the Willans vacuum turbine when the existing engines are working non-condensing, as the whole of the exhaust steam can then be used in the turbine to produce additional power, without an increase in the boiler output being necessary, much economy can also be obtained when condensing engines are employed. The question is simply this: Does the lack of cooling water preclude the use of a condenser? If it does a vacuum turbine is impossible, even though its erection and use in conjunction with reciprocating engines may *ipso facto* justify the installation of a condenser.

Non-Condensing Stations.—In considering each class of station, and the pros and cons for and against the erection of a vacuum turbine, it must be noted that in a non-condensing station a supply of circulating water for the condensing plant, which is a necessary adjunct of the vacuum turbine, is the first matter to be dealt with. The saving in steam consumption with a combined reciprocating engine and turbine set will probably be a quite sufficient set-off against the first cost of cooling towers or ponds, and is justification enough for the introduction of the condensing plant. The exhaust steam which is lost when running non-condensing will now be saved, while with a surface condensing plant of the "vacuum augmentor" type, the temperature of the air pump discharge is approximately the temperature corresponding to the vacuum, thus enabling the condensed steam to be passed into the boilers through an economiser, without previous heating being necessary.

Since the Willans vacuum turbine is primarily designed for receiving steam at about atmospheric pressure, and as non-condensing engines discharge their steam at this pressure, the engines will develop the same power whether discharging to the atmosphere or into a turbine; and no alteration to their valve gear or cylinders will be necessary. Further, the same output is obtained from the reciprocating engine and no more steam is used. Any power derived from the turbine is, therefore, a net gain when the power necessary for driving the condensing plant has been deducted; and this is but a small amount.

The operation of certain types of reciprocating engines working in conjunction with Willans vacuum turbines under different conditions, and the extra power obtainable from the same weight of steam by this arrangement, are shown in the following table:—

	Power obtainable from reciprocating engine.	Additional power obtainable from Willans vacuum turbine.
	Kw.	Kw.
Compound engines, working with saturated steam, non-condensing	500	375
Compound engines, working with superheated steam 100° F., non-condensing ...	500	320
Triple engines, working with saturated steam, non-condensing	500	340
Triple engines, working with steam superheated 100° F., non-condensing	500	300



WILLANS PARSONS 1,350 KW. VACUUM TURBINE (2,400 R.P.M.).
This machine is one of two sets installed at the works of Sir Bernard Samuelson & Co., Middlesbrough-on-Tees.

Condensing Stations.—The problems which have to be considered in connection with the installation of a vacuum turbine in a condensing station are not quite the same as those outlined above. The points which arise are: Can the output of the existing engines be maintained when exhausting into a turbine instead of into a condenser; if it is impossible for the existing engines to maintain their outputs under the altered conditions, to what extent will their output be reduced and this reduction counterbalanced by the output obtained from the turbine; is the existing condensing plant of sufficient capacity to deal with the steam and maintain a good vacuum for the purposes of the turbine; if not what means can be adopted for improving the vacuum without installing a new condensing plant?

When the previous full load output from the reciprocating engine can be maintained, the introduction of a turbine between the engine and condenser necessitates an increase in pressure in the exhaust chamber of the engine. For, when exhausting direct, this pressure will be between 2 lb. and 2·5 lb. absolute per square inch, a value which will have to be raised to about 16 lb. when the turbine is employed, in order to maintain the previous engine output. This will necessitate an alteration of valves or cylinders, or both, and an expenditure of a larger quantity of steam. These conditions will

impose no difficulties in many cases and the economies effected are evident from the following example :—

A 500 kw. triple expansion engine using steam at a pressure of 160 lb. per square inch superheated 100°F. and exhausting into a 25 in. vacuum will be considered. The introduction of a turbine in this case, will necessitate the engine exhausting at a pressure of 16 lb. absolute. The output of the engine will then remain the same as before, but it will require about 30 per cent. more steam ; though now the output of the combined set will have increased from 500 kw. to 800 kw. The engine was, before the introduction of the turbine, consuming 9,500 lb. of steam per hour or 19 lb. per kilowatt hour ; while after the introduction of the turbine the combined set was consuming 12,350 lb. of steam and producing 800 kw. with a consumption of 15·44 lb. of steam per kilowatt hour. That is an additional 300 kw. is produced for the consumption of 2,850 lb. of steam per hour, or at the rate of 9·5 lb. of steam per kilowatt hour, while the overall efficiency has risen by 3·56 lb. of steam pe kilowatt hour.

When the previous full-load output from the reciprocating engine falls, when exhausting into a turbine instead of into a condenser, even then saving may be effected by installing a vacuum turbine. This may be shown by taking the same 500 kw. engine as in the previous example. No alterations in the valves are made and the output may be assumed to fall to 380 kw. ; so that, while before using 9,500 lb. of steam per hour, it is now employing about 10,050 lb. per hour. This quantity allows the turbine to produce about 240 kw.

Without the turbine the engine exerted 500 kw. with a steam consumption of 19 lb. per kilowatt hour, while the combined set exerts 620 kw. with a steam consumption of 16·2 lb. per kilowatt hour ; so that an extra 120 kw. is produced at a rate of 4·58 lb. of steam per kilowatt hour, and the overall efficiency is increased by 1·8 lb. of steam per kilowatt hour.

The above examples tacitly assume that the existing condensers are capable of maintaining the desired vacuum of 27·5 in. and unless this is the case the estimated output will fall. It may be increased to its former value by increasing the quantity of cooling water or by fitting a vacuum augmentor ; and the particular method chosen depends on the conditions present.

To sum up, therefore, it may be said that the installation of a Willans vacuum turbine possesses many advantages when the existing engine is working continuously above its normal full load, as is the case with many a mill engine. This overload may then be transferred to a turbine arranged for working with exhaust steam from the engine. The turbine is capable of working on live steam should the engine break down, while should the turbine get out of order the engine can exhaust direct into a condenser.

Enough has been said to show that great economies are the result of the introduction of a turbine of this kind into both condensing and non-condensing steam-driven stations. The question of first cost has, it is true, to be considered, but such a consideration can only show that the increased earning capacity makes the extra expenditure quite worth while. Further, some extra expenditure would have to be made, as such work would not be undertaken until the station was working at near its full capacity, and the introduction of such a vacuum turbine would have the effect of staving off the evil day when still more serious extensions would become necessary.

EXPERIMENTAL ANALYSIS OF ARMATURE REACTION.*

BY DR. GISBERT KAPP.

Summary—The author describes two tests for separating the reactance voltage and the drop produced by armature back excitation in a polyphase armature. The machine is worked short-circuited and the excitation regulated so that the current in one phase remains the same, whilst the number of phases included in the circuit is varied.

There are several methods for experimentally separating the two effects which are comprised under the term "armature reaction," and among these the best known are Fischer-Hinnen's and Blondel's. In both of these a choking coil (or in three-phase machines three choking coils) are required. In both, the machine is worked alternately on direct short-circuit and on the choking coils, but whilst Fischer-Hinnen adjusts the excitation in both cases so as to get the same current, Blondel leaves the excitation unaltered and notes the current in both cases. Then from the observed values of excitation and current and with the help of the "no-load characteristic" it is possible to find : (*a*) The inductance of the armature, (*b*) the back excitation produced by the armature current; both these values being found for a current lagging by 90 deg., or nearly so, since a machine working on dead short-circuit, or on a purely inductive load, has a power factor nearly zero.

For both these methods the determination of inductance and back ampere-turns is made graphically, and its accuracy depends on the accuracy with which a point of intersection between two lines can be determined. If the characteristic is not strongly curved it is very difficult to obtain this point of intersection with even moderate accuracy, but the greatest drawback to either method lies in this, that choking coils capable of taking approximately full-load current and something like three-quarters to full voltage must be provided. Such coils are expensive, and although, as has been shown by Dr. Coales,* transformers with an initial continuous-current excitation may be used in their stead, this expedient can only be used if transformers of the right size and voltage happen to be available. It is with the object of avoiding the necessity of providing such special apparatus as choking coils or transformers on the one hand and eliminating the inaccuracy of the graphic construction if applied to machines of rising characteristics on the other, that I have endeavoured to devise the test now about to be described.

It should be noted that my test, as well as the tests of Fischer-Hinnen and Blondel, can only give the inductance approximately, for the inductance has not a constant value, but varies with the phase angle. By sending an alternating current from an independent source through the armature whilst this was kept fixed in two positions—namely, wires midway between pole centres and exactly over pole centres—I have found that the inductance in these cases varied as 1 to 3. When the machine is at work with some such power-factor as 0·8 the crest of the current wave will occur at about the moment that the wires are near the edge of the poles, and consequently the average inductance will lie somewhere between these extreme limits.

I have also made an independent test of the average inductance of the same armature in the following way : The three phases were connected in "mesh," and at one of the corners an ammeter was inserted in series with an independent source of alternating E.M.F. Since the generator had been previously used to determine the inductance of one phase separately, the shape of its E.M.F. curve would influence both tests in the same way, and as we are only concerned with the proportion between the average inductance and its extreme values, the influence of any upper harmonics in the curve of impressed E.M.F. cancels out. The result is given in the following tables :—

I.—*One Phase only in Circuit. Position of Maximum Reactance.*

Exciting force per pair of poles in ampere turns	0	1,600	4,800	7,400
Reactance of one phase in ohms	0·73	0·72	0·53	0·44

II.—*One Phase only in Circuit. Position of Minimum Reactance.*

Exciting force per pair of poles in ampere turns	—	0	4,000	11,000
Reactance of one phase in ohms	—	0·236	0·232	0·225

III.—*The Three Phases coupled in Mesh. Armature Rotating.*

Exciting force per pair of poles in ampere turns	—	—	0	1,600
Reactance per phase in ohms	—	—	0·316	0·316

It will be seen from I. that the reactance decreases with increasing excitation. This is natural. As the teeth in the armature get more saturated they are less able to take additional induction from the armature current. In the position of minimum reactance this effect is hardly noticeable, since the saturation in the teeth occurs near the pole-centres and hardly at all between the poles, where the wires are. From III. it will be seen that the average inductance is independent of excitation, about 36 per cent. greater than the minimum, and from 44 to 28 per cent. smaller than the maximum, according to saturation.

Test III. does not give the average inductance when the machine is working in the usual way. In III. the armature was kept running wide of synchronism ; therefore, the crest of the current wave occurred as often in the "maximum" as in the "minimum" position. When the machine is normally at work the crest value always occurs at a fixed point between these two positions, and it is not possible to estimate whether the average value of the reactance under this condition will be greater or smaller than the average found by test III. The shape of the pole-pieces, their circumferential width, the material of the pole-shoes (whether laminated or solid), and the number of slots in which each coil-side is housed, all have an influence. It is, however, probable that the average reactance in regular work will be a little greater than found by test III. On the other hand, the average reactance found by the Fischer-Hinnen, or Blondel, and by my tests is certain to be a little smaller than the average as determined by III., for the simple reason that in these tests the crest-value of the current occurs near the "minimum" position.

* Abstract of an original communication accepted by the Council of the Inst. of Electrical Engineers for publication in the "Journal."

* THE ELECTRICIAN, December 25, 1908, p. 412.

The two tests which are described below are only possible with polyphase armatures. Their general principle is to work the machine short-circuited, without the intervention of choking coils, and to regulate the excitation so that the current in one particular phase remains the same, whilst the number of phases included in the circuit is varied. By varying the current flowing through the other phases we vary the back excitation produced by the armature on the field, whilst at the same time the reactance voltage of the "particular phase" in which the current remains the same does not vary. Since the open circuit E.M.F. is (apart from the very small correction due to armature resistance which we neglect) the sum of the reactance voltage and the drop produced by armature back excitation, we can separate the two effects by taking readings under two different conditions. The following tests explain the process.

Star connected Armature with the Centre Accessible.—In Fig. 1 *a* is the "particular phase" in which the current is kept the same whilst it is varied in the other two. The accessible centre O is connected by switches S_1, S_2, S_3 with the three-phase terminals, the connection to the particular phase containing an ammeter. The machine is run at its proper speed, and a no-load characteristic is taken in the usual way, all three switches being, of course, open. Now S_1 is closed, and the excitation adjusted so that about full-load current flows through phase *a*. It is not necessary that the speed should be carefully adjusted: any frequency within 5 or 10 per cent. of the normal gives the same short-circuit current. At the same time, the excitation is noted and the corresponding E.M.F. taken from the no-load characteristic. Then the other two switches are closed. This causes short-circuit currents to flow in these other phases as well as in *a*, and the demagnetising action of the armature on the field is thereby increased, so that the ammeter will now show a smaller current in *a* than previously. To bring back the current to its old value we increase the excitation as much as may be required, and note again the excitation and the corresponding E.M.F. on the characteristic. We have now two E.M.F. readings and one current reading,

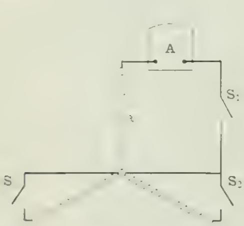


FIG. 1.

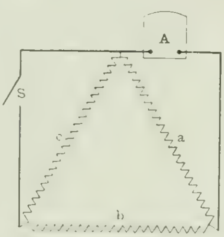


FIG. 2.

and that is all that is required to separate reactance and back excitation; but to eliminate errors of observation it is well to take the readings several times and for different currents—in fact, to plot the short-circuit characteristics for one phase and for the three phases in action. As is well known, these are straight lines, as is also the no-load E.M.F. characteristic at these low excitations with which one deals in a short-circuit test. Let X_1 and X_3 be the ampere turns of field excitation corresponding to a particular current I, when one and when three phases respectively are in action. Also let $X_b = c\,I$ be the back ampere turns produced by the armature current I, c being a constant; and let X_s represent that excitation which will produce an E.M.F. E_s just sufficient to counterbalance the reactance voltage. With a frequency ν the angular speed is $\omega = 2\pi\nu$, and we have $E_s = \omega LI$ where L is the inductance of one phase. Since I is the same in every phase we have for the two tests $X_1 = X_s + X_b$ and $X_3 = X_s + 3X_b$. Therefore, we get $X_s = (3X_1 - X_3)/2$. From the no load characteristic we get the corresponding value of E_s, and this gives the reactance $\omega L = E_s/I$. This test was made on a 30 kw. three-phase machine in the laboratory of the Birmingham University. It is the same machine on which the direct test for average reactance above mentioned gave 0·316 ohms. The readings gave the value of the resistance as 0·294 ohm. A Blondel test made on the same machine by another observer gave a reactance of 0·33 ohm at the same frequency of 50. The characteristic of the machine is, however, so very slightly curved that great accuracy by means of the graphic method cannot be expected. The armature has a three-hole winding with four wires in each hole. If all the wires were concentrated in one hole the armature back ampere-turns would be theoretically $12 \times 90 \times 1/2 \times \sqrt{2} = 760$. The actual value is only 642·5. It is probable that the reduction is due to the spreading of the coil side over one-third of the pole-pitch instead of its concentration at one point.

Mesh Connected Armature.—The test is arranged as shown in Fig. 2. Two of the terminals—namely, those of the "particular phase" are shorted through an ammeter A, and the other two phases may be shorted by closing the switch S. The machine, of which the no load characteristic at normal frequency has previously been taken, is now run at about normal speed (though also in this case a deviation from the normal up to 10 per cent. is immaterial), and the excitation is adjusted so that a definite current, say about 50 per cent. more than the normal phase current, shall be indicated by A. Phases *b* and *c*, being at the moment of maximum current nearer the pole-centres, will have more inductance, so that their share will be a little less than one-third and that of *a* will be a little more than two-thirds of the total current I indicated on A. Since, however, the circuits are in parallel, the disturbing effect of this inequality in the average reactance on the total observed current is not very serious. At any rate, the supposition of a division in the ratio of 1 to 2 and of the same reactance in all phases is a necessity if we would treat the problem mathematically.

Whatever may be the ratio in which the current divides between the two parallel circuits, it has a lag of 90 deg. in both, and its demagnetising action is therefore correctly given by $k\,I_1 = X_b$, if by I_1 we note the current indicated in A when the switch is open, k being (as before) a constant. Two of the coils, namely, *b* and *c*, carry crest value of the current when their sides are only 30 deg. instead of 90 deg. distant from the pole-centres. Their back exciting force may for this position be considered as proportional to sin 30°, or half what it would be if the current in these coils lagged by 90 deg. This will be the lag in all the three coils when the switch is closed. The current indicated is now smaller, and to bring the current in the "particular phase" *a* back to its old value I, we must increase the excitation so that A indicates the current $I\sqrt{3}$. The two currents for "switch open" and "switch closed" are therefore 1·5 I and $\sqrt{3}$ I, or—$I_2 = 1 \cdot 15\,I_1$. To I_1 corresponds the exciting force of X_1 ampere-turns. To I_2 corresponds the exciting force of X_2 ampere-turns. Both are noted on an ammeter in the field circuit. When the switch is closed the back excitation produced by the armature is $I_2\sqrt{3}$, and this is exactly double the amount produced by I_1 when the switch is open. We have therefore the following relations: $X_1 = X_s + X_b$, $X_2 = X_s + 2X_b$, $X_b = X_2 - X_1$, and $X_s = 2X_1 - X_2$. By reference to the no-load characteristic we find the corresponding value of E_s, and since the current flowing through the "particular phase" has throughout remained at the value—$I = I_1/1 \cdot 5$ the reactance is $\omega L = 1 \cdot 5\,E_s/I_1$. In applying the test to a mesh-connected armature, it is advisable to take all readings several times, so as to get the short-circuit lines for the two conditions of "switch open" and "switch closed" as accurately as possible.

A test made on the machine above mentioned gave a value for $\omega L = 0 \cdot 292$ ohms, the agreement with the determination of the reactance when the armature was star coupled being perfect. This should not be taken to indicate that the method is equally perfect; rather the reverse. The two determinations should give different values. Errors of observation happen to balance imperfection of method as regards reactance, whilst they accentuate each other as regards armature back excitation. In the star test the coefficient c was found to be 7·1, whereas now we find the coefficient $k = 8 \cdot 05$. The discrepancy is due to the assumption made that the current divides in the ratio of 2 to 1 between the "particular phase" and the other two phases.

As a general conclusion of this investigation, we may say that the new method of testing for reactance and back excitation gives these values for the case that the current has a lag of 90 deg. The method is absolutely correct when applied to a star-coupled armature, but only approximately correct when applied to a mesh-coupled armature.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s. and 5 per cent for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Welding and Cutting Metals by Aid of Gases or Electricity." By Dr. L. A. Groth. (London: A. Constable & Co.) 10s. 6d. net.

"Radioactivity and Geology." By J. Joly, F.R.S. (London: A. Constable & Co.) 7s. 6d. net.

"General Lectures on Electrical Engineering." By Charles Proteus Steinmetz. 2nd Edition. Compiled and edited by Joseph Le Roy Hayden. (New York: Robson & Adee.) $2.

"Handbuch Der Physik." Edited by Dr. A. Winkelmann. 2nd Vol. "Sound." (Leipzig: J. A. Barth.) M.25.

"Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Maryland, 1901-4." By Daniel L. Hazard. (Washington: Government Printing Office.)

DIFFERENTIAL BALLISTIC METHODS OF MEASURING HYSTERESIS LOSSES.

BY R. BEATTIE, D.SC., AND P. M. ELTON, B.SC.

Summary.—Ballistic methods of measuring hysteresis are very accurate, but have the disadvantage that they are generally troublesome. The authors describe a method that is quick in operation and has the advantage that it refers to short test pieces. Instead of obtaining the B-H curve, the δB-H curve is found by a differential measurement, the method preferred being that of momentarily short-circuiting a resistance in the magnetising circuit so that H is brought up to its maximum value and immediately returns to its previous value, a single specimen being used. The conditions for the interval of short-circuit are examined. The results are satisfactory, but the authors find that the loss in a ring is 1·65 times that found in strips, whether by the differential or the step-by-step method. Finally, some differential methods involving two specimens are described.

Indisputably our most accurate means of measuring hysteresis losses, the ballistic method would doubtless be appealed to more frequently than it actually is when such measurements are in question, were it not for two serious objections. On the one hand, the form of test piece required—a closed ring or a long rod—is highly impracticable from the point of view of the test room, where an easily prepared specimen is a first desideratum ; and, on the other hand, the manipulation of the method, as well as the subsequent reduction of the experimental results, is very tedious.

The difficulty with regard to the form of test piece is more imaginary than real. It has long been recognised that hysteresis measurements can be made on short bundles of straight strips by alternating current or wattmeter methods, and it is no less true, at least in theory, that specimens of the same kind

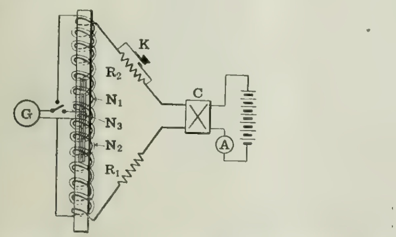


FIG. 1.—" SINGLE SPECIMEN " DIFFERENTIAL BALLISTIC METHOD, ARRANGED EITHER FOR " TOTAL LOSS " TEST (G CONNECTED TO N_2) OR FOR " SPECIFIC LOSS " TEST (G CONNECTED TO N_3).

are also suitable for ballistic tests. We may, for instance, place a straight test piece in a straight magnetising coil, N_1 (Fig. 1), carry the magnetism through a cycle in the usual way, and plot a curve connecting the mean total flux F (as measured by a ballistic galvanometer in circuit with a secondary coil, N_1, extending over the whole length of the magnetising coil) against the magnetising current I. The area of this F-I loop is a measure of the total loss throughout the bulk of the specimen, the loss in ergs per cubic centimetre per cycle in a specimen of volume V being $(N_1/V)\int I dF$, where both I and F are expressed in C.G.S. units and N_1 is the total number of turns on the magnetising coil. The equivalent uniform induction to which this loss must be referred is equal to 0·75 times the induction at the centre measured by means of the narrow exploring coil N_3.*

Or, again, adopting a different procedure, and keeping the ballistic galvanometer connected to N_3 throughout, we may trace a B-H loop by plotting the induction B at the centre against the applied magnetising force H, due to the coil alone. Owing to the fact that the demagnetising force arising from the free magnetism at the ends of the specimen is, for short specimens, proportional to the induction at the centre, the area of this loop is equal to the area of a true B-H loop, and is, therefore, a measure of the actual specific loss at the particular section where the exploring coil is wound.* The induction to which this loss must be referred is now, of course, equal to that at the centre.

These methods, which may be described as " total loss " and " specific loss " methods respectively, both give accurate results, and they permit the use of a test piece of convenient and practical form easily and quickly prepared. But the difficulty as to tediousness of manipulation still remains—would appear, in fact, to be enhanced rather than diminished by the adoption of short specimens as test pieces, since the hysteresis loops obtained with these (Fig. 2) are long, narrow, apparently difficult to determine accurately, and certainly difficult to measure up accurately. In reality it is quite otherwise, however, for, by adopting a certain method of conducting the experiment, which we now proceed to describe, a ballistic test on short specimens can be made with such surprising ease as to put it at once on an almost equal footing with the quickest of available methods of measuring hysteresis. And

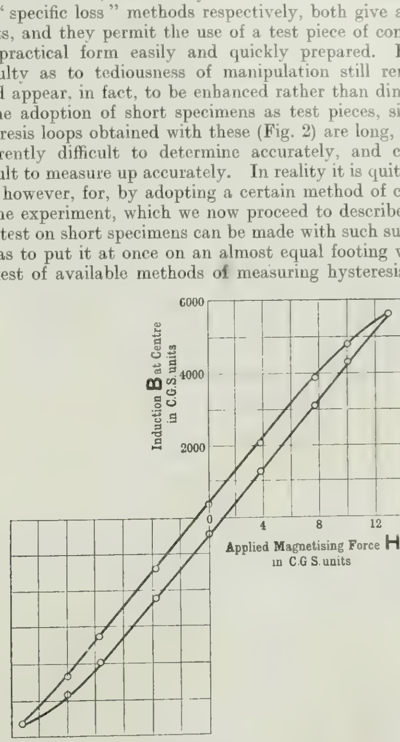


FIG. 2.—TYPICAL B-H_a LOOP FOR BUNDLE OF IRON STRIPS 20 IN. × ½ IN. × ½ IN.

it is precisely with short specimens that this desirable result is attained ; with rings, or closed-circuit test pieces, the employment of the special method alluded to, whilst considerably shortening the experimental work, does not effect anything like the same degree of simplification.

Principle of the Method.—In the application of the ballistic method to hysteresis measurements the usual procedure is to carry the magnetism of the test piece through a complete cycle (or half cycle) by varying the magnetising current in suitable small steps, the throw of the ballistic galvanometer at each change of magnetising current being noted. From these individual throws the ordinates of the B-H curve are then built up. This process is necessarily tedious owing to the large number of observations required—observations which cannot be taken in rapid succession—and from the proportionately large amount of arithmetical labour involved in reducing these observations preparatory to plotting the B-H curve. Inaccuracies are also liable to result, owing to the errors being cumulative.

These disadvantages were early recognised by several experimenters, and Vignoles,† Ewing,‡ and Hopkinson § inde-

* *See* THE ELECTRICIAN, January 15, 1909, p. 549, where other methods of estimating the equivalent uniform induction are also referred to. The factor 0·75 is what the writers find gives the best results with a bundle of ½ in. strips 20 in. long built up to a square section. A shorter bundle than this is not convenient as a test piece since it requires an excessively large magnetising force to drive the induction up to 10,000 lines per square centimetre, which is often taken as a standard in testing work.

* *See* THE ELECTRICIAN, Vol. LXII., p. 136, November 6, 1908.

† THE ELECTRICIAN, Vol. XXVII., p. 49, May 15, 1891.

‡ " Phil. Trans.," Vol. CLXXXIV., Series A, p. 985 (1893) ; also THE ELECTRICIAN, Vol. XXXII., p. 636, April 6, 1894.

§ " Proc. Roy. Soc.", Vol. LIII., p. 352 (1893). *See* also A. Hoyt Taylor, THE ELECTRICIAN, Vol. LVII., p. 968, October 5, 1906.

pendently devised modifications of the ordinary method which enable the actual ordinates PM, &c., (Fig. 3) to be directly measured. These modified methods are certainly great improvements from the point of view of accuracy. It is, however, possible to go a step further, and, by adopting a differential method, to measure the difference PQ or δ**B** between corresponding ordinates instead of the ordinates themselves. This difference is what enters directly into the estimation of the area of the **B**-**H** loop, and it is what has to be got at ultimately whatever experimental procedure happens to be adopted in the first instance. To measure δ**B** directly, therefore, means not only an increase in the attainable accuracy, but also a reduction of the necessary observations to just one-half the number required when the ordinates themselves are individually determined.

A number of differential methods enabling δ**B** to be obtained from a single throw of a ballistic galvanometer have been devised and tested by the writers, and will be referred to in the course of this Paper. Some of these, requiring the use of two exactly similar test pieces and the duplication of the magnetising coils, &c., are necessarily somewhat complicated, and on that account are less generally useful. There is, however, a most useful differential method easy to set up and to manipulate which requires but a single test piece. This method is based on the following principle: Suppose that, preparatory to taking a ballistic throw, the magnetism of the specimen is

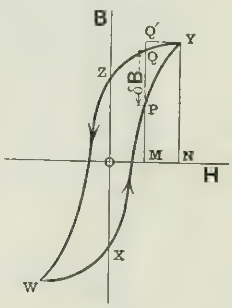


Fig. 3.

carried several times round a cycle (say, in the direction indicated by the arrows in Fig. 3) by reversing the full magnetising force ON. Suppose, further, that the process is stopped when the magnetising force has the value OM, and is increasing, the specimen being thus left in the magnetic condition represented by the point P. Let, now, the magnetising force be suddenly increased from OM to its full value ON (thereby causing the induction to increase from PM to YN) and, immediately after, suddenly reduced to its original value OM (thereby causing the induction to decrease from YN to QM). Provided these two induction changes take place in sufficiently rapid succession, the throw of a ballistic galvanometer in circuit with an exploring coil wrapped round the specimen will evidently be proportional to the total change of induction—*i.e.*, proportional to PQ or δ**B**.

The experimental arrangements by which these operations can be carried out are shown diagrammatically in Fig. 1.* Essentially they are the same as for an ordinary ballistic test, except as regards the means employed for varying the magnetising current. For this purpose a tapping key, K, is connected up so as to permit the short-circuiting of a part, R_2, of the resistance in series with the magnetising coil. In point of fact, K is specially constructed with a view to limiting the duration of contact when this is desired, but in reality it merely fulfils the functions of a simple tapping key. As such, therefore, it is represented in the diagram, and as such it may conveniently be referred to for the time being.

The course of an experiment is to start by rocking the commutator C, the key K being held down meanwhile. After one or two reversals the commutator is stopped in its mid position, which interrupts the current and leaves the magnetism at the point X (Fig. 3). Next K is opened and the commutator thrown over in the direction in which it was last moving. This carries the magnetism to the point P, which corresponds to a magnetising force OM = **H**, measured by the observed reading of the ammeter A. These preliminary adjustments having been made, K is closed momentarily and the resulting ballistic throw noted. During the short interval that K is closed the induction has time to rise from PM to YN, and, on opening K, it falls to QM; hence the total change of induction during the operation is PQ = δ**B**, which, therefore, is what the throw of the ballistic galvanometer measures.

In this way we get two related values of **H** and δ**B**. To obtain others we have only to repeat the whole of the above process with different values of R_2, the value of R_1, which determines the size of the hysteresis loop, being kept fixed.

It is easily seen that by giving suitable values to R_2 any ordinate, PQ, lying between X and Y can be measured, and a few of these serve to determine the area XYZ of a half hysteresis loop. This area is best estimated by plotting the observed δ**B** against the corresponding **H**, as in Fig. 5. We thus obtain a δ**B**-**H** curve in place of the usual **B**-**H** loop, and the area

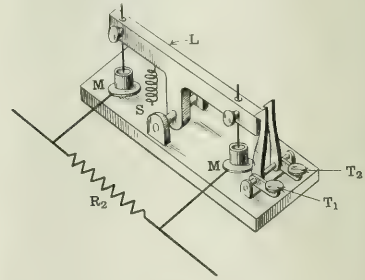


Fig. 4.

included under this δ**B**-**H** curve is necessarily equal to the area of a half **B**-**H** loop. We have accordingly

$$\text{Hysteresis loss} = \frac{1}{2\pi} \times \text{area included under } \delta\mathbf{B}\text{-}\mathbf{H} \text{ curve.}$$

Another observation is required to give the value of the maximum induction to which this hysteresis loss refers. This, of course, is obtained at once by noting the ballistic throw on reversing the commutator C whilst K is held down.

Conditions for Success.—Certain easily observed precautions have to be taken in order to ensure the success of this method. For instance, when K is used to momentarily short-circuit R_2, we must arrange so that the duration of contact is neither too long nor too short. Between the passage through the galvanometer of the quantity Q_1 of electricity induced by the change of induction from PM to YN, and the passage of the inverse quantity Q_2 induced by the change of induction from YN to QM, there is a time interval τ equal to the duration of contact of K. If τ is appreciable, the galvanometer does not measure accurately the difference between Q_1 and Q_2—*i.e.*, does not give the true value of δ**B**. So long as we are dealing with normal hysteresis loops (such as are obtained with ring specimens, or, more generally, with test pieces built up to form a closed magnetic circuit) no special care need, as a matter of fact, be taken to see that τ is of very exceptional shortness. But when straight specimens are employed the hysteresis loops are much distorted, and an appreciable amount of error may easily appear unless τ is kept very small compared with the periodic time of oscillation T of the galvanometer. To enable the shortest permissible duration of contact of K to be ascer-

* It may preclude the possibility of confusion or misunderstanding to think of the ballistic galvanometer in Fig. 1 as connected to N, *i.e.*, a "specific loss" method of measurement as being adopted. The special test-pieces devices to be described are, however, equally applicable whether a "total loss" or a "specific loss" method that is adopted; and whether the test piece is in the form of a ring or a bundle.

tained in any given case it is, therefore, necessary to calculate the magnitude of the possible error in the differential action of the galvanometer in terms of τ.

As only a rough estimate is required, it will suffice for this purpose to consider a ballistic galvanometer with negligible damping. The quantity Q_1 when discharged impulsively through the galvanometer at rest causes the moving system to start off with an angular velocity, which, being proportional to Q_1, may, for simplicity's sake, be represented by Q_1. Since the galvanometer is undamped, the subsequent motion of the suspended system is given by $d\theta/dt=Q_1 \cos ht$, where $h=2\pi/T$, so that during the short interval τ which elapses before the passage of the quantity Q_2 the system travels an angular distance $\theta_1=(Q_1/h)\sin h\tau$, and the velocity falls to $Q_1 \cos h\tau$. When, after time τ, the quantity Q_2 passes impulsively in an inverse direction, the velocity is suddenly reduced from $Q_1 \cos h\tau$ to $V_2=Q_1 \cos h\tau - Q_2$, which is, accordingly, the initial velocity with which the moving system starts off on its second stage of motion. The subsequent motion during this second stage is given by $d\theta/dt=V_2 \cos ht - \theta_1 h \sin ht$, which shows that the velocity falls to zero after a time $T_2 =(T/2\pi)\tan^{-1}(V_2/\theta_1 h)$. During this time the moving system travels a distance $\theta_2=(V_2/h)\sin hT_2+\theta_1(\cos hT_2-1)$, so that the total distance travelled from the commencement—*i.e.*, the amplitude of the first throw of the galvanometer—is

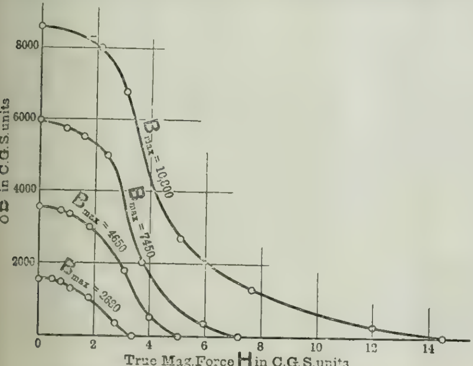


FIG. 5.—TYPICAL δB·H CURVES FOR IRON RING.

$\theta_1+\theta_2=\sin hT_2\{V_2+(Q_1^2/V_2)\sin^2 h\tau\}/h$. From this the percentage error arising from the non-simultaneous passage of Q_1 and Q_2 is readily shown to be

$$100(Q_1/\overline{Q_1-Q_2})^2 \sin^2 h\tau = 100 \cdot 4\pi^2 (Q_1/\overline{Q_1-Q_2})^2 \cdot \left(\frac{\tau}{T}\right)^2,$$

since τ is supposed to be small. For $Q_1/(Q_1-Q_2)$ we may, from Fig. 3, substitute PQ′/PQ, and thus write the expression for the percentage error in the final form

$$100 \cdot 4\pi^2 \left(\frac{PQ'}{PQ}\right)^2 \cdot \left(\frac{\tau}{T}\right)^2.$$

In a normal hysteresis loop PQ′/PQ is of the order of magnitude of 1; hence an accuracy of 1 per cent. may be secured even when τ is as large as T/60, or 0·10 second in the case of a galvanometer with a periodic time of six seconds. In the distorted loops obtained with short straight test pieces, however, PQ′/PQ may be as large as 10, and, therefore, to secure an accuracy of 1 per cent. τ must not exceed T/600, or 0·01 second with a galvanometer whose periodic time is six seconds.

Fig. 4 shows a convenient and easily constructed form of mercury key to take the place of the simple tapping key K, and secure a period of short-circuit of constant and suitable duration. A rocking lever, L, of brass carries needle contacts at each end, which dip into mercury cups, MM, these latter being connected to the ends of R_2 when the key is in use. The needles make simultaneous contact with their respective mercury cups only when the lever is passing through its mid position. Two independent triggers, T_1 T_2, enable the lever to be set either symmetrically ("half set" position) or fully depressed ("full set" position). On being released by the triggers the lever tilts over under the pull of the spring S and short-circuits R_2 for an interval of time which can be controlled by adjusting the needles and the tension of the spring. It was found that no great nicety of adjustment was required, as the duration of short-circuit could, in practice, be varied over quite a considerable range without affecting the extent of the ballistic throw; but usually the key was adjusted to short-circuit R_2 for about 0·005 second.

Whilst due care must be taken that the time of short-circuit of R_2 is sufficiently brief to secure a proper differential action of the ballistic galvanometer, it is no less necessary to guard against its being too brief. If the duration of the short-circuit is too brief, the magnetising current does not have sufficient time to rise to its full value before K is opened, and the method then fails. This is best provided against by a proper adjustment of the time-constant of the magnetising coil circuit. Clearly the conditions are most unfavourable when the apparatus is arranged to measure the initial ordinate XZ (Fig. 3), since the current has then to rise through its maximum range—*i.e.*, from zero to its full value—in the allotted space of time. In this case the growth of current which follows the closing of K takes place in accordance with the equation $i=(E/R_1)(1-e^{-\frac{R_1 t}{L}})$ where R_1 is the total resistance of the magnetising coil circuit with R_2 cut out, and L is its inductance. The time taken for the current to rise to within p per cent. of its full value is, therefore, $2{\cdot}3\ L/R_1 \log_{10}(100/p)$, and we must arrange that this rise occurs within the time of short-circuit τ as fixed by K. That is to say, we must have $L/R_1 \overline{\leqq} \tau/2{\cdot}3 \log_{10}(100/p)$. Thus, if p=one-third of 1 per cent. we must have $L/R_1 \overline{\leqq} \tau/5{\cdot}8$, and if p=one-tenth of 1 per cent. we require $L/R_1 \overline{\leqq} \tau/6{\cdot}9$. Stated as an easily applied practical rule, the time-constant of the magnetising coil circuit (with R_2 cut out) must not exceed, say, one-sixth the duration of contact of K. This allows the current to rise to within 0·25 per cent. of its full value before the end of the short-circuit of R_2, and ensures all the accuracy that will generally be required.

In the apparatus used by the writers for testing straight specimens the magnetising solenoid consisted of 1,400 turns of No. 22 S.W.G. copper wire wound in a single layer on a tube 1·5 in. in diameter and 5 ft. in length. With a straight test piece inside formed of a 20 in. bundle of ½ in. strips made up to a square section, the total inductance was 0·03 henry. The key K being set to work at τ=0·005 second, a resistance R_1=36 ohms was thus required to bring the time-constant of the magnetising coil down to the value prescribed by the preceding rule. In practice, a resistance R_1 varying from 50 to 100 ohms was employed so as to make quite certain of the current always attaining its full value.

It should be noted that if a fluxmeter is used in place of a ballistic galvanometer for differential testing, the time of contact of K may be much longer than that stated above, so that a special short-circuiting key is not absolutely necessary. K may then be an ordinary tapping key, or, preferably, a simple switch with rubbing contacts worked by hand. A few trials will soon show what are the allowable limits to the duration of contact.

(To be concluded.)

PHYSICAL SOCIETY.

At the meeting held on May 14th at the Imperial College of Science, Dr. C. CHREE, F.R.S., president, in the chair, a Paper on

"A Bifilar Vibration Galvanometer"

was read by Mr. W. DUDDELL. The Paper describes a new type of vibration galvanometer and a series of tests made upon it. Vibration galvanometers may be divided into two types: (1) Those in which the moving part consists of a piece of iron or steel and the current to be measured flows round fixed coils, as in the case of the Thomson galvanometer; (2) those in which the current to be measured flows round a moving coil placed in a fixed magnetic field on the syphon recorder principle. The vibration galvanometers of Max Wien and Rubens belong to the first class, while Mr. Campbell's vibration gal-

vanometer and the one described in the Paper belong to the second. In the instrument described the mass of the moving parts is reduced to a minimum, the moving coil being reduced to the two wires forming its two sides, similar to a bifilar oscillograph, but with this difference: Whereas the bifilar oscillograph is designed so as to make the damping aperiodic, the vibration galvanometer is designed so as to keep the damping as small as possible. A series of tests made upon the instrument showed that the total range of frequency was very large—namely, from about 90∼ per second up to 1,900∼ per second. The damping is very small, so that the resonance is very sharp. A series of measurements on the sensibility of the instrument showed that the sensibility to alternating current decreases very nearly inversely as the frequency for which the instrument is adjusted, whereas for direct current the sensibility decreases approximately inversely as the square of the frequency for which the instrument is adjusted, which is what usually takes place with direct-current galvanometers. The sensibility of the galvanometer for detecting small alternating voltages is reduced by the back E.M.F. of the instrument, and the Paper concludes with a determination of the magnitude of the back E.M.F. in the instrument shown at the meeting. The advantages of the galvanometer are its simplicity, ease in tuning, wide range of frequency for which it can be tuned, high sensibility, negligible self-induction and comparatively small back E.M.F.

Mr. A. CAMPBELL said that thanks were due to the author for an interesting account of the valuable and thorough investigation he had made of the behaviour of single-loop bifilar vibration galvanometers. Galvanometers of this type had been used at the Reichsanstalt for several years ("Zeitschr. für Instrumentenkunde," May, 1906) and had given good results with frequencies as high as 2,500∼ per second. He did not know what sensitivity was obtained with the German instruments, but there was no doubt Mr. Duddell's pattern of the same type was much more sensitive than the instrument of the moving-coil type which he (Mr. Campbell) described in 1907. Blondel pointed out in 1900 that in an oscillograph there was no advantage in having more than one turn of wire, but this appeared to be only true when the mirror was very small. As a large mirror with plenty of light and good definition greatly improved the ease and accuracy of observation, he gave the preference to a moving coil of more than one turn, even though the single-loop instrument was highly recommended by Dr. Orlich. With a moderately large mirror one could obtain good definition of a dark line with a scale distance of 600 cm. Mr. Campbell mentioned that Wien's vibration galvanometer ("Ann. der Physik," 1901) with very small magnets and minute mirror gave 70 mm. at 1 metre distance for 1 microampere at 100∼ per second, and had a resistance of 200 ohms. Mr. Duddell's curves were most instructive. He had verified experimentally the law which he (Mr. Campbell) had stated from theoretical considerations—namely, that with a given bifilar suspension (tuned to resonance) the sensitivity varies inversely as the frequency. The figures given tended to show that the shorter bifilars gave reduced sensitivity. With much shorter bifilars he had found great loss of sensitivity. In the moving-coil type with many turns the back E.M.F. was considerable, and might even double the effective impedance of the instrument and lower the volt sensitivity accordingly.

Dr. J. A. FLEMING asked the author if he had tried his instrument with intermittent currents of the right frequency. If the galvanometer was sensitive to currents such as were obtained by rectifying trains of oscillations from condensers, it might be useful as an optical call in wireless telegraphic stations.

Dr RUSSELL congratulated the author on the notable advance he had made in the design of vibration galvanometers. He much appreciated the clear presentation and the accuracy of the experimental results. He asked whether variations of the barometric pressure had any appreciable effect on the sensitivity of the instrument, and suggested that variations in the humidity of the atmosphere might possibly have some effect. So far as he was aware, the author was the first to point out the importance of the back E.M.F. due to the vibrating wires cutting the magnetic field. He thought that the experimental results given would be a great help in formulating a more exact mathematical theory of this type of apparatus. He showed that to a first approximation the author's results were in agreement with those deduced from the differential equation ordinarily given for the motion of the mirror. He asked whether the frequency of ordinary alternating-current supply circuits was sufficiently steady to avoid the necessity of constant tuning of the apparatus.

The CHAIRMAN asked the author if the mirror was always situated in the middle of the vibrating fibres.

The AUTHOR, referring to Mr. Campbell's remarks, said considerations of space prevented him from working with scale distances of 6 metres. With regard to Wien's instrument, it was easy to obtain high current sensibility but not high voltage sensibility. He had tried Prof. Fleming's suggestion, but his instrument was not sensitive enough for ordinary signals. With more uniform spark frequency it gave excellent results. In reply to Dr. Russell, he stated that the sensitivity of the galvanometer did vary slightly with the barometric pressure. In the ordinary differential equation the term giving the moment of the applied forces needed amending, and so also did the term for the damping couple. The complete equation was complex, and there were difficulties in the way of getting an exact solution. The frequency of ordinary supply circuits was quite constant enough for accurate work. In reply to Dr. Chree, he stated that the mirror was always symmetrically situated on the suspension.

A Paper by Messrs. W. P. FULLER and H. GRACE on the

"Effect of Temperature on the Hysteresis Loss in Iron in a Rotating Field"

was read by Prof. Marchant. The rotating field was produced by means of two phase currents. One phase was connected to a coil of long rectangular section and of sufficient length to produce a uniform field within a radius of 2 cm. from the centre. The second phase was connected to a similar coil enclosing this one and causing a flux at right angles to it. The resultant field at the centre was uniformly rotating. An iron disc, 4 cm. diameter, 0·027 cm. thick, was supported by a bifilar suspension and the torque measured by a mirror and scale in the usual way. The specimen was heated by means of nickel wire heaters placed above and below it, and the temperature measured by means of a thermo-junction placed close to the disc. The flux in the iron was measured by the voltage induced in a coil of eight turns of bare wire wound round it. To measure the voltage, the maximum value of which was of the order of 0·03 root mean square volts, a special galvanometer was constructed. This depends for its action on the forces exerted by a rotating field on a suspended coil carrying alternating currents. If E be the E.M.F. applied to the moving coil, and E_1 the E.M.F. due to the field on the coil, then, by turning the coils producing the field round until the deflection is a minimum, this deflection is proportional to $E-E_1$. The results of the experiment show that the effect of increasing the temperature of iron is to reduce the hysteresis loss at a given induction and to cause the maximum loss to occur at a lower value of the induction. In one specimen the maximum value of the loss at 220 C. was 12,300 ergs per cubic centimetre per cycle at an induction of 16,000 c.g.s. units. At 580 C. the maximum loss was 2,600 ergs at an induction of 10,700. The frequency in the experiments was 42 cycles per second.

Dr. W. H. ECCLES remarked that the effects of previous thermal treatment, and of the nature of the material on the properties studied by the authors, were so enormous that comparison of the present experiments with similar ones with alternating fields was difficult; but the authors' curves seemed to show that the effect of rise of temperature on hysteresis loss was less for rotating fields than for alternating fields if the fields were below about 12 c.g.s. The curves showed also that the maximum values of hysteresis loss in rotating fields were reached at lower and lower flux densities the higher the temperature, although the permeability varied but little. This was of imporance from the point of view of the molecular theory of magnetism: it showed that smaller forces sufficed to rotate the molecules within a magnetically stable group at high than at low temperatures. The authors' experiments might be regarded as adding strong confirmation to the molecular theory of magnetism.

Prof. MARCHANT said the iron tested was obtained direct from the manufacturers and its previous thermal treatment was not known. A permeability curve had, however, been obtained. He expressed his interest in Dr. Eccles' remarks upon the bearing of the experiments on the molecular theory of magnetism.

A Paper

"On a Method of Testing Photographic Shutters."

by Messrs. A. CAMPBELL and T. SMITH, was read by Mr. Smith. The authors described a simple and rapid method of testing the speeds and efficiencies of photographic shutters, with a maximum error of 0·0001 second at the highest speeds. A vibrating beam of light falling through a narrow slit on to a moving plate serves to measure the time. This beam is obtained by reflecting the light of a Nernst lamp from the mirror (area 50 sq. mm.) of a vibration galvanometer actuated by a current of fixed frequency (say, 100 or 500∼ per second) obtained from a microphone hummer. The use of the vibration galvanometer, in which the amplitude is enormously increased by resonance, greatly facilitates the measurements. When the total duration of exposure only is required, the vibrating beam of light is passed through the shutter, tracing a sine curve on the moving plate. The duration of exposure is immediately found by counting the number of ripples recorded on the plate. Ten records of the various speeds of a shutter can be taken side by side on one 5 in. by 4 in. plate in one minute.

When the efficiency in addition to the duration of exposure is required, the method adopted is essentially that of Sir Wm. Abney, but the time measurements are made with the vibrating beam of light instead of a screen. The sine curve now extends over the length of the plate and serves as a continuous time record, and is to be preferred to any intermittent method of measuring the time. A slit is placed in a diameter of the shutter opening as close to the shutter leaves as possible, and an image of a line source of light is made to fill this slit. By means of a concave mirror an image of this slit is formed on the plate by the side of the vibrating beam of light. As the shutter opens the length of the slit through which light can reach the plate increases, and the record on the plate gives the length of the slit which is opened at every instant of time. Measurements are then taken of the area of the shutter aperture corresponding to a

number of lengths of the slit opening. Combining these records the area of the shutter aperture at every instant of the exposure is obtained, and by integrating this area with respect to time the equivalent exposure at full aperture and the efficiency are calculated.

Mr. BECK expressed his interest in the method, which he said was the most satisfactory yet produced. It was difficult to say exactly what to call exposure. In photographing moving objects it was advisable to use as the effective time the time during which the central eight-tenths of the shutter was open.

Mr. DUDDELL said the method was an ingenious one for determining the efficiencies of shutters. He suggested that by using an arc it might be possible to reduce the size of the mirror and thus work at higher frequencies. Instead of using a slit it might be better to use a short focus cylindrical lens.

Mr. CAMPBELL, referring to Mr. Duddell's remarks, said that with a Nernst lamp it was possible to obtain high frequency curves showing very little tendency to tail off.

THE UTILISATION OF ELECTRICITY IN EYE HOSPITALS.

It will probably be the testimony of the surgeons connected with hospitals and similar establishments in large engineering centres that a considerable proportion of the cases of accident with which they have to deal are associated with eye trouble, due to mechanical injury. This is not very much to be wondered at, in spite of the large number of precautions now taken to extract as much as possible of floating dust and foreign matter from the air of grinding shops and similar places where small particles of matter are likely to be found, inasmuch as many of the engineering operations require close and careful watching, and it is very easy for a splinter of iron or steel to fly from the lathe or from under the chisel into the eye of the mechanic. In order to meet such trouble a special type of extractor for dealing with magnetic particles embedded in the eye has been devised by Messrs. John Hunter & Co., of Paradise-street, Liverpool, and has been installed in the Liverpool Eye and Ear Infirmary; St. Paul's Eye Hospital, Liverpool; the Royal Eye Hospital, Southampton; the Royal Infirmary, Newcastle-on-Tyne; and the Royal Eye Hospital, Manchester. It is, in addition, used in the private practice of some of our well-known surgeons.

These magnets are manufactured of two types. One is a fixed type, which is used for operation on a patient when he is standing or sitting down, the other type is arranged so that the whole magnet can be tilted at such an angle that it can be used upon a patient in a reclining position on a couch. In the former types the apparatus consists of a heavy cast-iron stand, carried on gunmetal wheels, which are mounted on ball bearings, so that the magnet can be easily moved about the operating room. The magnet itself consists of a core of best Swedish soft iron about 3 ft. long and 6 in. in diameter. It is turned off blunt at the ends and screwed so that pointers of different shapes can be fitted as desired. The core is mounted on a cradle, which cradle is fitted on a cast-iron stand, a groove is cut at the top of the stand, and steel balls are fitted in this groove, the cradle which has a corresponding groove turned in it riding on the balls. The whole magnet can thus easily be turned round with a circular horizontal motion. It is energised by two coils, which are wound with about 200 lb. of double cotton covered insulated wire. The two coils are connected in series and a switchboard is provided, which can either be mounted upon the stand of the magnet or in a convenient position on the wall of the operating room. This board has the necessary main switches and fuses, and is provided with a regulating resistance in order to vary the strength of current in the coils, and therefore the degree of magnetisation of the magnet. The maximum current which is usually allowed in the winding of these magnets is 8 amperes and the pull obtained is 30 lb. per square inch at a distance of 1 in. from the magnet end. The height of the magnet from the ground is about 4 ft. 6 in., and its total weight about 4 cwt.

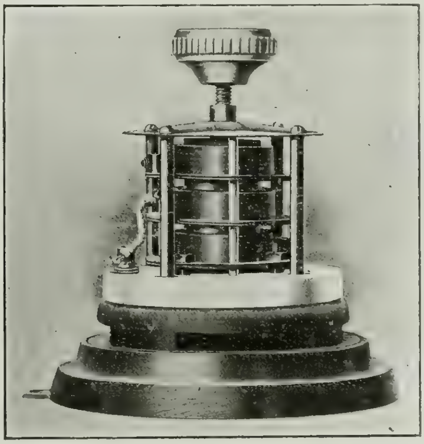
The magnet used for operating upon patients in a reclining position is similar in electrical details to the one described above, but instead of the magnet itself being carried on a cradle and arranged to move horizontally, it is mounted on trunnion bearings; a spindle is passed through the centre of the core at right angles to its length and a quadrant is fitted to the end of this spindle, which gears into a worm wheel fitted on the side of the stand. When the worm wheel is turned by hand the magnet tilts to the angle which is most convenient for operating upon the patient.

It will be seen from the above that electricity is proving itself of practical service in a sphere which would hardly be obvious on first thought, and it is interesting to note the acceptance with which this novel application of electric energy is being received among medical men.

A NEW ELECTRIC REGULATOR.

A supposed disadvantage of electric light is that it is impossible to use it in any way except in the "full on" position and that it cannot be regulated. It is often an advantage to certain persons to use a night-light in their rooms, but the ordinary electric light is too bright for this purpose, and some other means of providing a dim illumination has up to the present had to be resorted to. A means for obtaining such a dim light, and in fact of regulating an incandescent lamp through the whole range, from the "red hot hair pin" stage to "full on," has just been put on the market by the Electrical Regulators & Economisers (Ltd.), of Liverpool. The regulator by means of which this end is attained is shown in the accompanying illustration. In it no liquid is employed, but a mixture of "great natural elasticity," and consisting of materials not affected by very high temperatures, is used. This is contained in small cylinders each lined with insulating material and provided with a piston. No asbestos is employed.

Such a unit cylinder can be combined with others to form a regulator capable of carrying and regulating quite large currents, and such regulators will shortly be put on the market for general purposes. The points claimed for this regulator are dead steady working over long periods, greater range of control than in any other existing appliance, graduation such as cannot be obtained even with a liquid type of resistance, simplicity of construction, reliability and very low first cost. The standard type is applicable to any voltage from 4 to 250 volts without alteration or adjustment.



NEW REGULATOR. (Electrical Regulators & Economisers, Ltd.)

In connection with the use of this regulator for lamps it may be noted that switching metal filament lamps full on at one fell swoop has recently been shown to affect the life of the lamp owing to the stresses set up in the filament by the overshooting effect. This may to a great extent be avoided by gradually increasing the voltage to its full value; and it is preferable not to do this by contact steps. This fact may be readily demonstrated with this appliance by turning up the lamp gradually from a very low illumination and observing the bending of the filament; whilst if the regulator is turned very low and the lamp then switched on at the wall switch the reluctance of the filament to take up heat is demonstrated by the length of time elapsing between the switching on and the filament becoming luminous, thus making clear the heat inertia possessed by such lamps, in consequence of which, an initial rush of current occurs.

This fact is interesting as showing a weakness of the metal filament lamp, but a practical remedy is difficult. There is an obvious application for such a regulator in sick rooms, bedrooms, hospitals and theatres. It can also be applied to fan work and for starting and regulating small motors.

This latter application seems to us the direction in which such a regulator will be most widely used. It is cheap and seems to possess other advantages over the "wire" starter.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The thirty-sixth issue of the Supplement was published (Gratis) with the number of "THE ELECTRICIAN" for May 28th.

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STREET LIGHTING.

During the last year or two the competition between gas and electricity undertakings for the lighting of the streets of most of our towns has become very keen. The awakened activity on the part of the gas industry is due, doubtless, to their appreciation of the fact that the progress of electric lighting is threatening to oust the incandescent gas mantle from what has hitherto been regarded as one of its strongholds—viz., the lighting of small streets. Most gas undertakings have become reconciled to the installation of arc lamps for the illumination of important thoroughfares, but the carbon glow lamp has never been looked upon as a serious competitor in situations where the large amount of light furnished by arc lamps is unnecessary. The introduction of metal filament lamps on an extensive scale has, however, put a new complexion on affairs, and with this further competition the gas interests are making strenuous efforts to retain the street lighting which at present they provide. In this connection it has been no uncommon occurrence for experimental lamps to be erected for the purpose of showing what can be done by the various illuminants, and our readers will remember that in many cases the gas and electrical undertakings have been invited to compete by installing over short routes their suggested schemes for illuminating the streets. Where such tests are carried out on scientific lines and due attention is paid

to securing a fair and equitable basis of comparison, electrical engineers have little to fear as to the results obtained, and, in fact, would welcome the opportunity provided of demonstrating the high efficiency of electric lighting; but there is little doubt that such conditions rarely prevail, and in view of the difficulty of making an accurate comparison and of the many points involved, this is, perhaps, not surprising.

A case in point has lately arisen at Bradford, and there are indications that this case will be largely used by those interested in the gas industry as an example of the superiority of gas lighting, compared with electric arc lighting, for the illumination of large public thoroughfares. In a recent issue, when referring to the experimental lighting which has been under consideration by the Bradford City Council, our contemporary, "The Gas World," remarked: "The city owns both gasworks and electricity works, and, therefore, it matters not one jot to the ratepayers whether the streets are lighted by gas or by electricity, so long as they are lighted in the best and most economical manner. That gas has been selected under these conditions, and after careful and impartial trial, is a matter for congratulation, though not for surprise. The fact is, that gas must win on the merits every time, when merits are admitted into the equation." We would point out, however, that the words, "impartial trial," scarcely represent the actual condition of affairs. Full particulars of the trial will be found elsewhere in our present issue, and it will be seen that the sub-committee which reported to the Council on the trial arrived at their decision without troubling to consider any figures as to the comparative amount of illumination provided in the two cases, apparently forming their conclusions from an inspection of the lamps and from extraneous considerations. As the gas lamps were placed at a height of $11\frac{1}{2}$ ft. and the arc lamps were 25 ft. from the ground, it is, perhaps, not surprising that the members of the sub-committee were dazzled by the close proximity of the incandescent mantles—which are always carefully renewed immediately before such inspections. On another page will be found curves showing the distribution of light obtained with the two types of lamps used for the experimental lighting, and from these curves it will be seen how much greater is the illumination obtained with the arc lamps. Also, from an examination of the experimental lighting which we ourselves made last week, we can testify that the illumination provided by the flame arc lamps leaves little to be desired, a feature being its remarkable uniformity.

When it is remembered that the gas lamps were spaced on an average 19 yds. apart on each side of the road—*i.e.*, one lamp for each 9·5 yds. of thoroughfare, and that two tramway poles were also situated every 40 yds., the appearance of the pavement when the experimental gas lamps were erected can be imagined; in fact, it was designated a "skittle alley" in the local Press, and it was in marked contrast to the route where the flame arc lamps were installed on the tramway standards. There is no doubt that the excessive amount of lighting provided by the arc lamps and also by the gas lamps in the first test was unjustified by the circumstances, and this was evidently the opinion of the sub-committee, for they eventually arranged for half the gas-lamp columns to be removed and alternate arc lamps to be extinguished.

Careful investigation of the details of the experimental trial appears to show that the decision arrived at in favour of gas lighting was practically a foregone conclusion, and this view may be considered as supported by the fact that the financial results of the municipal gas undertaking have recently shown unmistakable signs of the progress made by the electricity undertaking; while instructions have actually been issued that all canvassing of gas consumers by the electricity department is to cease, except in the case of an extension of mains. This attitude throws much light on the situation, which is rendered more humorous by the fact that as soon as the electrical engineer issued his report, giving the cost of the arc lighting as 6s. 5d. per yard of street, it was followed by the report of the gas manager, in which the cost of the incandescent gas lighting was stated as 6s. $4\frac{3}{4}$d. per yard. Further comment is unnecessary, except to point out that electricity gave more than double the amount of light at about the same cost.

Some instructive information can, however, be obtained from the reports in question. Thus, much has recently been heard of the wonderful results obtained with high-pressure gas lighting. After an inspection of many existing installations the gas manager at Bradford had to report that such lighting would cost no less than about 18s. per yard of street, as compared with the figure of 6s. 5d. for flame arc lamps every 40 yds. Again, it will be seen that the gas manager claims greater penetrability for gas illumination in the case of fog, contrary to general experience. We must admit, however, that popular feeling in Bradford is at present favourable to incandescent gas lighting, largely on account of its colour, although on the introduction of this form of lighting some years ago the characteristic light of the mantles was generally considered a decided disadvantage.

To obtain the best results with arc lighting it is essential that the lamps should be placed high,—and the greater the candle-power the more important is this fact—but this point is not appreciated by the general public, who at present favour lamps at low levels, which dazzle—and injure—the eyes. Where the lamps can be placed at the correct height, and suitable globes used for distributing the light, the resulting illumination is remarkably uniform; and in this connection we should like to draw particular attention to the effects where ordinary and "dioptric" globes are employed. The distribution of light with the latter type of globe appears to be almost ideal for street illumination.

There is no doubt that in some cases electrical engineers will have a difficult task in overcoming popular prejudice, particularly where, as at Bradford, the public are satisfied with what in many towns would be considered totally inadequate lighting of the main streets; but there is also no doubt that eventually, when the loss of trade due to the inhabitants of neighbouring villages preferring to visit more up-to-date and better lighted towns is fully appreciated, and with the growing demand on all sides for increased illumination, electrical engineers will come by their own, for flame arc lamps undoubtedly provide at the present time the cheapest and—from the physiological point of view—the most scientific form of illumination for main thoroughfares.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

The Standard Handbook for Electrical Engineers. (London: E. & F. N. Spon. Pp. xx.—1,228. 17s. net.

In the preparation of this handbook, which is one of the most complete we have seen, many writers have been engaged. Altogether it consists of 20 sections, covering the whole science and practice of electrical engineering, including electrochemistry, telegraphy and telephony, and each section has been dealt with by a specialist. Thus, Mr. O. A. Kenyon has written several of the sections, whilst Mr. A. S. McAllister is responsible for those on "Electric Motors" and "Transformers," Mr. H. M. Hobart, in conjunction with Mr. Kenyon, for "Electric Generators," Mr. K. B. Miller for "Telephony," Mr. A. H. Armstrong for "Electric Traction," Messrs. E. Lyndon and O. H. Kenyon for "Batteries," Messrs. R. C. Beardsley and G. Shadd for "Central Stations," Messrs. A. N. Abbott and O. A. Kenyon for "Transmission and Distribution," Dr. Louis Bell for "Illumination," Dr. Roeber for "Electrochemistry," and Mr. W. H. Onken for "Wiring."

In compiling a book of this kind it is often difficult to draw the line between the textbook and the handbook. (We are glad to see that this is not called a pocket book.) Part of the work is perhaps too much like a textbook, which is undesirable, but other parts are excellent in giving condensed information of the type desired in a true handbook. We do not profess to have read every word, but in glancing through some of the sections we have noticed a few points that might receive attention in the next edition. Considering the importance of the silver voltameter some officially recognised method of using it might have been given. If apparatus is to be *described* then a slide wire type of potentiometer might well have been included. Under the heading of "Measurements" we were a little surprised to find motor rheostats and calculations for their design: this would seem more appropriate for the section on motors. If the double bridge method of measuring resistance is to be known by the name of Thomson, the latter should not be spelt with a *p*. In referring to oscillographs we think a reference to Duddell's instrument should have been made. In the section on "Properties of Materials" the electrochemical series of elements is given, but there is no indication that the order of this series depends on conditions. Useful information is given in regard to aluminium, but chemical readers will not be disposed to accept the statement that alumina is a harmless *salt*. In the ageing tests, due to Mr. Clinker, the temperature conditions are not quite clear. The classification of dielectrics and insulators, and the information so given, probably form one of the most useful parts of the book, and are typical of what a handbook should be. An excellent feature of the book is the use of heavy type, which renders prominent the subject of each paragraph.

The points referred to do not seriously detract from the value of the work, which engineers will find a very useful addition to their libraries.

Iron and Steel. By J. H. Stansbie. (London: A. Constable & Co.) Pp. xvi.—375. 6s. net.

Apart from the fact that iron is the one metal which, perhaps, more than all others has contributed to the development of civilisation, it, together with steel, possesses a great attraction for the engineer, especially if he be of the electrical persuasion. Unfortunately time, in the majority of cases, does not permit the study of a standard text book on the subject, and the matter is, therefore, liable to be neglected. This need no longer be the case, for Mr. Stansbie's book will, we think, meet a want in this respect, and will amply repay the time spent on it. It is a member of the well-known "Westminster" series, and is in no whit behind the other works of its kind that have come under our notice.

The book begins with a discussion of some elementary chemical matters, which may well be omitted by those having any knowledge of the subject. The subsequent chapter on "Materials Used in Iron and Steel Manufacture" should prove useful, though here again a certain amount of extraneous matter has been introduced, no doubt with a view to completeness. An historical *résumé* of iron manufacture from the times of Tubal Cain, or thereabouts, brings the author to a consideration of "Pig-iron and its Manufacture." This portion appears to be very complete, full descriptions of modern blast-furnace plant being supplemented by photographs and detailed drawings. Much interesting information is given on the composition of various alloys of iron and on modern foundry practice. The refining of crude pig-iron is of great importance both to ironmaster and user, and Mr. Stansbie has dealt with this subject as it deserves. The various refining processes are described at length, and special attention is paid to "puddling" and the products of the "puddling" furnace.

So much for what may be called the preliminary processes of manufacture, a subject which takes up the first 140 pages of the book. The author then passes on to the manufacture and properties of steel; and this portion of the work is as well done as the rest, special attention being, of course, paid to the Bessemer and Open Hearth processes. The following chapter, on "The Mechanical Treatment of Iron and Steel," contains an account of the various types of rolling mills and other apparatus now employed for working the metal. Mr. Stansbie does not, however, deal with the driving of such machinery, and the usefulness of the electric motor in this connection does not appear to be mentioned. Some interesting information is given about the mechanical properties of iron and steel, the appearance of the metals under the microscope and the lessons to be learnt therefrom. The effect of heat upon iron in its various allotropic forms and its eutectic properties are then discussed, while the way in which the properties of the metals vary with the amount of carbon "in solution" is discussed. The paragraphs on hardening and tempering should be of interest to engineers in general, and the description of the apparatus for achieving the desired degree of temper on a tool is as complete as can be expected.

The next chapter, on "Electric Smelting," will appeal specially to electrical engineers. The author has, however, seen fit to begin the chapter with a disquisition on dynamos and electrical theory generally before dealing with electric furnaces. The well-known furnaces due to Héroult, Kjellin and Stassano are described and illustrated; and the Rossi and Keller furnaces for smelting iron alloys are mentioned. We should, however, like to see rather more details about the cost of these processes, for there is no doubt that upon this their subsequent adoption depends. An interesting chapter on "Special Steels" concludes the book.

ANNUAL REPORT OF THE ELECTRICAL INSPECTOR OF FACTORIES.

We give below an abstract of the report of the Electrical Inspector of Factories, Mr. G. Scott Ram, on his work during 1908, which has just been published. The report begins by referring to the increasing use of electrical energy for motive power in factories, the figures for 1908 and the previous year being 443,000 and 357,000 respectively—an increase of 24 per cent. These figures are based on those given in THE ELECTRICIAN tables, and although 21 undertakings give no reply and certain small places are not included, the result given above is no doubt a reliable enough indication. The report then proceeds:—

Accidents in the following table show a slight increase over those of the previous year, but this is partly accounted for by the inclusion of accidents occurring in the generating stations and sub-stations of certain electric railways which were not included in previous tables. These account for 17 of the mechanical and 11 of the electrical accidents. Electrical stations of electric railways are under the Factory Act where any part of the current is used for lighting the railway, as, for instance, the station or tunnels. At the request of the Board of Trade, these electrical stations which were not previously under our inspection, are now visited by H.M. Inspectors of Factories. Probably the greater

Table I.—*Accidents at Electrical Generating Stations and Sub-stations*, 1908.

Description.	Companies and local authorities giving a supply by way of trade, and electric railways.		Private stations.	
	Non-fatal.	Fatal.	Non-fatal.	Fatal.
Non-Electrical.				
At engines, pumps, and generators	30	...	6	...
At boilers and steam plant.........	58	...	8	...
At coal handling plant..............	20	...	2	...
Falls	80	2	9	...
Struck by falling bodies............	36	...	3	...
Miscellaneous	87	1	7	...
	311	3	35	...
Electrical.				
At switchboards, when engaged in ordinary routine work; mostly due to faulty design of apparatus, or to mistakes on the part of the switchman	10	...	7	...
Cleaning, repairing, &c., at "live" switchboards or other "live" conductors	35	1	5	...
Cleaning, repairing, or other handling of switchboards supposed to have been made "dead":—				
(*a*) Skilled persons............	3	...	...	...
(*b*) Unskilled persons.........	...	...	...	...
Adjusting brushes, cleaning or lubricating commutators	16	...	2	...
Miscellaneous	10	1	2	...
	74	2	16	...

number of the electrical accidents under the second heading could have been avoided altogether if it had not been necessary to work on the conductors when alive. Several accidents occurred when the labourers were put to work without adequate precautions—the fatal accident was a case in point, and two other non-fatal accidents also arose from this cause. Three accidents from short circuit occurred through persons using metal rules. In the three accidents where the conductors were erroneously supposed to be dead, the injured persons were in each case cleaning or repairing extra high-pressure switches, and appear to have had only themselves to blame for not definitely ascertaining whether the pressure was cut off. In some of the accidents in lubricating or wiping commutators, in addition to severe electrical burns, very serious injury was also caused by the man's hand being dragged in between the commutator and the brush holder. Many of these accidents could be avoided by the use of a suitable holder for applying the wiper or the block of lubricant instead of holding it with the hand. Amongst the miscellaneous accidents there were three due to the use of hand lamps, one being fatal. In this case the lamp was being used inside a boiler. The pressure was 200 volts alternating. I dealt somewhat fully with this class of accident in my last year's report, giving illustrations of several types of dangerous lamps. The present case differs from the others in that the victim was not holding the lamp in his hand at the time, but was found lying upon it, a burn on his elbow showing where the contact was made. Another accident was due to a man touching the extra high pressure stator coils of a generator. I have drawn attention in previous reports to the inadequate guards often supplied by the makers of this class of machine. A remarkable feature of the accidents in this table is the number which occurred at extra high pressure systems without fatal results, although in most cases the injuries were very severe, and in some cases probably causing permanent disablement.

Table II.—*Reported Electrical Accidents in Factories, Engineering Works, &c., other than Electrical Generating Stations and Sub-Stations*, 1908.

Description.	Non-fatal.	Fatal.
Arcing of switches..	27	...
Arcing of fuses	19	...
Arcing at fuses, when replacing fuse wires..............	21	...
Portable apparatus, connectors, and flexible wires...	42	...
Unprotected conductors, switches, terminals, fuses, &c.	26	2
Working on live conductors, skilled persons	22	...
Working on live conductors, unskilled persons......	10	1
Miscellaneous accidents in electrical manufacturing works—mostly in testing operations	22	4
Miscellaneous	33	5
	222	12

The accidents due to arcing of switches occurred with only a few exceptions at motor starters and switches, were due to the absence of or inadequate protection of the apparatus. The cause of the arcing was generally the faulty construction of the switches. Those due to the arcing of fuses are mostly due to the absence of any protection at the fuse wires. Nine of them were at motor starting panels, where the man starting the motor is necessarily close to the fuses. Most of the accidents in replacing fuses were due to short circuits with bare metal fuse wires owing to there being no switch by which the pressure could be first cut off from the terminals. The number of accidents in the use of portable apparatus is considerable. In three the main injuries were shock in the use of hand lamps; in the remainder the injuries were burns due to short circuits. Fifteen of these, causing in most cases severe injuries to the man's hand, occurred when inserting the plug of the connector into the socket. Plug connectors as ordinarily designed are not satisfactory. Portable apparatus, and its flexible wires are very liable to get damaged when not in use, a short circuit in the conductors being formed. This is not detected until the next occasion that the apparatus is brought into use. An attempt is then made to put the plug into a live socket. The result is a flash at the contacts which burns the man's hand. The flash from the short circuit being often very severe on account of the circuit being much too heavily fused. Such accidents might be entirely avoided if electrical manufacturers would give these matters consideration in the design of the plugs. Such a plug should be arranged, firstly, so that the flexible wires enter it from below and not at the end, so that the wires do not pass through the hand of the person using it. Incidentally this arrangement offers the further advantage that the wires are not bent at the point where they enter the plug, the insulation being therefore less likely to be damaged at that spot, and further the wires are less likely to get loose in the terminals as persons cannot pull the plug out by means of the flexible wires as is not unfrequently done in the case of ordinary plugs. There should be a sufficiently large handle to afford a good grip. Between this handle and the live metal of the contact pins, terminals, &c., there should be a circular disc or shield to protect the user's hand in case of a flash at the moment of inserting the plug. The guard disc need not be large, for small plugs suitable for a hand lamp, $2\frac{1}{2}$ in. diameter would be sufficient. The flexible wires should enter the plug on the side of the guard disc away from the handle.

The accidents through unprotected conductors are mostly of a preventable nature. One of the fatal cases was due to the use of an unguarded high pressure arc lamp in a ship yard within reach of persons employed. The other was due to overhead wires carrying extra high pressure not being out of reach of a person on the roof of a building. It is not sufficient that dangerous wires should be placed out of reach merely of persons on the ground. They should be out of reach from any position in which any person is likely to have to be.

The danger involved in working on live conductors is evident from the fact that 22 of the 33 accidents occurred to skilled persons who should be fully acquainted with the risks. In the fatal case a boy of 16 was instructed to reverse the connections at the terminals of an alternating-current motor working at 275 volts pressure. There was no switch provided in the circuit whereby the pressure could have been first cut off. The entire absence of the most elementary precautions in this case, in spite of previous accidents, affords another example of the necessity for regulations.

The accidents in testing departments of electrical manufacturing works include four fatal cases. It is remarkable that the average age of twenty-one of the persons meeting with accidents in this class is only 20 years. Many of them are described as apprentice electrical engineers. The reason of this is no doubt that the young apprentice likes to get into the testing department, as the work is more interesting and instructive and probably less irksome than in the shops, and, on the other hand, he is useful to the employers on account of having had some training in a technical college. There can be no objection to the employment of young apprentices in this work provided that there is a responsible competent person to supervise the operations. The apprentice seldom has an adequate appreciation of the dangers, and takes risks which an older man would shun. Whilst many testing departments are most carefully conducted and supervised, there are others quite the reverse. The work of such a department frequently requires temporary arrangements of conductors and apparatus varying with each test, but this is no reason for neglecting the corresponding necessary temporary precautions. Much of the apparatus and conductors can, however, generally be arranged in a permanent manner and permanently safeguarded, and this should always be done so far as practicable. In some works anything is considered good enough for the test room. Switches without any quick-break action, and which would not be tolerated for similar work elsewhere are used; cables with the insulating material hanging in shreds are considered good enough, and so on, adding unnecessarily to the risks. Three of the fatalities occurred in connection with pressure testing. One was due to the inadequate guarding of a wire carrying a pressure of 20,000 volts. There was only a single bar wood fence insecurely fixed to screen off this wire and the apparatus in use from the rest of the test room, the wire being only a few inches within the fence. An apprentice was employed a few feet away at a table. He subsequently got up from the table and came into contact with the wire and was killed. A securely fixed and adequate fence should be used for such work, but can, of course, be arranged so as to be readily removable. Another of the fatal cases also emphasizes the necessity of adequate fencing to keep persons away from danger during pressure testing. This occurred at the testing tank in a cable works. There was a single bar barrier at the entrance to the gangway alongside the tank and danger notices were exhibited. A man employed at the test tank, in preparing the connections to the cables for testing, evidently did not consider that the notices applied to him. He passed the barrier and the notices, and came into contact with a 6,000 volt lead and was instantly killed. Another fatality occurred in the testing of

mises states the victim taking hold of the end of the test cable before the pressure was off. Precisely what led him to make the mistake is not clear. The fourth case was of an unusual kind, and appears to have been due to a very high instantaneous pressure, produced by breaking the field circuit of a large motor, giving a severe shock to a man holding the hand wheel of a rheostat in the circuit, although the hand wheel was insulated from the moving arm of the rheostat sufficiently for ordinary purposes.

The "miscellaneous" accidents include five fatalities. One of these occurred to a crane driver in the cab of a jib crane on a wharf. The system was 400 volts 3-phase. The main switch, ammeter, &c., were fixed on a steel plate which was in turn attached to wood work. A leakage had occurred at the ammeter causing this plate to become charged. The man was found lying on the floor of the cab and his hand was burnt. It is supposed that he touched this plate or the case of the ammeter whilst he also had his foot on the metal brake lever, and so received the shock. The metal plate should of course have been connected to earth, but this had not been done. There is also an alternative explanation of the accident, as the switch, which was without cover, was of a type which I have so often described and condemned, in which the hand is liable to touch live metal when grasping the handle. In either case the precautions were inadequate. The second fatality was on a 3-phase system, 440 volts, at a travelling coal stamper at coke ovens. The attendant attempted to get too close to the trolley wires without first turning off the switch provided for cutting off the pressure, and came into contact with the live wires. The third fatality occurred at an electric welding plant. The man, who was a smith's striker, took hold of the end of a bar of metal which was being heated, and was killed by shock. Although the normal pressure in the welding circuit would be only a few volts, a leakage had occurred in the transformer from the primary winding where the pressure was 300 volts. In this case the welder was of a type having one insulated jaw, the other being in metallic connection with the frame. The accident could not have occurred if the frame had been properly earthed. An attempt had been made to earth it by connecting by means of a single No. 18 wire to a small plate buried in the dry ground below the floor of the shop. A plate in such a position would be quite useless, even if the small connecting wire did not get broken. The fourth fatality occurred to a man at work on a pole carrying live wires at 200 volts, and it is not clear whether he was killed by the shock or the fall. The fifth fatality was similar, death being due to a fall following shock from a 500 volt trolley wire. In both of these cases the pressure should have been cut off the wires before allowing the men to work.

One or two other accidents in this class, although not involving loss of life, are worth notice. One was due to an overhead travelling crane becoming charged up, a man on the ground at the sling getting a shock. I have described similar accidents in former reports. Such cranes should be connected to earth through the running rails on the gantry. These rails should be electrically bonded together and earthed. A rubbing contact between the crane and the rails should be provided, as a connection through the bearings and the axles of the wheels cannot be relied upon on account of the film of oil or grease used for lubricating.

Another accident from shock occurred to a man when taking hold of a leaky lamp fitting on a rising and falling pendant. The voltage was 200 alternating. He was in connection with earth through some metal he was holding with the other hand. Another accident shows the necessity of using special flame-tight apparatus in places such as dry cleaning works or enamelling works where there is inflammable vapour about. In this case a fuse blowing set fire to a tank of benzene enamel 7 ft. away. Switches and fuses should not be in the same room with such substances where it can be avoided. Another accident again emphasises the importance of properly earthing motor frames, &c. A man received a severe shock when using an emery wheel directly connected to a motor. Another accident again shows the danger of leaky lamp holders in places where the person handling them is in connection with earth. A man standing on earthed metal was about to change a lamp, and on taking hold of the holder received a severe shock, rendering him insensible.

As examples of dangerous conditions of plant I found in electrical stations of authorised electricity supply undertakings a number of dangerous switchboard passage-ways, some where there was no protection whatever at the high-pressure apparatus, not even by cellular divisions between the different panels or conductors. In some the blades of isolating switches when in the "off" position, in which position, however, they were live, projected into the passage, in two cases just at the entrance where a person would be most likely to inadvertently come into contact with them. In a high-pressure generating station of a local authority the switchboard, which although not new had been recently remodelled, had dangerous passage-ways—one having exposed live conductors at high pressure on each side, the width of the passage between the live conductors being only 2 ft. 6 in. In a generating station of an electric supply company, the main extra high-pressure switchboard, not more than two years old, had a narrow passage-way at the back containing the switches and other apparatus along the side. There were bare connections from these to the bare 'bus-bars placed immediately above the passage and only 6 ft. 6 in. from the floor, no protection whatever being provided. The passage was, however, closed by a locked gate. In a transforming sub-station belonging to the same undertaking, the medium pressure distribution switchboard, consisting of switch fuses, was fixed on the wall behind the transformers. The extra high-pressure leads to the transformers were brought up in front of the transformers, and for the [illegible] tape had been deteriorated. These tail ends of the cables were therefore quite unsafe to touch, and yet anyone having to use the switch-fuses would perforce have to lean against them. [illegible] trap. In the same sub-station the extra high-pressure fuses were of an oil-immersion type. No oil was, however, in use or provided. I have frequently described cases where not only safety but ordinary convenience in working has been sacrificed by unnecessarily cramping the arrangement of plant and apparatus. I found this again in the main sub-station of a public supply undertaking, having a bulk supply from a power company. I found some quite new underground transforming sub-stations already put to work, the floors being covered with water due to leakage through the structure.

I found on factory premises and in public supply generating stations further examples of motor switches both for continuous and alternating current of a dangerous type, where the hand is liable to touch live metal when grasping the handle, fixed over iron floor plates where the user is in danger of getting a severe shock to earth, the precise conditions which have, in fact, led to fatal accidents. I found a number of cases of series incandescent lighting on 550 volt alternating circuits, with the lamp holders and metal shades not earthed, suspended out of doors or over iron floors where a leakage in the lamp holder might readily, as it has done before, lead to fatal accidents.

I also investigated, on behalf of the Mines Department, an electric shock fatality in a coal mine. This occurred on a concentric system with bare outer conductors earthed at the generating station. On the branch circuit where the accident occurred there were, however, fuses on both conductors. The outer conductors had become charged up owing to the connection with earth having become broken by reason of the fuse having blown while the fuse on the inner continued to hold. There should, of course, have been no fuses or break of continuity of any kind in the outer conductor. There was, however, a local earth connection beyond the fuses, but it did not prevent the outer conductor from becoming charged so that the man who grasped it was killed, his hand being burnt to the bone. This local earth connection was made to a water pipe nearly 200 yds. in length, partly lying in water. The connecting cable was, however, loose, both on the outer conductor and on the water pipe, and did not, therefore, make a good contact. It is unfortunately a very prevalent idea in regard to work above ground as well as in mines that any kind of connection is good enough for earthing purposes. Joints in earth connections require just as careful making as those in conductors.

Mr. Ram then deals with the question of earthing apparatus and machinery, and the very inefficient way in which this is usually done, leading to accidents and shocks. Instead of using a number of isolated earth plates it is a better plan to run a special earth strip with the necessary branches throughout the installation, connecting to the various parts which require earthing, this strip being itself connected to earth. It need be so connected only at one point if a really good earth is provided. The size of the earth cables should in every part of an installation bear a definite relation to the size of the conductors in each part, and should be large enough to carry, without overheating, current sufficient to blow the fuses protecting such part or branch.

Table III.—*Reported Electrical Fatalities, 1908. System and Voltage.*

No.	Month.	Place.	Voltage of System.	System. A = Alternating, C = Continuous. 1 = Single-phase, 3 = Three-phase.
1	January	West Hartlepool	1,500	A.
2	February	Manchester	20,000	A.
3	February	Edinburgh	?	A.
4	February	Eston Jetty......	400	A 3.
5	May	Jarrow	275	A 3.
6	May	Middlesbrough...	2 700	A 3.
7	May	Woolwich	6,000	A.
*8	July	West Ham	500	C.
9	August	Bolton	300	A 1.
10	August	Wigan	440	A 3.
*11	August	Winchburgh......	200	C.
12	September	Preston	500	C.
13	October............	Queenborough ...	6,500	A 3.
14	December.........	London.....	202	A 1.

* Fall following shock.

The report then gives a general *résumé* of the exhibits at the Manchester exhibition last October, the exhibits at which showed, it is considered that considerable attention is being made to the design of safety apparatus. Some of the more important exhibits are described in some detail. Attention is called to the way in which connection is made between the tubing carrying the supply cable and the motor. A space is often left; but this is unnecessary, for a length of flexible tubing can be used in which the wire is carried and the whole, motor and connecting tubing, can be moved sufficiently for belt tightening purposes. The report continues:

Although, as I have stated, the exhibits generally indicated that much more attention is paid by manufacturers to questions of safety than was the case a few years ago, there were nevertheless examples showing that this point of view is still frequently overlooked by the designers of apparatus. There were, for instance, extra high-pressure motors having insufficient protection of the high-pressure parts. There were numerous examples of switches constructed so that the user's hand is in danger of touching live metal. Grip fuses for heavy currents were shown, having the porcelain grip too small, in some cases scarcely 3 in. in length, so that the user could not grasp the handle with more than three fingers.

and would probably in consequence touch the live metal with his other finger. In another case a distribution board of excellent workmanship and having good grip fuses, $4\frac{1}{2}$ in. in the porcelain grip, was entirely spoiled by the arrangement being such that several of the grip fuses could not possibly be handled without the hand touching the live 'bus-bars or the main terminal lugs. Change-over switches were shown having the handle arranged in such a way that in switching on to one set of contacts the live blades coming from the other contacts would inevitably touch the user's hand or wrist.

In conclusion, reference is made to the new regulations, and to the inquiry held by Mr. James Swinburne, F.R.S., into the objections received to these rules. An account of the proceedings at this inquiry, and the rules as amended which will come into force on the first of next month, have already been published in THE ELECTRICIAN.

The regulations, it is hoped, will have the effect, by improving the standard of work generally, of reducing the number of preventable accidents. It is evident that a large number of the accidents which have occurred in the past have been caused by neglect of such precautions as will now be required. Nearly all the cases of bad and dangerous work and conditions which I have described and commented upon in my annual reports for some years are now covered by the regulations.

A STREET LIGHTING TEST AT BRADFORD.

Although as regards the lighting of side streets the ratepayers of the city of Bradford have little of which to complain, this does not apply to the main thoroughfares, where the low candle-power incandescent gas lamps serve merely as signposts, indicating the directions pursued by the various streets. In view of the fact that for many years the gas department made no charge for lighting the streets, the low standard of lighting prevailing is, perhaps, not surprising; but

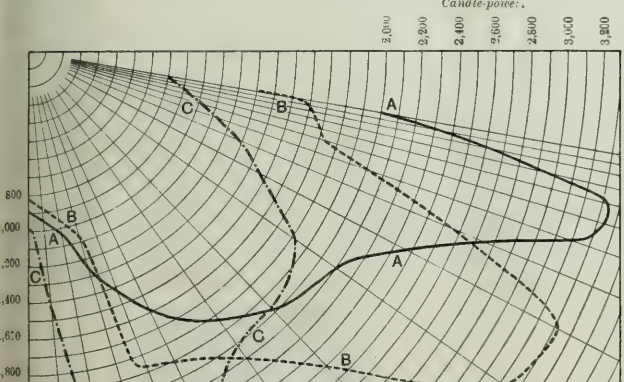


FIG. 1.—CURVES SHOWING DISTRIBUTION OF LIGHT FROM FLAME ARC LAMP.

A. With "dioptric" globe. B. With reflectors in ordinary globe. C. With ordinary opalescent globe.

it has resulted in the inhabitants becoming accustomed to what in most towns would be considered insufficient illumination. From time to time, however, applications are made by the more up-to-date residents for the provision of additional lighting in their respective districts.

As the result of such an application, a special sub-committee of the Finance and General Purposes committee was appointed some time ago to report on the subject of street lighting in the centre of the city. This sub-committee visited London for the purpose of inspecting and comparing the various systems of street lighting by gas and electricity, and eventually recommended that the Electricity committee and the Gas committee be each authorised to light up experimentally for purposes of comparison a length of about $\frac{1}{2}$ mile of some thoroughfare. The choice fell on Manningham-lane, for which road it was felt that improved lighting was necessary.

In accordance with this resolution, a length of 707 yds. of Manningham-lane—viz., between the Theatre Royal and Burlington-street—was illuminated by 18 "Excello" 16-hour, single-carbon, 8 ampere flame arc lamps. These were of 2,500 nominal c.p., and were arranged in two circuits, one on each side of the road. The existing tramway standards were utilised, so that the lamps were spaced about 40 yds. apart, and the brackets were fixed at a slight angle to the span wires supporting the trolley wires to allow of the lamps being raised and lowered by means of a winch without fouling the wire. The height of the arcs from the ground when the lamps were in position was 25 ft. 3 in., resulting in a good distribution of the light on the road and pavements, whilst at the same time foot passengers were not inconvenienced by the glare of the lamps, which is so noticeable when short standards, such as those customary with gas lighting, are employed.

As indicating the enormous improvement in the lighting, we may mention that the 18 arc lamps, each of 2,500 nominal c.p., replaced 22 gas lamps, for each of which 150 c.p. was claimed, two incandescent mantles being fixed in each lamp. Taking the actual candle-power of the arcs, as shown by the curves, to be 2,200 c.p., it will be seen that the total candle-power provided by the arc lamps was 39,600, as against 3,300 by the existing gas lamps—that is to say, 12 times as much.

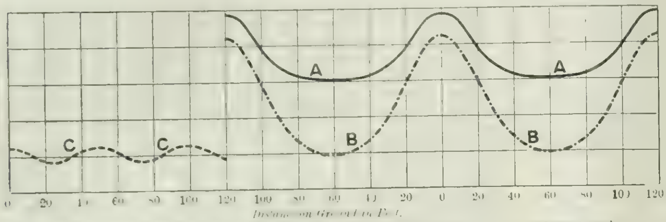
The Electricity committee offered to supply and maintain the lamps, including current, carbons, trimmers' wages, repairs, &c., for the sum of £12. 10s. per lamp per annum. This figure was based on current at 1d. per unit, £6 for wages, repairs and carbons, and an allowance of 10 per cent. for depreciation, &c. It should be noted that the total energy consumption was estimated at 19,461 units per annum, allowing for half the number of lamps being extinguished at 11 p.m. A great advantage claimed for the arc lamp method of illumination was that, owing to the possibility of utilising existing tramway standards, there was no obstruction of the pavement by additional posts. It is interesting to note that the cost of each lamp erected complete with overhead mains was £20.

In his report on the gas lighting experiment, the gas engineer stated that high-pressure gas lighting, although giving twice as much light per foot of gas used, would have necessitated considerable outlay on compressing plant, special mains and maintenance, and he did not consider that high-pressure lamps of 1,000 c.p. or 2,000 c.p., at a height of 20 ft. to 25 ft., would give such a uniform distribution of light as a larger number of smaller units placed closer together and at a lower level. The gas department had, therefore, erected 75 lamps in the portion of Manningham-lane from Burlington-street to the back of Mount Royd, a distance of 703 yds. The lamps were of the ordinary pattern fitted with three new type Bray burners, and were said to average about 3·84 cubic ft. of gas per hour, whilst the height of the mantles above the ground was $11\frac{1}{2}$ ft. The lamps were placed on an average at a distance of a little over 18 yds. apart on both sides of the road. The average cost of each lamp erected complete was stated to be £4. 19s., whilst the maintenance was estimated at £1. 4s. 3d. per lamp. Taking the previous year's figure for the cost of gas—viz., 1s. 5d. per 1,000 cubic ft.—the total cost worked out at £2. 19s. 11d. per lamp, or 6s. $4\frac{1}{4}$d. per yard of street (although when only 22 two-burner gas lamps were previously used the cost per yard of street was stated to be 2s. $5\frac{1}{2}$d. per yard). A plan of the street, showing the position of the lamps is given in Fig. 3.

After the experimental lighting had been in operation for some little time complaints were raised by members of the Council that the light provided by both schemes was excessive, and, in view of the high rates, extravagant. It was, therefore, decided that only half of the gas lamps were to be used in future, and that one series of arc lamps—*i.e.*, nine lamps—was also to be left out. After the sub-committee had again inspected the lighting they decided in favour of gas lamps on both sides of the road, spaced approximately 38 yds. apart. No particulars regarding the actual amount of illumination provided by each system of lighting were placed before the sub-committee, who judged the effect solely by their own observations.

The accompanying curves (Fig. 1) show the distribution of light for one of the arc lamps used in the tests. It will be noticed that three curves are given. These represent the distribution of light (1) when the ordinary globe supplied with the lamp was fitted, (2) when an arrangement of reflectors was fitted inside the globe, and (3) when a special type of globe, of "dioptric" pattern, which has only just been placed on the market, was used. The feature of this globe is the large amount of light which is projected in a direction approaching the horizontal. This feature makes the globe particularly suitable for street lighting, and the difference which results in the illumination of a road when the ordinary type of globe and the "dioptric" type is fitted is clearly shown in Fig. 4. This diagram illustrates the horizontal illumination in candle-feet obtained at a height of 4 ft. 3 in. with two flame arc lamps fixed 40 yds. apart, when globes of the

customary type and of the "dioptric" pattern are employed. It will be seen that the minimum illumination is largely increased in the latter case, whilst the maximum illumination is at the same time decreased, with the result that the illumination is much more uniform and the general appearance of the lighting is greatly improved. Fig. 2, which was supplied to us by Mr. T. Roles, the city electrical engineer, is interesting as showing the comparative results obtained with the various forms of lighting, but it must be remembered that the values given are calculated from the characteristic



A. Flame lamps with "dioptric" globes. B. Flame lamps with ordinary globes. C. Incandescent gas lamps.

Fig. 2.—Calculated Curves (obtained by Bradford Corporation) showing variation of illuminating power in centre of Road.

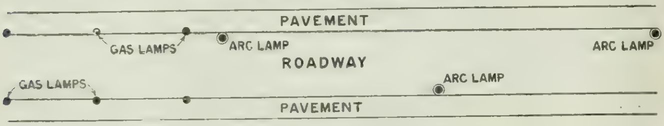


Fig. 3.—Plan of Road showing Position of Lamps.

curves of the lamps, and are not experimental determinations in the street; moreover the illuminations are approximately perpendicular to the rays, and, therefore, although affording a comparison they do not apply to street illumination as ordinarily determined.

It was generally stated that the inhabitants considered the gas lighting superior to electric lighting, and this is probably to some extent true, for the yellow colour of the arc lighting was objected to by a number of people as being unpleasant to the eye. The gas was also generally considered to give the better light, but this impression was undoubtedly due to the fact that the gas lanterns and the sources of light were very near the eyes of pedestrians, whilst the arc

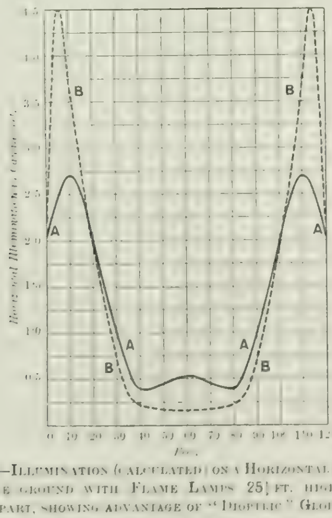


Fig. 4.—Illumination (calculated) on a Horizontal Surface 4½ ft. above the ground with Flame Lamps 25½ ft. high, and spaced 40 yds. apart, showing advantage of "Dioptric" Globe.

A. With "dioptric" globes. B. Globes of ordinary type.

lamps were high over the road, so in the latter case the eye was not so much affected by the lamps being in the field of view, and a better judgment could be formed of the illumination. The physiological effect is, undoubtedly, the cause of many erroneous popular impressions as to the amount of light obtained from electric arc lamps and gas lamps. No complaint whatever was made as to any unsteadiness of the light from the flame arc lamps.

There are several local reasons why the gas lighting was looked upon with considerable favour. The city of Bradford is made up of the original township of Bradford together with a number of other smaller townships which have been added thereto, and a certain amount of local jealousy is, therefore, apparent. It is contended by the inhabitants of the outlying townships that their main streets should be as well lighted as those in the centre of the city, and that if electricity is used for the purpose in the latter it should be similarly used in the former. Probably another factor in the decision was that the gas figures for the past few years have not been so satisfactory as they once were, due to the competition of the electricity department, and it was undoubtedly felt that were electric lighting to be adopted for the main streets a further blow would be given to the gas undertaking.

We obtained much of the information given above from an inspection of the street lighting at Bradford which we made last week. Our observations showed that with "dioptric" globes in use the illumination of the road was very uniform, and no objection, such as is occasionally raised against flame arc lighting, could possibly be brought forward as to patchy or uneven lighting. The gas lamps presented a long row of bright sources of light, but the actual illumination of the road was distinctly less than with the arc lighting, whilst in regard to shadows there was nothing to choose between the two methods of illumination, owing on the one hand to the large number of gas lamps, and on the other to the height of the flame lamps.

The array of posts obstructing the footpaths, usually associated with a large number of low candle-power lamps, would not be tolerated in many towns, and the removal of all additional obstructions by placing the arc lamps on the tramway standards considerably improves the appearance of the road. The Excello lamps burned with great steadiness, and the colour of the light, when once the public have become used to it, would prove much more pleasant than the greenish tinge associated with all incandescent gas lighting. Our inspection satisfied us that in comparative tests, where due regard is paid to the amount of illumination obtained and to the possibility of removing a multitude of posts from the pavements, flame arc lighting can easily be proved superior to the most modern type of lighting by incandescent gas.

CORRESPONDENCE.

MOTOR CONVERTERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of 21st ult. a letter from Mr. Rosenberg appears referring to the discussion at the I.E.E. when my Paper dealing with motor converters was read before that Institution.

When criticising the Paper Mr. Rosenberg did not confine himself to the point he now raises, but made several irrelevant statements of such surprising nature that I advised him, in the few seconds at my disposal for verbal reply, to read the Paper again.

I do not agree with correspondence or controversy in the technical press on the subject matter of a Paper read before a scientific institution until the Paper, the discussion and the full reply to the discussion have been published, but at the same time I cannot let Mr. Rosenberg's letter pass without saying that he is still labouring under a misapprehension, and if he will wait until my full reply is published I believe he will then agree that my previous recommendation was amply justified, and my statement to the effect that when comparing the motor converter and the rotary converter running under the same conditions (*i.e.*, when supplying the same leading wattless current to the mains) the factor K is the same for both—or, putting this in another way, the 30 per cent. wattless current referred to must for a true comparison be taken as the current in the stator and not in the rotor winding—is substantially correct.—I am, &c.,

Edinburgh, May 31. H. S. Hallo.

B.T.-H. CONTINUOUS-CURRENT MOTORS AND GENERATORS.

The electric motor has now, it will be agreed, become a quite standardised piece of apparatus. Each maker has his own particular way of doing some particular thing, but on the whole the finished production of one firm is not unlike the finished production of another, being given that equal care is expended in the design and that good quality materials are employed throughout.

This being the case, any departure from the beaten track is rather an achievement, and for this reason we are pleased to be able to notice a type of continuous-current motor just introduced by

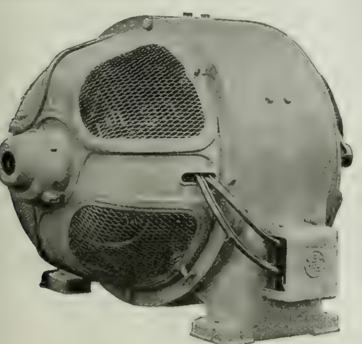


FIG. 1.—D.H. MOTOR WITH EXPANDED METAL COVERS. (BRITISH THOMSON-HOUSTON CO.)

the British Thomson-Houston Co., of Rugby, which appears to possess some novel features, while at the same time retaining all the serviceable details which are the property of this firm's well-known machines. In the construction of these motors only the best quality material is used, and this remark applies specially to the insulation employed on the armature and field coils. Great care is taken to remove all moisture. To do this the insulated conductors of which the coils are formed are subjected to a drying process and then treated with a special moisture-proof compound. Further, these coils are submitted to an alternating pressure of 1,500 volts for a period of 60 seconds when hot so that if the insulation is liable to break down this test should discover the fact.

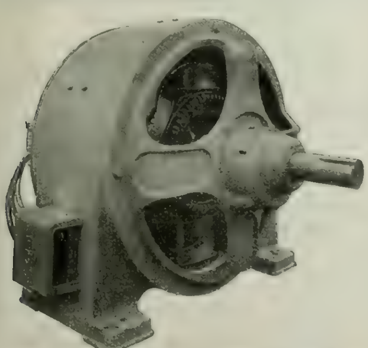


FIG. 2.—D.H. "PROTECTED" MOTOR. PULLEY END.

The armature core of these motors consists of laminations of sheet steel of high permeability. These laminations are slotted in the usual way to receive the winding and are clamped under pressure between substantial end flanges. The cores are provided with radial ventilating ducts to allow free circulation of air through the body of the armature to be obtained. At the ends of the armature and also in each ventilating duct, steel spacers are provided to support each tooth. This construction prevents, it is claimed, the vibration which sometimes occurs with unsupported teeth.

The armature winding is made up of form wound coils which are carefully insulated, as are also the slots in which they are embedded. The coils are secured by binding bands. The commutator is built up of hard-drawn copper segments which are insulated from each other by mica strips. The commutator shell is forced into position and rigidly keyed to prevent any relative movement between the armature winding and the commutator. This shell is provided with ventilating ducts. The magnet frame on these motors is of cast-iron and the poles are rigidly bolted to it. These poles are built up of laminated steel, and can be removed with their field spools without any displacement of the armature being necessary. This is certainly a point of great importance to the user. The field coils are held on by the projecting pole tips.

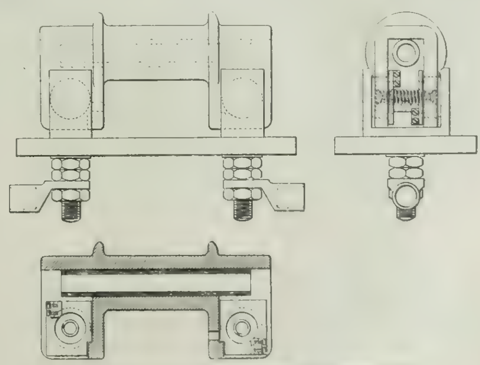
The brushes are of carbon and are carried in brushholders of the clock-spring type so constructed that the tension of any brush is uniform throughout the life of the brush and is readily adjusted without removing the brush from the commutator. Flexible connections are employed for carrying the current direct from each carbon brush to the body of the holder, thus making a positive connection between the two.

All these new motors are designed to stand a full load test for six hours with a thermometric rise in temperature not exceeding 72°F,, while they are capable of standing 25 per cent. overload for one hour and 50 per cent. momentarily. If the machines are totally enclosed these figures need some modification, and such machines can be provided with fans whereby forced ventilation is effected.

Our illustrations show the commutator end of one of these new motors fitted with expanded metal covers and the pulley end of another which is of the protected type.

A NEW PORCELAIN HANDLE FUSE.

In our last issue we gave some account of the specialities turned out by Messrs. Wellman-Seaver & Head in the domain of electric control apparatus, and we are now able to supplement this to some extent. Not one of the least important pieces of control apparatus is the fuse, and the new porcelain handle fuse which we illustrate in the accompanying drawing has been designed to overcome the troubles experienced with the ordinary type fuse with square brass ends fitting into ordinary copper clips. We only hope it will be able to effect this end. The disadvantages of the old type fuse were, that however carefully the brass end was fitted in the clips, the contact was always liable to be reduced by the clips getting bent with



ELEVATION AND SECTIONS OF NEW ENCLOSED FUSE.

rough usage; and most fuses, even the best designs, after being in use for some time, made contact only on part of their clips. Owing to the ends heating and expanding in use the porcelain broke at these points. The method of fixing by cementing a brass end on a porcelain handle was an unmechanical and unsatisfactory job. If the handle was broken a complete new fuse was necessary, involving heavy renewal costs where breakages were frequent.

These difficulties are got over in this fuse by making the whole fuse in porcelain with square hollow ends. The ends are provided with windows on two opposite sides, through which the contacts project, and which are held in position by a spiral spring between them. The fuse is then mounted in a solid machined clip.

The contacts are thus made self-aligning and make a very good contact. There is no cement. The spring allows for expansion without danger. The clips cannot be bent, and in the event of the porcelain handle being broken, the cost of replacement is small as only the porcelain needs renewing, the old contacts being easily fitted into the new frame in a few minutes.

NOTE ON HORIZONTAL RECEIVERS AND TRANSMITTERS IN WIRELESS TELEGRAPHY.*

BY PROF. H. M. MACDONALD, F.R.S.

In a previous communication † Mr. Marconi has given the results observed when a straight horizontal conductor is substituted for the usual vertical conductor employed as a transmitter or receiver at a wireless telegraph station. The object of the following note is to consider the theory of such an arrangement, or, at any rate, one aspect of it. The receiver, as being the more important, is considered first.

Let AB (Fig. 1) represent the horizontal receiver, consisting of a straight conductor having the end A connected to a spark-gap, CC_1, or other wave detector. The electric oscillations in AB can be represented by a distribution of Hertzian oscillators along AB, and, if L denotes the current strength at any point of AB, it must satisfy the conditions $L=0$ at B, the free end, and $dL/ds=0$ at A, since the electric force perpendicular to AB at A must vanish. If the distance of AB from the earth is not too small, the effect of the oscillations belonging to the image in the earth of AB on those in AB may be neglected, the radiation from the free end B will be approximately symmetrical with respect to AB, and the oscillations in AB are then

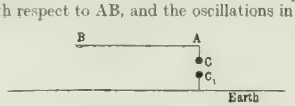


FIG. 1.

approximately the same as if BA formed part of a semi-infinite straight conductor in which a system of oscillations is being maintained, B being the free end and A the first node from the free end; the wave-length of these oscillations is very approximately five times the length of AB,‡ and therefore the receiver is of maximum efficiency when its length is one-fifth of the length of the transmitted wave, a result observed by Marconi.§ When the distance of AB from the earth is so small that the effect of the oscillations in the image of AB in the earth on the oscillations in AB is not negligible, the radiation from the free end B will not be symmetrical with respect to AB, but may be taken as being approximately symmetrical with respect to some line through B making an angle with BA; the wave-length of the oscillations in AB is, therefore, equal to the wave-length of the oscillations in a bent conductor joining AB: that is greater than five times the length of AB, and, therefore, in this case the receiving conductor has its maximum efficiency when its length is somewhat less than one-fifth of the length of the transmitted wave, a result also observed by Marconi. To examine the effect of the orientation of the receiver, consider a straight conductor, BAB′, twice the length of AB (Fig. 2), and its image, $B_1A_1B_1'$, in the horizontal plane, A and A_1 being their middle points respectively.

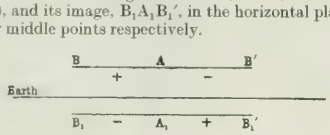


FIG. 2.

When electric oscillations are being maintained in BB′ with the corresponding set in B_1B_1', A and A_1 are nodes; hence, if a wave detector is placed in AA_1 no effect will be observed in it due to its own oscillations, and therefore the P.D. at CC_1, due to the forced oscillations in the receiver when the receiver AB is in the position Fig. 1 is equal and opposite at any instant to the P.D. at CC_1 when the receiver is in the position which results from turning it through two right angles round CC_1. Now, the total effect at CC_1 is made up of two parts, one due to the direct action of the advancing waves, the other due to the oscillations in the receiver. If in Fig. 1 the advancing waves be supposed to be travelling from left to right, the oscillations in the receiver may be regarded as the resultant of two sets of progressive waves, one travelling from B to A and the other from A to B; and, since the oscillations in the receiver are maintained by the advancing waves, the set of progressive waves in the receiver travelling from B to A must be in the same phase as the advancing waves at A. Further, since the electric force perpendicular to AB at A vanishes, the electric distribution on AC has at any instant the opposite sign to that on AB, and therefore the P.D. at CC_1 due to the oscillations in the receiver is at each instant in the opposite phase to the P.D. due to the direct action of the advancing waves. Hence, if α denote the maximum P.D. at CC_1 due to the direct action of the advancing waves, and β the maximum P.D. due to the oscillations in the receiver, the P.D. at CC_1 at any instant is $(\alpha-\beta)\cos pt$. When AB is turned through two right angles round CC_1, the advancing waves still travelling from left to right, the set of progressive waves in the receiver travelling from B to A must be in the opposite phase to the advancing waves at A, since the oscillations in the receiver are, as before, maintained by the advancing waves, and therefore the P.D. at CC_1 due to the oscillations in the receiver is in this case in the same phase as that due to the direct action of the advancing waves, and is at any instant $(\alpha+\beta)\cos pt$. Hence, the total effect at CC_1 is greater when the free end B is pointing directly away from the transmitter than when it is pointing directly towards it. In the above the receiver AB has been assumed to be placed perpendicularly to the wave fronts of the advancing waves. When, in Fig. 2, BB′ is in the plane of the wave fronts of the advancing waves no oscillations will be set up in BB′; and, therefore, when BB′ makes an angle, θ, with the direction of the advancing waves, the amplitude of the oscillations in BB′ lies between zero and the value corresponding to $\theta=0$. Hence, when the receiver AB makes an angle, θ, with the direction in which the transmitted waves are advancing, the P.D. at CC_1 is $\alpha\cos pt+f(\theta)\cos(pt+\epsilon)$, where $\beta>f(\theta)>0$, and ϵ depends on θ. If, then, a curve be drawn to represent the P.D. in terms of the orientation of the receiver, it will be of the form of the figure 8, with unequal loops, the larger loop being further from the transmitter, its greatest radius being $\alpha+\beta$.

When the horizontal conductor is used as a transmitter its effect is made up of two sets of oscillations, one from the oscillations in the horizontal conductor emanating from the free end, the other from the vertical spark-gap. At a distance the effect of the first set is the same as that of a horizontal Hertzian oscillator with its image in the horizontal; hence, choosing axes of reference such that z is vertical and x is measured horizontally in the direction of AB, the vertical electric force at a distance due to this set is

$$B\frac{\partial^2}{\partial x\partial z}\cdot\frac{\partial}{\partial z}\frac{\sin\kappa(r-Vt)}{r}.$$

The vertical electric force due to the second set is

$$A\left(\frac{\partial^2}{\partial z^2}+\kappa^2\right)\frac{\sin\kappa(r-Vt)}{r};$$

hence, retaining only the more important terms, the vertical electric force at the surface at a distance is

$$\left(A-B\frac{x}{r^2}\right)\frac{\kappa^2}{r}\sin\kappa(r-Vt)+A\frac{\kappa}{r^2}\cos\kappa(r-Vt),$$

where A and B have the same sign, as the waves proceeding from the free end are at the free end in approximately the opposite phase from those proceeding from CC_1. Hence, the square of the amplitude of the vertical force at a distance is

$$\left(A-\frac{B}{r}\cos\theta\right)^2\frac{\kappa^2}{r^2}+A^2\frac{\kappa^2}{r^4},$$

where θ is the angle the direction of the receiver makes with AB, and for a given value of r this gives a figure 8 curve, with unequal loops to represent the intensity of the transmitted waves.

The essential feature of the various systems of directed wireless telegraphy is the interference of two sets of waves differing in phase and proceeding from sources at a distance apart. Braun's* arrangement consists of three vertical antennæ, each 20 metres high, placed at the corners of an equilateral triangle whose side is 30 metres. The waves proceeding from one of these differs in phase by $\pi/2$ from the waves proceeding from the other two. For the best effect the perpendicular of the triangle is a quarter of a wave-length, as then the waves proceeding in one direction are in the same phase, while those proceeding in the opposite direction are in opposite phases. For this $\lambda/4=30\cos\pi/6$—that is, $\lambda=103$—or approximately five times the height of the attenna, agreeing with theory.

Artom's† arrangement consists of two equal antennæ, each inclined at an angle of 45 deg. to the horizontal, the oscillations in them differing in phase by $\pi/2$. The antennæ are bent through an angle of 90 deg. at the ends above the horizontal, and led to the conductors; the waves that interfere are those radiated from the bends, and the wave-length for the greatest effect will be greater than five times the length of the straight part of an antenna, the radiation from the bend not being symmetrical with respect to the antenna. For complete interference—that is, with the waves in one direction in the same phase—and the waves in the other direction in opposite phases, the distance between the two bends is a quarter of a wave-length; hence, if a is the length of the straight part of each of them, $\lambda/4=2a\cos\pi/4$, that is, $\lambda=5{\cdot}6a$. In Marconi's arrangement the two sources are the

* Paper read before the Royal Society, slightly abbreviated,
† THE ELECTRICIAN, May 4, 1906.
‡ Macdonald, "Electric Waves," 1902, Chap. X.
§ THE ELECTRICIAN, May 4, 1906, p. 102.

* "Jahrbuch Drahtl. Tele.," Vol. I.
† "Accad. dei Lincei," Roma, Vol. XV., p. 692, 1906.

spark-gap and the free end of the horizontal conductor, whose distance apart is approximately one-fifth of a wave-length, while the oscillations differ in phase approximately $\pi/2$, the waves at the bend differing in phase by π. It should be observed that in Braun's arrangement and Artom's arrangement the amplitudes of the two component sets of waves are for all distances in the same constant ratio, while in Marconi's arrangement the amplitudes are in a ratio which varies as the distance.

TRAIN LIGHTING BY TURBO-GENERATOR ON LOCOMOTIVE.*

Suburban train operation, differing from through-train operation in that there is no changing of locomotives and rarely of cars, offers exceptional opportuntiy for simplicity in electric train lighting. This is shown by the new equipment adopted by the Chicago, Burlington and Quincy Railroad in its suburban service out of Chicago. The arrangement, which has been tried on one train making a regular daily run in the evening from Chicago to Aurora, a distance of about 40 miles, consists in bolting a turbo-generator on the top of the locomotive between the two steam domes, electrical connections being taken to the cars.

A horizontal Curtis steam turbine drives a two-pole, 110-volt 20 kw. direct-current dynamo. The whole unit is ironclad, the covers being clamped in with gaskets, so that it is storm-proof. Steam is taken at the locomotive boiler pressure, the variation on different locomotives being taken care of by the governor. The turbine runs at 4,500 revs. per min. The whole unit is 5 ft. 6 in. long, 2 ft. 8 in. high and 1 ft. 11 in. wide, and weighs 2,300 lb.

There is a marble panel in the cab of the locomotive on which are mounted a voltmeter and a rheostat. No attention beyond opening the stop valve and regulating the resistance should the number of cars vary is necessary. Nine standard suburban passenger coaches are lighted and also the headlight and lamps in the locomotive cab. The locomotive headlight is a 50 c.p. carbon-filament. There are four electric lamps in the cab, and each car has 21 16 c.p. lamps.

The circuit from the dynamo is led to the rear of the tender where a straight Gibbs connector is applied, and these connectors are used throughout the train length. There are no steam connections between cars and no storage batteries, so that the system is simplicity itself.

Mr. C. B. Young, mechanical engineer of the Chicago, Burlington and Quincy Railroad Company, has designed the equipment which he considers the best and simplest system for suburban service. Practical railroad men appear to be greatly pleased with the system which this company has now adopted as standard for all its suburban trains.

*Abstracted from the "Electrical World."

LEGAL INTELLIGENCE.

Consolidated Nickel, Tin & Copper Mines v. Crompton & Co.

The Official Referee (Mr. Muir Mackenzie, K.C.) concluded the hearing of this case last week.

Mr. Macfarlane was further questioned as to the effect of overloading the motor. The chief reason, he said, why he came to the conclusion that it was advisable to make the motor partly ventilated was because of the burning out which was caused by the motor falling out of step and taking in large wattless current. Of course, even with the increased ventilation, the motor would still burn out if it were allowed to get out of step. His firm made as many machines without starters as with. Starters were usually used in connection with electric lighting plants.

Mr. Alan Williams, recalled, said that fuses were not intended to be any protection against what he might call moderate overloading—say, from 10 to 15 per cent. In fact, fuses were really no protection against overloading, because they were not made large enough to withstand the starting current and an overload of the magnitude of the starting current would be unreasonable. Fuses were really provided for another purpose altogether, and they were not used for the purposes of protection in a plant of that sort. For anything beyond a few seconds at starting it would be unreasonable to attempt to run a motor which nominally worked at 50 amperes at the 150 amperes to which the current rose at starting. Fuses were provided to protect the alternator, the switchboard and the main cables in the event of a short-circuit owing to injury to the cable. With reference to the fact that the armature of the machine revolved whilst the fields were stationary, although defendants had specified a reverse type, the machine installed was the better type for the work it had to do. It was true stationary armature machines were mostly used nowadays for high-tension work and with large machines, but for the output required in that particular case it was important to have a massive field with plenty of copper winding on it and a relatively lighter armature. The suggestion that the flywheels of the gas engine were not heavy enough was unreasonable. The weight of the flywheels was quite sufficient. If the gas was of such a bad quality as to allow the engine to get out of step, heavy flywheels would not prevent it. The man in charge of the plant did not know what to do when the breakdown occurred, and he did not seem to care. With a reasonable amount of skill, and with sufficient attention, the whole plant was perfectly well able to do the work required of it. He had not the slightest doubt that the burning out of the motor in September, November and December were caused by reduction in the mean speed of the alternator, due to bad gas, slipping belt and other causes. These things might have been all avoided had those in charge of the plant used care and skill.

Mr. H. R. J. Burstall (Messrs. Burstall & Monkhouse) said he saw the motor, which was now at work at Chacewater, while under test at Crompton's works at Chelmsford. It was started at 8:30 a.m. and ran until 2:30 p.m. The average load was about 70 h.p., 70 amperes by 480 volts was his note. It was then stopped for five minutes, and then it ran on until 4 p.m. at a load of 88 amperes—over 90 h.p. The normal power of the machine was specified at 55 h.p., so that for the first part of the test it was considerably overloaded. When it was stopped he took the top plate off and took the temperatures. The stator was 160 F. outside and 22 inside, the temperature of the air being 64. The rotor was very hot—about 250 deg. he thought. Even with that overload and with that temperature, there was no sign of softening of the insulation varnish in the stator. The temperature of 250 deg. had not damaged the rotor in any way. The machine ran well during the test and the bearings were cool. During the test the power factor varied between 0·91 and 0·92. He did not think that the want of a steadying bearing had anything to do with the first breakdown. The capacity of the motor would be increased by ventilating it, and it would be able to take a heavier overload without overheating. The addition of ventilation would not have converted an inefficient machine into an efficient one. On March 5, 1908, he visited the mines in company with Mr. Williams, and saw the whole of the installation above ground. He then found that the motor was either out of step or was stopped. He found the main switch had been allowed to remain in, allowing the current to pass through the motor, which was liable to damage the motor. The reason of the failures on these occasions was from the belt slipping so much that they could not get enough pressure or volts on the alternator, and that would cause the motor to fall out of step. Afterwards the old belt was put back, and the machine started satisfactorily. He had seen the specification and the letter of Messrs. Crompton dated Feb. 12. The plant installed was of the ordinary type. The armature was revolving, which was different from that specified, but that made no difference from a customer's point of view. The machine was the ordinary type of low-tension alternator. He thought the flywheels were suitable for the job, and that the governor was suitable with proper adjustment. He thought an autotransformer was not necessary, because you could get the same effect by lowering the volts or the alternator. Fuses were usually put in for protecting the motor. The installation had a pair of fuses. The protecting device was a pair of fuses. Those were no protection to the motor underrunning, which was no protection against overload. He saw no objection to that in that case. He had machines of 2,000 kw. running absolutely unprotected at the present time. He trusted to the man. He was speaking of machines running in the generating station at Deptford of the London Electric Supply Corpn. There the line was protected, but not the generator. At Chacewater the line was protected, but not the motor. He did not believe in automatic appliances where you had men in charge, because they led to carelessness. The first time he saw the motor was after the ventilating tubes had been put into it. He preferred not to say whether the increase of the air-gap reduced the power factor of an induction motor. He knew that generally it had that effect. The auto-transformer produced the very conditions which were required for starting. The same result could be got by lowering the volts in the alternator. The more power they had in the alternator the more chance of starting easily. He calculated the over-all efficiency at 50 or 60 per cent. working at full power. If they got it to half load he would expect the over-all efficiency to be about 30 per cent., or something like that. The shop test would not show whether the motor would start up under load or not.

Counsel having addressed the Court, judgment was reserved.

Patent Revocation Applications.

Last week the Comptroller-General of Patents dismissed two applications for the revocation of letters patent because the patented articles were not manufactured in this country.

In giving his decision on the application to revoke letters patent No. 8,401 of 1903 (for improvements in sound-magnifying horns for phonographs and the like) he said that it appeared to him fairly clear—at any rate in the case of "patented articles"—that as a general rule a patentee ought not to be called upon to manufacture any mechanism or machine which he had not specifically described and claimed in his specification. That would, above all, appear to be the case where such mechanism or machine was the subject of prior patents, and was only claimed in combination, if at all, in the patent under consideration. If the general principle stated was correct, the following general results would seem to follow—namely, if the patentee had claimed a wholly new machine or mechanism, he must manufacture that in this country or run the risk of coming within the provisions of sec. 27. If he claimed a new improvement in a well-known machine, he must manufacture the improvement, and not necessarily the whole machine; but if he claimed the improvement in combination with a machine consisting of well-known parts it might be that he must, besides manufacturing the improvement, put together the whole machine in this country, or at any rate the combination he claimed.

He dismissed the application, with 40 guineas costs.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Council of the Metropolitan Borough of Hammersmith require a fourth assistant engineer to act as junior engineer-in-charge and to take charge of an eight-hour shift. Salary £130, rising by annual increments of £5 to £150 per annum. Applications to the borough electrical engineer (Mr. G. Gilbert Bell), 85, Fulham Palace-road, W., by 10 a.m. Friday, June 11. See also an advertisement.

The Governors of the Heriot-Watt College, Edinburgh, invite applications for the position of assistant lecturer in electrical engineering as from Sept. 6 next. Salary £130 per annum. Further information from Prof. Baily at the College. Applications must be lodged by June 21. See also an advertisement.

A demonstrator and assistant in the laboratory is wanted in the department of electrical engineering of the Glasgow and West of Scotland Technical College. Salary £100 per annum. Applications by June 24 to Prof. Magnus Maclean, from whom further particulars may be obtained. See advertisement.

The managers of the Technical College, Dundee, invite applications for the position of lecturer in electrical and mechanical engineering. The person appointed will have full charge of the electrical department, and must be competent to take the senior branches of mechanical engineering. Salary £350. Applications to the Director of Studies, Technical Institute, Dundee, by June 15.

The Council of King's College (University of London) invite applications for the position of professor of physics. Applications by June 14. Particulars from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

The Governing Body of the South Western Polytechnic Institute (London) invite applications for the post of head of the mechanical engineering department. Commencing salary £350–£400. Applications to the Secretary by June 22.

Croydon Education committee invite applications for the post of principal of the polytechnics. Salary £300, rising to £350. Forms from the Clerk, Catherine-street, Croydon. Applications by June 26.

A firm of insulated wire and cable makers require an agent for the southern counties, not including London.

Mr. C. W. Thompson, of West Hartlepool, has been appointed chief engineer and manager of the Saltburn electricity works, which are owned by the Cleveland Trust.

Association of Teachers in Technical Institutions.—The third annual conference of this association was held at Liverpool on Monday and Tuesday. The president, Mr. John Wilson, M.Sc., was in the chair, and Mr. T. Burke, C.C., vice-chairman of Liverpool Technical Education sub-committee, welcomed the members of the association on behalf of the municipality. Mr. W. Hewitt, B.Sc., Director of Technical Instruction, Liverpool, also welcomed the delegates on behalf of the working staff of the Technical Education Department in Liverpool.

Mr. Wilson delivered his presidential address, and, after reviewing the progress made by the association during the past year, said the salary scheme suggested by the association brought the technical teacher up to the level as regards salary of the secondary school teacher, who had less work, less worry and less responsibility. To attract the best possible teachers for the evening classes payment commensurate with the difficulty and importance of the work must be offered, and there must be a reasonable security of tenure. The most effective and lasting work of the technical teacher was not, and could not be, recompensed financially. They asked for more consultation and conferences on technical education matters between the local education authorities and their teaching staffs. One main obstacle still lay in the opposition of the foremen and the trades unions, and the apathy of the workers themselves during the critical period from 14 to 21 years of age. As a result of the special attention rightly given to the pressing claims of secondary education, the needs of technical education had dropped into the background. That deficiency in secondary school accommodation had been largely made up. In recent years, as a result of being examined and controlled by the secondary branch of the Board of Education, their scientific and technical bias had almost entirely disappeared. They needed two distinct groups of secondary schools, one corresponding to the "grammar school" type and preparing for the universities or the learned professions, the other definitely preparing boys and girls for commerce, scientific and technical industries, trades and crafts. That group of secondary schools covered the types of schools generally known as day technical schools, commercial schools, trade schools, craft schools and the like. In all of these the general education of the pupils should be continued, along with the definite training intended to be of value when the pupil entered upon the struggle for existence in the industrial arena.

One of the weaknesses of English technical education, due to the lack of educational organisation on a national basis, was that most of their technical institutions were too closely modelled after the same pattern. Neighbouring institutions were too often trying to do almost exactly similar work, resulting in much educational and financial waste. Some institutions were attempting too many different types of educational work. One cause of that bewildering multiplicity of work often attempted by technical institutions was the lack of clear conceptions respecting the objective and methods of technical education. The technical institutions in the large towns should be of two distinct types, termed broadly trade schools and technical schools, or technical colleges or polytechnics. In the trade schools in the large towns the evening work should be of a technical evening continuation school character, the curricula to be of direct educational and industrial value, co-ordinated with and leading up to the evening work of the technical school or polytechnic, the management of which should also have control of the trade school. The technical schools or polytechnics, of which there should be one for each group of towns or large centre of population, should restrict themselves in the day time to students from 16 years onwards. The instruction given should be of that high standard which would be designated briefly as "university standing." The day technical school or polytechnic work must be regarded as being on an equal level with the ordinary university colleges. Further, there must be some measure of co-ordination of the work of these technical schools or polytechnics to ensure a high measure of specialisation without unnecessary overlapping. By common consent the organisation and curricula of the present evening continuation schools, save in a few towns, were very unsatisfactory, judging by such pupils as afterwards passed on to the evening technical schools. The evening continuation schools for boys engaged in trades, industries or crafts should lead on directly to the technical school. The principal feature of the organisation of the school must be the co-ordination with the technical school, the authorities of which should have a direct, if not even a controlling, voice in the management, curricula and appointment of the continuation school teachers. Further, the latter should be, as far as the scientific and technical subjects are concerned, technically trained men, and not elementary school teachers. He suggested that the time was now ripe for the appointment of a Royal (or Departmental) Commission on Technical Education to deal with the general question of the organisation and co-ordination of technical education.

On the motion of the honorary secretary (Mr. P. Abbott), the following resolution was carried :—

"The preliminary training which students receive at present before entering technical institutions is not such as to fit them for benefiting by the instruction provided. To improve this, the following reforms are desirable : (1) No child should be allowed to leave school before the age of 15 and the half-time system should be abolished ; (2) In the education of children attending elementary schools special attention should be given to the teaching of practical arithmetic, elementary science, and to manual training."

A number of resolutions dealing with the organisation of evening continuation schools, admission to technical schools, and the division of secondary schools into three branches (technical, secondary, commercial secondary and classical secondary) were passed.

On Tuesday, on the motion of the hon. secretary, the following resolution was adopted :—"This Association heartily approves of the general principles embodies in the following recommendations of the minority report of the Poor Law Commissioners : 'It should be illegal to employ boys below the age of 15 or any youth below 18 for more than 30 hours per week, and boys should be compelled to attend some suitable public institute giving physical and technical training for not less than 30 hours per week at periods to suit the convenience of employers in different industries.' "

Barking.—In order to provide for the supply of electric current to Messrs. de Pass & Co.'s premises, the Council have decided to obtain estimates for an additional 200 kw. alternator.

Bridlington.—In deference to the wishes of the L.G. Board, the Council have decided that as from March 31 last, the cost of meters is to be charged to revenue account.

Charge against English Electrical Engineers at Antwerp.—On May 27th the trial commenced of the four English electrical engineers (Messrs. Burton, Cowan, Hogarth and Robinson) who were arrested on March 23, 1908, on a charge of purloining drawings from the Bell Telephone Co., when they were leaving the company's service to return to London. After remaining in prison for a month the Court of Appeal ordered their release and the repayment of the £800 bail disbursed by the British Consul on their behalf. All four accused men were present at the trial.

M. Cornet, who was called by the judicial authorities as an expert, stated that the documents alleged to have been taken away by Burton were not of an absolutely secret character, and were rather the result of studies by the accused engineer, who wished to use his notes for his personal use.

MM. Deracourt and Sintruyen, photographers employed by the Bell Co., stated that they had taken photographs and made copies for Cowan and Robinson, but for the most part long before their departure from Antwerp. Sintruyen declared that the orders for the photographs were not signed by Cowan, but by someone else.

M. Pierard, chief engineer to the State Telegraphs and Telephones, stated that he was aware that engineers made a practice of taking notes, and that he himself possessed documents belonging to the State.

M. Damoiseau, engineer to the Bell Co., said that he saw nothing

really important in the documents which were said to have been purloined for the purpose of communicating them to competitors. It would never enter the head of a member of another firm to make use of documents so little in accordance with its own interests, and obtained in a manner so little in accordance with the dignity of an engineer.

On Friday last Prof. O. COLARD stated if he were publishing a work on telephony he would consider it a necessary act of courtesy to ask those firms from whom he obtained information for authority to publish it, but to make use of such information was not, in his opinion, criminal.

Mr. CONNOR, manager of the firm into whose employ defendants were entering, said that he was formerly chief engineer to the Bell Co., and supervised a number of important contracts in Brussels and elsewhere. There never had been any secrets at the Bell Co. Moreover, if a new system were discovered, rivals would know of it immediately, as it would be discussed at meetings of engineers. The copies taken were of no value, and he also maintained that in telephony a constructional secret was an impossibility. If anything important were discovered the inventor would immediately patent it. He asserted that no information obtained from the Bell Co. could be of any value to him.

On Wednesday counsel for the Public Prosecutor addressed the Court, and declared that there had been no theft. He asked for the acquittal of defendants, and at the same time expressed deep regret at the long detention in custody of the four engineers, who were kept in prison for a month and had had that charge hanging over their heads since March, 1908.

Me. DUPONT, counsel for the defence, analysed the evidence for the prosecution, and contended that neither theft nor abuse of confidence had been committed.

After 20 minutes' deliberation the Court announced that all defendants were acquitted. The Bell Telephone Co. was ordered to pay the costs of the action.

Cheshunt.—The Council have instructed their Clerk to ascertain from two or three electrical engineers what their fee would be for making a report on the question of electricity supply in the district.

Croydon.—The charge for electric current for private lighting has been reduced from 4½d. to 4d. per unit.

Darwen (Lancs.)—The charge for electric current for traction has been reduced from 1¾d. to 1½d. per unit.

Electric Lighting Acts (Amendment) Bill.—The Municipal Electrical Association have issued a circular to local authorities owning electricity works calling attention to clause 15 of the bill as amended in the House of Lords which would allow a local authority, through a contractor (but not otherwise), to provide electric fittings, &c., and they suggest the addition of a clause to the bill prohibiting the supply or distribution of electricity in the area of an authorised undertaker without the consent of such undertaker, unless authorised by Act of Parliament or by licence or provisional order under the Electric Lighting Acts.

Several Councils have passed resolutions in favour of the clause as originally drafted and also in support of the suggested new clause.

Greece.—An article in the "Bulletin Commercial" (Brussels) calls attention to the increasing demand in Greece for all kinds of electrical appliances and material, especially insulated underground and aerial cables, wire for indoor work, insulators, dynamos, motors, transformers, measuring instruments and carbons. The Hellenic Electrical Co. imports electrical material to the value of over £12,000 per annum.

Hammersmith (London).—Application has been made to the London County Council for sanction to a loan of £2,000 for completing the scheme for the conversion from gas to electricity of 259 public lamps in 55 streets.

Hessle.—Negotiations have been proceeding between the Urban Council and Hull Corporation as to the transfer of the Hessle Electric Lighting Order, 1905, and the Corporation have now offered to take over the order without pecuniary consideration.

International Protection of Inventions.—His Majesty has declared that as from Jan. 1, 1909, the provisions of sec. 91 of the Patents and Designs Act, 1907 (under which His Majesty has power to make arrangements with any foreign State for the mutual protection of inventions, designs and trademarks), shall apply to Austria-Hungary, with which State such arrangements have been made.

Italy.—The "Moniteur des Intérêts Matériels" (Brussels) states that the municipal authorities of Rome will shortly invite tenders for the construction and working of two electric tramways in the town.

Japan.—The British Vice-Consul at Osaka (Mr. A. R. Firth) says an American firm had until recently practically a monopoly of the demands for electrical machinery and apparatus in the Osaka district, but British and German firms have recently secured contracts. With the projected electric railways and extensions of electricity undertakings it is probable that large quantities of electrical machinery, &c., will be required during the next few years.

The report of the Yokohama Board of Trade for 1908 states that electric motors and dynamos imported into Japan were valued at 2,049,648 yen (£170,904), against 1,772,557 yen (£151,406) in 1907.

Kingston-on-Thames.—The Council have decided to adopt, as from Ladyday, the following charges for electrical energy for lighting business premises 5d. per unit for accounts of less than £100 per annum, 4¾d. per unit up to £150 per annum, 4½d. per unit up to £200 per annum, and 4¼d. per unit above £200.

Lancashire Tramways.—Bolton Corporation have approved an arrangement for the through running of tramcars between the systems of the South Lancashire Tramways Co. and Bolton Corporation.

Light Railways.—Application has been made for an order authorising amendment and extension of time of the Headcorn and Maidstone Junction Light Railway Orders 1906 and 1907, amending capital powers, authorising the use of motive power other than steam, the purchase of electric current, &c.

The Blackburn, Whalley & Padiham Light Railways (Revival and Extension of Time) Order has been submitted to the Board of Trade for confirmation. Objections by June 7.

L.C.C. Tramways.—The conduit system cars from King's Cross and Farringdon-road are now running to Cambridge Heath railway station. On the southern system overhead trolley cars from Loughborough Junction (which change over from the conduit system at Camberwell Green) now run to Herne Hill, and this branch is to be continued along Dulwich-road and Tulse Hill-road to Norwood Cemetery. The Loughborough Junction to Herne Hill section and the lines in Hampstead-road, High-street, Camden Town, Camden-road, Farringdon-road, King's Cross-road, and Swinton-street, which have been reconstructed on the conduit system, were opened on Friday last.

Maidstone.—158 street gas lamps are to be adapted for electric lighting. The charge for current will be £3 per lamp per annum.

Maldens and Coombe.—The Council have now approached Kingston-on-Thames and Wimbledon Councils in regard to the supply of electricity in the district.

Wimbledon Council offer to supply electricity in bulk on the following terms: (1) Maldens and Coombe Council to pay the instalments of sinking fund and interest in respect of loans contracted to meet the cost of laying one or more supply cables to such point or points within their district as may be arranged. (2) The price of energy to be 2d. per unit, measured at the Wimbledon generating station; but if the price of coal exceeds by 10 per cent. 22s. per ton for Welsh coal, or 15s. per ton for inland coal, this price to be increased pro rata. (3) Maldens and Coombe Council to agree to take a supply for a term of years equal to that allowed by the L.G. Board for the repayment of loans, with an option to determine the agreement at the end of 10 years on giving six months' notice, and repaying outstanding balance of loans and interest; and (4) the price of 2d. per unit to be subject to revision at the end of 10 years and of every five years thereafter.

Middlesex.—An agreement is to be entered into by London County Council and the Metropolitan Electric Tramways (Ltd.) for the working by the company of L.C.C. tramways between the Archway Tavern and the county boundary at Highgate Archway, at £2,500 per annum.

Middlesex Light Railways and Tramways committee have been authorised to expend up to £500 on works connected with cross-over roads, &c.

National Electrical Manufacturers' Association.—A Committee meeting of this Association will be held at Balfour House, Finsbury-pavement, London, E.C., on Tuesday, June 15, at 2.30 p.m.

New Cable Steamer.—A new steel screw cable steamer (the "Retriever") was launched on May 20 from the yard of the Goole Shipbuilding & Repairing Co. for the West Coast of America Telegraph Co. The dimensions of the vessel are 185 ft. on load-line by 28 ft. beam and 16 ft. 6 in. depth moulded. Messrs. Richardsons, Westgarth & Co., of Middlesbrough, have the contract for fitting the steamer with compound engines and a large boiler working at 120 lb. pressure. There are three cable tanks and special cable winch, bow gear, cable leads, &c. Sir John Denison-Pender, K.C.M.G., chairman of the West Coast Company, was present at the launching. The vessel will replace the Company's present cable steamer of the same name.

Obituary.—We regret to announce the death of Mr. Thomas Smith, the head of the firm of Thomas Smith & Sons, electric and steam crane makers, Rodley, near Leeds.

Oulton Broad.—The Council on Wednesday adopted a recommendation of the General Purposes committee to make inquiries of councils of districts of a similar size who have obtained provisional Orders as to how they have dealt with their powers.

Patentees and International Exhibitions.—The King on May 17 ordered that the provisions of sec. 45 of the Patents and Designs Act of 1907 (under which His Majesty may order that the exhibition of any invention at an international exhibition shall not prejhu-

dice the right of the inventor to apply for a patent and shall not prejudice the validity of the patent) shall apply to the Turin International Exhibition, 1911, and, further, that patentees shall be relieved from the provision in the act that notice shall be given to the Comptroller of Patents.

Personal.—Mr. Horace H. Leage has resigned his appointment as sales engineer with the Electrical Co. (A.E.G., Berlin) and has started business at 10, City-road, E.C., as manufacturers' agent and merchant in electrical accessories. Mr. Leage would be glad to receive manufacturers' catalogues and price lists.

Plymouth.—The assessment of the electricity works has been increased from £2,000 to £4,500.

Portsmouth.—The Electric Light committee recommend that out of the profit on the past year's working of the electricity department £1,700 be voted to the relief of rates.

Presentation.—Mr. F. H. Corson, chief electrical engineer at Blackburn, who has been appointed city electrical engineer at Gloucester, has been presented by the Blackburn staff and employés with a silver coffee pot, and a gold pendant and brooch combined (set with pearls and a peridot) for Mrs. Corson.

Mr. P. P. Wheelwright, borough electrical engineer, who presided at the presentation ceremony, said the gifts were a token of the esteem in which Mr. Corson was held by the subscribers. He had known Mr. Corson for seven years, and had always found him pleasant to work with and anxious to do his best for the prosperity of the department. He was to be congratulated upon being chosen out of 248 applicants for his new post, and the city of Gloucester was also to be congratulated upon having secured Mr. Corson for their electrical engineer.

Ald. W. Thompson, chairman of the Electricity and Tramways committee, in making the presentation, said Mr. Corson had been a hard-working and capable servant of the Corporation. They regretted losing him, but Blackburn's loss was Gloucester's gain.

Mr. Corson acknowledged the gifts in suitable terms.

Provisional Order Revocation.—The Board of Trade have revoked the Newton-in-Makerfield Electric Lighting Order, 1903, as from May 25.

Reigate.—Sanction has been received to a loan of £1,521 to cover excess expenditure on the electricity undertaking, but the L.G. Board have advised the Council to call in a consulting engineer to report generally upon the financial position of the undertaking, and, pending this, sanction has been withheld to a loan of £2,340 for extensions of mains, &c.

Roumania.—The communal authorities of Bacau have been authorised to contract a loan of £62,000 for waterworks and water-power electricity generating works.

A company is to be formed next month for the construction of electric tramways in Bucharest. Operations will be commenced with £120,000 capital.

Sao Paulo (Brazil).—The directors of the Sao Paulo Tramway, Light & Power Co. announce that they have received definite advice from Brazil to the effect that the statements which have been circulated on the subject of the threatened organisation of a rival company and local opposition to the company are misleading, and for the most part without foundation.

Spain.—The British Consul at Gijon (Spain), Mr. A. Lovelace, states that electrical machinery is being imported in increasing quantities, chiefly from Germany, and two German firms have established themselves at Gijon with German employes.

The Sociedad Tranvia del Este de Madrid have obtained a concession for the construction and working of an electric tramway from the Paseo de Recoletos to the Calle de la Florida, Madrid.

Stevenage.—The Board of Trade have deferred the revocation of the Council's provisional order for 12 months. Offers are to be invited for taking over the order.

Stoke-on-Trent.—The salary of the borough electrical engineer (Mr. P. J. S. Tiddeman) has been increased from £350 to £400.

Vladivostock (Russia).—Messrs. J. G. White & Co. have submitted to the Municipal Council a draft of the terms upon which they are willing to establish electricity supply works and tramways and carry out certain water supply works.

Walthamstow.—Wiring contractors are to be supplied with electric current at half the ordinary lighting rates for showroom purposes.

West Ham.—Pending the purchase by West Ham of six new tramcars Leyton Council are to lend six for not less than six months on payment of 1d. per car-mile run, with a minimum mileage of 600 miles per car per week.

The irrecoverables on the amount of private consumers' accounts for current for the past quarter was 0·23 per cent., against 0·43 per cent. in the corresponding period of 1908. The amount of arrears on private consumers' accounts is 0·80 per cent., against 0·30 per cent.

In 1908 the expenditure on new motors was £3,580, and the income £1,392, against £3,965 and £559 respectively in 1907. The estimated expenditure under this head for 1909 is £1,890 and income £2,280. There was a deficit on motors on hire for 1908 of £598 and a profit for 1909 of £820. From the time when the Corporation commenced hiring out motors in 1900 up to March, 1908, it was the practice to deliver and fix motors free of charge, and the rents charged were in many cases inadequate to cover maintenance, not allowing for depreciation, the idea being to make the profit out of the increased sale of current. This was altered from March 1908, and no fixing or delivering is now done free, and rents have been raised to a figure covering all charges. Up to 1909 the amount spent on motors was £13,198, of which £2,027 has been written off.

Application is to be made for sanction to borrow £5,000 for mains and services during the ensuing 12 months.

Willesden (London).—An additional cable is to be laid between Dollis Hill-lane and Melrose-avenue at a cost of £3,050.

The Electrical Engineer reports that the change effected last year in part of the Cricklewood area from d.c. to a.c. supply has proved satisfactory and economical, and the area is to be extended.

Wireless Telegraph Notes.—According to a report recently made by the U.S. Consul at Tsingtau, the Chinese Board of Communications are inviting tenders for wireless telegraphic installations which it is proposed to establish between long-distant points in north-west Chinese Turkestan, which are practically inaccessible with ordinary methods of communication. The sites of the wireless stations will, it is stated, be between the Altai mountains and Ahsien. It is contemplated to make this the commencement of a series of wireless points for linking up the districts between Peking and the extreme north-west of China.

It will be remembered that the High Court some time ago gave judgment in the matter of the litigation between Lloyds and the Marconi Wireless Telegraph Co. In conformity with this judgment the company is equipping with Marconi apparatus Lloyds station at the North Foreland.

Worthing.—An inquiry was held last week into the application of the Council to borrow £3,900 for laying two new feeder cables and extension of distributing mains. There was no opposition.

York.—Application has been made for sanction to a loan of £550 for a new traction switchboard. It is proposed to adopt arc lighting along the new tramway routes.

Outing.—On the 22nd ult. the head office staff of Callender's Cable & Construction Co. held their third annual outing, which took the form of an excursion to Brighton, and a luncheon and tea at the Old Ship Hotel.

The Managing Director (Mr. T. O. Callender) presided at the luncheon and said he was pleased to learn that the shorthand class had been such an unqualified success, and that it had been so favourably commented upon. The members of their clerical staff were afforded special facilities for securing a knowledge of Pitman's shorthand. One hour each morning was allowed for a lesson, and so interested were the staff that there was a regular attendance of from 15 to 20 each morning. Mr. H. Vince, who was appointed by the company to conduct the class, has for the past 12 years been engaged as a shorthand instructor in the evening schools of the London County Council. He also trusted that the newly formed swimming club would be taken up with enthusiasm, as he was of opinion that every member of such a maritime nation as ours should be a qualified swimmer.

Mr. Dunkley (hon. sec. of the outing fund) asked Mr. Callender to thank the board for their generous donation, and also expressed the pleasure of the staff at the presence of the visitors.

The Corps of Electrical Engineers (London Division).—The first annual athletic meeting of this corps was held at Stamford Bridge Grounds, Fulham, on Wednesday evening last, with the primary object of selecting men to represent the corps in the territorial Sports at the Stadium on the 26th of this month.

The weather conditions were distinctly against any records being made, and the times were, in fact, in most cases quite moderate. Without making any invidious comparisons, the best performances were certainly those of Sap. E. C. Abbott-Young in the 100 yards, Sap. G. Lees in the quarter mile and Sap. J. R. Birch in the mile. The first of these runners should certainly be heard of again. An inter-company tug of war provided an exceedingly good contest, in spite of the fact that one company did not put in a team. The prizes and medals won were distributed at the end of the meeting by Col. R. E. Crompton, C.B., commanding officer of the corps. The officials included the following: Referee, Major H. M. Leaf; judges, Captains J. H. S. Phillips, H. E. Webb-Bowen, K. W. E. Edgecumbe and W. H. Merritt, and Quartermaster Hon. Major W. Bunn; timekeeper, Second-Lieut. F. H. Masters, who carried out his duties by means of a Smith's split-second chronograph, and Hon. Sec., Quartermaster-Sergt. G. A. Applebee.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Blackburn.—For the year ended March 25 the total receipts of the tramways department were £60,131. 13s. 2d., the traffic revenue being £56,792. 17s. 3½d., or 12·04d. per car-mile.

Traffic expenses were £14,564.17s.10d., general expenses £3,545.11s.6d., general repairs and maintenance £13,322. 14s. 2d., and power expenses £12,069. 16s. 11d., total £43,503. 0s. 5d., leaving a balance of £16,628. 12s. 9d. After paying interest (£7,112. 15s.), sinking fund contributions (£7,750. 16s. 10d.), &c., there was a deficiency of £4,803. 17s. 6d. The gross capital expenditure is £334,006. The number of passengers carried was 10,737,528, and the car-miles run 1,132,023. The total number of units of energy used was 2,069,117 (1·82 units per car-mile), and the percentage of working expenses to receipts was 72·34.

The accounts of the electricity department for the year ended March 25 show total income £35,156. 9s. 9d. Expenses were £18,287. 3s., including £9,015. 7s. 9d. for generation, £5,158. 16s. 5d. for repairs and maintenance of buildings, plant, mains, &c., £2,582. 17s. 5d. for rates and taxes, and £1,444. 8s. 6d. for management. Gross profit was £16,869. 6s. 9d., and after paying interest, sinking fund, &c., net profit was £976. 2s. 10d., against £1,443 in the previous year. 4,424,267 units were generated (4,212,300 units sold), 1,799,049 to private consumers, 2,069,119 supplied for traction and 344,132 for public lighting. There are 209 arcs and 470 incandescents (the same as last year) for public lighting, and the maximum supply demanded was 2,600 kw.

The borough electrical engineer (Mr. P. P. Wheelwright) reports that the motor and apparatus hiring department has been of great assistance in developing the motor load, and he recommends that no restriction be placed on its progress. The long list of trades which have adopted the electric drive is striking testimony of the increasing popularity of electric power. Like other towns, the undertaking has been affected by the increased use of metallic filament lamps, the units sold only showing an increase of 2 per cent. over 1907-8, while the number of consumers increased from 1,700 to 2,000, or about 18 per cent. The total connections in equivalent 30 watt lamps are 175,550, an increase of 11 per cent. Motors totalling 1,216 H.P. have been installed on the hire-purchase system.

Blackpool.—The capital expenditure of the Corporation tramways department, which has not been increased during the past year, is £282,613.

The income for the year ended March was £52,117 (against £53,740 in previous year), expenditure £33,491 (£32,419), gross profit £18,626 (£21,321) and net profit, after meeting interest and sinking fund, £3,658 (£6,436), which has been placed to permanent way renewal fund. 8,138,569 (8,135,006) passengers were carried and 945,229 (943,268) car-miles run. Traffic revenue was 12·93d. and total revenue 13·23d. per car-mile. Working expenses were 5·95d. excluding, and 8·50d. including, power cost. The average fare was 1·38d. per passenger.

Bolton.—The accounts of the electricity department for the year ended March 31 show total income of £59,153. 3s. 8d., including £18,475. 17s. 2d. net from private lighting, £17,468. 4s. 10d. from power and £19,175. 19s. 6d. from traction and £2,556. 10s. 9d. profit on fittings trade account, the balance being made of motor and meter rental.

The expenses were £26,321. 16s. 7d., and included £20,025. 1s. 6d. for cost of generation, £977. 11s. 10d. for distribution, £1,760. 15s. 1d. for management and £3,203. 18s. 3d. for rent, rates and taxes and £354. 9s. 9d. for the purchase of new meters. The gross profit was £32,831.7s.3d., and after paying interest and providing for depreciation the net profit was £5,804. 15s. 8d., making, with £4,375. 10s. 5d. brought forward, a disposable balance of £10,180. 6s. 1d., out of which £6,500 was voted to relief of rates, £1,000 written off Duncan-street sub-station account and £2,680. 6s. 1d. carried forward. 12,447,966 units were generated; 1,570,392 were supplied for private lighting, 4,183,853 to the tramways department and 4,923,519 to power users.

The results have been affected by depression in the cotton trade and by a strike which lasted for seven weeks. Like other municipalities, the electricity department has also felt the introduction of metallic filament lamps. The average price is slightly lower than in 1907-8, and the total revenue is also lower. Owing to an increase of £1,000 in rates the works cost has increased.

Brighton.—The accounts of the electricity department for the year ended March have been issued and show net profit £564. 17s. 7d., against a deficit of £3,657 for previous year.

Income increased from £88,082. 10s. 11d. to £88,815. 1s. 2d., and the expenses decreased from £46,753. 6s. 10d. to £43,572. 13s. 6d., leaving gross profit £45,242. 7s. 8d. There are 4,773 consumers against 4,523, and the equivalent number of 8 c.p. lamps connected is 333,143, against 319,628. 8,037,711 (8,002,376) units were sold, including 5,083,945 for private lighting and power, 28,243 to Hove Corporation in bulk and 1,889,410 to the tramway department.

Crewe.—For the year ended March 31 the total income of the electricity department was £7,509. 4s. 9d., including £3,799. 9s. 7d. from the sale of current by meter and £3,565. 10s. 5d. from public lighting.

The expenses were £3,618. 13s. 7d., and included £2,152. 3s. 2d. for generation, £105. 6s. 7d. for distribution, £398. 13s. 7d. for public lighting, £416. 7s. 8d. for rent, rates and taxes and £500. 10s. 9d. for management expenses. The gross profit was £3,890. 11s. 2d., and after paying interest (£1,265. 16s. 5d.), sinking fund (£870. 2s. 2d.) and repayment of loans (£891. 13s. 11d.) there was a net profit of £981. 5s. 3d. The total capital expenditure is £54,154. 10s. 8d., an increase of £1,719. 18s. 11d. 674,589 units of electric current were generated and 596,901 units were sold (300,174 to private consumers). There are 30 arc lamps and 748 incandescent posts for street lighting. The maximum supply demanded was 420 kw.

Dover.—The Council recently applied for sanction to a loan of £1,190 for excess expenditure on the electricity undertaking.

The L.G. Board, however, state, with regard to the application and to the accumulated deficiency on revenue account for the four years ended March 31, 1908 (a total of £3,338), that if the Council are not prepared to take the necessary steps with a view to an amendment of sec. 7 of the Dover Corporation Act, 1903, they must comply with its provisions by raising their charge for electrical energy. The Board also asked for particulars as to the application of the sinking fund, &c.

The Electricity committee consulted Messrs. Price, Waterhouse & Co. on the financial position, and the firm made certain recommendations with regard to the undertaking and the provision to be made for meeting the deficiency on revenue account. The Town Clerk is to reply to the points raised by the Board, and to state with regard to the deficiency that it is proposed to comply with the requirements of sec. 7 of the 1903 act by including the amount of the deficiency in the estimate for the ensuing year and charging such rate to the consumers as will cover that sum together with the estimated cost of the year's working and the necessary payment into the sinking fund.

Dundee.—Revenue of the electricity department for the past year showed an increase of about £2,000, and expenses a decrease of £300.

Gross profit was £12,047, against £9,741 in 1908 After paying interest and sinking fund (£11,868) there was a net profit of £1,256 A large saving has been effected in the coal bill, notwithstanding that 600,000 more units were generated. A saving of £4,500 was effected on mains and services repairs, but there was an increase of £567 on assessments and taxes and £128 on insurance. The convener of the Gas and Electricity committee (Mr. Don) and the city electrical engineer (Mr. H. Richardson) have been congratulated on the results of their work.

Fulham (London).—For the year ended March these was a surplus of £3,573 on the working of the electricity undertaking, against £1,408 in the previous year.

After complying with the district auditor's requirements as to payment of proportions of accrued principal and interest, the net surplus is £1,914, making, with £408 brought forward, £2,322, of which £2,000 has been transferred to machinery maintenance and reserve.

The Electricity committee have decided that the requirements of the London County Council as to the establishment of testing stations are to be opposed as unnecessary and inexpedient, and other Metropolitan Borough Councils possessing electricity undertakings are to be communicated with with a view to joint opposition to the proposed requirements of the County Council.

Gloucester.—The ninth annual report of the electricity department states that during the past year 43 new consumers were added (with an aggregate of 2,307 8 c.p. lamps) and 47 consumers extended their installations to the extent of a total of 2,207 8c.p. lamps, making a total of 4,514 8 c.p. lamps connected during the year.

Applications for electric power are steadily increasing. The units sold were 1,390,253 (lighting and power 547,308, traction 598,366, public lighting 190,716, and refuse destructor 53,863), against 1,320,782 in 1907-8, and 1,299,629 in 1906-7. The average price obtained was 1·99d. against 2·03d. Capital expenditure has risen from £88,967.19s.11d. in 1908 to £90,334. 9s. 9d. The total income for the year was £12,353. 18s. 11d., and expenditure was £6,738. 7s. 2d., leaving gross profit £5,615. 11s. 9d., or 6¼ per cent. on capital outlay. Interest and repayment of loans absorbed £5,605. 4s. 10d., leaving net profit £10s. 6s. 11d., against a deficit of £1,206 in 1908. The cost per unit sold has dropped from 1·38d. in 1908 to 1·13d. in 1909, the largest decrease being in coal. The coal consumed was 4,490 tons, against 4,908 tons in 1907-8, the total saving being £587.

Hampstead (London).—For the year ended March the total income of the electricity department was £62,878, against £65,738 for 1907-8. The decrease is attributed to the extended use of metal filament lamps.

Keighley.—The receipts of the electricity department were £5,670. 11s., for the nine months ended March 31, the date to which the accounts will be made up in future.

The expenses were £3,226. 0s. 5d. and the gross profit £2,444. 10s. 6d. After paying interest (£1,122), sinking fund instalment (1,214. 15s. 1d.), &c., there was a net profit of £30. 9s. 10d. The total works costs were 0·81d. (against 0·85d.) per unit, and the total costs were 1·89d. (against 2·16d.). The improvements are due to an increase in the number of units sold for power and to a decrease in the price of coal.

The report of the borough electrical engineer (Mr. J. McF. SMYTH) states that recent developments in power supply point to the probability of a very large expansion in the near future, and the Corporation are recommended to make provision to give a cheap and reliable supply of electricity for power, especially to the mills. To be in a position to do this high-speed steam turbines and three-phase alternators (of not less than 1,000 kw.) must be used. Mr. Smyth's estimate of the cost of the proposed plant is £20,000, of which £16,000 would be spent in the first year.

The accounts have been approved by the Council.

Lancaster.—The income of the electricity department for the year ended March 25 was £9,645. 6s. 8d., including £5,725. 18s. 7d. net from the sale of current for private lighting, £746. 9s. 1d. for power, £115. 3s. under special agreements, £1,776 2s. 5d. from the tramways department and £786 from public lighting.

The expenses were £5,669. 16s. 10d., and included £2,671. 4s. 6d. for generation, £656. 8s. 6d. for distribution, £644. 9s. 4d. for extensions of machinery and plant, mains, &c., £847. 11s. 9d. for management, and £472. 8s. for rent, rates and taxes, and after paying miscellaneous charges the net balance was £3,975. 9s. 10d. Interest absorbed £1,154. 17s. 4d., contribution to stock dividends account £645. 6s. 6d., and sinking fund £1,573. 4s. 5d., leaving a net profit of £711. 7s. 10d., of which £700 has been placed to the district fund in relief of rates and £11. 7s. 10d. carried to reserve. The capital expenditure is £63,252. 0s. 10d., an increase of £31. 10s. during the year. 765,450 units of current were sold. The lamp connections are equivalent to 64,029 8 c.p. lamps.

In the report of the borough electrical engineer (Mr. W. A. Tester) it is stated that there was only a very slight increase (0·47 per cent.) in the total number of units sold; the amount supplied to the public lamps had not altered, but the power supply by contract increased by about 29 per cent., and there was also a slight increase in the number of units supplied to the tramways, but there was a fall of 4·33 per cent. in private lighting owing to the increasing use of metallic filament lamps. On the other hand, the number of connections had increased by 10 per cent. Economies effected in the works had resulted in the amount of current used at the works being reduced by 21 per cent., and the current not accounted for has also been reduced by 50 per cent. The works costs were 0·84d. per unit, compared with 1·1d., the total costs being 1·25d., against 1·50d. The total net profit was £1,356, of which over £664 was applied in extensions of plant and mains.

The income of the tramways department was £5,016. 8s. 9d., including £4,839. 7s. 10d. from traffic revenue. The traffic expenses were £1,990. 5s. 11d., general expenses £598. 3s. 8d., general repairs and maintenance £1,131. 15s. 11d., and power expenses (247,632 units at 1·7d.) £1,754. 1s. 3d. After providing for interest and sinking fund there was a deficit of £3,235. 7s. 10d., against £2,749. 9s. 1,301,886 passengers were carried and 158,792 car-miles run. The average traffic revenue per car-mile was 7·31d., and the average working expenses (including power cost) were 8·22d.

Lincoln.—The accounts of the electricity department were approved by the Council on Tuesday.

The gross profit was £6,496, of which £3,974 was required for loans and interest, £98 was applied to meeting deficiency on tramways, and £1,000 transferred to tramways risks insurance account, leaving net profit £1,423. The output of current was 18 per cent. greater than in the previous year.

Tramways account showed gross profit £2,457, and after paying £2,555 for loans and interest, there was a net deficiency of £98.

Mr. Pratt, chairman of the Electricity committee, said they were in an excellent position in regard to both undertakings, and the output of units in the electricity department showed a large increase.

Newcastle-on-Tyne.—The report and accounts of the tramways department were presented to the Tramways committee on Wednesday.

The chairman (Sir Joseph Ellis), who moved the adoption of the report, stated that the capital expenditure to date was £1,165,673, but by sinking fund, &c., they had paid off £224,459. The year's profit was £81,513. 5s. 10d., against £94,466. 2s. 11d. last year. Their expenses were £122,609, against £116,852, an increase of over £6,000. The general working expenses were lower, but the increase was caused by rates and taxes £12,730, against £7,431 and by permanent way repairs (£8,747. 17s. 6d., against £5,628. 17s. 2d.), alterations to tramcars, &c. The total revenue was £204,123, against £211,318, a decrease of about £7,000, due to depressed trade. £81,513. 6s. 10d. was required to pay interest and redemption fund, and £1,551. 10s. 3d. to liquidate the debt on the old horse tramway, £1,300 for the right to supply their own energy to their car sheds at Byker (which were situate in Walker), and after paying other expenses the net profit was £7,557. 12s. 10d., which he moved should be added to the reserve and renewals fund. They had made a very great sacrifice in reducing fares and lengthening fare stages last year.

The report and accounts were approved.

St. Helens (Lancs.)—In submitting the annual accounts of the electricity department for the past year, Ald. Beecham stated at the Council meeting on Wednesday that there had been a considerable increase in the number of units sold for power. Total income was £19,533, an increase of £285 over previous year. Cost of production was reduced from 0·81d. to 0·77d. per unit, which was among the lowest in the country. Gross profit was £9,778, and after paying interest on loans and sinking fund contribution, the surplus was £376, an increase of £100.

Sunderland.—The annual report of the electricity department for the year ended March 31 states that the revenue was £48,480, against £58,205 in 1907-8.

Expenses were £22,328 (including £7,112 for coal) and gross profit was £26,151, against £23,121. Interest required £12,753, sinking fund £14,951, had appropriated redemption fund £112, and special expenditure £1,266. After meeting these charges there was a deficiency of £2,905, against £1,908. The number of units sold was 6,581,825, against an estimate of 7,819,800.

The borough electrical engineer (Mr. A. S. Blackman) states that power consumers took 2,515,516 units, a decrease of 1,829,338. Ordinary consumers increased from 1,224 to 1,238, but the sales were down about 10 per cent., due in part to the small power consumers supplied from the public network, in part to the more general adoption of metallic filament lamps, and in part to the depression in trade. The total units consumed by this class was 1,888,908. For public lighting there were one additional arc lamp and 24 osram lamps, and the increase in the units sold for arc lighting was about 11 per cent. For traction 1,770,411 units were sold, a decrease of about 3½ per cent. Business has been so bad that consumers have economised to the utmost. The decrease over the whole output is 23·8 per cent., while the revenue is 17 per cent. less. The increase in capital expenditure during the year was £16,453, and was wholly due to the payment of balances upon plant extensions already in hand. The total capital expenditure is now £419,748. Notwithstanding the reduced output, there is a substantial reduction in works costs. Mr. Blackman regards the future with confidence; money is required for dealing with the old plant and for building up a reserve fund, and this will, it is stated, be forthcoming in due course.

West Bromwich.—The total income of the electricity department for the year ended March was £13,071, an increase of £579 over 1907-8.

The income from private consumers showed an increase of £45, from power consumers an increase of £1,054, and public lighting an increase of £31; but there was a decrease of £552 in the receipts from the tramways department. The total number of units sold was 2,011,985, an increase of 187,098. The gross profit was £6,855, an increase of £799, and the net profit £2,442, an increase of £411.

The borough electrical engineer (Mr. W. A. Jackson) states that the increase in the sales is the largest since the inception of the undertaking, notwithstanding the decrease in the units sold for traction. The action of the Electricity committee in giving manufacturers the benefit of cheap rates for power has been more than justified, and has resulted in decreased works costs. Economies effected have reduced the cost of production by 11 per cent., and the net profit is 3·38 per cent. on the capital.

On the tramways undertaking the net profit is £271, to which has to be added £66 from the account for repairs and maintenance of tracks, thus reducing the deficit to date to £756.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

DEVONPORT Corporation Electricity committee invite tenders for the supply of stores for the 12 months ending June 30, 1910, including d.c. meters, paper-insulated cables, rubber covered wires, flexibles, cutouts and lubricating oils. Particulars and forms of tender from the borough electrical engineer (Mr. J. W. Spark), Newport-street, East Stonehouse, Devon. See also an advertisement.

Tenders are invited for the supply of one overhead travelling crane to MELBOURNE (Australia) City Council. Tender forms, conditions, &c., from the agents for the City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C. Tenders to the Chairman of the Electrical Supply committee, Town Hall, Melbourne, must be received by 2 p.m. Wednesday, Aug. 4. See also an advertisement.

Tenders are invited for the supply of a branching multiple magneto switchboard to the Postmaster-General's Department in NEW SOUTH

WALES. Tender forms and specification may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of 150 relays (non-polar) to the Postmaster-General's Department in the State of NEW SOUTH WALES. Tender forms and general conditions may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

The Electricity committee of STEPNEY (London) Borough Council, invite tenders for the supply during the period ending June 30, 1911, of ampere-hour meters, demand indicators and time switches, and arc lamps. Specifications, forms of tender, &c., may be obtained from the borough electrical engineer and manager, Mr. W. C. P. Tapper, 27, Osborn-street, Whitechapel, E., where tenders must be delivered by noon June 14.

SALFORD Electricity committee invite tenders for the supply, delivery and erection at the Corporation electricity station, Frederick-street, Pendleton, of a battery booster and switchgear. Specification and form of tender from the borough electrical engineer, Mr. Victor A. H. McCowen, M.I.E.E. Tenders to the Chairman of the Electricity committee, by noon of Monday, June 14.

TUNBRIDGE WELLS Corporation invite tenders from manufacturers for supply and delivery of l.t. cables during the ensuing 12 months. Specifications, &c., from the consulting engineer, Mr. Horace Boot, at the Electricity Works, Tunbridge Wells. Tenders to town clerk, Mr. W. C. Cripps, Town Hall, Tunbridge Wells, by 10 a.m. June 12.

SOUTHAMPTON Corporation invite tenders for the supply of sundry heavy cables for l.t. trunk mains required by the electricity department, in accordance with the specification, particulars and conditions which may be obtained from the borough electrical engineer, Mr. H. F. Street. Tenders to the town clerk, Mr. R. R. Linthorne.

LONDON County Council want tenders by 11 a.m. June 22 for the roadwork and platelaying of the authorised tramways in Southwark-street and Blackfriars-road and on the Victoria-embankment east of John Carpenter-street. Specification, &c., from the Chief Engineer, County Hall, Spring-gardens, S.W.

LONDON County Council require tenders by 11 a.m. June 22 for the supply and fixing at Greenwich generating station of steam, exhaust, feed and drain piping, valves, &c., and cast-iron condenser water piping, valves, &c. Forms from the offices, Spring-gardens, London, S.W.

In connection with their additional sewage disposal works at LEIGH, the Leigh and Atherton Joint Sewerage Board want tenders by 10 a.m. June 11 for the supply of dynamos, motors, cables, &c., and for electric lighting. Specifications, &c., from Messrs. Banks, Fairclough & Stephen, engineers, Leigh, Lancs.

The Visiting committee of the NORTH WALES Counties Asylum invite tenders for fitting up the asylum with telephones, fire alarms, night recording clocks and entrance bells. Particulars at the Asylum or from Mr. Wm. Barker, Denbigh.

CARLISLE Corporation want tenders by noon, June 14, for the supply and erection of underfeed stokers, superheaters, and a 300 kw. d.c. mixed-pressure steam turbo-generator. Specifications, &c., from the City Electrical Engineer.

CLACTON Council want tenders by noon, June 16, for stores, including electric service fittings, joint box compound, bitumen, cotton waste, oils, &c. Forms of tender, &c., from the Clerk.

LEEDS Tramways committee want tenders for the supply of a 100 H.P. motor. Specification, &c., from the Tramways General Office on or before June 8.

GREAT YARMOUTH Co-operative Society want tenders by 6 p.m., June 8, for the extension of the electric lighting at the Central Stores, Middle Market-road, Great Yarmouth.

Tenders are invited for eight sections of common battery switchboard and subscribers' apparatus for Hawthorn Exchange for the Postmaster-General's Department, VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited for supply of 50 coin attachments (suitable for coins of different values) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

TENDERS RECEIVED AND ACCEPTED.

Dartford Council have accepted the tenders of Ferranti Limited and Chamberlain & Hookham for meters; Johnson & Phillips for service cables, &c.; S. W. Gibson & Co. for general stores; and J. P. Hall & Sons for condensing plant with Rees roturbo pump.

New Zealand Government have accepted the tender of P. Pitman for the supply of two hydraulic governors for regulating the speed of two 80 B.H.P. Pelton wheels at the Mount Egmont branch railway, New Zealand.

The Education committee of the London County Council have placed an order with the General Electric Co. for the supply of a motor generator for the school of building at Brixton, and also for extensions of the switchboard at £350. 10s.

Hammersmith (London) Council have accepted the tender of Fraser & Chalmers for the supply and erection of a coal conveyor and projector at £660. There were four tenders, varying from £660 to £1.440.

Hounslow Council have accepted the tender of the Tudor Accumulator Co. for the supply and maintenance of 26 additional cells to the storage battery.

Kingston-on Thames Council have placed orders with Siemens Bros. & Co. and W. T. Henley's Telegraph Works Co. for supply of cables and with the Electrical Co. for metallic filament lamps.

Bridlington Council have accepted the tender of Holdsworth & Sons for a Lancashire boiler at £648. 10s., and that of the Anchor Cable Co. for cables for a year.

The tender of Gunton & Knox for construction of telephone conduits at Newcastle (N.S.W.) has been accepted by the Postmaster-General's Department.

The Postmaster-General's Department, Melbourne, Australia, have ordered from the Western Electric Co. extra apparatus for Windsor telephone exchange junction line at £565.

Splatt, Wall & Co. have secured the contract for an electric lift for the nurses' quarters at Perth (W. Australia) Hospital at £535.

Gibson, Battle & Co. are supplying an electric lift for the Fisher Library, Sydney University.

Noyes Bros. (Sydney) have a contract for pumping machinery, electric generating plant, &c., for Hawkesbury Agricultural College.

Franki & Co. have secured the contract for the equipment electricity supply works at Rochester (Victoria).

Cheshire Education committee have accepted the tender of J. Wood for electric bell fitting, &c., at the new Cheadle schools.

Walthamstow Council have accepted the tender of W. T. Henley's Telegraph Works Co. for the supply of paper insulated cables.

Leyton Council have accepted the tender of the Standard Cable Mfg. Co., for the annual supply of service line cable.

Dewsbury Guardians have accepted the tender of Fox & Co, for electrical work at the new nurses' home.

The Bastian Meter Co. have again secured the contract for the supply of 5-ampere meters to Edinburgh Corporation.

Southampton Corporation have accepted the tender of Babcock & Wilcox for a boiler at £1,530.

BUSINESS NOTICES.

The partnership between Hy. Fredk. Calcutt and Edwd. Radburn, electrical and motor engineers, Watford, has been dissolved by order of Hertfordshire County Court.

The partnership between E. H. Johnson, A. R. F. M. Reinhardt, A. J. Grose, R. Niepel, and J. M. Bein (trading as the E.M.F. Manufacturing Co.), Ironmonger-lane, London, E.C., has been dissolved.

John Moore Dawson and Thos. Rigg (trading as the De Laval Igniter Co.), accumulator experts, Haden-street, Moseley-road, Birmingham, have dissolved partnership.

Mr. G. Wüthrich has appointed Messrs. W. B. & J. Bain, 65, Waterloo-street, Glasgow, to represent him in Scotland for the sale of the machinery, plant and apparatus manufactured by the Maschinenfabrik Oerlikon. The resources at the command of Messrs. Bain will ensure prompt attention to the requirements of clients.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

An advertisement contains particulars of some electrical engineering plant (including two 110 H.P. d.c. Siemens motors, with starter, &c., one 105 H.P. single-phase motor, two 4 H.P. electric capstans, one 2-ton electric derrick crane and one 5 H.P. electric locomotive) which is for sale.

Factory Sites.—West Ham Corporation electricity supply department are showing commendable energy and enterprise in advertising the advantages of West Ham as a manufacturing centre. They have recently issued a list of vacant factory sites and manufacturing premises in the West Ham area, and at the same time point out

the advantages of the cheap supply of electric power which is now given by the electricity supply department. Persons interested can obtain further particulars of the properties contained in the list from the Sales Manager, 84, Romford-road, Stratford.

"Tantalum" Lamp Prices.—Reductions.—A new list is issued by Messrs. Siemens Brothers Dynamo Works, Tyssen-street, Dalston, London, dealing with the various types of "Tantalum" lamps now on the market, and announcing reduction in prices. The list illustrates the well-known "Tantalum" high-voltage lamps, which are to be sold at 3s. 6d. in bell-shaped bulbs and 3s. 9d. in spherical bulbs. The spherical lamp is a new departure. Further, the standard bell-shaped or the spherical "Tantalum" lamps of 50–80 volts, 12 c.p. and 16 c.p., are now to be sold at 2s. each. The price sheet also shows illustrations of a new "Tantalum" candle lamp, supplied for 24–40 volts, in 5 c.p. and 10 c.p., which will find a ready market for use with candelabra fittings, designs and prices of which, we understand, can also be obtained from Messrs. Siemens Bros. The new factory at Dalston, which was opened some few months ago, possesses great facilities for the manufacture of these lamps, and the rapid progress in the development of the lamp is well shown by the foregoing reduction in prices.

"**A.E.G. Zeitung.**"—The June issue of this journal contains an article on "A Visit of a north-Bohemian Engineer to the A.E.G.," on "Æsthetics in the Industry," by Prof. Peter Behrens, and on "Automobile Omnibuses." The issue is quite up to the usual standard.

CATALOGUES, &c.

B.T.-H. Motors.—The B.T.-H. motor is by this time a well-known piece of engineering apparatus; and it is, therefore, of special interest to note that the British Thomson-Houston Co. have just put on the market a new design of motor, which, it is claimed, possesses several distinct advantages. The pamphlet describing these motors contains full details of their design and operation, and is well illustrated. The matter being of some importance at the present time, we have devoted a certain amount of space to it in another portion of the paper, and to this article we refer our readers.

Surgical Lamps.—The Sanitas Electrical Co. issued recently a catalogue dealing in a very extensive manner with their electro-therapeutic apparatus, and this has now been amplified by the addition of some 40 pages, devoted entirely to the latest development in lamps for surgical purposes. It is quite impossible, in the space at our disposal, to go into this at all fully, but we can say that the lamps cover a wide range, and, as far as we can see, every possible need in this direction is met. Those interested in this class of work should provide themselves with a copy of one of these catalogues.

Litholite Insulators.—Litholite (Ltd.), of Hackney, N.E., have forwarded us a copy of a new list of standard Litholite insulators. This is so arranged that new sheets can be added from time to time. It contains sectional drawings and full dimensions of all the insulators manufactured by this firm. These, as is well known, cover a wide range.

Flexible Couplings.—We have received from the Power Plant Co., of West Drayton, a pamphlet dealing with their patent couplings. These, besides being flexible, are also insulating and reversible. The pamphlet contains full details of sectional drawings of the various sizes of the couplings made by the firm.

Ironclad Switches.—In another portion of this issue we publish a statement by Mr. G. Scott Ram on the greater care which is now being taken in the design of motor control apparatus. This statement is borne out by an inspection of a double-pole ironclad switch, which has just been put on the market by E. F. Moy (Ltd.). The switch is designed for work on motor circuits, and is made in one size only, to carry 10 amperes at 550 volts. Care is taken in providing proper insulation of all parts. The switch has a quick break action, and the whole apparatus appears to be quite an engineering job.

Electrical Machinery.—Messrs. T. W. Broadbent (Ltd.), of Huddersfield, send us a copy of their new leaflet containing details of their continuous-current machines, shunt regulators and switches. We are pleased to learn that, in spite of the trade depression, the firm have numerous large orders on hand, and we can only hope that this happy state of things will continue. The machines are of good design and should be able to satisfactorily perform the work they are built to do.

New Conduit Accessories.—The Armorduct Mfg. Co. are issuing a catalogue illustrating and describing new types of conduit fittings, &c.

Coventry Challenge Cycles.—We have received from the Challenge Cycle Co., of Coventry, a pamphlet which gives full particulars of this company's well-known machines.

Helsby Activities.—The British Insulated & Helsby Cables have made several additions to their numerous and useful leaflets. These include one showing a list of the "Chief Contracts for Telephone Cables containing 200 Pairs and Over," recently executed by the company. Prescot joint boxes of various types are illustrated and described in three other leaflets, while the last contains details of the Helsby magneto mine exploders and shot-firing cables. The mine exploder contains a series of powerful permanent steel magnets between the pole pieces, of which an armature is rotated by means of double spur and pinion gear operated by detachable handles. These exploders are made both for high-tension and low-tension shot-firing work.

Electric Fans.—This being the season of electric fans, Messrs. Baxendale & Co., of Manchester, have issued a pamphlet dealing with their standard types. These include table fans for both alternating and direct-current circuits, which can when desired be fitted with an oscillating base. Porthole fans and friction gear fans for both direct and alternating current, as well as exhaust fans and propeller fans, are also supplied.

Mirrlees-Diesel Oil Engines.—Mirrlees, Bickerton & Day forward a descriptive booklet of the various types of "Mirrlees-Diesel" oil engines made by them. Concise information is given showing the working of this particular type of engine, as well as an interesting account of the gradual development of the "Mirrlees-Diesel" machine from the original Diesel patents. Several tables showing the cost of running are included, and these should be of interest to engineers in general.

BANKRUPTCIES, LIQUIDATIONS, &c.

The public examination of Lancelot W. de Grave, electrical engineer, 19, Queen-street, Derby, will be held at the Court House, St. Peter's Churchyard, Derby, on June 15.

At the first meeting of creditors on Saturday the liabilities were stated to be £271. 12s. 6d., assets estimated at £45. 9s. 11d. Debtor started in business about 10 years ago as an electrical engin eer, subsequently as a metal worker, and in 1907 he purchased a cycle business. Attributed failure to lack of capital and trade depression.

The public examination of J. R. W. Middleton and A. E. E. Daniels, electrical engineers, trading as Middleton & Co., at King-street, Dover, were examined at Canterbury County Court last week. Particulars of this bankruptcy appeared in our last issue (p. 279). After various questions had been answered by debtors, the examination was adjourned for a month, debtors being ordered to file accounts and statements in the meantime.

The trustee (Mr. Chas. H. Plant, 13, Winckley-street, Preston) in the bankruptcy of Richd. Sutcliffe Blackburn, electrical engineer, Osborne-street, and Ribstone Works, Hebden Bridge, has been released.

Claims against Geo. Sutcliffe (trading as Geo. Sutcliffe & Co.), electrical engineer, 22, Church-street, Abertillery, by June 10 to Mr. E. F. Gardner, 144, Commercial-street, Newport, Mon.

A first and final dividend of 1s. 3d. will be payable on June 10 at Government-buildings, Swansea, to the creditors of Thos. Arthur Evans, electrical and mechanical engineer and contractor, 14, Heathfield-street, Swansea.

Claims against the Amalgamated Radio-Telegraph Co. (Ltd.) (in liq.) by July 6 to Messrs. F. W. Pixley & H. Allen, 58, Coleman-street, London, E.C.

A meeting will be held at 3, London-wall-buildings, London E.C., on June 29, to receive an account of the winding-up of the Cornwall Electric Power Synd. (Ltd.)

Mr. Alan G. Robson, 69, Pilgrim-street, Newcastle-on-Tyne, has been appointed liquidator of the Eldon Electric Co., Ltd. (in liq.), in place of Mr. W. Sparks, who has resigned.

In pursuance of sec. 188 of the Companies (Consolidation) Act a meeting of the creditors of Marples, Leach & Co. (Ltd.) which was called by the joint liquidators (Messrs. Geo. Ambach and R. Clements), was held at 28, Artillery-lane, London, E.C., on May 29.

No proper printed statement of affairs was presented, but Mr. Clements read figures from a balance-sheet of the company prepared as at May 14 last. According to this the liabilities were £22,979, of which £17,565 was due to trade creditors, and in addition there were debentures for £7,500. There were also contingent liabilities of no less than £18,000, but it was not known what portion of these would rank on the estate for dividend. The assets were put at £33,257. 1s. 2d., including cash in hand £872. 7s. 2d., debtors £10,538. 10s. 10d., stock at valuation £16,611. 2s., fixtures, &c., £1,868. 19s. 10d., plant and machinery £689. 7s. 11d., and investments in the Time Ring Spinning Co. £2,676. 13s. 5d. It was pointed out that, apart from contingent liabilities, there was a large surplus. Arrangements were being made with a well-known German company to take over the assets of the company, and the whole of the claims of creditors would then be paid in full. It was not known what portion of the contingent liabilities would rank.

Until the liability was known the German company could not take over the business, as they might be called upon to meet the contingent liabilities, or what portion of them ranked on the estate. The negotiations were still in progress, but it was not to be expected that the purchasers would make themselves responsible for the contingent liabilities.

Replying to a question, the liquidator said that the company which proposed to take over the concern was the Bergmann Electrical Co. of Berlin. A creditor said that the Bergmann Co. might buy the assets from the liquidators of the company, and Mr. Clements replied that they might get over the difficulty by way of an assignment, and, in fact, that was what they proposed doing, if it could be done. In regard to the contingent liabilities, Mr. Clements stated that some time ago the company entered into an arrangement with the Time Ring Spinning Co. under which the company were to receive an order from the Spinning Co. to carry out an installation contract amounting to about £18,000, but in addition the company were, if necessary, to invest about £15,000. So far the company had paid £2,500 on the shares they held in the Spinning Co., and a further call of £750 was now due. There were also other minor contingent liabilities, including a claim against them in respect to the sale of certain lamps. The contract regarding the mill was entered into about 12 months ago. The mill was not yet built, but when it was completed the company was to fit it up.

A creditor said it was a rank speculation, and not a matter of business, and another creditor expressed the opinion that it was a very hazardous agreement to enter into.

Replying to a question, the liquidator stated that, under the articles of association, the directors had the right to invest money in outside concerns.

A creditor said that the article only meant the investment of any surplus cash the company might possess. Apparently the company had never had any surplus cash for investment, and the directors had no right to enter into such an agreement. He was of opinion that the investment in the Spinning Co. was *ultra vires*, and that the directors should be held responsible.

Mr. Clements said whether the investment was *ultra vires* was a question for counsel to decide. The securing of the contract for £18,000 was conditional on the investment of £15,000, and was a purely business arrangement. The company whose name had been mentioned in connection with the purchase of the concern were by far the largest creditors in this matter.

A resolution approving of the appointment of the present liquidators was opposed by several creditors. It was stated that the debentures would be taken over by the purchasers, and no receiver had been appointed by the debenture holders. The last issue of debentures was made on Jan. 25 of the present year, and the balance-sheet showed that the company was then solvent. After a somewhat protracted discussion, it was decided by a large majority to adjourn the meeting for a month, the liquidators being asked in the meantime to obtain further and more definite information regarding the contingent liabilities.

Winding-up Petition.—A petition for the winding up of Auto-Controllers (Ltd.) has been presented to Dorset County Court by Mr. E. G. Bryant, and will be heard at the Town Hall, Poole, on June 14.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

March 1, 1909.

4,928 MALLINSON. Electrically-driven rotary pumps.
4,991 CODD. Armatures for magneto machines.
4,997 GILES. Safety device for the dissipation of excess voltage in electrical systems. (Date applied for, 29/5/08.)*†
5,003 MOSER. Generating a synchronous alternating current of limited or defined strength.
5,018 BENNETT, ESTES & EVANS. Trolleys or rotary collectors for electric cables.*

March 2, 1909.

5,040 WHALLEY. Electric indicators.
5,061 SOMERS & CROWLEY. Distributing electrical energy.
5,062 SOMERS & CROWLEY. Storage battery.
5,070 POTTER. Electric apparatus for street and other lighting.
5,081 MURPHY. Rectifying electric currents.*
5,114 HEYWORTH. Secret telephone transmitters.*

March 3, 1909.

5,131 HERBERT. Magnetic instructor.
5,145 CONNER. Electrical relay.
5,168 CROMPTON & CO., MACFARLANE & BURGE. Electrical regenerative control apparatus and systems.*
5,209 B.T.-H. CO. (G.E. Co., U.S.) Motor-generator sets.*
5,210 HOPPS. Ignition devices for internal-combustion engines.

March 4, 1909.

5,223 LACEY. Safety shut-off appliance for electrical controllers.
5,235 DUDGEON & CROSS. Trolley heads.
5,238 VICKERY. Controlling magnetic moments.
5,249 MUNRO & RAILLESS ELECTRIC TRACTION CO. Trolley heads or current collectors.
5,279 SMITH. Electrical signalling apparatus.
5,280 LAKE. (Cutler-Hammer Mfg. Co., U.S.) Multiple-switch starters.*
5,302 TATE. Electric terminals.
5,318 ALLGEMEINE ELEKTRICITATS GES. Control of dynamo-electric machines. (Date applied for, 4/3/08.)*†

March 5, 1909.

5,413 GUGGENHEIMER & GOSSEN. Measuring alternating electric currents.*
5,418 B.T.-H. CO. (G.E. Co., U.S.) Controlling electric circuits.

March 6, 1909.

5,425 PHILLIMORE. Jointing for aluminium cables.
5,426 OPPENHEIMER. (Akt.-Ges. Mix & [illegible]) [illegible]
5,427 ALLISON. Switch of transformer for electric currents.
5,459 MCCLELLAND. Maximum current indicator for electricity.

March 8, 1909.

5,563 DICKSON. Electromagnet.
5,564 PUIG. Points for railways, electric trains and tramways.*
5,565 CUMONT & COMPAGNIE DE SIGNAUX ELECTRIQUES [illegible] CHEMINS DE FER. Electrical control of railway signals. (Date applied for, 25/3/08.)*†
5,566 BEVAN. Telegraphic instruments.
5,567 REGNART. Electric candle lamps.*
5,578 EISENSTEIN. Wireless telegraphy. (Addition to No. 10,019/08.)*
5,605 EDGCUMBE & EVERETT. Relays for protection of electric circuits.
5,611 NAYLOR. Electrical plug boxes.

March 9, 1909.

5,623 TAYLOR. Electric accumulator sub-stations fed from alternating-current systems.
5,690 JACOBY. Reversing alternating-current commutator machines. (Date applied for under Rule 13, 23/12/08. Comprised in No. 27,967, 23/12/08.)
5,703 HARRISON & FRAZER. Transformers.
5,706 LAKE. (Gibson Mfg. Co., U.S.) Telephone mouthpieces.*
5,717 ALLGEMEINE ELEKTRICITATS-GES. Protective devices for alternating-current systems. (Date applied for, 12/3/08.)*†

March 10, 1909.

5,732 S. H. SMITH, W. I. SMITH & GREEN. Switch for use with transformers for metallic filament lamps.
5,751 TUCKER. Electrical switches.
5,777 BELL & PLETTS. Apparatus for electrically heating air and other media.
5,778 EVERETT & EDGCUMBE. Thermal relays for the protection of electric circuits.
5,783 SCLATER & BOOTHROYD. Apparatus for using low-pressure electric lamps on alternating systems of distribution.
5,805 FLOOD. Electric switches.
5,820 B.T.-H. CO. (G.E. Co., U.S.) Electric measuring instruments.
5,821 B.T.-H. CO. (G.E. Co., U.S.) Reducing oxides.*

March 11, 1909.

5,828 KER. Automatically inserting or cutting out resistance in electrical circuits.
5,888 SUCHOSTAWER. Electric motors and generators.
5,891 RAWLINGS, HANDCOCK & DYKES. Fixings for making attachments to walls or ceilings for electrical conductors and other purposes.
5,893 HOYT & SINSABAUGH. Spark plugs.*
5,904 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*
5,909 LAKE. (Cutler Hammer Mfg. Co., U.S.) Multiple-switch starters.*
5,935 B.T.-H. CO. (G.E. Co., U.S.) Electrical measuring instruments.

March 12, 1909.

5,955 TWIGG. Electric sparking plugs.
5,958, 5,959, 5,960, 5,961 & 5,962 GIBBS. Production of metallic articles by electro-deposition. (Date applied for, 27/2/08. Comprised in No. 4,410, 27/2/08.)
6,004 HACKETT. Combined tramway and telegraph pole. (Date applied for, 14/8/08.)*†
6,008 FESSENDEN. Producing indications by received electromagnetic waves.*

SPECIFICATIONS PUBLISHED.

1907 SPECIFICATIONS.

21,761 GRIFFIN. Electromagnetic sparkling plugs (Post-dated 2/4/08.)
26,607 FELTEN & GUILLEAUME LAHMEYERWERKE AKT.-GES. Direct-current electrical machinery. (Date applied for, 6/12/06.)
28,412 FESSENDEN. Signalling by electromagnetic waves. (Date applied for 14/1/07.)
28,647 FESSENDEN. High-frequency electrical oscillations and apparatus. (Date applied for, 4/2/07.)

1908 SPECIFICATIONS.

333 ELIESON. Electric accumulators.
4,744 FRIEDHEIM. Electrolytic deposition of metal on hollow articles. (Date applied for, 4/3/07. Addition to No. 7,563/07.)
4,857 B.T.-H. CO. & PARK. Track brakes for tramways and railways.
4,962 ATKINSON & GARSIDE. Electric controllers or switches.
5,440 CRAIG. Portable motor-generators for charging cells and other purposes.
5,628 MYERS & GEDGE. Switch for the control and transmission of electric energy.
5,681 LONG. Electric light fittings.
5,686 CHRISTIAN. Current-collecting devices for electric railway vehicles.
5,974 B.T.-H. CO. (G.E. Co., U.S.) Dynamo-electric machines.
6,059 BARON. Suspension devices for electric lamps.
6,187 HODGSON. Electric switches for charging and discharging electric accumulators.
6,228 GROB. Electric lighting and heating of vehicles. (Date applied for, 20/3/07.)
6,323 STEINERT & STEIN. Electromagnetic separation. (Date applied for, 21/3/07.)
6,421 CROMPTON & CO. & CROMPTON. Electric arc lamps.
6,449 MORRIS. Electrolytic production of aluminium oxide.
6,562 B.T.-H. CO. (Rupley.) Electric clock-winding mechanisms.

COMPANIES' MEETINGS AND REPORTS.

ARON ELECTRICITY METER (LTD.)—For the year ended March 31, after providing for general charges and depreciation, the net profit was £20,067. 10s. 3d., making, with £3,971. 9s. 9d. from last year, a total available profit of £24,039, out of which the directors distributed in December last a dividend of 3 per cent. on the preference shares, absorbing £3,746. 17s. 6d., leaving £20,292. 2s. 6d. The directors recommend payment of the balance preference dividend (£8,742. 14s. 5d.) and the transfer of £5,000 to reserve towards goodwill and patents, leaving £6,549. 8s. 1d. to be carried forward. The report states that the business continues to be satisfactory in all branches. The factories in Schweidnitz and Paris are being increased to meet the growing demand for the company's manufactures. The taximeter business continues to develop.

JOHNSON & PHILLIPS (LTD.)—The chairman (Mr. Robt. W. Blackwell) stated at the meeting last week that the balance on trading account was £10,037, and with £6,873 brought forward the total to be dealt with was £16,910. After providing for appropriations amounting to £16,229 the balance (£681) had been carried forward. The fall which had occurred in their business was largely—in fact, practically wholly—due to the business in that, and in any enterprise connected with electrical manufacturing, being in a stagnant condition. The cable business, which for many years had been the backbone of the concern, had been well maintained, and it was their belief that it would continue to prosper. There were signs that the current year would be very much in excess of what it was during the past year. Their sole trouble, however, had been the absolute stagnation in the whole manufacturing industry of the country, and they had had to take their share of that loss. The delay in holding the meeting was to enable the board to make a thorough investigation into

the detailed figures of the past year, and such comparisons as might lead them to arrive at a safe conclusion. They had, naturally, not wished to rush the matter, or to go outside the usual staff of the company in the preparation of the figures. So far as they could see, the prospects of the present year were very much better. He could not say what the condition might be at the end of the year, but the work in hand was better, more lucrative, and there was much more of it than in the corresponding period of last year. They had, furthermore, taken the opportunity to cut down a great portion of the expenditure on the staff of the company, and they believed the company was in a sound position at the present moment, and that the working staff arrangements were better by far than they were a year ago. Such expert work as they had in hand had so far produced very good results. They were specially satisfied at the present moment with the appearance of the new form of arc lamps which had been evolved by Mr. James Brockie. The new lamp was about to be placed on the market—both the magazine and flame lamps and the small arc lamps, in all of which they expected there would be a considerable trade in the future. Looking round to the trade in general, they really did not see that they had had more than their share of the ill-fortune which had attended the electrical engineering business generally.

KALGOORLIE ELECTRIC POWER & LIGHTING CO. (LTD.)—At the recent meeting Mr. Roger W. Wallace, K.C., said that their plant had been working very satisfactorily during the past year, with the exception of part of the new unit. This had cost over £20,000, but they had been able to find the money without raising fresh capital. The strike at the mines had materially affected their revenue. Their manager in Australia (Mr. Crocker) had informed them that they required still further to increase their plant, as new developments at the mines pointed to an increased use of electricity.

KALGOORLIE ELECTRIC TRAMWAYS (LTD.)—The gross receipts for 1908 amounted to £47,368, compared with £48,008 for 1907. The net profits were £15,400, against £16,270. During the year the cars travelled 72,6497 miles and carried 3,028,419 passengers, compared with 650,530 miles run and 3,052,241 passengers carried during 1907. The earnings per car-mile were 17·53d., and the expenses 11·25d., against 17·63d. and 11·17d. respectively in 1907. The expenses per cent. of earnings in 1908 were 64·17, compared with 63·36. The report states that, in regard to future prospects, it is undeniable that affairs generally in Western Australia, and especially at Kalgoorlie, are undergoing a very encouraging change as compared with the past few years.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

BRIDGWATER CONSTRUCTION CO. (LTD.) (103,219.)—Reg. May 26, capital £1,250 in £1 shares, to take over the business of a constructional, electric and hydraulic engineer. Private company. First directors, S. Bridgwater and Miss F. Bridgwater. Reg. office, 453, Holloway-road, London, N.

BRISTOL ELECTRO-CHEMICAL CO. (LTD.) (103,193.)—Reg. May 25, capital £500 in £1 shares, to carry on the business of manufacturers of and dealers in carbide of calcium and other chemicals. Private company. Reg. office, care of Thorp & Saunders, Salisbury House, Londen-wall, E.C.

LECHLADE ELECTRIC LIGHT & POWER CO. (LTD.) (103,163.)—Reg. May 22, capital £400 in £1 shares, to carry on the business of electricians, mechanical engineers, generators of electricity, &c. Private company. First directors, A. C. Nash, E. R. Nash and B. P. Gibbons. Reg. office, High-street, Lechlade, Glos.

S.M.F. SYND. (LTD.) (103,145.)—Reg. May 21, capital £8,000 in £10 shares, to acquire a concession for tramways between Ponte Delgoda and Furnas, in the Island of San Miguel, Azores, and to carry on at San Miguel or elsewhere the business of constructors of tramways, and buildings, &c. First directors are P. Burtin, T. Guillard and G. C. d'Ancourt. Reg. office, 21, Liverpool-street, London, E.C.

SMALL POWER DYNAMO & MOTOR CO. (LTD.) (103,094.)—Reg. May 19, capital £15,000 in £1 shares, to take over the business of electrical and mechanical engineers carried on by J. Bentham, F. S. Blakey, R. Wilson and Jane Bentham, at Higher Openshaw, Manchester, as the Small Power Dynamo & Motor Co. Private company. First directors, J. Bentham, F. S. Blakey and R. Wilson. Reg. office, Old-lane, Higher Openshaw, Manchester.

TAYLOR'S PATENT SAFETY SHUNTING LEVER (LTD.) (103,169.)—Reg. May 23, capital £40,000 in £1 shares, to acquire the benefit of certain existing inventions relating to improvements for operating points and signals on railways and tramways, and to carry on the business of mechanical, electrical and general engineers, &c. Private company. First directors, H. W. Sanderson, W. Halford, A. E. Mitchell and S. Jeffreys.

STATUTORY RETURNS.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—Return to March 24 gives capital as £400,000 in 74,000 ordinary and 6,000 preference shares of £5 each, of which 49,436 ordinary and 6,000 preference shares have been taken up. £5 per share called up on 37,770 ordinary and 6,000 preference, and £218,850 has been received. £58,330 is considered as paid on 11,666 ordinary. Mortgages and charges, £175,000 debenture stock.

HASTINGS & DISTRICT ELECTRIC TRAMWAYS (LTD.)—Return to April 1 gives capital as £500,000 in 50,000 preference and 50,000 ordinary shares of £5 each, of which 40,000 preference and 28,235 ordinary have been taken up. £200,000 has been paid on 40,000 preference and £141,175 is considered as paid on 28,235 ordinary. Mortgages and charges, £250,000.

LONDON PLATINO BRAZILIAN TELEGRAPH CO. (LTD.)—In return to May 12 capital is £400,000 in £10 shares, of which 37,480 have been taken up. £374,800 is considered as paid. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—A memorandum of satisfaction in full, by instalments from Nov. 14, 1901, to Sept. 9, 1908, of charges dated April 15, 1901, to June 30, 1908, securing in all £103,297. 13s. 1d., has been filed.

ELECTRO-MECHANICAL BRAKE CO. (LTD.)—Two mortgages dated April 27 and May 4, to secure £250 and £350 respectively, charged on (a) moneys due or to become due to the company from the Midland Engineering Co. and (b) moneys due or to be become due to the company from the Birmingham Corporation tramways department. Holders, Metropolitan Bank of England and Wales.

OMEGA ELECTRIC LAMP CO. (LTD.)—Issue on May 14 of £500 debentures, part of a series of which particulars have already been filed.

RECEIVERSHIP.

MARPLES, LEACH & CO. (LTD.)—A notice of the appointment of R. Clements, 14, Hilly Fields-crescent, Brockley, as receiver on May 14, 1909, under powers contained in 1st mortgage debentures, dated Jan. 25, 1909, has been filed.

CITY NOTES.

MEMORANDA (June 3).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $24\frac{5}{16}$d. per oz. Consols $84\frac{1}{4}$—$84\frac{3}{8}$ for money and $84\frac{3}{8}$—$84\frac{1}{2}$ for account. Consols Pay Day, July 1; Stock and Shares Continuation Days, June 9 and 23; Ticket Days, June 10 and 24; Pay Days, June 11 and 25; Mining Shares Carry Over Day, June 8.

PRICES OF METALS (London).—*Copper*, cash, 60; three months $60\frac{13}{16}$. *Lead*, English, $13\frac{3}{8}$—$13\frac{3}{4}$; foreign, cash, $13\frac{1}{8}$—$13\frac{3}{16}$; three months, $13\frac{1}{2}$; *Spelter*, cash, 22—$22\frac{1}{8}$; three months, $22\frac{1}{8}$—$22\frac{3}{8}$. *Tin*, English, 131—133; foreign, cash, $131\frac{7}{8}$ three months, $132\frac{1}{4}$—$133\frac{1}{8}$. *Iron*, Cleveland, cash, 48/11 and three months, $49/6\frac{1}{2}$. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CANADIAN GENERAL ELECTRIC CO.—The directors have declared a dividend of $1\frac{3}{4}$ per cent. on the income stock for the quarter ended June 30.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following will be struck off the Register of Joint Stock companies unless cause to the contrary is shown before Aug. 28: Anglo-Iberian Electric Light & Power Co., Carl Oppermann Electric Carriage Co., Electric Carriage & Storage Co.

FREDERICK SMITH & CO., WIRE MANUFACTURERS (LIMITED AND REDUCED).—A petition for confirming a resolution reducing the capital of this company from £200,000 to £115,000 has been presented to the High Court. The proposed reduction is the result of the recent sale of the Salford branch of the company's business, a large part of the capital of the company being no longer required for the purposes of the Halifax business, which now constitutes the company's undertaking.

MACKAY COMPANIES.—The regular quarterly dividend of 1 per cent. on the preferred shares and the regular quarterly dividend of 1 per cent. on the common shares in the Mackay companies will be paid on July 1. The transfer books will not be closed. Dividend cheques of English and Continental shareholders will be made payable at the rate of 4s. $1\frac{1}{2}$d. to the dollar, at the option of the payee, at the Union of London and Smith's Bank, London, E.C.

MIDLAND ELECTRIC CORPN. FOR POWER DISTRIBUTION (LTD.)—The accounts for the year 1908 show a loss of £11,517, increasing the debit balance to be carried forward to £82,602.

SIEMENS BROS. & CO. (LTD.)—The directors recommend a dividend of 4 per cent. (4s. per share) for the past year. £2,528 was written off shares in other companies and £3,459 carried to the pension fund.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have ordered a further issue of \$51,500 30-year 5 per cent. gold bonds of the *Kaministiquia Power Co. (Ltd.)*, to be quoted in the official list. The committee have been asked to appoint special settling days in and grant quotations to a further issue of 900,000 £1 fully and partly paid 6 per cent. cumulative preference shares of the *Victoria Falls & Transvaal Power Co. (Ltd.)*, and 169,406 £5 fully paid 5 per cent. third preference shares of the *Anglo-Argentine Tramways Co. (Ltd.)*, and also to appoint special settling days in 20,000 £10 fully paid 6 per cent. cumulative preference shares of *Hurst, Nelson & Co. (Ltd.)* and £100,000 5 per cent. prior lien debenture stock of the *Brush Electrical Engineering Co. (Ltd.)* and to grant quotations to £50,000 $4\frac{1}{2}$ per cent. debenture stock of the *Anchor Cable Co. (Ltd.)*; a further issue of 39,070 £5 fully paid ordinary and 39,070 £5 fully paid 7 per cent. cumulative preference shares of the *British Aluminium Co. (Ltd.)*; a further issue of £63,124 4 per cent. guaranteed debenture stock of the *Central Electric Supply Co. (Ltd.)*; 13,500 £10 fully paid ordinary shares of the *Gateshead & District Tramways Co.*, and a further issue of £68,200 £100 first mortgage 6 per cent. 35-year sinking fund gold bonds of the *West Kootenay Power & Light Co. (Ltd.)*

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.		Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
			£	£		£	£
Aberdeen Corporation	...		...	...	...	...	...
Airdrie	May	21	225	− 3	20	4,301	− 78
Anglo-Argentine	„	27	39,484	+ 284	21	827,417	+ 44,196
Ayr Corporation	„	24	238	− 28	2	513	− 101
Baker St. & Waterloo Ry.	„	29	3,320	+ 380	21	70,110	+ 5,945
Barnsley	„	23	165	− 17	20	3,296	− 97
Barrow	„	21	212	− 1	20	4,141	− 290
Bath Electric Trams, Ltd.	„	26	845	− 79	21	14,110	+ 649
Birmingham Corporation	„	29	6,751	+ 357	9	55,763	+ 847
Birmingham & Mid.	„	14	824	+ 15	19	15,228	− 110
Blackburn Corporation	„	26	1,131	− 1	9	10,201	+ 73
Blackpool and Fleetwood	„	28	460	+ 78	...	...	...
Bolton Corporation	„	30	2,295	− 132	9	20,833	− 97
Bombay	April	29	R37,039	+ R1,019	17	R654,035	+ R45,314
Bournemouth Corporation	May	26	1,521	+ 46	8	13,411	+ 200
Bradford Corporation	...		...	...	...	...	...
Brighton Corporation	„	30	974	+ 101	9	7,886	+ 731
Bristol Trams & Carriage	„	28	5,494	+ 480	1	5,494	+ 480
Burnley Corporation	„	29	1,254	− 6	9	11,588	+ 303
Burton Corporation	„	30	2?0	+ 14	9	2,258	− 6
Bury Corporation	„	30	1,157	− 103	†9	9,178	− 202
Calcutta Tramways Co.	„	29	R48,114	+ R6,592	21	R1,043,464	+ R92,472
Camborne-Redruth	„	29	132	+ 9	22	2,538	− 70
Cardiff Corporation	...		...	...	...	...	...
Cavehill	„	21	89	− 19	20	1,380	− 163
Central London Railway	„	29	5,783	− 1,294	21	115,693	− 12,001
Charing C., Euston & H'stead	„	29	4,010	+ 605	21	81,025	+ 13,665
Chatham & Dist. Lt. Rys.	„	27	850	+ 70	21	15,552	+ 1,255
City & South London Rly.	„	30	3,160	+ 339	21	68,437	+ 938
City of Birmingham	„	21	2,772	− 103	20	53,803	− 539
Colchester Corporation	„	26	176	− 15	...	...	...
Cork Electric Trams Co.	„	27	497	− 46	21	7,940	− 893
Croydon Corporation	„	28	1,553	+ 31	8	12,422	+ 480
Devonport & Dist. Trams	„	21	352	− 84	20	7,313	− 1,292
Dover Corporation	„	22	200	+ 12	8	1,440	+ 8
Dublin & Lucan Railway	„	23	137	+ 7	21	2,500	+ 201
Dublin United	„	28	5,710	+ 159	21	105,570	+ 1,033
Dudley-Stourbridge	„	21	786	− 34	20	14,792	− 216
Dundee Corporation	„	26	1,273	+ 7	†2	1,789	− 153
East Ham Council	„	29	1,031	+ 171	§8	8,528	+ 1,515
Exeter Corporation	„	28	565	+ 250	9	2,878	+ 352
Gateshead & Dist. Trams	„	21	967	− 1	20	19,505	− 98
Glasgow Corporation	„	29	17,810	− 490	52	881,587	− 16,438
Glossop Trams	„	29	115	− 12	22	2,584	− 97
Gravesend—Northfleet	„	21	197	− 15	20	3,692	− 145
Great Northern & City Rly.	„	29	1,404	− 153	21	31,961	− 3,849
Gt. Northern, Piccadilly, &c.	„	29	5,790	+ 290	21	121,650	+ 7,720
Greenock & Port Glasgow	„	21	598	+ 36	20	9,717	+ 21
Hartlepool Tramways	„	21	228	+ 3	20	4,074	− 103
Hastings Elec. Trams Co.	„	27	954	− 19	21	17,333	− 464
Hong Kong	„	29	$7,663	+ $282	21	$172,145	+ $11,581
Huddersfield Corpn.	„	29	1,630	+ 42	8	14,067	+ 623
Hull Corporation	„	29	2,573	+ 193	8	21,017	+ 157
Ilford District Council	...		...	...	...	...	...
Ilkeston District Council	„	26	135	− 7	8	1,036	− 93
Ipswich Corporation	„	29	191	+ 17	9	3,139	+ 111
Isle of Thanet Co.	„	29	541	+ 80	§26	10,773	+ 417
Jarrow	„	21	112	+ 2	20	2,145	+ 192
Keighley Corporation	„	27	177	+ 2	8	1,368	+ 46
Kidderminster & District	„	21	92	− 12	20	1,716	− 66
Kilmarnock Corporation	„	29	147	...	2	394	− 59
Lanarkshire Trams Co.	„	27	1,238	− 49	21	25,256	− 1,583
Lancashire United	„	26	1,307	− 153	21	26,133	+ 98
Leamington	„	21	154	+ 3	20	2,984	+ 208
Leeds Corporation	„	29	6,786	+ 38	9	56,563	+ 2,484
Leicester Corporation	...		...	...	...	...	...
Leith Corporation	„	29	574	+ 48	2	1,277	+ 93
Lincoln Corporation	„	29	122	+ 7	9	1,110	+ 53
Liverpool Corporation	„	22	10,626	− 350	‖20	211,690	− 1,326
Liverpool Overhead Rly.	„	30	1,336	− 116	22	28,566	− 2,122
Llandudno & Colwyn Bay Ry	„	28	195	+ 81	23	3,649	+ 1,396
*London County Council	...		...	...	...	...	...
London United	„	29	6,895	− 1,047	‖24	116,043	− 7,361
Lowestoft	...		...	...	...	...	...
Maidstone Corporation	„	29	182	− 11	8	1,512	− 74
Manchester Corporation	...		...	...	...	...	...
Mersey Railway	„	29	1,994	+ 162	21	41,265	+ 1,246
Merthyr	„	21	213	...	20	4,076	+ 4
Metropolitan Dist. Railway	„	29	10,310	+ 1,003	21	205,447	+ 18,579
Metropolitan Elec. Trams	„	21	6,187	− 123	20	113,032	+ 11,980
Middleton	„	21	337	− 42	20	6,320	− 295
Nelson Corporation	„	29	135	− 14	19	1,197	− 45
Newcastle-on-Tyne Corp.	„	29	3,927	+ 213	8	33,987	+ 382
Newport (Mon.)	„	29	666	+ 11	9	5,829	+ 45
Northampton Corporation	„	28	499	+ 40	§9	3,967	+ 291
Oldham, Ashton & Hyde	„	21	537	− 76	20	10,835	− 758
Oldham Corporation	„	30	1,941	− 121	9	18,163	− 863
Perth (N.B.) Corporation	...		...	...	...	...	...
Perth (W.A.) Elec. Trams	„	28	1,351	− 59	21	30,612	− 28
Peterborough	„	21	109	− 18	20	2,058	− 139
Portsmouth Corporation	...		...	...	...	...	...
Potteries	„	21	1,792	+ 19	20	34,908	− 1,136
Preston Corporation	„	26	756	+ 53	8	5,864	+ 119
Rotherham Corporation	„	27	595	− 17	8	4,922	− 92
Rothesay	„	21	198	− 5	20	1,671	− 19
Salford Corporation	„	31	4,5?9	− 362	19	39,718	...
Sheerness	„	21	45	− 12	20	877	− 127
Sheffield Corporation	„	30	5,760	− 54	§9	52,818	− 560
Singapore Trams	„	29	$9,033	+ $497	21	$301,734	+ $2,055
South Metropolitan	„	21	777	− 121	20	11,161	+ 234
South Staffs	„	21	801	− 58	20	16,233	− 913
Southend Corporation	...		...	...	...	...	...
Southport Tramways	„	21	2?5	+ 3	20	4,844	+ 124
Stalyb'dge, Hyde, &c., Jt. Bd.	„	23	717	− 45	§3	6,585	− 88
Sunderland Corporation	„	30	1,202	+ 6	9	9,539	− 295
Sunderland District	„	26	449	− 22	30	13,232	− 370
Swansea Trams	„	21	886	+ 16	20	17,723	+ 446
Swindon Corporation	„	26	137	− 13	...	...	...
Taunton	„	21	31	− 3	20	647	− 60
Tynemouth and District	„	21	199	+ 2	20	2,958	− 80
Tyneside Trams Co.	„	26	433	+ 55	21	8,401	+ 638
Wallasey District Council	„	29	925	+ 25	§8	7,803	+ 163
Walsall Corpn.	„	20	509	− 19	21	10,498	− 823
Warrington Corpn.	„	27	376	+ 11	8	3,033	− 54
West Ham Corporation	„	20	2,248	− 13	7	16,766	+ 1,389
Weston-super-Mare	„	21	104	+ 25	20	1,046	+ 152
Wolverhampton Co.	„	21	389	− 46	20	7,903	− 876
Wolverhampton Corpn.	„	26	793	+ 13	21	14,836	− 985
Worcester	„	21	262	− 16	20	4,907	− 8
Wrexham	„	21	92	− 4	20	1,854	− 59
Yorkshire W.R. Trams	„	30	1,275	+ 45	22	24,955	...
Yorkshire Woollen District	„	21	929	+ 16	20	17,160	− 481

(a) These comparisons are with the corresponding period last year. § Plus 3 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share.	Last Dividend	Name.	Price Wed. June 2.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to June 2. Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7.0	Bournemouth & Poole Elec. Sup. Ord.	9½–10	6 ? 0	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	3½–1¼	4 9 0	Feb. Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼–10¾	5 11 6	Feb. Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101–105	4 5 6	Jan. July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½–4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93–96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½–9	5 11 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	8–8½	4 2 ?	Mar, Sept	..	—
St.	4%	†Cent l Elec. Sup. Co. 4% Guar. Db. Stock	97–100	4 ? 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜–4¼	5 1? ?	Feb, Aug	3?	..
5	2/3	Do. 4½ per Cent. Pref.	4½–4¾	4 12 0	Feb, Aug	—	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98–101	3 19 0	Jan. July	..	—
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99½–10?	4 ? 0	..	100¾	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾–4¼	5 8 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜–4½	4 9 3	March ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102–105	4 7 6	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10½–11	5 10 0	Feb, Aug	10?	10¾
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼–11½	4 13 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121–123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101–104	4 6 6	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1¾–2¼	—	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3½–3¾	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8½–8¾	5 14 0	Feb, Aug	?	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞–11⅛	5 8 0	Mar, Sept	10¼	..
St.	4½%	Do. 4½% Deb. Stock (red.)	106–109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100–103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½–5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97–100	4 10 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7¼–7¾	5 10 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7⅛–7⅝	5 5 0	Feb, Aug	..	—
5	6%	Do. 6 per Cent. 1st Pref.	6⅜–6⅝	4 14 6	Jan, July	..	—
t.	4%	Do. 4 per Cent. Deb. Stock (red.)	94–97	4 3 0	..	—	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98–101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	86–89	5 1 0	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞–2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛–5⅜	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92–96	4 3 6	Jan, July	—	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅝–4⅞	5 18 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾–5⅛	4 7 6	Jan, July	4?	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107–110	4 2 0	June, Dec	—	—
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	86–88	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95–98	4 12 0	June, Dec	..	—
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4¾–5	4 2 1	Feb, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	86–90	5 0 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅞–5	2 10 7	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5–5¼	4 17 6	Feb, Aug	..	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	98–100	4 0 10	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99–101	4 19 0	..	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91–93	4 17 10	Jan, July	—	..
10	8/0	Notting Hill Electric Ord.	11½–12½	5 12 0	March ..	—	—
5	4/6	Oxford Electric Ord.	6–6½	5 8 0	March ..	6⅜	..
St.	4%	Do. 4 per Cent. Deb. Stock	94–97	4 2 6	Jan, July	..	—
5	5/0	St. James' & Pall Mall Elec. Ord.	9–9½	5 5 0	Feb, Aug	9?	..
5	3/6	Do. 7 per Cent. Pref.	7–7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	83–90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	⅝–⅞	..	Feb	..	..
1	4/0	South London Electric Supply Ord.	2¼–2½	6 8 0	April ...	—	..
St.	..	Do. 5% 1st Mort. Stk. Red.	1½–1¾	..	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝–⅞	4 14 0	..	—	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	1⅛–1⅜	5 7 0	Feb, Aug	..	—
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100–103	4 7 6	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	⅝–1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2–2¼	10 0 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80–84	5 7 3	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9⅛–9⅜	5 4 0	Mar, Sept	9?	9¼
5	2/8	Do. 4½ per Cent. Cum. Pref.	5⅛–5½	4 11 0	Jan, July	5¼	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	97–99	4 1 0	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.	¼–⅜	..	April....	—	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜–½	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	88–92	4 18 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89–92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	5½–9¼	6 9 9	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½–9	4 9 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100–101	3 19 2	Feb, Aug	..	—
10	..	British Electric Traction Ord.	1¼–1⅜	..	June, Dec	..	..
10	8/0	Do. 6 per Cent. Cum. Pref.	2⅜–3⅜	8 13 0	Feb, Aug	..	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	89–93	5 7 0	April, Oct	92¼	—
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68–72	6 5 0	May, Nov	—	..
St.	3½%	Central London Ordinary Stock	68–70	5 0 0	Feb, Aug	69	68
St.	4%	Do. 4 per Cent. Pref. Stock	85–87	5 12 0	Feb, Aug	—	..
St.	2½%	Do. Deferred Stock	51–53	4 14 3	Feb	—	..
100	4%	Do. 4 per Cent. Debs.	102–104	3 16 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92–94	4 5 0	Jan, July	—	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼–4¾	4 15 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97–101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	32½–33½	4 9 6	Feb, Aug	32¾	32
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110–112	4 9 0	Feb, Aug	..	—
St.	5%	Do. (1896)	103–109	4 11 ?	Feb, Aug	—	..
St.	5%	Do. (1901)	103–105	4 1? 0	Feb, Aug	..	—
St.	5%	Do. (1903)	93–96	5 4 0	Feb, Aug	—	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99–101	3 19 0	May, Nov	..	—
10	6/0	Dublin United Trams. Ord	—	4 15 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	13–14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	½–¾	..	Feb, Aug	..	—
10	..	G. Northern, Picc. & Brompton 4% G. Pt.	8¼–[illegible]	—	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	91–95	4 3 6	Jan, July	—	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2–2½	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	82–87	5 3 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	5½–6	8 ? 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6¾–7¼	7 1? 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	87–89	5 1 11	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	55–60	6 13 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9¾–10¼	5 17 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91–93	5 7 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	[illegible]–1	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	5–6	8 ? ?	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82–84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2¼–2¾	1? 10 ?	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	70–74	5 8 0	Jan, July	.	..
St.	..	Mersey Con. Ord. Stock	1–2	—	Feb, Aug.	—	—
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April..	[illegible]	[illegible]
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97–99	4 11 0	Jan, July	95¾	97
St.	½%	Metropolitan Railway Consolidated	38¾–39¼	1 5 0	Feb, Aug	38½	38¾
St.	3%	Do. Surplus Lands Stocks	70–72	4 3 0	Feb, Aug	70?	70¼
St.	3½%	Do. 3½ per Cent. Preference	89–91	3 17 0	Feb, Aug	90⅜	9?
St	3½%	Do. 3½ per Cent. "A" Preference	82–84	4 3 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82–84	4 3 6	Feb, Aug	—	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	93–95	3 13 3	Jan, July	94½	..

In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share.	Last Divi-dend	Name.	Price Wed., June 2.	Rate % Yield-ed. £ s. d.	Dividend Due.	Business Week to June 2 High-est.	Low-est.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	...	...
St.	..	Metropolitan District Railway Ord.	16½—16⅝	—	Feb, Aug	16½	16½
St	..	Do. Extension Pref. (5 per Cent.)	41 —43	—	Feb, Aug	42¼	41
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	69 —71	4 18 6	Feb, Aug	—	—
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	78 —80	3 15 0	Jan, July	..	—
St.	4%	Do. 4 per Cent. Midland Rent-charge	103 —106	3 15 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	89 —92	4 7 0	Mar, Sept	90½	90
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	141 —143	4 3 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	96½	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅛—⅜	—	May	..	..
1	..	Potteries Electric Traction Ord.	3/16—5/16	—	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	—
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	84 —88	5 14 0	Jan, July	..	—
..	...	UndergdE.Rys.Lon.6 In.bds.with coup.3	36 - 38	..	June, Dec	..	..
..	5	Do. 5% Prior Lien Bonds	101½—102½	4 17 6	..	102½	101½
—	4½	Do. 4½% Bonds with coup. 8	88 —90	5 0 0	..	89½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	—	—	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	86 —90	5 0 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	9/32—13/32	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	[illegible]	6 12 0	April, Oct	..	..
1	2/6	Babcock & Wilcox Ord.	4[illegible]—4[illegible]	4 11 0	April, Oct	4 3/16	4 1/16
1	0/7½	Do. Pref.	1⅛—1½	4 0 0	..	..	—
5	6/0	British Insulated & Helsby Cables Ord.	7⅜—7¼	6 9 0	July, Feb	..	...
5	3/0	Do. 6 per Cent. Pref.	6½—6⅞	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	¼—½	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	96½—98½	6 1 6	..	97½	97⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	40 —44	9 2 0	Jan, July	...	..
St.	4½%	Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.	9⅝—10⅝	6 15 6	Jan, July	10¼	10 1/16
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	..	..
1	1/0	†Castner-Kellner Alkali Co.	1⅞—1[illegible]	6 16 0	May, Nov	1 7/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	102 —106	4 4 0	Feb, Aug	104½	..
	0/7½	Chadburn's (Ship) Telegraph Ord.	31/32—1 1/32	7 10 0	March ..	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1 1/16	5 13 0	April, Oct	..	..
1	0/[illegible]	Consolidated Electrical Co.	[illegible]	5 12 0	August ...	—	..
1	1/0	Consolidated Signal Co.	1[illegible]—1 5/16	7 12 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1	6 0 0	April, Oct	..	..
3	8/0	*Crompton & Co. (Nos. 1 to 86,000)	1 —1½	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	95 —98	5 2 0	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
[illegible]	2/0	Dick, Kerr & Co. Ord.	1 1/16—[illegible]	8 0 0	Sept	—	..
[illegible]	0/7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1[illegible]	4 16 9	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
[illegible]	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	½—¾	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	—
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	70 —75	5 6 8	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	[illegible]	—
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 3 0	Jan, July	..	..
2	..	Electric Construction Co.	[illegible]	..	Jan, July	..	..
2	2/9	Do. 7 per Cent. Cum. Pref.	[illegible]—1¼	11 4 0	July	..	..
St	4	Do. 4 per Cent. Perp. 1st Mort. Debs.	60 —64	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7[illegible]—7⅜	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11⅞—12⅜	6 2 6	Feb, Aug	11[illegible]	..
5	2/8	Do. 4½ per Cent. Pref.	5¼—5½	4 6 0	Feb, Aug	..	..
St	4½%	† Do. 4½ per Cent. 1st Mort. Deb. Stock	104 —106	4 5 0	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Wrks.	11¼—11½	6 10 0	Feb, Aug	11½	..
10	..	Do. 5 per Cent. Cum. Pref.	10½—11	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	..	—
1	..	National Elec. Construction Co.	⅛—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	¼—½	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	..	—
1	..	Simplex Conduits Ord.	1½		—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½		..	..	..
12	24/0	Telegraph Construction & Maintenance	32½—34	5 6 0	Mar, July	33½	32½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	101	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 10 6	..	2[illegible]	2[illegible]
1	1/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1¼	4 8 0	..	1[illegible]	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	..	..
St	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	103½	102
100	4½%	† Do. 4½ per Cent. 2nd Mort. Deb. (red.)	102½ —104½	4 6 0	June, Dec	..	—
100	5%	† Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 6	..	105	..
10	6	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	[illegible]	3 15 0	Apr, Oct	—	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2[illegible]—[illegible]	9 2 0	Apr, Oct	—	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	76 —[illegible]	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¼—3¼	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	94 —96	5 3 6	June, Dec	..	..
St.	[illegible]	Anglo-American	57 —59	5 12 0	F,My,Ag,N	..	..
St.	[illegible]	Do. Preferred	101 —102	5 18 0	F,My,Ag,N	102½	101⅛
St.	[illegible]	Do. Deferred	16½—17½	2 6 6	F,My,Ag,N	17[illegible]	16⅞
St	4%	Commercial Cable 4 per Cent. Deb. Stk.	91½—93½	4 5 6	Ja,Ap,Jy,O	92½	91½
10	6/0	Cuba Submarine Ord.	8¾—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	—
5	2/0	Direct Spanish Ord.	2⅞—3⅜	5 15 0	April, Oct	—	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9	5 9 0	April, Oct	—	..
50	4½%	Do. 4½ per Cent. Deb.	100% 102%	4 8 0	Jan, July	..	..
20	4/0	Direct United States Cable	13¼—13½	6 8 0	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	101 —103	4 7 0	June, Dec	..	..
St.	[illegible]	Eastern Ordinary	131½—136½	5 2 [illegible]	Ja,My,Jy,O	13[illegible]	124½
St.	[illegible]	Do. 3½ per Cent. Pref. Stock	85½—87	4 0 6	Ja,My,Jy,O	[illegible]	[illegible]
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —106	3 16 0	May, Nov	104[illegible]	..
[illegible]	6/0	Eastern Extension	12⅛—12½	6 4 0	Ja,Ap,Jy,O	12[illegible]	12⅛
[illegible]	4%	Do. 4 per Cent. Deb. Stock	10[illegible]—103½	3 18 6	Feb, Aug	..	..
[illegible]	4%	Eastern & S. Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	..	..
[illegible]	[illegible]	G. N. (of Copenhagen), with Coupon 76	27 —28	6 8 0	Jan, July	..	..
100	4½%	Halifax & Bermudas 4½% 1st Mt. Db. (red.)	101 —103	4 7 6	June, Dec	..	..
[illegible]	[illegible]	Indo-European Tel. [illegible] all	61½ —62½	5 13 9	May, Nov	...	..
100	$1	Mackay Companies Common	78 —82	4 16 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	73 —76	5 5 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]—1	..	April	[illegible]	...
100	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	100 —102	3 18 0	June, Dec	..	—
2½	1/8	West Coast of America	1⅛ —1⅜	4 12 0	May	...	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	101	..
10	..	West India & Panama	⅝—¾	..	May, Nov	..	—
10	6/0	† Do. 6 per Cent. 1st Pref	[illegible]—[illegible]	6 10 0	May, Nov	[illegible]	—
10	[illegible]	Do. 6% 2nd Pref. [illegible] of arrears	8 —9	6 13 6	May, Nov	..	—
100	5%	Do. 5 per Cent. Debs.	102 —104	4 16 6	Jan, July	—	..
[illegible]	3/0	Western Telegraph	13⅞—14⅛	4 19 0	Mr,Jn,O,D	14	13[illegible]
[illegible]	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	102[illegible]	1[illegible]
...	4%	Western Union Telegh. $1 000 4% Bonds	93 —95	4 6 0	..	..	—

Share.	Last Divi-dend	Name.	Price Wed., June 2.	Rate % Yield-ed. £ s. d.	Dividend Due.	Business Week High-est.	Low-est.
		TELEPHONES.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	143½—144½	6 11 0	..	..	
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	95½—100½	3 19 6	Jan, July	..	
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99½—101½	4 18 6	Mar, Sept	..	
5	3/0	Chili Telephone	8 —8⅜	4 16 9	August ..	8¼	
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..	
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	
St.	6%	National Co. Pref. Stock	107 —108½	5 10 6	Feb, Aug	107½	
St.	6%	Do. Def. Stock	122 —124	4 17 0	Feb, Aug	124½	
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¼—11	5 9 0	Feb, Aug	..	
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11	5 9 0	Feb, Aug	..	
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5⅝	4 5 0	Feb, Aug	5⅜	
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	..	
St.	4%	Do 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	
1	1/0	Oriental	1[illegible]—1[illegible]	5 7 6	April, Oct	..	
1	0/7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1[illegible]	4 17 6	April, Oct	—	
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	88½	
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100 —102	4 8 0	Jan, July	100½	
5	3/0	United River Plate	6¾—7⅛	6 11 6	July	7[illegible]	
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	June, Dec	..	
St.	4½%	Do. 4½ Deb. St. Red.	104 —105½	4 6 0	Jan, July	—	
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3½—3⅝	8 5 0	Jan, July	..	
10	2/0	Globe Telegraph & Trust	10½—11¼	5 8 0	SpDcMrJu	11⅛	
10	3/0	Do. 6 per Cent. Pref.	12⅞—13⅜	4 10 6	SpDcMrJu	13⅜	
10	6%	Submarine Cables Trust (Cert.)	127 —130	4 12 0	April, Oct	129	
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6½—6⅞	4 14 0	April, Oct	6⅝	
5	5/0	Do. 10% Non-cum. 2nd Pref.	9⅝—9⅞	5 1 6	Jan, July	9⅞	
St.	4%	Do. 4% Deb. Stock	94 — 96	4 3 6	June, Dec	95	
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 0	Jan, July	..	
5	3/6	Brisbane Electric Trams. Invest. Ord.	5½—6	5 0 0	May	6	
5	2/6	Do. 5 per Cent. Cum. Pref.	4[illegible]—[illegible]	4 16 9	May, Nov	..	
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	103 —107	4 4 0	Jan, July	..	
St.	8%	British Columbia El. Ry. Df. Ord.	142 —146	5 9 6	Mar, Sept	..	
St.	6%	Do. Pref. Ord. Stock	123 —127	4 14 6	May, Nov	..	
St.	5%	Do. 5% Cum. Perp. Pref. Stock	109 —112	4 9 0	Jan, July	..	
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 0	April, Oct	..	
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 9	Jan, July	..	
St.	4½%	Do. 4½% Perp Con. Deb. St.	98½ -100½	4 4 6	—	100	
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —100	5 0 0	Mar, Sept	99⅜	
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	98 —100	6 0 0	Feb, Aug	99½	
5	2/0	Calcutta Tramways (1 to 137,010)	4⅛—4⅜	4 14 9	Mar, Sept	4⅜	
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅝—5⅛	4 18 0	Jan, July	..	
1	4½%	Do. 4½% 1st Deb. Stock (red.)	100 —103	4 7 0	Jan, July	..	
St.	..	Cape Electric Tram Shares	⅜—⅝	..		..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅞—6⅛	4 5 6	F,My,A,N	[illegible]	
St.	4%	Do 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	
..	6%	Colombo Tr. & Ltg. 6% 1st Mt. Db.	91 —94	6 6 6	May, Nov	..	
100	5%	†Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	83 —88	5 16 0	June, Dec	..	
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	95 —98	5 2 0	Feb, Aug	..	
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..	
100	5%	Do. 5 per Cent. "A" Deb. Stock	89 —93	5 7 6	Jan, July	..	
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 1[illegible] 6	Jan, July	6[illegible]	
5	1/0	Lisbon Elec. Trams. Ord.	1[illegible]—1[illegible]	4 14 0	July	..	
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	June, July	—	
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	90 —91	5 7 0	Jan, July	—	
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	92 —95	5 5 0	Jan, July	—	
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	94 —97	5 2 6	Feb, Aug	..	
100	$1½	Mexico Trams Co. Com. St.	150 —152	3 6 0	..	152½	
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	95½—96½	5 3 6	..	96¼	
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6		101	
1	1/0	Perth Elec. Trams Ord	⅝—¾	6 13 0	May	..	
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	—	
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5⅞	5 2 0	..	5[illegible]	
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	100 —103	4 8 0	..	..	
100	..	Rio Janeiro Tram, Lt. & P. Co.	103½—104½	..	..	104	
..	5%	Do. 30 yr. Gold Bnds.	96½— 96½	5 3 6	..	97½	
100	5%	Do. 50 yr. Mt. Bnds	86½— 88		..	89	
—	..	Sao Paulo Tramway, Light & Power Co. $100 Stock	156 —158	6 6 6	..	..	
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	98 —99	5 1 0	June, Dec	..	
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5⅝	5 11 0	Mar, Sept	..	
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	10	
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93 —96	4 14 0	Jan, July	..	
5	3/3	Calcutta Elec. Supply Ord.	6⅛—6⅜	6 18 3	April, Oct	6½	
100	$1½	Canadian Gen. Elec. Co. Com. St.	120 —123	5 14 0	..	124½	
100	3½	Do. 7% Cm. Pf. Stock	120 —122	..	..	122	
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —101	4 19 0	Jan, July	..	
500	5%	Elect. Development Co of Ontario	89 — 91	5 10 0	..	89½	
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1½—2	..	Feb, Aug	..	
St.	5%	Do. 5 per Cent. Deb Stock	89 —92	5 8 0	Jan, July	—	
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87½—90½	5 10 6	Jan, July	..	
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	
10s	..	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	¼	
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	8 6 0	April, Oct	..	
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	88 —89½	5 12 0	..	89	
St.	$1	Mexican Lt. & Power Co. Com. St.	76 —78	5 15 6	—	76½	
500	5%	Do. 5% 1st Mort. Gold Bnds.	93½—94½	5 10 0	..	93	
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	125 —128	4 13 6	F,My,A,N	..	
1	1/7½	River Plate Electricity Co. Ord.	1⅛—1¼	6 6 8	April	1[illegible]	
1	1/2⅞	Do. 6 per Cent. non-Cum. Pref	1[illegible]—1[illegible]	5 1 0	May	1[illegible]	
St.	5%	Do. 5 per Cent. Deb. Stock	103 —107	4 13 6	Jan, July	..	
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅜—5⅝	5 6 6	April, Oct	5½	
100	$1	Shawinigan Water & Power Co. Ca	95½—97½	4 2 6	—	96½	
..	5%	Do. 5 per Cent. Bds.	107 —109	4 11 6	Jan, July	107⅝	
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	96 —98	4 12 0	..	97½	
..	6d.	Victoria Falls Power Co. Pref.	[illegible]	5 7 6	Jan, July	..	

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote th[illegible]

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NOTES.

Rival Wireless Systems.

THERE was a great deal of interest in the discourse delivered by Dr. J. A. FLEMING at the Royal Institution on Friday evening last on the subject of "Researches in Radio-Telegraphy"; but perhaps the point of greatest interest to those connected with such work was the brief description given of the new discharger used by the Telefunken Company. Our readers already know that some question has arisen as to the similarity of this discharger and that due to Baron VON LEPEL. The Lepel discharger consists of two water-cooled discs about 3 in. in diameter, separated by a couple of rings of thin paper, so that there is a very small gap between the two discs; and the pressure applied is in the neighbourhood of 400 to 500 volts. As explained by Dr. FLEMING in his discourse, and in greater detail in a short article in our present issue, the Telefunken discharger consists of several small gaps (11 in the example shown), the plates being of copper 5 in. in diameter, and separated from each other by mica rings, so that the gap is no greater than 0·01 in. between each pair of copper surfaces. This discharger replaces the ordinary spark-gap in the primary circuit, and as the damping of very short sparks is extremely large, the primary oscillations are rapidly stopped and the secondary circuit oscillates only with a single period. Thus we see that in the case of the Telefunken discharger it may be said that highly damped primary sparks are used, and in the Lepel discharger that an oscillatory arc is created. For the moment we shall not go further into this point; but it again raises a question which has sometimes been asked, namely, What is an arc, and what is a spark?

The Colonies and the Cables.

THERE has been a good deal of discussion during the past week on the subject of submarine cable rates, and the discussions have been notable for the same failure to grasp the real position of this matter as was displayed at the Colonial Institute some months ago, and subsequently at the Mansion House, when the subjects of Penny-a-Word Telegrams and State-owned Cables were discussed. The speakers, many of them prominent men, all seem to have lost sight of the fact that large reductions in the charge for messages over long cables must of necessity mean many more cables, involving the expenditure of millions of money. This is a question which must not be looked at merely from the point of view of loss of revenue; those who have ventilated their views on the subject at the Press Conference seem to have regarded it as the only point to be considered. It must be remembered that rapidity and accuracy are the very essentials of the telegraph service, and that these essentials could only be secured by a fully sufficient number of cables to carry the traffic at all times. The necessity for many more cables would raise the important questions of interest on capital, depreciation and maintenance, working expenses and, finally, the provision and upkeep of the necessary cable repair steamers to ensure that the cables should be in constant working order. A point, of which more than sufficient is made, is that of the "idle hours" of the cables. Owing to difference in time, this is a much shorter period than is generally supposed and, of course, only applies to the hours during

which the cables are not fully occupied. Until those who are discussing this matter at the Conference of Press Representatives fully comprehend the important bearing which the points above mentioned have upon the general question of the reduction of cable rates, they will not be arguing from correct premises; and on a subject involving such heavy expenditure as would the provision of long submarine cables to meet the demand arising from any further large reduction in the present charges for cabling, it cannot be claimed that a fair start has been made in approaching so vast a subject. With some of the proposals submitted, and with many of the remarks put forward at the Conference, we have neither space nor inclination to deal, for they are outside the range of calm discussion.

Insulation Resistance.

To obtain the insulation resistance required by the various authorities before an electrical installation can be connected to the supply mains is frequently a source of much trouble to the wiring contractor, and as the consumer usually does not appreciate the technical reasons for any delay in obtaining a supply of electricity, he is consequently biased against electrical methods. There is no doubt that the insulation resistances demanded by electric supply authorities have sometimes been absurdly high—thus, 230 megohms divided by the number of lamps installed was in some cases stipulated—but experience has shown that such high values are not necessarily a proof of good materials, and that, even if obtained on the initial test, they are not always maintained under working conditions. The insulation resistance to earth specified in the Wiring Rules of the Institution of Electrical Engineers is 30 megohms divided by the number of *points*, in the case of the wiring alone before the erection of fittings, whilst with fittings erected the value in megohms must be 25 divided by the number of *lamps*. In our last issue we mentioned the desirability of uniformity in the regulations for electrical installations, and this particularly applies to the case of insulation resistance. In this connection it should be noticed that, in preparing the new Phœnix rules, the value of the insulation resistance required for electrical installations has been more than doubled, and is now 40 megohms divided by the number of *points*, an arc lamp being considered as equivalent to 10 points, compared with one megohm in the Institution rules. These values certainly appear to us to be unnecessarily high for an average installation, and it is to be regretted that when the change was made a value more nearly equal to that required by the Institution was not adopted.

Fuses.

Another direction in which considerable divergence is shown between the Phœnix rules and those of the Institution is in connection with fuses, and we doubt if it is advisable to fix the overload capacity of fuses, at any rate the smaller sizes, at so low a figure as 50 per cent. of the normal current corresponding to the size of the conductors protected; the more so, since a current density of only 1,000 amperes per square inch is allowed for conductors according to the Phœnix rules, whilst the Institution rules allow current densities up to 2,300 amperes per square inch in the case of small wires. Again, the Phœnix rule would mean that if copper fuses were employed they might at times run at an undesirably high temperature. In the Institution wiring rules a more reasonable basis is taken, viz., that fuses shall effectually interrupt the current when a short-circuit occurs, and also in the case of an overload of 200 per cent., provided that in all cases they prevent the temperature of the conductors protected from rising above the specified limits. If fuses of too low a capacity are employed, they are liable to blow unnecessarily due to minor causes, with the result that the consumer comes to regard them as uncertain and a nuisance. If, as is usual, they are inserted merely to protect the apparatus or conductors from dangerous overload a higher limit than 50 per cent. might be allowed, so that the circuit would only be interrupted in the case of absolute danger. Unnecessary failures of supply due to melted fuses may cause consumers to go to the other extreme and to insert fuses of excessive capacity.

Electricity Meter approved by Board of Trade.—The Board of Trade on June 2nd approved the pattern and construction of the meter numbered B116,660 (for the measurement of electrical energy when supplied on the constant potential alternating system) deposited at the Board of Trade on March 5, 1908 by the British Westinghouse Electric & Mfg. Co., and known as the Westinghouse type N single-phase watt-hour meter, provided that the meter be as described in the specification deposited at the Board of Trade on May 26, 1909, and numbered H 7,162. The Board have further approved of the means provided for fixing meters of this description and for connecting them with the service mains.

Electric Traction in France.—According to the "Electrical Review and Western Electrician" the Allgemeine Elektricitäts Gesellschaft has secured an order from the Midi Railway for an electric locomotive for both goods and passenger service. The normal speed of the locomotive will be 27·9 miles per hour, and the maximum 46·5 miles per hour. The line voltage is 10,000 volts, and the single-phase system will be used. The locomotive will carry two Winter-Eichberg motors, each of 800 H.P. capacity on an hour rating, and 600 H.P. capacity on a continuous rating. The locomotive will have three driving and two trailing axles. The motors will be connected to driving rods without the use of gearing

Effect of Circuit-breakers on the Wear of the Electrical Equipment of Tramcars.—According to the "Street Railway Journal," the rate at which the motors, controllers, wiring and other electrical parts of a car equipment wear out depends more closely on the proper adjustment of the car circuit-breakers than on any other piece of apparatus. The adjustment of the circuit-breaker should be checked by the use of a rheostat and ammeter at least once a month, and in doing so the current should be gradually raised when approaching the tripping point, otherwise the true reading will not be obtained. It is the practice in some shops to set the breaker by the use of a calibrated scale or dial. Such a scale is not necessarily correct, and, if it were, the method is not one to be relied upon, as the friction of the tripping mechanism changes on account of rust. Again, the circuit-breakers are not always put on a car in the position which the manufacturer intended, and any changes in position alter the gravitational control, and hence the calibration of the breaker. To determine the correct setting for a circuit-breaker, a car should be put in regular service over the line on which it is intended to run, and, with an ammeter and proper acceleration, the correct current at which to set the breaker can be determined.

A Modern Railway Problem: Steam or Electricity.—At the Royal Institution on Thursday, June 3rd, Prof. W. E. Dalby delivered the first of a series of two lectures on this subject. At the beginning of his lecture Prof. Dalby went into the economical side of the question, and showed that, while a steam locomotive was self-contained, the restricted space into which the equipment had to be fitted, and the impossibility of using condensers, made the equipment generally

AERIAL FLIGHT AT BUSHY.

Last month the Government recognised the importance of aeronautics by appointing a committee to which aeronautical problems would be referred, and nominated Dr. R. T. Glazebrook, F.R.S., Director of the National Physical Laboratory, as one of the members. We have not been to Bushy to verify the flight so graphically shown above, but we gather it is rather a flight on the part of the artist's imagination into the near future.

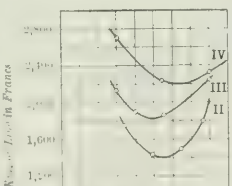
very inefficient; and of the energy contained in the coal only a very small percentage was converted into mechanical energy. On the other hand, with electric traction the economies which could be obtained in generating the steam were greater, owing to the fact that the generating plant could be grouped together in large units at a central station; and condensers could be used. Owing, however, to the fact that the energy had to be transmitted from the generating station to the place where it was used, and that transformation was also necessary, both of which gave rise to losses, the actual mechanical energy available at the road wheels of an electrically-driven train was not very different from that in the case of a steam locomotive. One of the advantages of electric traction was that the dead weight of the locomotive was avoided, as the motors were fixed on the axles of a passenger coach, and, further, a motor could be put on every axle of a train without inconvenience, so that in theory the driving power of an electric train was unlimited. About 1,000 H.P., on the other hand, was the maximum available from a steam locomotive. Questions of adhesion also played an important point in the latter case. The question of speed, however, was not without its economical aspect, and it must be recognised that to obtain such a speed as 100 miles an hour passengers would have to pay considerably more than they were doing at present. In this connection the lecturer instanced the s.s. "Mauretania," which it would not be possible to drive at its present speed if the passengers alone had to bear the expense. Prof. Dalby then went into the question of relative advantages of steam and electric traction over a given route. He said that at the present time to obtain a fast service, limited to a speed of from 50 to 55 miles an hour, between two towns 100 miles apart no more economical arrangement could be devised than a steam locomotive. If a high speed up to, say, 100 miles an hour was desired, electric traction would, of course, be necessary; but such speeds would not be possible on existing roads owing to the curves. On a straight line such

speeds could be obtained, as shown by the Marienfeld–Zossen experiments some years ago. Passengers would not, however, under those conditions, be able to travel for 1d. per mile, but would have to be prepared to pay two or three times that amount. The lecture was fully illustrated by means of lantern slides, which showed the developments that had taken place since the early days in the design of steam locomotives. Standard examples of electric locomotives and motor cars were also given, together with curves showing the operation of the two types of engine.

Progress in Single-phase Electric Traction.—According to the "Elektrotechnik und Maschinenbau," the Prussian railway authorities have recently ordered a single-phase electric locomotive for working on a 6,000 volt circuit with a frequency of 25. This locomotive will be fitted with two 300 H.P. motors and will be tested on the Orianenburg experimental line as to its suitability for goods train work. Three locomotives and seven motor cars, for use on a single-phase circuit of 8,000 volts pressure and a frequency of 25, have also been ordered for the Albatal Railway from Karlsruhe to Herrenalb. Similar equipment is being supplied for the Pamplona-Sanguesa line in Spain and for the line from Naples to Piedmont. All this work is being carried out by the Allgemeine Elektricitäts Gesellschaft.

"L'Industrie Electrique" states that la Compagnie des Omnibus et Tramways de Lyons has just successfully put in operation two lines from that town to Jons and Mirribet respectively. This is said to be the first example in France of a line being worked by single-phase current with a trolley voltage of 6,600 volts. The total length worked by this system is about 10 miles. Catenary suspension is used for the trolley wire. The necessary energy is bought in the neighbourhood and is transformed up from 550 volts by two 225 kw. motor-generators, the generators of which supply current at the trolley pressure of 6,600 volts. Four motor cars, each fitted with two 45 H.P. motors, are at present in use.

Calculation of High-tension Power Transmission Lines. A Paper on this subject by M. Gaisset has appeared in a recent number of "L'Eclairage Electrique." The author considers the calculation of the transmission poles and conductors, and it is shown that the maximum stress must never exceed about one-quarter to one-third of the breaking stress. The wires should, of course, be so arranged that they can never touch each other, and the installation costs per kilometre of the conductors should never exceed with the greatest possible span a certain fixed limit. Calculations made by the author show the costs per kilometre on a straight run are a function of the height of the poles. The results are given in the accompanying curves, where curve 1 is for wooden masts, curve 2 for U iron masts, curve 3 for armoured concrete masts and curve 4 for lattice-work masts. It will be seen from these that for each type of mast there is a certain height for which the installation costs of the line are a minimum. It is only possible to compare together seriously curves 3 and 4, as with these a mean life of 30 years can be obtained, while the average life of the wooden masts is only about 15 years. The values given for curve 1 should, therefore, really be doubled. For transmission lines with many curves the values for wooden and concrete masts have to be taken considerably higher, owing to the necessary stiffening required.



Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Jamaica—Colon ...	May 6, 1909 ...	June 3, 1909
Dakar—Conakry ...	May 13, 1909 ...	—
Tangier—Cadiz ...	May 19, 1909 ...	—
Cayenne—Salinas ...	June 7, 1909	—
Paramaribo—Cayenne ...	June 8, 1909	—

6,600 Volt Single-Phase Railway.—According to the "Electrical World" a single-phase railway $77\frac{1}{2}$ miles long has been putin operation between South Bend, Ind., and Pullman, Ill. The line is known as the Chicago, Lake Shore & South Bend Railway. The rolling stock at present consists of 48 passenger cars, 12 flat cars, 1 snowplough, and 1 "utility" car. Each of the larger passenger cars is equipped with four 125 H.P. single-phase motors arranged for multiple-unit control. Along the main portion of the route the trolley pressure is 6,600 volts, but through the cities and in the shops and yards the trolley E.M.F. is lowered to 700 volts. In each case single-phase current is utilised, no direct current being employed. The trolley wire is of 4/0 grooved section, supported by a $\frac{1}{2}$ in. steel catenary cable. There are 10 sub-stations. Two are at the ends of a 33,000 volt transmission line and eight are used for supplying energy at low tension in the city section and in the car shops near Michigan City. The cars are provided with both wheel and pantograph collectors; the latter are used only at 6,600 volts, while the former can be operated at either 700 volts or 6,600 volts.

Electric Traction at Buenos Ayres.—According to the "Railway Times" the suburban traffic dealt with by the railways entering Buenos Ayres has undergone a remarkable increase during recent years, and the question of electrification has been under consideration for some time. A municipal tube railway project was also set on foot, but so far this has come to nothing. The Central Argentine Railway, by virtue of its amalgamation with the Rosario line, carries more passengers in and out of the city than any other company, and the board has just decided to have a report prepared on the electrification of the suburban lines. Mr. Charles H. Merz has been appointed to prepare this report, and will leave for Buenos Ayres in August. It is understood that there is a possibility of a comprehensive scheme being drawn up for the conversion of the local and suburban lines of the other companies as well. In the event of electrification being decided on, British electrical manufacturers should obtain substantial orders for plant and equipment, in addition to the special rolling stock that will be required. To show the extent of the Buenos Ayres suburban traffic it may be mentioned that 1,145,000 passengers yearly use its station at Retiro, whilst 1,313,000 are dealt with at the Retiro New Station, on the Rosario section. The Buenos Ayres Great Southern handles about $2\frac{1}{4}$ millions annually at its Plaza Constitucion Station, the Buenos Ayres Western $1\frac{1}{4}$ millions at Callo de Septiembre, and the Pacific 412,000 at Retiro. At one of its suburban stations, the Central Argentine has 600,000 passengers yearly, and at six more considerably over a quarter of a million are dealt with, whilst similar figures are shown by the Buenos Ayres Great Southern.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 11th (to-day).

PHYSICAL SOCIETY.

8 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: "The Arthur Wright Electrical Device for Evaluating and Solving Equations," by Dr. A. Russell and Mr. A. Wright; "The Echelon Spectroscope, its Secondary Action and the Structure of the Green Hg Line," by Mr. H. Stansfield; "The Proposed International Unit of Candle-power," by Mr. C. C. Paterson; "Inductance and Resistance in Telephone and other Circuits," by Dr. J. W. Nicholson; "Note on Terrestrial Magnetism," by Mr. G. W. Walker, and "On the Form of Pulses constituting White Light," by Mr. A. Eagle.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Problems of Helium and Radium," by Sir James Dewar, F.R.S.

TUESDAY, June 15th.

THE FARADAY SOCIETY.

8 p.m. Meeting in the Library of the Institution of Electrical Engineers, 92, Victoria-street, S.W. Address on "The National and International Conservation of Water for Power," by Mr. E. B. Taylor. Papers on: "The Formation of Silicon Sulphide in the Desulphurisation of Iron," by Mr. W. Fielding; "A Contribution to the Study of Electric Furnaces as Applied to the Manufacture of Iron and Steel," by Mr. C. A. Keller; "Automatically Circulating Furnaces of the Gin Type for the Electrical Production of Steel," by Mr. G. Gin.

THE RELATIVE ADVANTAGES OF RECIPROCATING ENGINES AND TURBINES FOR TRACTION GENERATING STATIONS.*

BY G. RIZZO.

Summary.—The author first discusses the various aspects of the boiler-house problem, and shows how, by the use of superheated steam and proper attention to good stoking, much greater efficiency could be obtained than is always done at present. He then passes on to consider the heat cycles produced by both reciprocating engines and turbines, when working under various conditions, and shows how the vacuum which it is most efficient to use is dependent on a number of conflicting factors. A summary of the costs for erecting a station containing all the most modern improvements is given in conclusion.

It is very difficult to draw a general conclusion from the more or less complete answers sent in to the *questionnaire*. It would, moreover, be inaccurate to describe these answers as true general deductions, on account of the difference in fact that exists. For, in spite of the difference in the quantitative values given in answer to the *questionnaire*, it must be admitted that in each particular case the arrangements adopted are those which are best suited to the particular end to be attained.

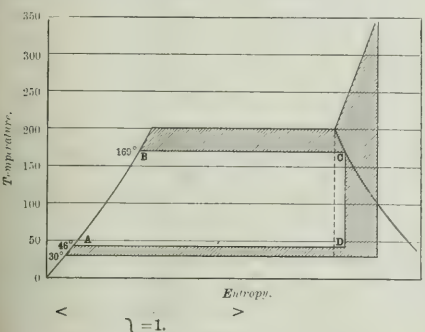


Fig. 1.

In dealing with the researches of Prof. Hirn on superheated steam, the author shows how these were at first overlooked, and how it was not until the multiple-expansion engine had attained a certain degree of perfection that the question was considered. It is now recognised that the use of superheated steam is necessary, and, as a result, modern superheaters are well designed, and form, with the boiler, an arrangement of maximum efficiency without too great a reduction in the heating surface. In spite of all arrangements that have been designed, however, all the heat contained in the issuing gases cannot be utilised, so that they, of necessity, leave the boiler at a high temperature. Great saving may, however, be effected by installing economisers which absorb a part of the heat remaining in the gases and lower their temperature to about 125°C.

No. 5 Turbine.

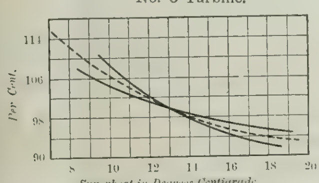


Fig. 2.—Influence of Superheat on Steam Consumption.

The report then deals with the question of the chemical composition of the issuing gases, and shows that complete combustion should give a gas containing 21 per cent. of carbon dioxide, though in practice about 13 or 14 per cent. is the maximum reached. If a boiler were installed without an economiser, the gases would then escape at 300°C., and if the percentage of carbon dioxide present were only 7, the total losses would be 31 per cent. If, however, the temperature of the gases can be reduced to 125 deg. by employing an economiser, and thus improving the conditions of combustion, a percentage of carbon dioxide of about 14 can be obtained, thus reducing the losses to about 7 per cent. The amount of carbon dioxide present, therefore, determines the economy of the combustion.

Good stoking depends to a very great extent on the skill of the personnel, differences of as much as 40 per cent. in the steam-raising capacity of the boiler having been traced to this property. In this connection the author gives an account of numerous tests which have been undertaken, and which fully bear out his statements on this subject.

No. 1 Reciprocating Engine.

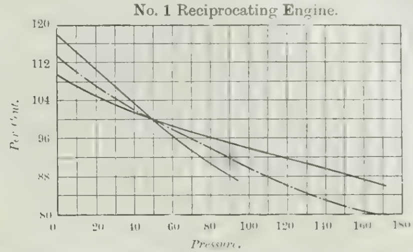


Fig. 3.—Influence of Variation in Pressure on Steam Consumption.

As regards mechanical stoking, this method allows a greater boiler efficiency to be obtained, the increase in evaporative power being from 20 to 60 per cent. Their use, moreover, simplifies the muscular work of the human stoker, so that the boiler-room staff can give their full attention to the fires. It has been shown that by the use of an automatic stoker an economy of about 3 per cent. can be obtained, though in practice this would increase to 5 or 6 per cent., for during the tests the stoker was continually under observation, while under ordinary conditions this would not be the case. Another advantage of automatic stokers is that from 6·6 lb. to 8·7 lb. of coal can be burnt per square foot of grate surface per hour, while the actual feeding is effected in a much more economical manner, as constant changes of temperature owing to the opening of the furnace door are avoided.

No. 2 Reciprocating Engine.

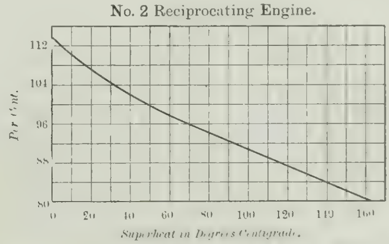


Fig. 4.—Influence of Superheat on Steam Consumption.

Another place where loss should be avoided as far as possible, is in the steam pipes. When the steam is saturated the loss in the pipe-work is a function of the condensed steam, while with superheated steam the fall in temperature gives the loss. The first loss has no influence on the thermal efficiency of the engine, while the second has; the relative loss depending on the dimensions of the pipe work and on the velocity of the steam. Care should, therefore, be taken to avoid great length in the pipes and the employment of complicated bends, as they give rise to much loss when superheated steam is

No. 3 Reciprocating Engine.

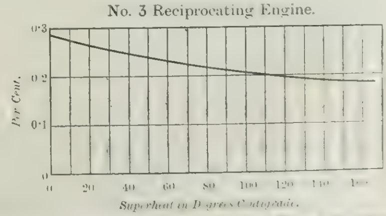


Fig. 5.—Influence of Superheat on Steam Consumption.

* Abstract of a report by M. G. Rizzo, assistant general manager of the Société Générale des Chemins de Fer économiques Brussels, on the replies received by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Locale in response to the *questionnaire* sent out to members. This was presented at the biennial meeting (1908) at Munich.

used. It is better to take care of the lagging, and to protect all the radiating surfaces. By taking the precautions detailed above it is possible to obtain with superheated steam 75 to 78 per cent. of the heat energy contained in the coal at the admission valve of the engine.

In modern installations a heat cycle, similar to the entropy diagram shown in Fig. 1, is obtained. This requires good boilers generating steam at a pressure of at least 12 atmospheres, good superheaters delivering superheated steam to the engine at a temperature of 300°C., and condensers giving the best possible vacuum.

These conditions must be realised when steam turbines are employed in order to obtain an economical consumption, which will only be comparable to that of a good reciprocating engine if the output of the turbine is from 1,500 kw. to 2,000 kw. For instance, the entropy diagram of a machine working on saturated steam at eight atmospheres with a vacuum of 80 per cent. is represented by the area ABCD, which is equivalent to 155·5 calories. If the working pressure is raised to 16 atmospheres, the corresponding temperature of saturated steam being 200 deg., the area of the entropy

No. 4 Reciprocating Engine.

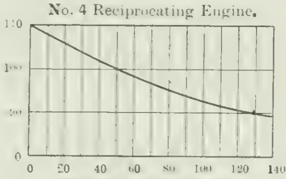


Fig. 6. Influence of Superheat on Steam Consumption.

diagram will increase by 16 per cent. If the vacuum is increased to 96 per cent., the steam temperature being lowered by 30 deg., the area will increase by 14·5 per cent. If the steam is superheated to 350 deg., the area of the entropy diagram will increase by 21 per cent., and the total area of the heat cycle will represent 235·5 calories. In the first place, 616·4 calories have been provided, and in the second 712·9. The theoretical heat efficiencies are, therefore, 25·4 and 33 per cent. respectively. By combining these efficiencies with those of the engine itself an overall efficiency comparable with that of a gas engine is obtained.

The reciprocating engine is only able to take partial advantage of the complete expansion of the steam, as the third cylinder of a triple-expansion engine only uses about 45 per cent. of the energy theoretically present in the steam, while the two others use 80 per cent.

No. 6 Turbine.

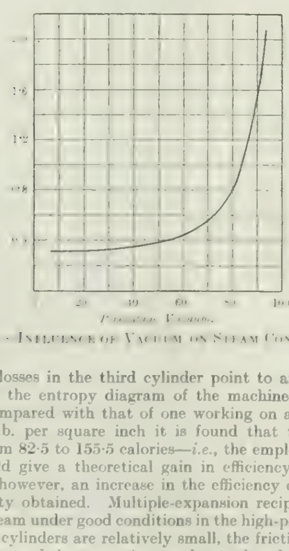
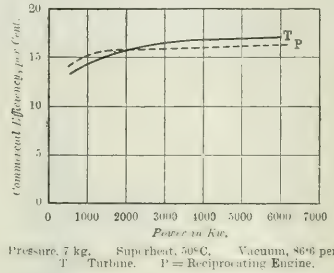


Fig. 7.—Influence of Vacuum on Steam Consumption.

The energy losses in the third cylinder point to an incomplete expansion. If the entropy diagram of the machine exhausting into the air is compared with that of one working on a condenser pressure of 1·4 lb. per square inch it is found that the heat utilised increases from 82·5 to 155·5 calories—*i.e.*, the employment of a condenser should give a theoretical gain in efficiency of 45 per cent. Practically, however, an increase in the efficiency of 20 per cent. is with difficulty obtained. Multiple-expansion reciprocating engines utilise the steam under good conditions in the high-pressure cylinders, for as these cylinders are relatively small, the friction and radiation losses are low, and the expansion can be employed up to that of the connecting pipe to the next cylinder. The low-pressure cylinder, however, does not permit a total utilisation of the expansion to be obtained—at least, the dimensions of the cylinder in which it would be possible to obtain such an expansion would be very large, and would lead to such losses from friction, condensing and wire drawing as would render the arrangement practically impossible.

If a reciprocating engine of 1,450 H.P. consumes 10 lb. of steam at 12 atmospheres per effective horse-power-hour, the steam being superheated to 300 deg., and there being a pressure of 0·84 lb. per square inch in the condenser, it is found that 1·1 cubic ft. of steam are exhausted into the condenser per second. If the average velocity of the piston is 12½ ft. per second the low-pressure cylinder would have to have a diameter of 12 ft. to deal with this volume. By allowing the steam to escape at a speed of 16½ ft. per second the cross-section of the exhaust valve must be 8¾ sq. ft., and this value will be about double if a pressure of 0·56 lb. per square inch at the exhaust has to be obtained. According to the experiments of Prof. Josse, it appears that by raising the vacuum of a reciprocating



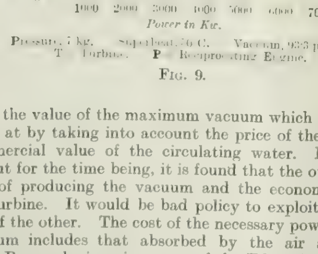
Pressure, 7 kg. Superheat, 50°C. Vacuum, 86·6 per cent.
T = Turbine. P = Reciprocating Engine.

Fig. 8.

engine by 10 per cent. between the limits of 70 and 80 per cent., an overall increase in the efficiency of 5 per cent. is obtained. By increasing the vacuum by the same amount between 80 and 90 per cent. the overall efficiency is raised 2 per cent. in steam consumption.

The above disadvantages do not come into the question in the case of the turbine. This machine uses up the low-pressure steam, and it is possible to employ a flow of several thousand cubic feet per hour without the size of the machine becoming very large. It is, therefore, possible to obtain a complete expansion and all the other advantages connected with it; so that it may be said that the limit in economical production of the vacuum is practically dependent on that of the highest vacuum which can be obtained—*i.e.*, in a turbine the vacuum corresponding to a maximum economy coincides with the best vacuum that can be obtained. Fig. 2 gives for a turbine the percentage diminution in steam consumption per 1 per cent. rise in vacuum.

It should not be lost sight of, however, that the vacuum should be obtained by simple methods; and, consequently, in each in-

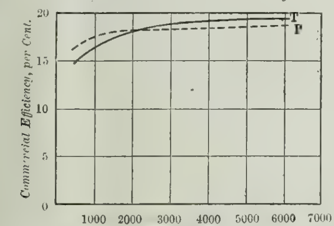


Pressure, 7 kg. Superheat, 50 C. Vacuum, 93·3 per cent.
T Turbine. P Reciprocating Engine.

Fig. 9.

stallation the value of the maximum vacuum which can be obtained is arrived at by taking into account the price of the apparatus and the commercial value of the circulating water. If these factors are left out for the time being, it is found that the other charges are the cost of producing the vacuum and the economy obtained by using a turbine. It would be bad policy to exploit the one at the expense of the other. The cost of the necessary power for obtaining the vacuum includes that absorbed by the air and circulating pumps. By employing air pumps of the Edwards type it is found that the power absorbed is practically independent of the vacuum when this is between 66 cm. and 75·5 cm. As regards the power absorbed by the circulating pump, this will depend on many factors, which will vary with the particular case. For a given condenser the power absorbed by the circulating pump will be proportional

to the product of the volume of the water circulating per second, by the resistance head in feet opposed to the circulation. This being determined, it may be said that the most economical vacuum, in the widest sense, will be that which corresponds to a minimum steam consumption per effective horse-power. On account of the importance of the condenser from the point of view of steam economy, researches have been made to obtain the most efficient condenser. These researches had for their object the discovery of

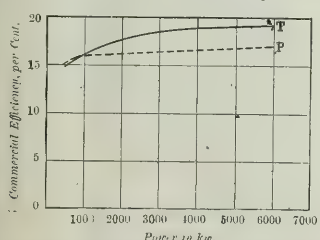


Pressure, 7 kg. Superheat, 100°C. Vacuum, 86·6 per cent.
T = Turbine. P = Reciprocating Engine.

FIG. 10.

an apparatus which gave the most perfect vacuum, maintained by the least expenditure of circulating water, with the least condensing surface, and with the smallest capacity per pound of steam condensed.

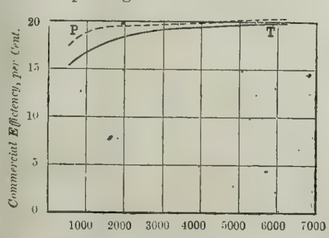
Prof. R. L. Weighton has shown that the type of condenser known as the "Contraflo" possesses many distinct advantages over the older types. Comparative tests made on it and on older types of condenser show that to increase the efficiency of this equipment the



Pressure, 7 kg. Superheat, 100°C. Vacuum, 93·3 per cent.
T = Turbine. P = Reciprocating Engine.

FIG. 11.

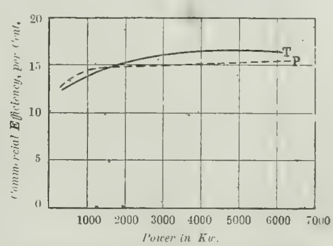
condensed water should be passed through the condenser as quickly as possible, and that the velocity of the circulating water should be as high as practicable. Also the latter should enter at the bottom and leave at top of the condensers, while its temperature at the outlet should correspond to the vacuum obtained. The temperature of the condenser water should be from 3 deg. to 5 deg. higher than the temperature corresponding to the vacuum obtained.



Pressure, 15 kg. Superheat, 50°C. Vacuum, 86·6 per cent.
T = Turbine. P = Reciprocating Engine.

FIG. 12.

Pearson and Stoney, considering the importance of condensers in a steam turbine station, and, above all, the part that they play in economical steam consumption, have designed an apparatus subsidiary to the condenser which is intended to increase the vacuum. In Fig. 3 is indicated the influence of the variation of pressure on the steam consumption. The diagram consists of two curves for two different machines, giving the limiting conditions. The consumption corresponding to a pressure of 13 atmospheres has been taken as unity, the steam being superheated through 50 deg.; the engine running on a 86·7 per cent. vacuum. The ordinates of this curve give the steam consumption at 50 deg. of superheat expressed as a percentage of that at a pressure of 13 kg. The curves in Fig. 4 show the influence of superheat on the steam consumption, steam at a pressure of 13 kg., superheat at 50 deg., and a vacuum of 86·6 per cent. being taken as a basis. The two curves show the limiting effects of the superheat on two different machines. As is well known, superheat is specially desirable for machines which, when running on saturated steam, are rather inefficient; for example, engines having large cooling surfaces, or with large useless spaces. Fig. 5 gives the effect of superheat on the consumption of a reciprocating engine, taking as a basis 50 deg. of superheat. The ordinates of this curve represent the steam consumption expressed in percentages

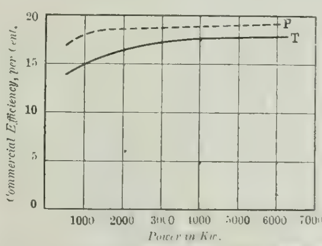


Pressure 16 kg. Superheat, 50C. Vacuum, 93·3 per cent.
T = Turbine. P = Reciprocating Engine.

FIG. 13.

of that corresponding to 50 deg. of superheat. Fig. 6 represents the percentage variation in the consumption of a reciprocating engine per degrees Centigrade increase in superheat, the steam being at 13 kg. and the vacuum 86·6 per cent. Fig. 2 gives the effect of superheat on the steam consumption of the turbine. The ordinates of this curve give the values of the consumption as percentages of that corresponding to 50 deg. of superheat. Fig. 7 represents the effect of vacuum on the consumption of turbines. The ordinates of this curve give the variation as a percentage of the steam consumption for each percentage variation in the vacuum. Figs. 8 to 15 give the commercial efficiencies for different conditions of load pressure, vacuum and superheat of reciprocating engines as compared with turbines.

The cost per kilowatt-hour in a steam generating station containing all the improvements detailed above, and possessing condensing water in sufficient quantity, is then considered. It is evident that



Pressure, 16 kg. Superheat, 100°C. Vacuum, 86·6 per cent.
T = Turbine. P = Reciprocating Engine.

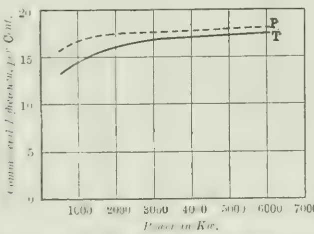
FIG. 14.

in each particular case different factors influencing the various expenses and establishing the price per kilowatt-hour will have to be taken into account. The example here given is that of a station supplying a tramway load. This station contains three horizontal compound tandem engines, the expansion of which can be varied by a regulator, and which work condensing and on superheated steam at 300°C. Each machine is capable of developing 1,450 effective H.P. continuously when working at a pressure of 12 atmospheres and a condenser pressure of 7 cm. of mercury. This power corresponds to an admission of a volume of steam equal to 28 per cent. of that of the high-pressure cylinder. The diameter of the high-pressure cylinder is 2 ft. 4 in., and that of the low-pressure cylinder 4 ft. The stroke of the pistons is 4 ft. and the speed is 94 revs. per min. Each machine is directly coupled to a 1,000 kw. three-phase alternator, the power factor being 0·9. The rotor of

this alternator is of the flywheel type, its moment of inertia being 1,100 tons-m². The exciter sets, which work at 110 volts, are fixed on the end of the shaft of each machine. The switchboard contains all the measuring instruments and usual switchgear, together with the feeder panels and the switches for operating auxiliary machinery. The boiler house contains four boilers of the Babcock & Wilcox type, having a heating surface of 3,700 sq. ft. An interior superheater delivers steam at 325 deg., while the boilers are fitted with automatic stokers. The installation also has four groups of Green's economisers of 90 tubes each, a steam feed pump and another electrically driven. The chimney is 180 ft. high and has a diameter of 8·6 ft. at the top. It is capable of exerting a draught of 13 mm. at the furnace registers, and allows the operation of all the six boilers at full load at the same time. The capital outlay for this installation is given in the following table :—

Engines, including pipe work	£14,400
Generators, including exciters, &c.	7,200
Switchboard and cables	1,800
Boilers	6,600
Economisers	2,400
Pumps and pipe work	2,800
Coal conveyor	1,000
Coal stores	2,000
Land and buildings	10,000
Chimney, cranes and erection	4,000
Miscellaneous	2,000
Total	£54,200

As regards the consumption of coal per kilowatt-hour, it may be noted that with the alternator at one-third load the machine consumes 5,200 calories per kilowatt-hour, at half load 5,130, at three-quarter load 5,530, and at full load 4,850. By applying the correc-



Pressure 15 kg. Superheat, 100 C. Vacuum, 93·3 per cent.
T Turbine. P Reciprocating Engine.

FIG. 15.

tion due to the efficiency of the pipe work and that of the boiler, the generating set when running at one-third load develops 1 kw.-hour per 6,800 calories, at half load 1 kw.-hour per 6,700 calories, at three-quarter load 1 kw.-hour per 5,960, and at full load 1 kw.-hour per 6,400 calories. One kw.-hour can, therefore, be produced per 1·8 lb. of coal if the load on the network varies between 666 kw. and 2,000 kw. This consumption of 1·8 lb. of coal takes into account all the losses, including that of lighting the boilers in the morning. Taking the total output of the station as 8,500,000 kw.—*i.e.*, 2,850 kw.-hours per kilowatt installed—and taking 5 per cent. interest on capital, together with a depreciation of 4·6 per cent. for the machinery and 3 per cent. for the buildings, we arrive at an expenditure of 0·14d. per kilowatt-hour. The other expenses of the station, including wages, lubrication and maintenance charges, may be estimated at 0·07 per kilowatt-hour, while coal may be taken as costing 0·225d. per kilowatt-hour. The total cost per kilowatt-hour, therefore, works out at 0·435d.

BOOKS RECEIVED.

([illegible] of the undermentioned works can be had from *The Electrician* office, post free, [illegible] price, adding 3d. for books published under 2s. and 5 per cent [illegible] net. Add 10 per cent. for abroad or for foreign books.)

"High Frequency Currents." By H. Evelyn Crook. 2nd edition. (London: Baillière, Tindall & Cox.) 7s. 6d. net.

"Practical Alternating Currents and Alternating Current Testing." By Charles F. Smith. 3rd edition. (Manchester: The Scientific Publishing Co.) 6s. nett.

"Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1902-4." By Daniel L. Hazard. (Washington: Government Printing Office.)

"Anlasser und Regler für Elektrische Motoren und Generatoren." By Rudolf Krause. (Berlin: Julius Springer.) M.5.

THE TELEFUNKEN OR QUENCHED SPARK DISCHARGER.

BY J. A. FLEMING, F.R.S.

In my lecture last Friday evening at the Royal Institution time did not permit me to do more than give a brief description and show one experiment with the multiple small-gap flat plate discharger which has been devised by the experts of the Gesellschaft für Drahtlose Telegraphie for giving practical effect to Prof. M. Wien's method of excitation by shock in spark telegraphy. The methods now in use by that company were being described by Count Arco in a lecture at Cologne at the same hour as my lecture in London, under the title "Das Neue Telefunken System." Although Count Arco had kindly forwarded to me an advance copy of his lecture, I refrained at his request from more than a general statement of the nature of the discharger pending the publication of his lecture in the "Elektrotechnische Zeitschrift."

As there seems to be an impression that the Telefunken discharger and that of von Lepel are identical, it may be well if I describe here, briefly, experiments which I had not time to show on Friday evening, and which seem to me to prove that the operative principles involved in the two appliances are different. I explained in the lecture that when isochronous primary and secondary oscillation circuits are connected induc-

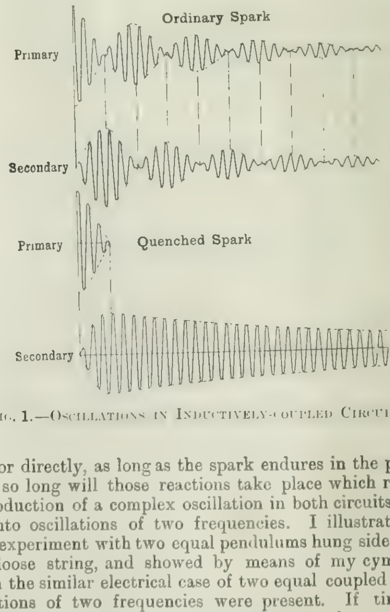


FIG. 1.—OSCILLATIONS IN INDUCTIVELY-COUPLED CIRCUITS.

tively or directly, as long as the spark endures in the primary circuit so long will those reactions take place which result in the production of a complex oscillation in both circuits resolvable into oscillations of two frequencies. I illustrated this by an experiment with two equal pendulums hung side by side on a loose string, and showed by means of my cymometer that in the similar electrical case of two equal coupled circuits oscillations of two frequencies were present. If time had permitted, it could have been also shown by the cymometer that these two oscillations were present in the primary as well as in the secondary oscillation circuit when using the ordinary spark-gap in the primary. The Telefunken discharger is based on the known fact that the damping of very short sparks is extremely large, and that if we can "quench" or stop the primary oscillations after one or two swings the secondary circuit then continues to oscillate freely with a single period, as shown in Fig. 1.

The discharger I used consisted of 12 round flanged plates of copper, 5 in. in diameter, the surfaces being turned true and having a groove in them (see Fig. 2). A mica ring is interposed between each pair of copper plates of such size that the mica half covers each groove. This groove is important, for without it the discharge spark tends to take place always at the edge of the mica. The mica is of such thickness as to make an air space of not greater than 0·01 in. between the

flat copper surfaces. In this discharger we have then, say, 11 air gaps, each about 0·01 in. wide and of circular section. When this discharger replaces the ordinary spark-gap in the primary circuit it damps out instantly the primary spark, and hence excites the free oscillations in the secondary circuit by shock. If, then, we place the cymometer alongside of the secondary circuit we find in it oscillations of only one frequency and not two. Also, if we place it alongside the primary circuit, we cannot detect in that circuit any oscillations, because they are so rapidly damped out that they have too small a mean-square value to affect the cymometer or cause the Neon tube to glow perceptibly.

In consequence of this rapid damping it is possible to employ an alternator having a frequency of 1,000 to 2,000 to create a corresponding number of primary discharge sparks per second, without producing any true arc discharge. The rapid cooling of the discharge surfaces entirely prevents it.

The discs for this purpose are made of copper or silvered copper plates, and in the case of large discharges the discs are made hollow and water-cooled.

The rapid succession of highly-damped primary sparks creates then an equally rapid succesion of very feebly damped trains of oscillations in the secondary circuit having a very large mean-square value, and therefore possessing many of the

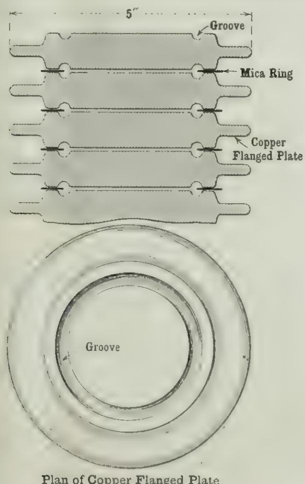


FIG. 2.—PLAN AND SECTION SHOWING PORTION OF DISCHARGER.

properties of undamped oscillations generated without any true-arc effect. The operation of this discharger seems to me therefore essentially different from one in which an oscillatory arc is created between metal surfaces by the employment of a continuous or direct current, neither is its operation dependent on the presence of an atmosphere of hydro-carbon vapour. On the contrary, it may be described as having most perfect arc-quenching properties possible.

The Telefunken discharger could not, therefore, be placed in the circuit of the antenna as is the generator shown in the diagram of circuits in the article describing the von Lepel system in THE ELECTRICIAN of May 14th, whereas that later mode of connection is quite consistent with a performance of a discharger which is essentially an arc method and not a spark method.

Three other properties of the Telefunken discharger deserve notice. It is almost noiseless, and, being entirely enclosed, could be used in an inflammable atmosphere. It seems, therefore, likely to be of use in balloons or airships, where an open or naked spark could not be employed. Finally, as the whole of the energy transferred to the secondary circuit expends itself in the production of radiation of one single wave-length it must be more economical than methods which generate waves of two wave-lengths, but capture at the receiver radiation conveyed by only one of these wave-lengths.

THE UTILISATION OF THE TOTAL RADIATION FROM AN INDUCTIVELY COUPLED ANTENNA IN RADIO-TELEGRAPHY.

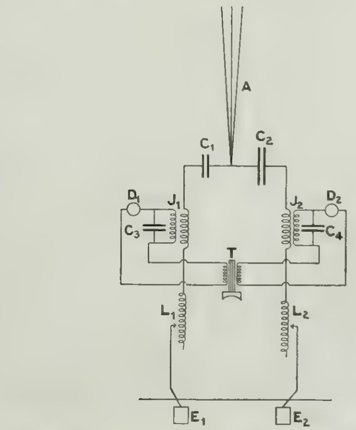
BY J. A. FLEMING, F.R.S.

When a radiating antenna in a radio-telegraphic station is coupled inductively and not very loosely to a spark condenser circuit, it is well known that a compound radiation which may be resolved into waves of two wave-lengths is radiated from it. If the coupled circuits are separately syntonised, and each taken separately has a natural frequency n corresponding to a wave length λ, then when coupled with a coefficient k the waves radiated have wave lengths λ_1 and λ_2 such that

$$\lambda_1 = \lambda\sqrt{1+k},$$
$$\lambda_2 = \lambda\sqrt{1-k}.$$

If a corresponding receiving antenna is set up it is generally syntonised only to one of these wave-lengths, and hence a considerable part of the radiated energy may not be absorbed by the receiver circuit.

It is clear, however, that if we render the radiation from the transmitting antenna monocymatic—that is, consisting of



A, Antenna.
C_1, C_2, Condensers.
L_1, L_2, Inductances.

D_1, D_2, Rectifying detectors in receiving circuits.
T, Double-wound telephone.

waves of a single wave-length—the energy loss would be avoided which is incurred when we capture the waves of one wave-length only. This is achieved at present in Germany by the adoption of methods of spark excitation which are based on Prof. M. Wien's method of rapid damping of the primary spark. If we are employing an inductively coupled transmitter then, as long as the primary spark continues, the primary and secondary system are in inductive relation and re-acting on each other to produce the double wave or dicymatic radiation. If, however, as Wien suggested in 1906, we can damp out with great rapidity the primary spark, then the primary circuit becomes open almost immediately and ceases to act on the secondary. The free oscillations of the antenna then continue and the system radiates waves of only one wave-length. This is achieved in practice by taking advantage of the very large damping of very short sparks by employing a spark discharger consisting of a number of metal surfaces with very small space intervals between them. The primary spark is then quenched with great rapidity and the action upon the secondary or antenna circuit is of the nature of a blow or shock, setting up the free oscillations of the secondary. For this reason this method of excitation is called, in Germany, "Stosserregung."

It has occurred to me lately that the ordinary spark method in which fairly close or inductive coupling and a non-quenched spark are employed, can be made more efficient if we absorb

both the waves radiated simultaneously from the transmitter at the receiving end.

This can be done by employing two receiving sets coupled independently to one receiving antenna as in Mr. Marconi's method for simultaneous reception of two sets of signals, one of these syntonised to one of the wave-lengths of the inductively coupled transmitting antenna and the other one to the second wave-length. The oscillation detectors employed must be of a type suitable for telephonic reception, such, for instance, as a rectifying contact-detector, a glow lamp detector, or a magnetic detector. (*See* illustration.)

Associated with these two receiving sets a double-wound telephone should be employed, one circuit of which is in connection with the detector of one receiving set and the other with that of the other. In this manner the telephone would be simultaneously affected by the two trains of waves of different wave-lengths emitted by the transmitting antenna, each train affecting its own receiving set attached to the receiving antenna in the manner shown in the diagram.

The energy conveyed to the telephone diaphragm would, therefore, come from the radiated waves of both wave lengths and not from only one of them. Hence a closer coupling than usual could be employed. It is usual in inductively coupled transmitters to employ a coefficient of coupling which is fairly low, say 10 per cent. The two waves radiated then have wave lengths in the ratio of $\sqrt{9} : \sqrt{11}$. On the other hand, the energy conveyed to the antenna by such loose coupling is greatly reduced, and if we desire to pick up energy from both waves by a single receiving set, its circuits must be very much damped. This is an obstacle to sharp tuning or reasonable isolation of the receiver. On the plan suggested above—viz., by the use of two receiving sets and a double-wound telephone—it would be possible to employ a fairly close coupling in the transmitter, also to employ feeble damping in the receiver circuits and utilise the energy conveyed by both sets of waves in reception so as to effect a better economy in the total efficiency of transmission.

THE MANUFACTURE OF NITRATES FROM THE ATMOSPHERE BY THE ELECTRIC ARC—BIRKELAND-EYDE PROCESS.*

BY SAM EYDE.

Reference is first made to early experiments, and the Birkeland-Eyde process is then described. The difference between previous methods and that of Birkeland-Eyde is that the latter have applied large quantities of electric energy in the electric arc, and have found out the best method of doing this, while it was previously believed that it was small quantities of energy that gave relatively the best results. On electrodes of 1·5 cm. thick copper tubing, through which water passes for cooling them, one can take up over 1,500 H.P., with a flame 1·8 metres in diameter. The chamber in which the flame burns is circular, of only a few centimetres width, and about 2 metres diameter. After the oxide of nitrogen is formed in the furnace, it is converted in the oxidation tank into dioxide of nitrogen, and in the absorption towers into nitric acid.

The first attempts were made at Frognerkilens factory in 1903. As we could not obtain more than 20 kw. of electric energy there, the experimental station was removed in October, 1903, to a building of our own on Ankerlökken, with power from the Christiania municipal electric power station, and, to obtain still more power, to Vasmoen, near Arendal, and later to Notodden. Of the 36 furnaces installed, 32 receive their power from Svælgfos and four from Tinfos power station.

The temperature of our flames exceeds 3,000°C. or perhaps 3,500°C. The temperature of the escaping gases may vary between 800 deg. and 1,000 deg. during ordinary working. The furnaces are made of cast steel and iron, the middle of the furnace being built out to a circular flame chamber. The electrodes are led radially into this flame chamber. By aid of centrifugal fans, the air is brought into each furnace through tubes from the basement. When the air in the flame chamber has been treated by the electric flames, the nitrous gases formed pass out through a channel built along the casing of the furnace and thence out through the lower part of the furnace to two fireproof-lined gas-collecting pipes, about 2 metres in diameter, which convey the gas through the basement out to the steam boiler house. In the boiler house, the gas passes through four steam boilers, in which the temperature, which was, as mentioned, 1,000°C., is reduced. The heat given off by the gas is used for concentrating the products, and in the winter time for warming the factory buildings. The steam produced in the boilers is utilised in the further treatment of the products. In the boiler house there are also two large and two small air compressors, which supply compressed air for pumping acids and lye in the factory's various chemical departments.

The gases pass on from the steam boilers through an iron pipe into the cooling house, with the object of completing the cooling commenced in the steam boilers. This cooling is necessary in order to obtain a suitable absorption. Each cooler consists of a great number of aluminium tubes, over which cold water runs, while the hot gases pass through them. The temperature of the gas is considerably reduced. From the cooling chambers the gases go on to the oxidation tanks.

These oxidation tanks are vertical iron cylinders lined with acid-proof stone. The object is to give the cooled gases a sufficient period of repose, in which the oxidation of the oxide of nitrogen may have time to take place. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces. From the oxidation tanks the gases are led into the absorption towers. All the towers are filled with broken quartz, which is neither affected by nitrous gases nor by nitric acid. To assist the passage of the gases on their way from the furnaces there are centrifugal fans constructed of aluminium on each row of towers. The gases enter at the base of the first tower, go up through the quartz packing, and thence by a large earthenware pipe enter the top of another tower, through which they pass downwards through the quartz to the bottom of the third tower, and so on until the air, relieved of all nitrous gases, leaves the last tower. Water trickles through the granite towers, and this is gradually converted into a weak nitric acid, while the liquid used in the wooden towers is a solution of soda. The absorbing liquid enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases come in immediate contact with the absorbing liquid. In the granite towers nitric acid is thus formed, and in the wooden towers a solution of nitrate of soda.

The liquid emerges in a constant even stream from the bottom of the towers, that from the granite towers running into a granite cistern. Hence it flows into the "montejus," which serve to pump up the acid, which has to pass repeatedly through the tower before it has become strong enough for the purpose for which it is intended. The "montejus" are of stoneware strengthened with iron shields, are worked by compressed air, and send the acid up into large stoneware jars. From these jars the acid again runs through the towers as described. The "montejus" work automatically. The wooden towers are percolated, as already mentioned, by a solution of soda, otherwise the whole process is practically similar to that in the granite towers. The solution of soda, owing to its far greater power of absorption, effects the separation of the last remains of nitrogenous gases from the accompanying air. Of the entire quantity of nitrous gases passed through the absorption system about 97 per cent. is absorbed. The finished nitric acid coming from the towers, which has a strength of about 30 per cent. by volume, is collected in granite cisterns, from which it is drawn to what is called the "dissolution works." These consists of granite vats filled with limestone, over which the acid is poured. This drives off, with violent effervescence, the carbonic acid contained in the limestone, while the nitric acid takes its place and forms a watery solution of nitrate of lime or calcium nitrate. This solution of nitrate of lime is now pumped into vacuum evaporating apparatus. The object of boiling in vacuum is the well-known fact that great saving is thereby effected in the heat required.

The steam required for the evaporation is obtained from the steam boilers, heated, as before mentioned, by furnace gases. The concentration of the nitrate solution in the evaporising plant is continued until the specific weight of the liquid at a given temperature shows a content of 13 per cent. of nitrogen. This solution is then sufficiently evaporated, and can be pumped up into the solidification chambers. These are fitted with shallow iron pans, under which cold air is pumped to accelerate cooling. After some time the nitrate stiffens into a brittle, crystalline mass, hard as stone. This is broken up into lumps, and is taken into the crushing machines. These consist of ball crushing mills, which reduce the mass to a granular state. The coarse powder so produced is raised by elevator to a vat, from the bottom of which it is tapped into casks holding 100 kilos. net weight.

The barrels are made at our own coopers' shop and are lined with paper to guard against damp. The colour of the product depends

* Abstract of a Paper read before the Royal Society of Arts.

on the limestone used in the manufacture. The nitrate of lime is used in various chemical works as well as for manure, the only difference being that, for the former purpose, the product is not ground fine, but is run direct in the liquid state into thin iron drums, in which it stiffens into a solid mass.

As to the further treatment of the nitrite formed in the alkaline towers, when this is pumped away from the towers it contains, besides nitrite and water, also some nitrate of soda and bicarbonate. The further process is designed to separate the pure nitrite from the other substances. This is accomplished by first boiling away some of the water, which is done, as in the case of the nitrate solution, by steam from the steam boilers, heated by the furnace gases. The nitrite solution, concentrated to a suitable boiling state, is run into crystallisation pans, in which the crystallisation of the nitrite takes place. The crystals are separated by centrifugal means and are conveyed by a screw transporter to a drying apparatus, where they are subjected to a current of hot air. The finished product is then run into casks containing 300 kilos. each. These are likewise made in our own shops. This nitrite of soda is used as the raw material in the manufacture of certain kinds of aniline colours. The manufacture of nitrite is carried on in a special building.

In the entire process of manufacture, both of nitrite and nitrate, no coal is used; all the machinery is worked by electric power, and for heating and evaporating the nitrate and nitrite solutions the only steam employed is that obtained by the hot gases passing through a system of steam boilers. We are, moreover, in our industry, not confined to the two products hitherto mentioned—nitrate of lime and nitrite of soda; but have possibilities for the development of a whole series of new industries, of which I will specially name the production of nitric acid, nitrate of ammonia, nitrate of potassium and others. We have succeeded, in conjunction with the Nobel (nitroglycerine, &c.) Synd., in concentrating our weak acids by means of gases from our furnaces, to acids of a high percentage which can be transported.

The concluding portion of the Paper describes trials with nitrate of lime for agricultural purposes in Norway, Sweden, France, Germany, Austria-Hungary, Italy, and also in the United Kingdom. These experiments show that nitrate of lime is equal to nitrate of soda as a manure.

THE ELECTRIFICATION OF THE L.B. & S.C. RAILWAY'S SOUTH LONDON LINE.

Thanks to the courtesy of Mr. Philip Dawson, electrical adviser to the L.B. & S.C. Railway Co., who designed all the work in connection with the electrification of the South London Line, and under whose supervision the entire work is being carried out, we are in a position to give further details regarding some of the more special features adopted in the overhead construction.

A description of this kind is not out of place in view of the fact that a regular train service for educating drivers has been in operation since the beginning of May, and that it is expected that the service will be extended into Victoria station during the course of next month. It is probable that the management may not wish to begin the dense service it proposes to run on the electrified line till after the summer holidays, and we may then expect a very improved service to be in operation between Victoria and London Bridge by the end of September or beginning of October. This service should be much appreciated by the suburbans who live in the neighbourhood of this line, in consequence of the great increase in speed and frequency, which, owing to the adoption of electricity, the Brighton Company will be able to give them.

It is understood that the company are already so well satisfied with the results at present obtained from the preliminary running that they seriously consider extending the service to the Crystal Palace, and we feel sure that such an action on their part will be good policy, and that the expenditure will be well repaid by the considerable increase in traffic which such an extension would bring.

We had occasion last week to refer to Mr. Aspinall's important address to the Institution of Mechanical Engineers, and would take this opportunity of pointing out that his experience clearly demonstrates that no success is possible unless electrification is pushed sufficiently far out, and we trust that this view will be taken by the Brighton Company, and that they will immediately extend their electrification.

The overhead construction designed by Mr. Philip Dawson and adopted on the L.B.&S.C. Railway is different to anything which has hitherto been erected, and although the original plans date back nearly four years—that is to say, before the results of the New York, New Haven & Hartford electrification were available—it is satisfactory to consider that the conditions had so far been gauged as apparently to render the construction adopted satisfactory from all points of view.

In the first place, each catenary is separately erected and separately adjustable by means of two turnbuckles placed in each catenary span. By this means erection is facilitated in the case of lines with dense traffic and renewals of individual spans made easy. Furthermore, in case of having to cut a span to enable a wrecking crane to be worked in case of a bad accident, this could be easily and rapidly done and the span made good in a very short

Fig. 1.—L.B. & S.C. Railway Overhead Construction (Section Insulators) at Wandsworth-road Station.

time. All spans are numbered, and it is possible to calculate the sag required for each so as to obtain perfectly balanced stresses on the supports, and this has been proved by actual experiment to be the case In this construction only three types of insulators have been used, and each type has special fittings which enable it, complete with the fittings which are attached to it, to be used in every case where this particular size is employed—in other words, each insulator is interchangeable. All three types of insulators are of the spool pattern, and they are all used in such a way that the axis of the insulator is in the horizontal plane, so as to provide for the surfaces of the corrugations being kept fairly clean by natural means.

Double insulation is used throughout the whole construction, and only porcelain is used as an insulator. The double insulation is supplied by what is called the main insulator and a smaller one known as the auxiliary one. All the main insulators have been tested to 65,000 volts for 30 minutes and the auxiliary ones to 25,000 volts for the same period.

The third type of insulator is used in connection with the section insulators and for supporting the trolley or collector bow fixed to the top of the motor coach roof. The

trolley wire is circular in section and ½ in. in diameter, having a groove on either side into which the mechanical clips fit by means of which the conductor is supported from the catenaries. The droppers supporting the trolley wire are solid rods, having loops at one end hung in corresponding loops, fixed by means of special clips to the trolley

Fig. 2.—L.B. & S.C. Railway Overhead Construction (wind ties on bridge over Brixton Station, South Eastern & Chatham Railway).

wire. When the length of a dropper exceeds 3 ft. 6 in., droppers composed of two sections, one hung from the other by means of a loop, are used, so as to give the greatest flexibility in the vertical plane whilst assuring the greatest rigidity in the horizontal one. The relative weight of the clips to that of the trolley wire is so small that, with the arrangement of supports adopted, there is no knock of any

Fig. 3. L.B. & S.C. Railway Overhead Construction, showing wires under low foot bridge at Wandsworth Road Station.

kind when the collector bow passes under a trolley wire clip. Under low bridges the flexible method of supports is also carried out, although, in order to prevent a bow from tilting, a second conductor has had to be introduced.

Figs. 1 and 2 show the general construction described above. In the former illustration a section insulator is shown as well as the general construction adopted where girders span the whole construction. It should be pointed out that, as far as the method of connection of the feeder cables to the overhead line is concerned, that shown in the illustration is not the permanent one adopted, but is only temporarily installed. Fig. 2 shows the construction over a bridge in which the wind ties have been used to support the catenaries from. The special construction used at low bridges, as well as the duplication of the wires at these spots, required in order to keep the bow from coming too near any portion of the bridge structure, is shown in Fig. 3. In this illustration the special arrangement adopted to provide flexibility of the trolley wire in the vertical plane is clearly shown. This is obtained by using a special form of span wire construction.

Fig. 4 shows the side bracket arm construction adopted, and in this connection it should be pointed out that the entire overhead construction has been so designed that no tools, except possibly a hammer and a chisel, are required for removing or replacing any of the main insulators, and that this can be done in a minute or two.

Fig. 4. L.B. & S.C Railway Overhead Construction (side brackets), looking from Denmark Hill.

Some sort of pull or push-off is required, not only at curves, but also in order to provide on the straight lines for the stagger or zig-zag of the wire required to prevent grooving of the collector strip. Hitherto this has been effected by introducing additional insulators into the construction. In the case of the Brighton line electrification this has been avoided by the arrangement clearly shown in Fig. 5. It will be seen that the pull-offs consist of tubes fixed by means of a clamp to the turnbuckle on either side of the secondary insulators, and that for the apex of the angle formed by them a hinged tube is fixed to clip on the top of each trolley wire. By this means, whilst laterally the trolley wire is rigidly held in its proper position, its vertical flexibility is in no way interfered with. It is believed that this is the first time that a pull-off arrangement has been designed which does not require the use of additional insulators.

Fig. 6 shows the construction adopted at cross-over roads. It will be observed that the double catenary construction is maintained throughout, the two catenaries being insulated by a double strain insulator, as shown just over the section

insulator. It will be also noticed that "deflectors" have been introduced in order to enable the bow to run smoothly over the cross-over road, and to obviate its catching in the angle where the two trolley wires join each other.

We hope at a later date to be in a position to give a complete description of this very interesting installation,

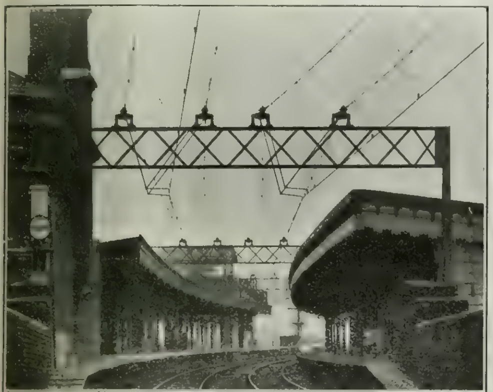


Fig. 5.—L.B. & S.C. Railway Overhead Construction, showing pull-off arrangement used at Battersea Park Station, looking towards Victoria Station.

the results of which are so eagerly being awaited by all the railway and engineering world.

The contractors for the complete electrification of the South London Line were the Allgemeine Electricitäts Gesellschaft, of Berlin. Their sub-contractors for the whole of the overhead construction, switch-cabins and cable work were Messrs. Robert W. Blackwell & Co. The cables were supplied by Messrs. Siemens Bros. & Co. and

Fig. 6.—L.B. & S.C. Railway Overhead Construction, showing cross over road installed at Brixton Station.

Messrs. Johnson & Phillips. The switchgear was manufactured by the British Thomson-Houston Co. at Rugby, the trolley wire being supplied by Messrs. Fred Smith & Co.

The whole of the rolling stock was supplied by the Metropolitan Amalgamated Carriage & Wagon Co., of Birmingham, all the work being carried out to the plans and specifications and under the supervision of the electrical adviser of the railway company.

DISTILLATION OF TURPENTINE BY ELECTRICITY.*

BY F. T. SNYDER.

In obtaining turpentine from pine wood by distillation care has to be taken that the temperature is kept within certain narrow limits. If the temperature be too high part of the turpentine produced is destroyed, while if it be too low, part is left in the wood.

It has been known for many years that the fir wood of the North Pacific Coast contains a considerable quantity of turpentine, and efforts had been made to utilise it as a basis for the commercial production of turpentine. The principal difficulties encountered were those inherent in the close regulation of temperature necessary. Some years ago, the obvious possibility of close temperature regulation obtainable with heat from electricity suggested this method for the distillation of turpentine from fir wood. At Vancouver, British Columbia, a considerable supply of waste fir wood was available, in the form of saw-mill refuse, and electricity from water power was obtainable at a low cost. An experimental electric turpentine plant, with a capacity of 1/16 of a cord, was erected and tested, and subsequently reported upon by Dr. T. H. Bray, of the Massachusetts Institute of Technology. As a result of Dr. Bray's report, a commercial plant, with a capacity of three cords per day, was erected, and has been in operation at Vancouver since July, 1907.

The wood is placed in a can which is enclosed in a brick retort, forming one of a group which are placed together to reduce radiation. The top of the can forms a flange, which fits into a groove round the top of the retort. This groove is filled with tar and forms a gas seal when the can is in the retort. Current at a pressure of 110 volts is carried through wrought-iron strips threaded through the brickwork at the side of each retort. The current supply is controlled by a switchboard of ordinary type, on which is also fixed the direct-reading pyrometers, one of which registers the temperature at the outside of the can and one the temperature at the centre of the can, showing the maximum and minimum temperature conditions in the can. The leads of these pyrometers end in flexible extensions on the top of the retorts which can be changed from can to can. The turpentine vapour is taken from the retort through are removable copper outlet pipe. This outlet pipe leads to a condenser, which consists of an upright copper pipe, down which a spray of water is passed through the ascending turpentine vapour, and which terminates in a tank at the bottom. The tank serves as a separator for the condensed turpentine and water, the turpentine readily floating to the top of the water. The excess water from the spray is withdrawn from the bottom of the tank, and the turpentine taken off from the top of the tank into a storage system.

The brickwork of the retort, when a can newly filled with wood is put in it, is at a temperature of about 250°C. The cold can rapidly absorbs heat from this brickwork, the temperature of the brickwork being kept up by a current of 400 amperes, which is passed through the resistance strips for about two hours. During this time, the temperature at the outside of the can rises from 75 deg. to 130°C., at which temperature turpentine begins to come off and at which time the centre of the can is at 45°C. The current is then shut off, and the temperature of the can slowly rises by absorption of heat from the brickwork for two hours longer, when the temperature has reached 150°C. on the outside of the can and 205°C. in the centre of the can. The turpentine has then been substantially all removed. In practice, it is found that from 90 to 95 per cent. of the turpentine in the wood, as determined by analysis, is removed during this interval. While the turpentine is coming off, the pitch in the wood melts and runs down to the bottom of the can and out through perforations, and is collected in the bottom of the retort, from which it is drawn off, at the end of the run.

It will be noted that the temperature of the interior of the can at the end of the turpentine run is hotter than the outside. This is due to the heat which is liberated by the decomposition of the hydrocarbons in the wood. At this point the can is lifted by the overhead crane from the turpentine retort and put into the adjoining retort, a new can of raw wood taking its place in the turpentine retort. In its new position, the original can of wood, from which the turpentine has been extracted, is connected up by another copper outlet pipe to the adjacent condenser. This change of retort and piping keeps the turpentine condenser and piping from being fouled by tar oil or tar products. Due to the continued decomposition of the wood, the temperature steadily rises without further use of electricity, and the resulting decomposition gives a product known commercially as "tar oil" and which comes off as vapour and is condensed. The other product of this decomposition is wood tar, which trickles down as the rosin did in the turpentine retort and is

* Abstract of a Paper read before the American Electrochemical Society. From the "Transactions," Vol. XIII.

collected in the bottom of the tar retort. It is found in practice that this tar tends to break up at the final temperature of the tar retort, and it is consequently drawn off continuously, during the tar run, into the barrels in which it is to be shipped. At the end of three hours of the tar run, the temperature in the centre of the can has risen to 375°C. and tar oil and tar stop coming off. The can is then lifted out and stood on a sand floor, which makes an air seal with the lower edges of the can and protects from combustion the contents of the can, which now consists of charcoal. When the can and its charcoal contents are cool, which takes about three hours, the perforated bottom of the can is tripped and the can lifted, allowing the charcoal to fall out. This charcoal is then put in sacks, as required by the trade which consumes it.

Five products are produced from the wood, turpentine and rosin in the turpentine retort, tar oil and tar in the tar retort, and a residual product of charcoal. The amount and kinds of product derived from any supply of wood depend on the character of the wood. The following will indicate the results which are being secured from the British Columbia Coast fir per 1,000 lb. of wood :—

Turpentine	6·7 gallons
Rosin	158 pounds
Tar oil	5·1 gallons
Tar	68 pounds
Charcoal	323 pounds

It may be noted that this charcoal, being retort charcoal and cooled out of contact with air, is tough and suitable for special purposes. The amount of wood held by a can varies with the quality of the wood, but averages at Vancouver about 1,000 lb. The electricity used per can is about 90 kw. hours and costs, at Vancouver, 9d. per can of wood.

The plant is operated by one man on each shift, there being two 12 hour shifts per day. When the wood is large, an extra man is employed on the day shift to split it.

ELECTRICITY AND "THE TIMES."

Coincident with many other changes now going forward at "The Times" offices, in London, an extensive electric power plant is being installed by "The Times'" own staff. When completed it will supersede a steam plant which, with its predecessors, has supplied power to the building for over 100 years.

The requirements of a morning newspaper in the way of power are heavy and continuous, and time, even to the second, is the very essence of the contract. In order to ensure absolute reliability of supply, current is obtained from the two companies whose supply is available in the City of London, two services being taken from the Charing Cross & City Co.'s mains and one from the mains of the City of London Electric Lighting Co. All three services enter the building from the adjacent Queen Victoria-street subway.

The two first-mentioned services enter a specially-constructed fireproof chamber, wherein are fixed the service cut-outs and meters, and from these the cables pass through to a second similar chamber containing a triple change-over switchboard of novel design. The panels are of 1½ in. specially-selected white marble, polished back and front, mounted on 3 in. steel framework, the feet resting on stone piers and the back stays being built in the wall of the chamber, leaving a clear space of 4 ft. behind the board. The floor of these chambers is of teak, and is 2 ft. higher than the basement floor, and both chambers are protected by heavy iron doors.

As shown in Fig. 1, this change-over switchboard consists of 12 separate panels, insulated by ebonite bushes from the frame. On the panels are mounted two triple-pole change-over switches of 1,500 amperes capacity. The City of London service is brought direct into this chamber, and after passing through the cutouts and meters is taken to the back of the panels.

It is possible by means of the arrangement shown in Fig. 1 to change over instantly in case of failure of either service to any other, and it is equally impossible to throw any two services in parallel. This feature is, of course, very important. Each service supplies continuous current on the three-wire system at 400 and 200 volts.

From the back of the change-over board armoured cables (1 sq. in., 0·5 sq. in. and 1 sq. in.) are laid underground, for a distance of about 60 yds., in a wooden trough filled in solid with asphalt and then concreted in. From this point they rise up to the main switchboard gallery in the press room, and are built in the brickwork for the whole distance, the only place where they are exposed being on the gallery itself. The reason for the great care taken in running the cables is so that, in case of fire in any part of the building, the cables would not be affected.

The switchboard gallery is situated 20 ft. above the floor of the machine room, and is about 60 ft. long by 12 ft. wide. From this gallery a fine view is obtained all over the machine room, with its new monster Goss Octuple press and platforms supporting the Crompton-Kohler control panels. The main switchboard (shown in Fig. 2) is fixed in a central position, and is 25 ft. 9 in. in length by 7 ft. in height. It is of polished white marble supported in a massive steel framework, and rests on a solid teak floor. A clear space of 3 ft. is provided between the 'bus bars at the back of the board and wall.

The arrangement of panels is as follows: There is a change-over switch at each end, the left-hand one (Fig. 2), of 300 amperes capacity, being for lighting only and supplying the adjacent two panels, whilst the right-hand switch is for the power supply, and is of 1,200 amperes capacity. This "power supply" switch feeds five panels, each panel containing two power circuits. There is also a recording panel for registering the whole of the current used and the pressure of supply.

The change-over switches on this distribution switchboard are provided so that in the event of it being necessary at any time to run "The Times" own stand-by plant it could be done; in which case it would be possible to change over the lighting independently of the power, or vice versa.

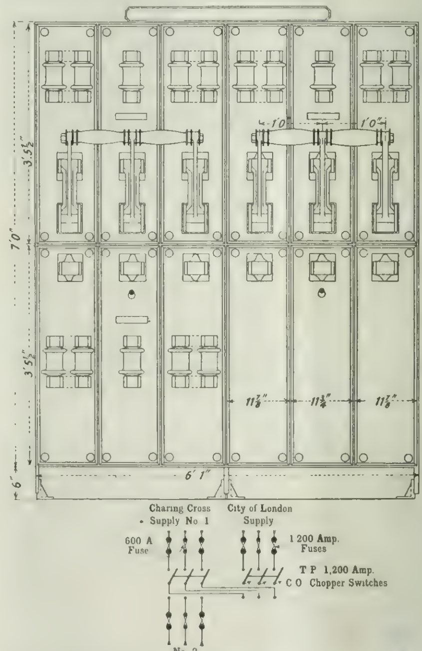


Fig. 1.—Arrangement of Main Change-over Switchboard for "The Times" Building.

The main cables from the basement are connected to the top terminals of the power change-over switch, and from this point cables are taken to the lighting switch after passing through submeters (Aron), which are fixed on the wall above the switchboard and behind the lighting panels. The various circuits from the switchboard panels pass under a false floor, and are fixed on the wall underneath the gallery, from whence they run to the various distributing boards throughout the building.

It need scarcely be remarked that the installation is of considerable size, and it is interesting to note that screwed steel conduit is used throughout. This conduit is efficiently earthed, and, with the exception of the large Crompton-Kohler press equipments, the cables for which are taken direct from the switchboard panels, the three-wire system of distribution has been adopted. It is worth noting that the neutral wires of the three-wire circuits are coupled direct to the neutral 'bus bar. A feature of the switchboard is the entire absence of circuit-breakers and the ornamental design.

The switchboards were made by Messrs. Crompton & Co. to specifications prepared by Mr. E. G. Simester, the electrical engineer of "The Times" installation.

There was a record issue of "The Times" on Empire Day, May 24. The issue was the first to be printed on a new Goss four-deck Octuple machine capable of turning out over 60,000 copies per hour of an ordinary number of the paper.

Our readers will be interested to know that the whole of the Empire edition (which comprised 72 pages), was printed by machinery driven by Crompton motors provided with the Kohler patent system of control. Messrs. Crompton claim that this is the only system which enables printing machines to be run automatically through all gradations of speed—from dead slow up to full speed and down again—without shock or jerk. This is accomplished by an ingenious system of push-button regulation.

Within the past year "The Times," having outgrown the capacity of their old presses, were compelled to place orders for new ones. One of these is now installed and running, and it was upon this machine that the Empire edition was printed. This press is the highest speed machine ever installed for printing purposes in England, and is known as an Octuple machine of the well-known Goss manufacture.

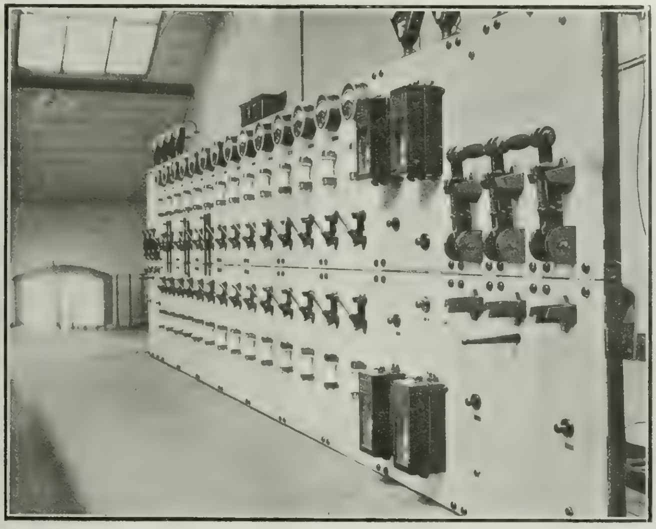


FIG. 2.—MAIN SWITCHBOARD IN "THE TIMES" MACHINE ROOM.

To operate such a press at a speed that furnishes over 1,000 copies of an ordinary issue per minute, it was necessary to have the highest class of electrical equipment possible, and with this end in view, the proprietors installed what is known as the Kohler system of multiple push-button electrical speed control, which, in conjunction with the electric motors furnished by Messrs. Crompton, operate this machine. There are four Crompton motors, two 60 H.P. main driving motors, and two auxiliary 10 H.P. slow motion motors, the latter being used for turning the press at slow speeds for make-ready, plate-changing, paper leading and similar essential operations of this class of machinery. The motors are placed in a pit below the printing machine, and are connected to the shafting through special gearing and couplings, as shown in the illustration, Fig. 5 herewith.

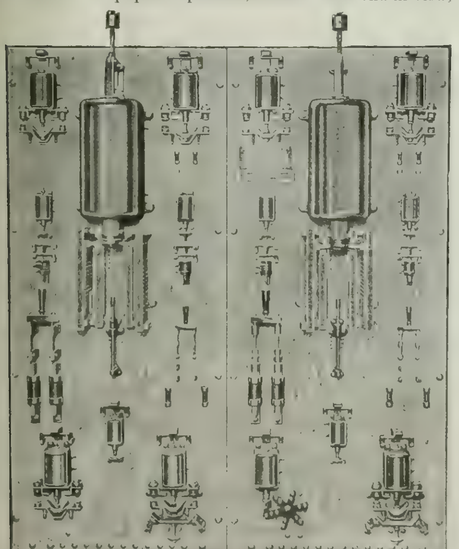


FIG. 3.—THE KOHLER CONTROL MECHANISM.

The control mechanism for the motors operating the machine consists of the Kohler standard type four motor automatic solenoid controller as shown in Fig. 3.

This system of control is remarkable for its ingenuity, and, while it may appear complex to the ordinary observer, to those who understand the special requirements of printing operations it is extremely simple. Prominent in "The Times" press-room are the speed control panels built of marble. Mounted on these are the necessary electrical devices controlling the Octuple machine. The controllers are placed in convenient positions, near to and facing the press they are to control. There are 16 push-button "stations" (one is shown in Fig. 6) located in convenient places on the press. Each station consists of an iron box about 4 in. wide by 6 in. long and 3 in. deep. Each station carries five buttons, marked respectively "ON," "STOP," "OFF," "RUN," "SAFE." Any combination of the machine can be operated from any one of these stations, it being possible for the minder to start, speed up or speed down the machine, or stop it by pushing a button at any station. The "ON" button is used for starting and regulating the speed from minimum to maximum. The "OFF" button is used for decreasing speed. The "STOP" button is used to stop the machine. The "SAFE" button is used to protect the machine minder against any sudden starting when he is working in or on the machine. When he pushes the "SAFE" button he literally locks the press so that no one can move any part of the machine until the "RUN" button is pushed. A child could start, stop or regulate the speed of this huge and complicated machine with absolute safety.

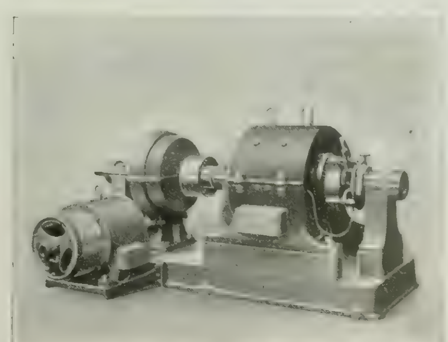


FIG. 4. CROMPTON KOHLER MOTOR EQUIPMENT FOR "THE TIMES" PRINTING PRESS.

There are about 30 running speeds provided on the Kohler controllers, the lowest about 10 revs. per min. of the main driving shaft

of the press on through various steps to any desired speed up to maximum, or from maximum speed down through these steps to standstill; or the press will run at any one of the intermediate speeds. The lower speeds are obtained through the slow-motion motors and the higher speeds through the main motor. A slow-motion motor starts the machine, and when a certain speed is reached the load is automatically shunted on to the main driving motor, and the small motor is automatically cut into service as the large one is cut out. So perfect is the electrical control obtained through the Kohler system that a ½ in. movement of the cylinders can be made while putting on the impression blankets or the plates. One of the motor equipments, consisting of a small and large motor, is shown in Fig. 4, and in position under the floor of the machine room in Fig. 5.

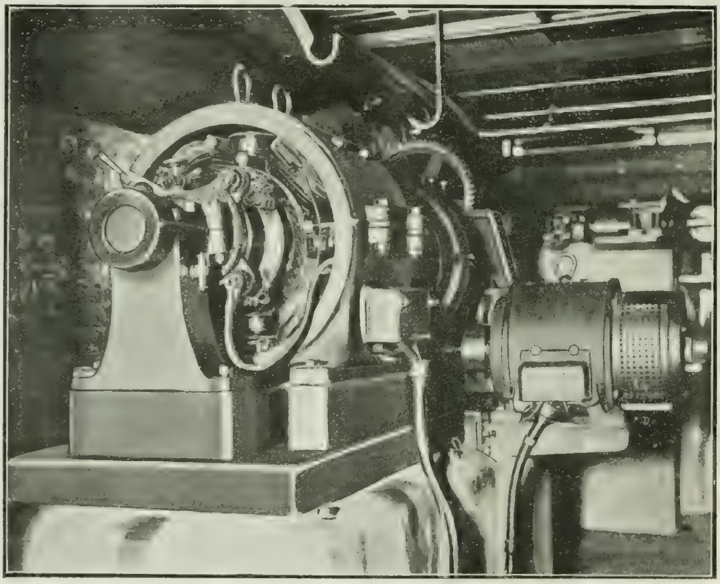


FIG. 5.—CROMPTON-KOHLER MOTOR EQUIPMENT FOR NEW GOSS OCTUPLE PRESS.

When a press has been brought to the desired speed for "threading" the paper, the "SAFE" button can be pushed, and it will be impossible to increase the speed until the "SAFE" button is released; thus reducing the liability of accident to the minder or his assistants when threading the paper, a somewhat delicate operation. The "SAFE" button can also be used to prevent any increase above any desired speed, as for instance in colour printing on rotary machines, where a moderate speed is wanted. Suppose a case where a minder wishes to run his machine at one half speed (or, say, 100 revs. per min.). He presses the "ON" button until he reaches that speed, and then presses the "SAFE" button, and the press will continue to run at that speed until the "SAFE" button is released, excepting where the minder wishes to slow down or stop. This he can do at any time, even though the "SAFE" button is in.

FIG. 6.—PUSH-BUTTON CONTROL.

The time required to bring the machine from standstill up to maximum, or from maximum to standstill, is adjusted to suit the minder, but is usually about 20 seconds. The time required to stop the press is only the few seconds necessary to prevent stripping of gears. The press can be stopped from any one of the sixteen stations.

It sometimes happens that the machine "chokes" with the paper, or the bearings become overheated, causing heavy overloads. With the Kohler system any undue load on the press causes it automatically to come to a dead stop, thereby avoiding injury to either the press or the motors. If for any reason, whether by failure of current, mechanical accident, or design, the press is stopped, the controller immediately and automatically returns to the starting-point. The push-buttons are so arranged that it is impossible to make any mistake. Even if all the buttons were pressed at once, there can be no accident. It does not signify how the buttons are manipulated, no injury can come to the press.

In the operation of double combination machinery like that at "The Times" office, which really consists of two presses, it is sometimes necessary that each half of the press be run independently. The Kohler system provides for this, as there are two complete outfits and these are operated individually when the press is run in two parts and in parallel when the press is run as a whole. The press is a four-decker, and any combination of decks can be run on either or both motor outfits, and there are separate push-button control stations on each deck.

One of the greatest advantages obtained by use of the Kohler system lies in the fact that the motors can be of the ordinary standard type, so that parts of motors used in connection with the system can always be obtained without delay. The Kohler system is also adapted for small rotaries and flat-bed presses, and indeed for any class of machinery where perfection of control is required. It has been satisfactorily applied to lithographic machines on the Continent. It is to-day operating over 600 printing presses of different designs, and as proof of the small cost of maintenance it may be mentioned that the "Morning Post" has had the Kohler equipment in use for five years, and it has never yet been found necessary to renew the carbon contacts of the switches forming the control mechanism. Also, it is stated that, although so many Kohler equipments are now in use, one has never been known to fail.

We are indebted to "The Times" engineering department, to Messrs. Crompton & Co. and to Messrs. Kohler Bros., for kindly supplying us with the information and illustrations contained in this article.

Regulable Tungsten Lamp.—According to the "Electrical World," a lamp containing two filaments has just been brought out, in which the working filament is made of tungsten and a smaller one of carbon. The former consumes 35 watts and gives 27 c.p., while the latter consumes 8 watts and gives 1 c.p. Current can be changed over from one to the other either by turning the bulb or pulling a string.

DIFFERENTIAL BALLISTIC METHODS OF MEASURING HYSTERESIS LOSSES.

BY R. BEATTIE, D.SC., AND P. M. ELTON, B.SC.

(*Concluded from page 301.*)

Summary.—Ballistic methods of measuring hysteresis are very accurate, but have the disadvantage that they are generally troublesome. The authors describe a method that is quick in operation and has the advantage that it refers to short test pieces. Instead of obtaining the **B**-**H** curve, the δ**B**-**H** curve is found by a differential measurement, the method preferred being that of momentarily short-circuiting a resistance in the magnetising circuit so that **H** is brought up to its maximum value and immediately returns to its previous value, a single specimen being used. The conditions for the interval of short-circuit are examined. The results are satisfactory, but the authors find that the loss in a ring is 1·65 times that found in strips, whether by the differential or the step-by-step method. Finally, some differential methods involving two specimens are described.

Experimental Results.—We have tested the accuracy of the differential method just described by applying it to ring samples of a number of different qualities of sheet iron, and then comparing the results with those obtained by the ordinary step-by-step ballistic process. As seen from the numbers in the second and third columns of Table I., the agreement was in every case almost exact.

Table I.—*Results of Ballistic Tests for Hysteresis Loss on Rings and Bundles of Sheet Iron. The Numbers represent Watts per Pound at* $\mathbf{B}_{max.}$ 4,000 *and a frequency of* 100.

Material.	Rings. "Step-by-step" process.	Rings. "Differential" process.	Bundles. "Step-by-step" and "Differential" processes.	Loss in ring / Loss in bundle
Sankey's "Stalloy" quality	0·345	0·348	0·205	1·68
Sankey's armature quality	0·504	0·493	0·305	1·64
Sankey's "Lohys" quality	0·515	0·510	0·315	1·64
Sankey's pole piece quality	0·544	0·545	0·33	1·65
				Mean 1·65

NOTE.—The values for bundles were found to be the same whether a "specific loss" method of test was employed in which the loss was referred to the measured induction at the centre, or whether a "total loss" method was adopted, in which the loss was referred to the *equivalent* induction deduced in the manner indicated at the commencement of the Paper.

But on applying the differential method to test the same materials in the form of strips ½ in. wide and 20 in. long built up to form test bundles of square section, we were surprised to get lower values for the loss than in the case of rings (*see* fourth column of Table I.). At first we were inclined to suspect either some error in the carrying out of the experiments themselves, or else something fundamentally wrong in the principle of the method adopted, which happened to be a "specific loss" one. In adopting a method of this kind we really measure $\int \mathbf{H}_t d\mathbf{B} + \int \mathbf{H}_d d\mathbf{B}$, where $\mathbf{H}_t$ is the true magnetising force and $\mathbf{H}_d$ is the magnetising force arising from the free magnetism at the ends of the test piece. But, as previously shown by one of us,* the second of these integrals vanishes for specimens such as we were employing, and the method should, therefore, have led to correct results. There was always, to be sure, the possibility of $\int \mathbf{H}_d d\mathbf{B}$ not being absolutely zero; but in that case the method would have given values in excess of the true one. Nothing, therefore, in the theoretical basis of the method in any way explains the appearance of abnormally low values. Moreover, identically the same low values were obtained with a "total loss" differential method, in which no assumptions of a similar kind are involved, and in which there is therefore no possibility of error.

In an endeavour to find a possible explanation of the discrepancy, it was thought that perhaps the induction did not have time to rise to its full value in the brief interval allowed by the short-circuiting of R_2. This was tested by varying the duration of contact of K, and also by carrying out the test—both in the "specific loss" and in the "total loss" form—by the step-by-step process instead of differentially; but no difference in the results could be detected, thus showing that in the differential method the induction did, in fact, have time to reach its full value corresponding to the maximum magnetising current. This was further tested in a more direct manner by arranging a key in the galvanometer circuit so that when K was momentarily closed, as in making a differential test, the galvanometer circuit was automatically broken just an instant before K was opened. Under these conditions the throw of the galvanometer measured the actual rise of induction during the operating of K, and this was invariably found to be the same as the rise of induction which occurred on permanently depressing K.

After a careful but fruitless investigation of every conceivable source of error, we were finally led to the conclusion that the observed discrepancy is something real, and that the hysteresis loss when measured ballistically in a bundle is actually less than when measured in a ring between the same limits of induction. This conclusion was arrived at not without hesitation, for, hysteresis being essentially a molecular phenomenon, it is difficult to understand why it should depend in any way upon the outward shape of the test piece. In all likelihood a partial,

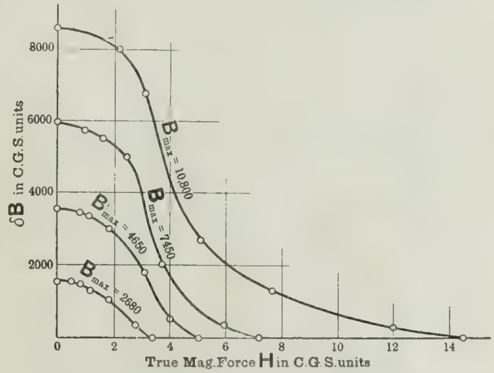


FIG. 5.—TYPICAL δB H CURVES FOR IRON RING.

if not a complete, explanation may eventually be found in the rate at which the cycle is performed, for it was noticed that the loss, as measured by an alternating current method at a frequency of 100, was precisely the same whether a bundle or a ring was employed. However, it would be premature to enter upon a fuller discussion of the matter here, as it is still under investigation. It must suffice for the present to point out, as an undoubted fact, that there is always a considerable difference in the results of ballistic tests for hysteresis loss according as a ring or a bundle of strips is used as test piece, and that this difference is always the same whatever method—"total loss" or "specific loss," "differential" or "step-by-step"—is adopted.

Notwithstanding this, ballistic tests on bundles of strips are still available as a means of determining the true loss in the material. For, as far as our experiments have gone, the loss in a bundle appears to be always a definite fraction—almost exactly three-fifths—of the loss in a ring. The loss as measured in a bundle when multiplied by 1·65 thus gives the true loss. Strictly speaking, the value of this correcting factor refers to standard bundles having the dimensions already stated; but it is not appreciably affected by altering the dimensions of the bundle within wide limits, so that no special nicety of adjustment is necessary when making up a bundle for test purposes.

A "Two-Throw" Method Possible with Bundles.—Having discussed the admissibility of bundles as test pieces, it becomes

* THE ELECTRICIAN, Vol. LXII., p. 136, Nov. 6, 1908.

necessary to emphasise what has not yet been made sufficiently clear, though alluded to at the commencement—namely, the extreme ease with which hysteresis tests by the differential method can be carried out on bundles.

The results of ballistic tests by differential methods are, as already explained, best exhibited in the form of δ**B**-**H** curves. With ring specimens the hysteresis loops differ greatly in shape according to the limits of induction; so, of course, do the corresponding δ**B**-**H** curves (Fig. 5), and it is evident that to determine the true shape of such curves several ordinates—at least five or six—must be measured, necessitating the observation of an equal number of differential ballistic throws.

But with bundles as test pieces the shape of the hysteresis loop is more or less forced upon it, being determined rather by the dimensions of the test piece than by the nature of the material of which it is composed. In consequence, we find that the δ**B**-**H** curves (Fig. 6) are now all very nearly of the same shape, whatever the quality of the material, and, within certain very wide limits, whatever the maximum induction during the cycle. If the δ**B**-**H** curves were all identically of the same shape, the area under any one would be obtained by

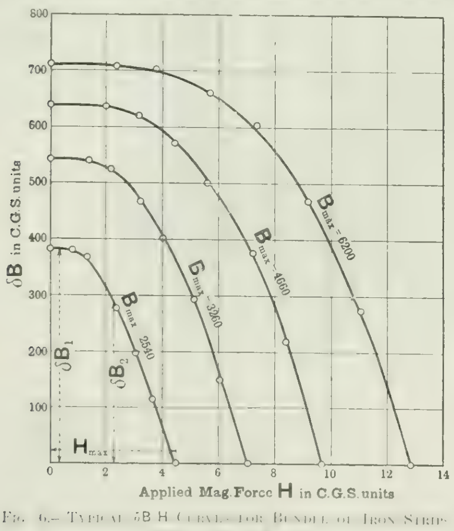


FIG. 6.—TYPICAL δB-H CURVES FOR BUNDLE OF IRON STRIPS 20 IN. × [illegible] IN. × [illegible] IN.

multiplying, say, the initial ordinate $\delta \mathbf{B}_1$ by the length of the base $\mathbf{H}_{max.}$ and by a suitable constant; and, therefore, a single differential throw only would be required to obtain the value of the hysteresis loss.

In point of fact, however, the similarity of shape is not sufficiently exact to permit a rule quite as simple as this to be applied with any degree of accuracy. But the determination of two ordinates—an initial ordinate $\delta \mathbf{B}_1$ and a mid ordinate $\delta \mathbf{B}_2$—suffices to determine the area with as much accuracy as is generally required. If the curves were truly parabolic in shape, Simpson's rule would give the area correctly from two such ordinates by the formula

$$\text{Area} = \frac{\mathbf{H}_{max.}}{6}(\delta \mathbf{B}_1 + 4\delta \mathbf{B}_2),$$

and the actual δ**B**-**H** curves are sufficiently close approximations to parabolas to enable this "two-ordinate" rule to be used with confidence, and with the certainty of the values obtained by it being right to within at least 1 per cent. (*see* Table II.).

In practice, therefore, with bundles of strips as test pieces, two differential ballistic throws alone have to be observed: one with the resistance R_2 (Fig. 1) equal to infinity, and the other with R_2 equal to half the total resistance of the magnetising coil circuit. When once the apparatus has been set

Table II.—*Illustrating Accuracy of "Two-Ordinate" Rule for estimating Area under* δ**B**-**H** *Curves for Bundles of Iron Strips. The Areas are in Arbitrary Units.*

Material.	$\mathbf{B}_{max}$	True area.	Area by "two-ordinate" rule.
Sankey's pole piece quality	1,580	393	400
	2,370	704	700
	3,770	1,430	1,440
	4,940	2,020	2,040
	6,360	2,770	2,750
	7,340	3,270	3,260
Sankey's "Lohys" quality	3,260	1,030	1,050
	3,950	1,420	1,420
	4,660	1,780	1,770
	5,370	2,150	2,180
	6,200	2,690	2,690
	8,060	3,980	3,980
Sankey's "Stalloy" quality	4,070	1,390	1,400
	4,830	1,880	1,890
	5,670	2,380	2,370
	6,310	2,800	2,780
	7,110	3,430	3,350
	7,930	4,040	3,920

up and adjusted, these two observations, together with a third to determine the maximum induction, can be taken in the course of a minute or less. And, given the necessary constants, the calculation of the true hysteresis loss can be made in an equally short space of time by the formula

$$\left.\begin{array}{l}\text{Hysteresis loss in ergs per}\\ \text{cubic centimetre per cycle}\end{array}\right\} = 1{\cdot}65 \, . \, \frac{\mathbf{H}_{max.}}{12\pi} \, . \, (\delta \mathbf{B}_1 + 4\delta \mathbf{B}_2) \quad . \quad (1)$$

in which the only empirical element is the factor 1·65 representing the ratio of the loss in a ring to that in a bundle.

This last formula obviously refers to the "specific loss" method, $\delta \mathbf{B}_1$ and $\delta \mathbf{B}_2$ denoting induction differences measured at the centre of the test piece, and $\mathbf{H}_{max.}$ being the maximum magnetising force due to the magnetising coil alone—*i.e.*, $\mathbf{H}_{max.}$ is equal to 1·26 times the maximum ampere-turns per centimetre length of the magnetising coil.

Considerations similar to the above likewise apply to the "total loss" method, in which the loss is deduced from the area of a δF-I curve. These curves do not differ perceptibly in shape from δ**B**-**H** curves, and the areas under them may therefore be correctly estimated by a "two-ordinate" method leading to the formula

$$\left.\begin{array}{l}\text{Hysteresis loss in ergs per}\\ \text{cubic centimetre per cycle}\end{array}\right\} = 1{\cdot}65 \, . \, \frac{N_1 I_{max.}}{3V} \, (\delta F_1 + 4\delta F_2) \quad . \quad (2)$$

Here the flux differences δF_1 and δF_2 denote respectively the initial and mid ordinates of the δF-I curve, and are obtained exactly in the same way as the induction differences $\delta \mathbf{B}_1$ and $\delta \mathbf{B}_2$, except that the ballistic galvanometer is connected to N_2 instead of N_3 (Fig. 1). $I_{max.}$ is the maximum magnetising current in C.G.S. units, V the volume of the bundle of strips, N_1 the total number of turns on the magnetising coil, and 1·65 the correcting factor to which reference has just been made.*

"*Two-Specimen*" *Differential Methods.*—Besides the method already described—which may conveniently be called a "single-specimen" method—there are other possible ways in which the differential ballistic principle, as applied to

* Put in the shape of working formulæ, (1) and (2) may be written

$$\left.\begin{array}{l}\text{Hysteresis loss in ergs per}\\ \text{cubic centimetre per cycle}\end{array}\right\} = 1{\cdot}65 \, . \, \frac{KR}{30\,l\,a} \, . \, \frac{N_1}{N_3} \, . \, I_{max.}(\delta\theta_1 + 4\delta\theta_2)$$

for the "specific loss" method, and

$$\left.\begin{array}{l}\text{Hysteresis loss in ergs per}\\ \text{cubic centimetre per cycle}\end{array}\right\} = 1{\cdot}65 \, . \, \frac{KR_2}{30V} \, . \, \frac{N_1}{N_2} \, . \, I_{max.}(\delta\theta_1 + 4\delta\theta_2)$$

for the "total loss" method. $\delta\theta_1$ and $\delta\theta_2$ here mean the differential ballistic throws obtained with R_2 = infinity and $R_2 = R_1$ respectively, K is the constant of the ballistic galvanometer, R_2 the total resistance of the galvanometer circuit, l the total length of the magnetising coil, a the sectional area of the test piece, N_1 N_2 N_3 the number of turns on the respective coils (Fig. 1), and $I_{max.}$ the maximum magnetising current in amperes. It will be noticed that the only dimension of the test piece which enters into the first of these formulæ is the sectional area a, whilst the volume V enters into the second, thus justifying the use of the titles "specific loss" and "total loss" to describe the respective methods.

hysteresis measurements, can be carried out. All these alternative methods, however, require the use of two exactly similar specimens, and the duplication of the magnetising coil. To that extent they are more complicated than the "single-specimen" method, but in certain other respects they are simpler, and some of them may even be preferred to it.

The simplest and most practical of these alternative methods is represented in Fig. 7. Two magnetising coils, which must be wound with exactly the same number of turns per centimetre length, are in this case connected in parallel, with equal resistances, R_1 R_1, in series. A resistance, R_2, can be thrown into the circuit of either coil by means of the key K, which is

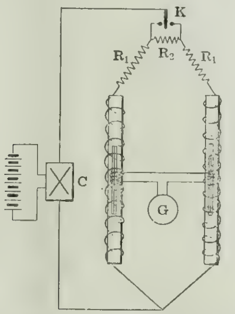


FIG. 7.—"Two Specimen" Differential Ballistic Method arranged for "Specific Loss" Test.

an ordinary two-way key constructed so as not to break circuit in passing from one contact to the other. As shown, the secondary coils wound round the test pieces are connected in series with the ballistic galvanometer G.

To operate this method, K is placed in its mid position, which allows exactly equal magnetising currents to flow through the two coils. The commutator C is then reversed a few times and stopped in its mid position, leaving the magnetism of both test pieces at X (Fig. 3). K is next set to one side and the commutator thrown over in the direction in which it was last moving, which brings the magnetism of one test piece up to P, and of the other to Y. Lastly, K is thrown

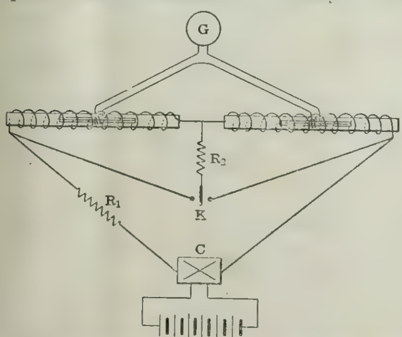


FIG. 8.—"Two Specimen" Differential Ballistic Method arranged for "Specific Loss" Test.

quickly over to the other contact, cutting R_2 out of one circuit and inserting it in the other, with the result that the magnetism in one test piece suddenly falls from Y to Q, and in the other suddenly rises from P to Y. Provided the secondary coils are connected up so that the quantities induced by these two flux changes go in opposite directions through the galvanometer, the ballistic throw will measure PQ or $\delta\mathsf{B}$.

The special advantage of this method is that the induction changes take place simultaneously and not successively, as, of necessity, they must in the "single specimen" method. The key K may, therefore, be operated as quickly as one pleases; the key itself, moreover, need not be of special construction, since any ordinary two-way key will serve so long as it fulfils the required condition of not breaking circuit in passing from one contact to the other.

Two modifications of the arrangement shown in Fig. 7, though of a much less practical character, are at least worth mentioning. In the first of these, Fig. 8, the magnetising coils are placed in series, and the resistances R_2 can be connected as a shunt across one or the other by the key K which is constructed to break circuit in passing from contact to contact. The commutator C is reversed and stopped with K in its mid position and touching neither contact. K is then set to one side and C thrown over in the proper direction. This brings the magnetism of one test piece to P and of the other to Y. Moving K to the opposite side causes the magnetism of the first test piece to fall to Q and of the other to rise to Y, giving, with a properly connected galvanometer, a ballistic throw proportional to $\delta\mathsf{B}$. The disadvantage of this method compared with that of Fig. 7 arises from the difficulty of keeping the main current exactly constant during the manipulation of K.

The arrangement of Fig. 9 is in reality identical with that of Fig. 8, except that auxiliary magnetising coils are used in place of the shunting resistance R_2. The manipulation, however, remains the same. With K in its mid position and touching neither contact, the current circulates through both the main and auxiliary coils, the latter, say, being connected up to aid the former. When C has been reversed, stopped, K set

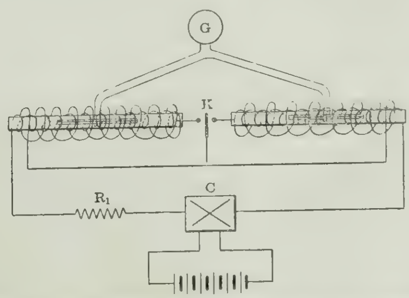


FIG. 9.—"Two Specimen" Differential Ballistic Method arranged for "Specific Loss" Test.

against one contact, and C thrown over, the magnetism of one test piece is represented by P and of the other by Y. Moving K against the other stop changes the magnetism of the first to Y and of the second to Q, and gives a ballistic throw proportional to $\delta\mathsf{B}$.

The disadvantages of the method are the same as for the last, with the added disadvantage that, in order to measure several different ordinates, arrangements must be made for shunting the auxiliary coils, or else several auxiliary coils each wound with a different number of turns must be provided.

UTILISATION OF ATMOSPHERIC NITROGEN PARTICULARLY FOR THE MANUFACTURE OF AIR-SALTPETRE *

BY DR. A. BERNTHSEN.

In spite of the fact that at first sight atmospheric nitrogen appears to be a rather useless substance, and was so considered for many years, the compounds of this gas play such an important part in the nutrition of living organisms that the task of discovering new sources of these compounds has become one of the most interesting and pressing problems of the day. The author, therefore, at the beginning of his Paper, considers this subject from an historical point of view, and shows how important it is in agriculture to supplement

* Abstract of a Paper read at the Seventh International Congress of Applied Chemistry, London, 1909.

the natural sources of the nitrogen required by the plants by artificial means. Liebig first drew attention to the ignorant way in which the soil was being used up, and protested strongly against the waste of manure. In spite of the opposition which was at first made to his teachings, his ideas have taken root, and the question of artificial production of manure has become of highest importance.

Besides their use in agriculture, nitrogen compounds are being employed to a very large extent industrially, and in spite of the enormous fields of natural saltpetre which exist in South America the demand is considerably greater than the supply. The possibility of the exhaustion of the supply of saltpetre was first pointed out by Sir William Crookes in 1899, who also showed that owing to the increase in population the yield per acre of the ground would have to be considerably increased in order to provide an adequate food supply.

The problems which are the corollary of the above conditions have been solved by the utilisation of atmospheric nitrogen for various purposes, and this fixation has been carried out by very different methods, which can be divided into three groups. The first of these requires the direct formation of ammonia from its elements. In the second, the nitrogen, which is first isolated, is then converted into metallic nitrides and cyanogen compounds, which can in their turn be decomposed into ammonia. In the third group direct oxidation of atmospheric nitrogen and its conversion into nitrates is attempted. As regards the first of these methods, though interesting, much has not been done along practical lines. In the second, researches were carried out nearly 70 years ago by Bunsen, and Marguerite and Sourdeval also worked upon the subject. The well-known nitrolime product, the production of which is due to Frank and Caro, also belongs to this class. These substances have had some industrial application, but it is at present too early to prophesy what their success will be. It will also have to be discovered whether the nitrolime is entirely suitable for application to the soil, or whether it will be advisable first to convert it into ammonium sulphate and how much loss of efficiency there will be on this account.

As to the third method of bringing nitrogen into a state of combination suitable for use on a practical scale, this consists in converting the gas by direct oxidation into oxides of nitrogen, which are then transformed into nitric acid and nitrates. This direct combination requires a high temperature, but the degree of combination is limited by the fact that the same temperature which brings about the formation also tends to decompose the compound again into its constituents. At temperatures under 1,200°C. nitric oxide is stable against the action of heat, but at this temperature the amount formed is very small. At 1,500°C. only one-tenth per cent. of the nitrogen in the air is converted into nitric oxide, and a very much higher temperature is necessary to bring about a reasonable degree of oxidation. Muthmann and Hofer, and especially Nernst, have studied this subject, and from their results it appears that at a temperature of 2,200°C. the gases contain 1 per cent. of nitric oxide, at 2,571°C. they contain 2 per cent., at 2,854°C 3 per cent. and at 3,327°C. 5 per cent. The air must, therefore, be heated to as high a temperature as possible and then cooled down again with the utmost rapidity, so that little opportunity may be given to the nitric oxide to decompose into its elements.

The author then deals with the methods which have been proposed for fixing nitrogen by this means in an historical manner, and draws attention to the work of Pawlikowsky, Hauser, Brunler, Ketteler and others and to that of Cavendish and Priestly. Numerous other names in this field are also mentioned and their work dealt with, namely, Lord Rayleigh Crookes, Lepel, Guye and Navillo, MacDougal and Howles, Kowalsky and Moscicki, Brode, Pauling, Le Blanc and Nurenen, Birkeland and Eyde, and Schonherr. The method used by Bradley and Lovejoy at Niagara is described, and that employed by Birkeland and Eyde in Norway is also dealt with.

Another interesting process is that of the Badische Anilin- und Soda-Fabrik who, after manufacturing indigo on a commercial scale, have recently paid special attention to the new problem. As the result of these labours, Otto Schönherr succeeded in 1905 in discovering, and with the assistance of the engineer Hessberger, working out, a process of producing an electric arc, and was thus enabled to solve the problem in a surprisingly simple manner, presenting considerable advantages over the method of Birkeland and Eyde. It is not a mere modification of their process, as has sometimes been falsely assumed, but differs fundamentally from it, for while Birkeland and Eyde cause the electric discharge to burn in a strong magnetic field, and thus spread it out in the shape of a flat, more or less circular disc, Schönherr dispenses entirely with magnets and magnetic fields, and produces his arc inside an iron tube of comparatively small diameter, at the same time passing the air through the tube, and thus bringing it into contact with the arc. He has described his process at a lecture in Berlin, of which a full report has just appeared in the "Elektrotechnische Zeitschrift," Nos. 16 and 17, 1909. The manner in which the arc is developed is in itself very peculiar and interesting. The iron tube, or arc tube, as it is designated, contains an insulated electrode at one end, and can itself serve as the second electrode. The arc, at its formation, springs from the insulated electrode to an adjacent part of the arc tube, which is only a few millimetres away, but the air, which is passing through the tube, being preferably introduced with a tangential or rotary motion, immediately carries the end of the arc along the wall of the tube, so that it either enters the tube at a considerable distance from the electrode, or ends on a special electrode placed for the purpose, say, at the other end of the arc tube. A slight modification consists in using an arc tube of non-conducting material, and inserting in it a wire-spiral along which the end of the arc can travel, or providing other means for bringing about the initial formation of the arc. In each case, a column of arc flame is obtained, burning quietly in the axis of the tube, and surrounded by the air which is being passed through the tube. The arc, as seen through a mica-covered opening, emits an intense light, and is quite stable, as opposed to arcs which are formed in the open air, since these latter are easily extinguishable. The air passing through the tube comes into contact with the arc, becomes partially converted into nitric oxide, and is then rapidly cooled down by contact with the outside layers of air, and consequently a decomposition back again to nitrogen and oxygen is avoided. The cooling action is still further increased by surrounding the upper end of the arc tube with running water, after the manner of the Liebig's condenser. The gases leaving the tube contain about 2 per cent. of nitric oxide—that is, they are from one and a half times to nearly twice as concentrated as the gases which Birkeland and Eyde produce.

The method of introducing the air can be very varied. For instance, instead of the air being passed in its entirety into the space between the electrode and the wall of the tube, it can be introduced partly or wholly into the tube at other points above or below the electrode, and it can be made to enter the tube either through one or more openings or through a number of openings which are distributed over a part or the whole of the tube. The opening may be in the form of a ring extending all round the tube, or several such ring-shaped openings can be employed, or instead of these, long slits, either parallel or at an angle to the axis of the tube, can be provided. The openings may be situated so that the air enters at right angles or at any other angle to the axis of the tube. In the latter case, the gases generally pass through the tube with a rotary motion.

With the aid of Schönherr's invention, it is possible to send extraordinarily large quantities of electrical energy through a single tube. A small experimental apparatus, for instance, uses about 5·5 H.P. and works at a tension of 5,000 volts. The experimental furnaces at Christianssand have a capacity of about 600 H.P. at 4,200 volts, and although it appears possible to build furnaces which could consume 2,000 H.P., those regularly used will probably be built for 1,000 H.P. These furnaces require about 40,000 cubic ft. of air every hour, and the arcs produced are nearly 8 yds. long.

The construction of the furnace on the large scale is as follows: The air passes into the arc tube through a number of tangentially-bored holes in the part of the tube surrounding the electrode, and over these holes is an iron ring or cylinder, which can be moved from the outside by means of a lever, so that any desired number of the holes can be closed, and consequently, the strength of the rotary motion of the air regulated, and this in turn assists in regulating the length of the arc. The insulated electrode can be cooled by means of water or air, and it is also provided with a central hollow space through which passes an iron rod. The arc actually springs from this iron rod, and as it burns or volatilises away, it can be pushed forward by a simple arrangement: the rate of burning, however, is very slow. An ignition lever, or other simple arrangement, is provided so that the arc can be started afresh, should it from any cause become extinguished; this, however, is very rarely the case. The furnace itself is connected electrically to earth, so that any part of the apparatus, with the exception of the insulated electrode, can be handled with impunity. The gases which leave the arc tube pass down a channel lined with brick, and concentrically surrounding the inner parts of the furnace. They are thus made to give up a portion of their heat to the air which is entering the furnace, and which is subsequently passed through the arc tube, thereby raising it to a fairly high temperature.

The apparatus is extremely simple, and at the same time very durable; ordinary iron tubes are employed, there are no movable parts and no expensive electromagnets, and the manufacture runs smoothly without interruptions.

Though in this process there is very little loss of electrical energy in producing the arc, yet only a small percentage of the energy serves to bring about chemical reaction, the rest is converted into heat. This latter, however, is not by any means wasted, 30 per cent. of it is employed producing hot water, 40 per cent. heats the boilers, 10 per cent. has to be removed by cooling, and only 17 per cent. is lost by radiation. The evaporation of the calcium nitrate solutions obtained is carried out solely by the heat generated in the arc.

Numerous experimenters have studied the chemical action of this kind in arcs, and under certain conditions it has been found that a gas mixture containing 10 per cent. of nitric oxide could be obtained. The arc produced is of comparatively low temperature and the combination appears to be brought about by some electrical phenomenon. The process is certainly very interesting from the theoretical point of view, but it is too early to give an opinion on its practical utility. The yield of nitric oxide can be increased by mixing oxygen with the atmospheric air instead of using the latter alone, but the advantages are only apparent, owing to the greater expense. It has also been suggested by Messrs. Siemens & Halske and Sir Wm. Ramsay to separate the air into its different constituents and use the nitrogen for producing nitrolime and the oxygen for manufacturing saltpetre. This arrangement does not at present appear likely to be successful.

It is interesting to note that the arcs produced in Schönherr's process send out electrical waves, and as a result of this a method has been worked out by the Badische Anilin- & Soda-Fabrik for producing electrical oscillations of great frequency suitable for use in wireless telegraphy.

Having once obtained the oxides of nitrogen, it is necessary to bring them into a marketable state, either into the form of nitric acid, nitrates, or nitrites. Up to the present both nitric acid and nitrites have been manufactured from saltpetre by chemical reaction, and are, therefore, both more expensive than the latter substance. As, however, the demand for nitric acid and nitrites is limited, the chief aim of every large factory is to convert the supply of nitrogen into the form of saltpetre, for which there is an unlimited market. The nitrogen tetroxide passes through water, so that two-thirds of the nitrogen present is converted into nitric acid, while one-third reappears as nitric oxide. This again combines with the excess of oxygen present in the gases to form oxygen tetroxide, and the same reactions are gone through again. On neutralising this acid with soda a concentrated solution of sodium nitrate is obtained, which can be evaporated until the solid salt crystallises out. In practice limestone is, however, employed instead of soda, so that calcium nitrate is obtained. This substance is at least as valuable as sodium nitrate for manuring purposes, and is consequently isolated as such and put on the market under the name of "Norwegian saltpetre" or "air saltpetre."

By other suitable methods strong nitric acids, nitrites and oxygen tetroxide can also be obtained. The furnace gases can also be passed over quicklime, which absorbs them, the final product containing dry calcium nitrite.

The absorption at Notodden is at present carried out according to the "acid" process; the first product is dilute nitric acid, which is subsequently converted into calcium nitrate. The apparatus necessary is very extensive, on account both of the small contents of nitric oxide in the gases, and also of the very large volume of the gases treated. The hot gases, on leaving the electric furnace, are first made to pass through boilers, thereby giving up some of their heat, and creating the supply of steam used for heating the vacuum pans, in which the solutions of calcium nitrite are evaporated. These vacuum pans can be heated directly by the furnace gases if desired, or by the intermediate agency of steam. The gases are then still further cooled and afterwards passed into a large empty tower or other receiver, in which time and opportunity are given for the nitric oxide to be oxidised to nitrogen tetroxide. If the gases contain 2 per cent. of nitric oxide, 12 seconds are required for the oxidation of 50 per cent. of it, while the oxidation of 90 per cent. requires 100 seconds. The gases are then passed into very large granite towers about 65 ft. high and filled with lumps of quartz, and in these towers, the acid absorption is effected by means of water, or of the dilute nitric acid which is collected at the bottom of the tower. In order to recover the oxides of nitrogen which remain unabsorbed, the gases are finally treated with milk of lime or soda, and give rise either to a mixture of nitrite and nitrate or to pure nitrite.

The more dilute the gases are, the more difficult is the absorption, and consequently the greater concentration of the gases obtained by the process of the Badische Anilin- & Soda-Fabrik, constitutes a not unimportant advantage over Birkeland and Eyde's process.

More recent experiments at the Badische Anilin- & Soda-Fabrik have shown the possibility of effecting the absorption directly with milk of lime, and, in this case, the "acid" absorption could be dispensed with, and the absorbing towers and the initial outlay on plant considerably reduced.

The calcium nitrate obtained by any of these operations can, without further treatment, replace Chili saltpetre for purposes of agriculture, and is in some cases even better. Even a mixture of calcium nitrate with nitrite and free lime appears to have no harmful effect. Such operations as these require abundant and cheap water power, which conditions the Birkeland and Eyde concern have obtained in Norway. The Badische Anilin & Soda-Fabrik have also obtained a concession whereby the construction of a factory with a capacity of 50,000 H.P. will be possible.

Considerable quantities of air saltpetre will shortly be put on the market, and probably, within a few years, the annual output will reach 100,000 tons. This quantity is none too large when we remember that the world's demand increases by at least that much every two years. Chili saltpetre is not likely to influence unfavourably the development of the factories already started, especially as air saltpetre has decided advantages over the old material, being free from perchlorate and other injurious compounds. Further, it contains lime which is very beneficial for the plant, whereas the soda in Chili saltpetre is very often directly harmful. Experiments made on this subject bear out these contentions.

It has recently been asserted by Caro that it is more rational to manufacture nitrolime than saltpetre, because the former requires only one-third of the amount of electricity to fix the same quantity of nitrogen, and the economy of both processes depends on the quantity of power used. Such a comparison can easily lead to confusion. The production of air saltpetre requires, in addition to electrical power, only the very cheapest materials, namely, water and limestone, whereas, in order to produce nitrolime, coal has to be employed, and, in addition, the nitrogen used in the process cannot be taken in the form of air, but first must be separated from the oxygen. These points have to be taken into consideration; it is not sufficient merely to compare the electrical energy used in each case. Moreover, there are other points in favour of the production of air saltpetre. Not only has the nitrogen contained in it a higher value than that in ammonium sulphate, or in nitrolime, but, by the oxidation of nitrogen, the nitric acid, nitrates and nitrites, which are so indispensable in the chemical industry, are obtained. These compounds have a higher value than air saltpetre, the nitrogen in nitric acid being worth more than twice as much as that in ammonia. The prospects of a profitable conversion into nitric acid, of the ammonia obtained from nitrolime, appear very doubtful.

As a matter of fact, however, our previous considerations have shown us that the world's demand for combined nitrogen is growing so enormously, that there is room and to spare for these two processes and others as well to develop side by side.

It has in recent times been suggested that the large waterfalls in Germany should be taken over by the State for the purpose of electrifying the railways, and for supplying power to small manufacturers. It is, however, difficult to find a purpose to which the water power could be better applied in the interests of the State than in the production of combined nitrogen, and further, there is, at the present time, no other industry which would be in a position to take up such large quantities of cheap power. We have a classical illustration of this in the case of Norway, where, although small quantities of water power are sought after, up to the present, it has been difficult to find a use for the large waterfalls. This is probably due to the fact that the distribution of electricity in these parts of the country in which the population is scattered, and the houses and small villages lie far apart, would require so high an outlay for installation that a general adaptation for lighting purposes, and for supplying power on a small scale, is out of the question. The reverse, however, applies to the utilisation of the large falls for the production of air saltpetre; such production would be coupled with remarkable advantages, for it would open up large industries, just in those parts of the country which from natural causes have hitherto been most neglected. Another factor which must not be underestimated when considering the advantages of the new air saltpetre industry, is its non-participation in the destruction of the valuable coal deposits, which have been stored up for us during such countless ages. It obtains the power it requires from water, or, as it has been fancifully termed "white coal," which can be employed over and over again without being exhausted, since as soon as it has been used, it is raised up again into the sky by the agency of the sun, and this circulation has gone on through countless ages, and will continue as long as we have any need of saltpetre.

We have, consequently, every reason, from such different points of view as those of the agriculturist, the industrial chemist, and the whole of mankind, to hope that the new process for the combustion of nitrogen will continue to develop and flourish.

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HYSTERESIS TESTS.

The magnetic testing of iron is so important, both industrially and scientifically, that much thought has been given to the devising of simple methods. Nevertheless, the measurement of hysteresis loss is generally a somewhat tedious process. The iron ring, so ideal from the magnetic point of view, is undesirable in practice, and the same must be said of long strips. To work with short strips has been the aim of many investigators. In THE ELECTRICIAN of November 6, 1908, Dr. R. BEATTIE showed that a bundle of short strips in a straight solenoid could be used with certain limitations and gave a convenient method. But in any case the evaluation of a hysteresis loop is troublesome, and when short strips are used the difficulty becomes even greater, because the strong demagnetising action causes the loop to be very narrow, and thus errors may creep in more readily. In our last issue, Dr. BEATTIE and Mr. ELTON made the valuable suggestion that *differences* in the two B ordinates corresponding to any given value of H should be determined directly by a ballistic galvanometer and a special form of key, instead of determining these ordinates separately and subsequently taking their differences. If the form of the loop is immaterial, this difference gives all that is desired; it can be measured more accurately, and it has the further advantage that when δB is plotted against H the curves

for short strips are so nearly parabolic that the determination of two values of δB is enough to give the area desired with sufficient accuracy for most purposes. There is a curious fact, however, to which the authors call attention in this week's issue. The accuracy of the method was first tested by measuring the hysteresis loss of rings by the "step-by-step" process and also by the "differential" process. The values of the loss were the same. Secondly, when the samples were tested as short bundles both methods were again in agreement; but in this case the loss was consistently less than in the rings. The experiments showed that the loss in a ring is about 1·65 times that in a short bundle, and this result was verified for several qualities of iron. It is difficult to understand so large a difference. The interest of the problem is increased by the circumstance that when an alternating current with a frequency of 100 was used the loss was found to be the same for strips as for rings. The use of short strips, however, depends for its accuracy upon certain assumptions, such as the relation of the demagnetising force to the force due to the coil, and the assumption that the equivalent uniform induction is 0·75 times that at the centre.

There are some points on which our readers will, no doubt, desire further information. In connection with the ballistic experiments the ideas connected with the equivalent uniform induction are, perhaps, not without difficulty. In the case of the alternating current there are difficulties in the way of an accurate knowledge of the form factor of the E.M.F. induced with a secondary coil wound round the specimen. It would be interesting to know whether the equality of loss which occurs with the alternating current is brought about by an increase in the loss in the strips or by a diminution in the loss in the rings, or whether both effects occurred. Were the results the same for different maximum inductions? There may seem some difficulty in suggesting any essential difference between short strips and rings where such a molecular phenomenon as hysteresis is concerned; it may be remarked, however, that in rings the lines of induction are tangential to the edges and do not issue from the iron, whereas in strips they pass out into the surrounding medium. Thus, the edges of strips may well serve as places where molecular disturbances propagate themselves into the interior, and a certain difference in the two cases might result. The fact remains that if the strip is made long enough it becomes equivalent to a ring as far as demagnetising effect is concerned; but would the hysteresis be increased to that of a ring? The whole problem raises many interesting questions, which, we hope, will be cleared up by Dr. BEATTIE and Mr. ELTON in a further investigation.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Boiler Feed Water. By FRED. A. ANDERSON. (London: "The Electrician" Printing and Publishing Co.) Pp. 160. 6s. net.

The author in his preface modestly describes his treatise as a compilation, but it contains many original views and suggestions derived from his experience of the subject in actual working, and his inevitable discovery of the fact that several points connected with the corrosion and priming of boilers require further investigation. In this regard he rightly advocates a closer association of the chemist and engineer in an immediate examination on the spot of the details of cases that may arise. For this purpose he emphasises the necessity of having simple and rapid tests always at hand, with adequate knowledge on the part of those in attendance. A great part of the book is devoted to lucid and full directions as to how short chemical tests are to be applied in continuous supervision, accompanied by occasional more complete mineral analyses of waters and deposits. A valuable feature is the citation of a number of these detailed analyses and of the conclusions drawn from the constitution.

In the introduction it is shown that "the mere insuring of a boiler with a boiler insurance company will not entirely absolve the engineer in charge of all responsibility, as is sometimes erroneously supposed to be the case." The author condemns the old practice of putting "compositions" into the boiler itself for the purpose of preventing incrustation or of breaking up already formed scale, remarking that these preparations are mostly compounded of cheap and common chemicals sold at a high price, and, moreover, would be far better applied outside than inside the boiler. He quotes a German official report showing that many of them, particularly the organic infusions that once had a considerable vogue, are not only useless but actually injurious, and that all of them are extravagantly dear. The water should always be rationally supervised and prepared before it enters the boiler.

In Chapter II., dealing, on the whole ably, with the difficult subjects of scale formation and corrosion, some of the statements, as might be expected, are not incontrovertible. Page 18 distinctly understates the objectional influence in boiler waters of high proportions of the more soluble calcium and magnesium salts, such as magnesium sulphate, in saying that they have "no scale-forming tendency, nor, as far as is known, any corrosive qualities." The author's experiment (p. 17) on the inter-action of magnesium sulphate and sodium chloride is admittedly inconclusive. The progressive change of the deposit of sulphate of lime, at higher steam temperatures, from gypsum to anhydrite, attended by greater insolubility and by the formation of a denser and more crystalline crust, should have been mentioned at p. 13. In "the very extraordinary cases that are continually occurring such as, for instance, the attack of one boiler only out of a range, all working under the same conditions and fed with the same water" (p. 19), one would surmise that the metal of the boiler had something to do with the anomaly. It ought not to be difficult to prove the presence of electrical currents (p. 21). The question of priming is briefly considered, but not elucidated.

Chapters III. and IV., on Analysis (why "of *hard* waters" only?) and Calculation of Results, are very clear and full, but would have been improved by judicious compression, when room could have been found for directions for making the volumetric solutions (pp. 28, &c.) instead of referring to text books. The tests for nitric acid are not the most usual, nor, we think, the best ones. Something should have been said as to the significance of silica, of iron and of other metals in boiler waters and incrustations.

An excellent and very practical chapter follows on Water Softening, and a caution is given and exemplified (p. 112) against accepting statements that particular apparatus by working in a special manner will effect the object "with much less than the theoretical quantity of chemicals."

The injurious effects of oil or grease forms the subject of Chapter VI., and various explanations of the action are discussed, while methods of determination are well described (pp. 121-125). With regard to remedies, exhaust steam separators are stated to afford a partial solution of the problem, but "none of them have up to the present succeeded in effecting the complete removal of the oil" (p. 125); filters remove "free oil" and coarse suspended matter but not emulsified oil. The only method for removing the whole of the oil is to use a suitable precipitant and afterwards filter out the precipitate. The chemicals recommended from experience are sulphate of alumina and carbonate of soda; lime water is also sometimes successful. "In other cases it has been found that

when surface condenser water is mixed with one third to one-fourth of its bulk of freshly-softened hard water, and the mixture filtered," every trace of emulsified oil has been removed, "and the method is successfully at work on a large scale."

Chapter VII. deals with Steam Boilers, their selection, management, cleaning and inspection, and contains some valuable suggestions. It is said on p. 1 that the work specially relates to land installations, and marine boilers are only briefly referred to on p. 153.

A good index concludes this well-printed and useful treatise.

S. RIDEAL.

Natural Sources of Power. By ROBERT S. BALL. (London: A. Constable & Co. Pp. xvi. 336. 6s. net.

The utilisation of natural souces of power suggests a very wide range of subjects, such as the production of power from natural gas, the harnessing of the tides and many like topics.

The present work, however, deals only with the power available from the wind and from waterfalls, and, in the compass of about 300 pages, the author gives a clear account of the elementary engineering features of these two subjects.

The earlier section, after a preliminary account of the fundamental principles of hydraulics, discusses the various problems arising in connection with the turbine and the construction of water power plants in a simple fashion, and with a sparing use of mathematics, for which the reader will be grateful.

Hydraulic power installations have been so exhaustively treated that there is not much room for originality in this part of the book, and the chief feature of interest is the section devoted to wind power and the construction of modern windmills with their applications for various purposes.

The great improvements in this branch of engineering in recent years has resulted in the building up of a very large industry, and the reader will find in this book a great deal of practical up-to-date information about these machines in a very readable form.

E. G. C.

Die Chemischen Stromquellen der Elektrizitat. By Dr. CURT GRIMM. Vol. IV. of "Die Schwachstromtechnik in Einzeldor-stellungen." Edited by J. Baumann and Dr. L. Rellstab. (Munchen: R. Oldenbourg.) Pp. xii. 201. M.6.

Elemente und Akkumulatoren ihre Theorie und Technik. By Dr W. BEIN. (Leipzig: J. A. Barth) Pp. vii.—233. M.4.40.

A book upon any subject already possessing a fairly comprehensive literature should justify itself by a presentation either of new facts or of new views and theories about old facts, or, better still, by a blend of both these qualifications. We are afraid that neither of these standards can be made to cover the works on primary and secondary batteries, such as the two now before us, which issue from the German press at an average rate of one per annum.

To do Dr. Grimm justice, he shows every willingness to record new facts, and it is not his fault that there are so few of them. We gather from his pages that the Germans are somewhat more successful than ourselves in still devising modifications in the details of design and construction of well-known types, especially the Lelande and the Leclanché cells, and we note that none of the so-called "dry" forms of the latter are complete without a report, distinctly drier than themselves, from a Government laboratory. All else is ancient history, and as we turn the leaves and encounter the familiar cuts and descriptions of gravity Daniells, and bottle bichromates and Faure grids, a gentle melancholy siezes us, and we meditate on the fixity of human knowledge.

We are to-day no better able to convert the energy of chemical combination into electricity on a large and practical scale than we were 50 years ago. Now, as then, zinc is the one source from which any useful result can be obtained, and, consequently, the batteries of Daniell, Grove, Bunsen and Lelande still remain the last word upon the subject.

Such a state of affairs might be understandable if we were still confined to views upon the fundamental principles of electrochemical action which had undergone no change since those days, but Dr. Bein's book, nearly half of which is devoted to theoretical matters, gives us a further reminder, if such were needed, of the enormous amplifications and modifications that have taken place since the days of Faraday. Terms abound, such as "electrolytic dissociation," "osmotic pressure," "migration of ions," and so forth, which would have been hardly comprehensible by the early investigators, and yet to-day the views which they connote have been so often expounded that, as we just now said, they afford no excuse for a further exposition.

We know of no other hypothesis, besides that of electrolytic dissociation, which has within such a short time so fully justified itself by the complete way in which it has explained and co-ordinated previously ascertained facts, and yet has failed so utterly in pointing the way for any further advances into the unknown. Apparently we must wait for some further large and important development of theory before the Drs. Grimms and Beins of the future will be able to find any fresh material for the building of books on *elemente und akkumulatoren.*

E. J. WADE.

THE PHŒNIX FIRE OFFICE RULES FOR ELECTRICAL INSTALLATIONS.

In our last issue we referred briefly to the new edition of these rules, which have been brought up to date by Mr. S. G. Castle Russell, electrical adviser to the Phœnix Office. The "Phœnix" rules were first issued in February, 1882, by Mr. Musgrave Heaphy, who was also responsible for the subsequent editions up to last year. In the introductory note to the present (the 38th) edition a warning is given in regard to the necessity of exercising care in accepting a tender for wiring, inferior work being liable to result in a fire breaking out sooner or later. Intending users are strongly recommended to retain advising engineers to design and supervise the erection of an installation. Safety and economy are more likely to be assured under such supervision. We refer below to the main points of interest in the present edition of the rules.

Conductors.—The conductivity of copper conductors must not be below 98 per cent. of that of pure copper, as defined by the Engineering Standards Committee (instead of 100 per cent. according to Matthiessen's standard). Current density is still to be taken as 1,000 amperes per square inch, up to currents of 100 amperes, and no change is made in the minimum size of conductors, except that in fittings 3/22's S.W.G are recommended instead of one No. 20 S.W.G. The standard of insulation for conductors to be used in damp places or in new buildings, and also for pressures between 250 and 500 volts, is to be 2,500 megohms per mile (formerly 2,000 megohms).

Iron and Steel and Metal Piping. Additional regulations are as follows: All piping should be erected before any conductors are drawn in. All joints in piping should be treated with aluminium paint. The use of tee pieces and elbows is not recommended; plain junction boxes should be used throughout. No single pipe must contain more than four wires. Open seam piping with socket connections is not recommended, and is only allowed for surface work and where the pressure does not exceed 250 volts.

Wood or other Casing. Wood casing will be allowed in dry positions only. Wiring joints are only allowed in casing where unavoidable (in the old regulations permission was necessary).

Lead covered Wiring. This is now allowed, but it must be protected where it is liable to mechanical injury or chemical action. The lead covering must be earthed, and where alternating currents are used both lead and return conductors must be in the same lead tube or covering.

Systems with unguarded return are now allowed after permission has been obtained.

Flexible Wires and Cords.—These must not be joined to hard wiring, except by means of screw connections in a fireproof junction box. The insulation of flexible cords must consist of two coats (minimum thickness of each 10 mils) of pure Para rubber of high quality, or of one coat of pure Para rubber of high quality next the copper and two coats of vulcanising rubber (the minimum radial thickness of rubber must be a total of 40 mils). Flexible cords not provided with an efficient flameproof outer covering must not be used in shop windows containing inflammable goods.

Surface Systems of Flexible Twin Wiring will only be allowed in situations where the wires will not be liable to mechanical injury or damp, chemical action, &c. The systems must be carried out to the approval of the Fire Office.

Earthing.—The wire must never be of less section than 14 No. S.W.G. It is recommended that one end of the earthing wire should be soldered to an approved earth connection and the other end attached to the case of the main switchboard or other iron-cased apparatus by means of a detachable screw lug. This will facilitate the taking of tests to ensure clearance of the system from gas piping and foreign earths.

Arc Lamps.—Cotton mills and certain other mills are now included with hazardous risks as situations where, if arc lamps are allowed to be used, they must (unless of inverted type) have two globes, each completely and independently surrounding the arc, and the lamps should be of such design and make that the arc cannot be sustained unless the inner globe remains intact.

Portable Lamps.—The inlet holes for wires must be bushed. Flexible twin wires used in connection must be substantially insulated.

Switch Lampholders.—The use of these holders is not recommended. Where allowed they should be grouped and switch-controlled.

Main Switchboards.—Where the switchboard is in connection with a system of iron or steel barrel, or other system with earth covering, it should be enclosed in a cast-iron case and glazed front. Where it is in connection with a wood casing or unprotected system, enclosing cases made of hard wood will be allowed.

Distribution Fuseboards must be of same general construction as for main switchboards, and must be enclosed as for main boards. (This would imply a cast-iron case where tubing systems are employed.)

Main and Branch Switches.—Lamp switches, two-way switches, &c., must be of approved type, and of not less than 5 amperes capacity, and enclosed in fireproof boxes, the covers of which must be insulated.

Fuses.—This term has replaced that of "cut-outs." A 50 per cent. overload (except under certain circumstances when a larger amount is allowed) is still specified for fuses, but the minimum break is now 2 in. (1 in. was formerly allowed for 100 volts pressure). The distributing circuits from fuse boards must not carry more than 8 amperes at 25 volts, 6 amperes at 50 volts, 5 amperes at 100 volts, and 3 amperes at 200 to 250 volts.

Magnetic cut-outs and circuit-breakers must be of approved type.

Dynamos and Motors.—These rules have been entirely rewritten. The maximum temperature of the dynamo at full load must not exceed 70°F. above the surrounding atmosphere. The rules for motors are :—

Motors must be enclosed in substantial metal cases, which may form part of the construction of the motor ; any openings in the case for ventilating purposes must be covered with metal grids. Slip rings of induction motors must be totally enclosed in metal cases, wherever they are exposed to the liability of mechanical injury or access of dust or damp, &c. Motors must not be placed in positions where they may be exposed to mechanical injury, extreme damp or dust, unless suitably enclosed to prevent mechanical injury, ingress of dust or fluff or possibility of injury from access of damp. In risks where inflammable dust or vapour is present the motor must be enclosed in a substantial metal case without ventilating apertures, the pulley being external to the case. The case may be connected by suitable enclosed ducts or pipes to the outside air. All adjacent woodwork, both vertical and horizontal, must be efficiently protected with fireproof material. Wood floors on which motors are fixed must be lined with a sheet of metal.

Each motor must be protected by a switch and a fuse, or its equivalent, in each connecting lead. In specially exempted cases, such as a travelling crane, or a tool with one or two motors, then one switch to control the whole will be allowed. Each motor should be on a separate circuit. Each motor should be furnished with an approved automatic no-voltage and overload release. The frames of motors and all metal piping and metal-cased apparatus in connection must be efficiently connected to earth.

The temperature rise of motors under normal working conditions must not exceed 70 F. above the surrounding atmosphere as measured by a thermometer, provided the total temperature does not exceed 140 F. The terminals of motors should be so constructed as to ensure that they are efficiently protected by metal covers or an equivalent device. In positions where motors are liable to collect dust, &c., and a totally enclosed motor is not required, the motor should be cleaned periodically by means of a small compressor or hand bellows. Excessive depreciation and trouble are found to occur through neglect in keeping the interior of the motors clean and free from dust.

Auto-transformers must be of sufficient capacity to stand an overload of 25 per cent. for short periods. The transformers must be totally enclosed in strong cast-iron cases with removable lids. Terminals to be within the iron cases and the leading-in holes for cables fitted with bushes, except when metal pipes are screwed direct into the case. The metal cases and frames of transformers must be earthed.

Transformers.—These rules have now been reduced to only a small fraction of their former length.

Supply Mains.—The conductors should be carried in iron barrel, and the apparatus in connection should be enclosed in substantial iron cases.

Telephone Wires and Telegraph Wires, &c.—No telephone wire should be of less section than No. 20 S.W.G., and the insulation of the circuit inside a building should never drop below 1 megohm. A high-voltage fuse also must be placed upon each telephone wire.

Trolley Wires.—Each wire over a trolley wire must have at its entrance into any building a safety device of such a nature that, if the pressure of current in the wire exceeded at any time 50 per cent. above the normal pressure, then the device would instantly act and cut off the current from the building. No motor is allowed to receive current from any tramway or railway trolley wire with an earth return unless special permission has been obtained from the Fire Office.

Electrical Cranes.—As it is impossible to draw up rules that shall apply to all cases, when electrical cranes are proposed to be used full particulars of the work and the safeguards adopted should be sent to the Fire Office for approval. It may be mentioned that the conductors must be at least 6 in. from each other, as well as from other metal, woodwork or side of the gantry or other structure from which they are supported.

Electrical Heating.—All radiators should be fixed to, or stand upon, approved fireproof insulators. A wire guard should protect the radiator lamps. Every floor socket should be so constructed that the contacts are automatically covered when the plug is removed. Electrically heated flat irons and similar apparatus should each have double fuses and a switch, and be independently earthed.

Special Risks.—Theatres, drapers' shops, warehouses, stores, churches, mills, breweries, central stations, motor garages, &c., are dealt with in the rules.

Tests.—The insulation resistance to earth and between poles over the whole installation must never get below 40 megohms divided by the number of points installed, and tested at double the working pressure with all fittings and apparatus connected. (This insulation resistance is about double that formerly required, and seems rather a high standard for average conditions.) The insulation resistance of each motor must never fall below 1 megohm. Each arc lamp will be taken as equivalent to 10 points. The insulation resistance to earth of each heater must never fall below 1 megohm.

The fall of potential in conductors must never exceed 2 per cent. at the farthest point in any circuit.

RESEARCHES IN RADIOTELEGRAPHY.*

BY PROF. J. A. FLEMING, D.SC., F.R.S.

Radiotelegraphy, popularly called wireless telegraphy, has outlived the tentative achievements of its precocious infancy and obtained for itself a settled but important position amongst our means of communication. This stage, however, has only been reached after a long struggle with experimental difficulties and much labour in analysing the processes involved. As many of these matters are of general scientific interest, it is proposed briefly to summarise some of the results of recent research.

You are doubtless all aware that every radiotelegraphic station comprises three elements. There is first the external organ called the air wire or antenna, by which the electromagnetic waves are radiated and absorbed. This antenna consists of one or more wires extending up into the air, either vertically or sloping, or partly vertical and partly horizontal. These wires are insulated at the upper ends and may be arranged fan fashion, or may form one or more nearly closed loops, placed in a vertical position. The antenna is, so to speak, the mouth or ear of the station, by which it speaks through the æther, or by which it hears the ætherial whispers coming to it from other stations. The æther waves are produced by very rapid electric currents moving to and fro in the antenna wires, and these, like the vibrations of a violin string, or the ærial oscillations in an organ pipe, set up a periodic disturbance in the surrounding medium, which in the electrical case consists of alternating electric and magnetic forces taking place at each point in space around the antenna.

There are, then, appliances in the station collectively called the transmitter, which have for their function to create these powerful electric oscillations in the antenna, and to control them so as to send out short or long trains of æther waves in accordance with the dot or dash signals of the Morse alphabet. Lastly, there is the receiving

* Lecture (slightly abbreviated) delivered on Friday evening last before the Royal Institution.

apparatus which, when connected to the antenna, serves to detect the presence in it of the very feeble oscillations which are being generated in the antenna by the powerful oscillations in the antenna of some far-distant sending station. It is usual to employ the same antenna at any one station both for sending and receiving, and to switch it over from the transmitter to the receiver according as we wish to send or receive messages, although methods have been described and are being developed for using the antenna simultaneously for both purposes.

I will first illustrate by a few experiments the manner in which these electric oscillations are set up in the air wire, and the nature of the effects produced by them in the surrounding space. We have here a very long wire which, for the purpose of keeping it within a small compass, is coiled upon an ebonite tube. Two such spirals are placed side by side and connected at the bottom through two other small coils of wire (see Fig. 1). In contiguity to these last two coils of wire are two others, which are in series with a condenser or battery of Leyden jars and a spark gap. If we charge the condenser by an induction coil and let it discharge across the gap, we produce rapidly succeeding trains of electric oscillations in the condenser circuit, and these induce other currents in the open or helix circuit of similar kind. The result is that electricity rushes up and down the spiral wires, which we may consider to represent two very long air wires or antennæ. We have, therefore, alternately free charges of electricity at the top ends of the wires and electric currents passing to and fro across the middle point. We may compare this movement of electricity in the helix to the oscillations of a liquid in a U-tube when it is disturbed. In the electrical case we have at each spark discharge 20 or 30 electrical swings or oscillations, separated by relatively long intervals of silence, the intervals between two swings in the train being about one four-hundred-thousandth part of a second, whilst the interval between the groups or trains of swings is about one-fiftieth of a second.

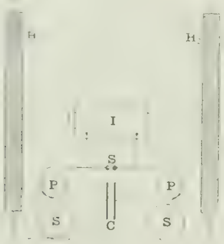


Fig. 1.

Such electrical oscillations in the wire produce two effects in external space, called respectively electric and magnetic force. In the case of a simple vertical air wire the magnetic force is distributed along concentric circular lines embracing the wire, whilst the electric force is distributed along certain looped lines in the plane of the wire. If, however, we employ a close-wound spiral antenna, as in our experiment, the positions of the electric and magnetic forces are interchanged as compared with those of the single vertical wire.

As the currents in the air wire reverse their direction, the magnetic and electric effects in the external space also reverse, but not everywhere at the same moment. The magnetic and electric forces are [illegible] of the æther, and in virtue of the inertia and elasticity of the medium they are propagated from point to point with a finite velocity which is the same as that of light. We can explore the field near the antenna and obtain an approximate idea of its nature and intensity by the use of a Neon vacuum tube. At certain intervals of distance in the space the magnetic and electric forces reverse direction in the same way at the same instant, and this distance is called a wave-length.

In the case of a straight air wire the magnitude of the forces at considerable distances varies inversely as the distance from the antenna, and the antenna radiates equally in all directions. If, however, we employ a U-shaped antenna, as in the present experiment, the currents being in opposite directions in the two branches, then along a median line transverse to their common plane, their actions will neutralise each other, and the radiation will be symmetrical only with respect to the plane of the antenna. In constructing an antenna intended to radiate in all directions it is necessary to connect the lower end to a large plate of metal or network of wires either sunk in the earth or placed just above the surface. In the former case this plate is called an earth plate, and in the latter a balancing capacity. It is necessary that this balancing capacity, if insulated, should be of sufficient size to take up all the electricity which rushes out of the antenna at each oscillation without sensible rise in potential. If we are only employing an antenna of moderate capacity for short-distance signalling, then an insulated balancing capacity would not be of unwieldy dimensions, and may be constructed of a number of wires stretched out or laid on the ground or insulated a little way above it. When, however, we have to employ a very large antenna of great capacity for long-distance work, then the provision of a suitable balancing capacity would involve constructive difficulties which are best obviated by making the earth itself the balancing capacity—in other words, by connecting the base of the antenna to an extensive network of wires or large metal plates buried in the ground. It has been asserted that the direct earth connection damps out the free oscillations in the antenna more quickly than would be the case if an insulated balancing capacity is employed. Although this may be true to a certain extent, we have to set against it the fact that the use of an insulated balancing capacity is out of the question in many cases—as on board ship, where a connection to the hull of the vessel is always made. Also for any but small antennæ the insulated balancing capacity is inconveniently extensive, and it is in every way better to put it below ground—in other words, to employ an earth-plate and compensate for any slight earth damping by an antenna of rather larger capacity.

This matter is, however, only part of a much larger question, viz., the function of the earth in radiotelegraphy. It is well known that the nature of the earth's soil or surface between the sending and receiving stations has a great effect upon electric waves passing over it. Various imperfect explanations were given of this action in early days, but the basis for a better knowledge has been laid by the experimental researches of Admiral Sir Henry Jackson and the theoretical discussions of M. Brylinski and Dr. Zenneck. To follow their explanations it must be borne in mind that high-frequency electric currents as used in radiotelegraphy are confined chiefly to the surface of conductors by means of which they are conducted. Such a current does not distribute itself uniformly over the whole cross-section of a wire carrying it, but is confined to a thin skin or surface layer. This can be proved by the following experiment. We take a copper wire spiral or loop and make it part of a circuit in which a high-frequency current exists. If we measure in any way the current in that circuit we find it has a certain value. If we substitute for the copper wire an iron wire of the same size we find that the current in the circuit is then much less. This can be discovered by placing near the circuit in question another testing circuit comprising an inductance and a capacity and some means for testing the amplitude of the oscillations set up in this secondary circuit. This decrease is not due to the mere fact that the iron has a greater resistance than copper, but to the fact that the iron is magnetisable, and such magnetisation absorbs energy owing to so-called hysteresis. If, however, we dip the iron for a moment into molten zinc and deposit on it a thin surface layer of zinc, or galvanise it, we find it then becomes almost as good as a solid copper wire for conveying high frequency currents. On the other hand, if we burn off the zinc from a piece of galvanised iron wire we render it a worse conductor for high frequency oscillations. This experiment proves that such oscillations are conveyed by a thin surface layer of the conductor. In the case of a copper wire for oscillations having a frequency of 1 million the current penetrates about $\frac{1}{5}$ mm., and in the case of an iron wire about $\frac{1}{40}$ mm. into the metal.

For non-magnetic substances the depth to which a current of a given frequency penetrates into a conductor is greater in proportion as the conductivity of the material is less. Hence high-frequency currents penetrate further into carbon than into metal. Accordingly a much thicker layer of carbon than of zinc would be needed to shield the iron spiral in our last experiment. The same thing happens in the case of an electric wave propagated over a terrestrial surface. If the surface is a very good conductor the wave hardly penetrates into it, but glides over the surface. If it is a poor conductor the wave penetrates into it to a greater extent, and the worse the conductivity the deeper the penetration.

The materials of which the earth's crust is composed, with some exceptions, owe their electric conductivity chiefly to the presence of water in them. They are called electrolytic conductors. Substances like marble and slate when free from iron oxide are fairly good insulators. Dry sand or hard dry rocks are poor conductors, but wet sand and moist earth are fairly good conductors. Sea water, owing to the salt in it, is a much better conductor than fresh water. The following table gives some figures, which, however, are only approximate, for the specific resistance of various terrestrial materials in ohms per metre cube. It will be seen that dry sand or soils are of very high specific resistance, and damp or wet sand or clay fairly low:

If our earth's surface had a conductivity equal, say, to that of copper, then the electric radiation from an antenna would glide over

Table I.—*Approximate Conductivity and Dielectric Constant of Various Terrestrial Materials.*

Material.	Specific resistance in ohms per metre cube.	Dielectric constant Air 1.
Sea water	1	80
Fresh water	100 to 1,000	80
Moist earth	10 to 1,000	5 to 15
Dry earth	10,000 and upwards	2 to 6
Wet sand	1 to 1,000	9
Dry river sand	very large	2 to 3
Wet clay	30 to 100	...
Dry clay	10,000 and upwards	2 to 5
Slate	10,000 to 100,000	...
Marble	5,000,000	6
Mercury	0·000001	infinity

the surface without penetration. In the case of the actual earth there is, however, considerable penetration of the wave into the surface, and therefore absorption of energy by it.

Brylinski and also Zenneck have calculated the depth to which electric waves of such frequency as are used in radiotelegraphy penetrate into the sea or terrestrial strata of various conductivities. For mathematical reasons, it is customary to define it by stating the depth in metres or centimetres at which the wave amplitude is reduced to $1/\epsilon = 0{\cdot}367$ of its amplitude at the surface. I have represented in a diagram some of Zenneck's results calculated for waves of 1,000 ft. in length, and for terrestrial surface materials of various kinds, conductivities and dielectric constants (*see* Fig. 2). You will see that in the case of sea water an electric wave travelling over it penetrates only to the depth of a metre or two, whereas in the case of very dry soil it would penetrate much deeper. Owing to the conductivity of the soil, this movement of lines of magnetic force

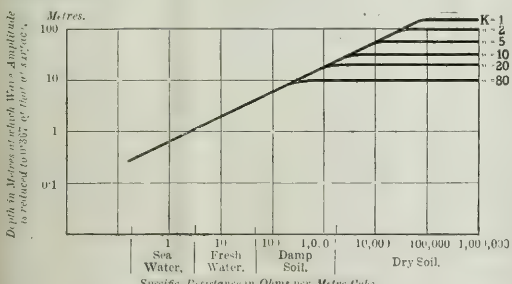


FIG. 2.—DEPTH OF PENETRATION OF WAVES 1,000 FT. IN LENGTH. (Dr. Zenneck.)

through it sets up currents of electricity which expend their energy in heat. This energy must come from the original store imparted to the sending antenna, and therefore the wave is robbed of its energy as it travels over the surface.

(*To be continued.*)

CORRESPONDENCE.

DIFFERENTIAL BALLISTIC METHODS OF MEASURING HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I wonder if Dr. Beattie and Mr. Elton have applied the method they describe in the current issue of your journal to test pieces in which there is marked viscosity, or which are solid, as in the case of a ring of magnet steel. About a year ago I tried this method and found it defective.—I am, &c.,

King's College, London, June 8. ERNEST WILSON.

MANSBRIDGE CONDENSERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in your report of the Paper by Mr. Mordey on "Some Tests and Uses of Condensers," read before the Institution of Electrical Engineers on May 20th, a communication from Mr. Addenbrooke, in which he states that some time ago he tested a Mansbridge condenser and obtained a power factor about double that given by Mr. Mordey in his Paper.

We should like to state that we have, as the results of our experiments with these condensers for high-tension work, lately made considerable improvements both in the materials and in the method of making these condensers. Very probably the one tested by Mr. Addenbrooke was our ordinary Mansbridge telephone condenser.

Later in his communication, he refers to the possibility of these condensers heating; and in regard to this we should like to point out that they can be subdivided and ventilated with the greatest ease.—We are, &c.,

BRITISH INSULATED & HELSBY CABLES (LTD.)

Helsby, June 5. (J. Brotherton, Manager, Helsby Works).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have received from the British Insulated & Helsby Cables (Ltd.) a copy of the letter they have addressed to you respecting my remarks on Mr. Mordey's Paper.

Some of their points are cleared up in the communication itself, which I sent to the Institution, and which you abstracted. I therein stated that the tests were made some time since—as a matter of fact, last autumn—and they were made rather near the breakdown point of the condenser, which would tend to give a higher power factor, and it is quite possible, as I mentioned, that Mr. Mordey may have had a more favourable sample, especially as I now understand the British Insulated & Helsby Cables (Ltd.) are making a special type of condenser more adapted for high-pressure work.

I do not think there can be any doubt that my figure is a correct one for the condenser I tested, as I used the electrostatic system which I have now employed for some time, and the results of testing with which I find agree closely with results obtained by continental observers.

In stating that I thought, speaking generally, the power factor of this type of condenser should not be taken under 1 per cent. without further evidence, I was influenced not only by my own tests but by tests made on paper condensers by the United States Bureau of Standards. In these tests it is shown that the power factor of paper condensers treated with paraffin may vary from about 0·2 of 1 per cent. to 1 per cent., and further to 3 per cent. and even much higher. Out of 20 condensers tested by them four had rather lower losses than those given by Mr. Mordey in his Paper, and 16 had larger losses; in a number of cases much larger losses. As these tests of the Bureau of Standards were made by the bridge method, with low voltages, it is probable that these power factors are rather below what would be found under working conditions.

I did not by any means intend to imply that better figures are not obtainable. It is clear that they are, under proper conditions; but whether such results can be secured regularly without undue expense, only an extended series of tests could prove. The prospects of being able to do this seem hopeful, and should it be proved that they can be obtained regularly, a considerable step would be made in convincing engineers of the reliability of condensers, and the feasibility of applying them in the heavier branches of electrical engineering.—I am, &c.,

Westminster, June 9. G. L. ADDENBROOKE.

ENGLISH TECHNICAL EDUCATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad Mr. Broughton has taken this matter up and that it has given him the opportunity of ventilating the excellent suggestion contained in the last paragraph of his letter.

With regard to the general question of the work done by evening technical classes, it is patent that a certain proportion of engineering apprentices have no opportunity, owing to their location, of taking the excellent courses of training available at the technical schools for evening students.

I have before me figures regarding the attendance last winter at a course of lectures, exercise classes, &c., in Electric Technology in a small provincial town which possesses no day technical college, and in which what work is done in this direction is almost perforce done by men engaged in the

engineering works of the town. There were some 30 meetings, and the attendance, starting at 32, finished at 24, the average attendance being 27. The number of names on the students' roll was 37. From this one gathers that there existed a demand, and that there was a well maintained application to study, which, I would suggest, indicates good work being done.

With regard to the objections to lectures being given by men engaged in actual practice, I mentioned that *some* of them might be thus given, having in mind the general case and that at any rate lectures on special subjects might be dealt with successfully by experts. I appreciated the difficulty of finding men with the necessary spare time (and pointed it out), and with regard to their ability to express their ideas in a suitable form my experience of some few lectures of the kind has been fortunate in this respect.

As an old student of one of the technical colleges, I should be sorry to depreciate the work done by the permanent staff at these institutions. The solid groundwork of study is, of course, best in their hands. They would, however, get considerable help from the contact with current practice suggested by Mr. Broughton; and since this arrangement is by no means yet the general rule, my point as to evening lectures may have temporary weight at least.—I am, &c.,

Chelmsford, June 4. CHARLES H. WRIGHT.

MOTOR STARTERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Ward Leonard Electric Co., of Bronxville, U.S.A., for whom we act as British agents, desire us to call the attention of your readers to some points concerning the motor starter described on p. 101 of your issue of April 30th last.

1. It is claimed that this starter is fitted with a "no voltage release." This characteristic appears to us to be inaccurate, because the release coil is responsive to amperes only. The writer of the article recognises this, because he says, "Should the current fail or fall below a predetermined value, the magnet will be de-energised," &c. It is obvious that conditions may arise when the current may fall to zero and cause the release to occur whilst there is still full voltage on the motor. Should not the term "no voltage release," which repeatedly occurs in the article, therefore, read "no current release"?

2. A motor connected up in accordance with the diagram of connections shown in Fig. 2 would not start. When the contact lever is brought to the first live position, the armature being at rest short-circuits the field, which remains practically unexcited instead of having, as is necessary, its full excitation.

3. As far back as 1895 the Carpenter Enamel Rheostat Co. made a motor starter with a series coil only, which held the latch in such a position that the latch retained the spring-actuated arm, whilst the same series coil would force the opposite end of the latch to a position which allowed it to release the arm. This is practically the same arrangement as that described in your article as having been recently invented, whilst it has the merits of being simpler and arranged so that the motor will start.

We have less hesitation in calling your attention to this matter, because during our extensive experience as suppliers of motor starters we have found that the above method of connecting them up is continually being attempted, with results usually effecting complete destruction of the starters and frequently damage to the motor itself.—We are, &c.,

London, June 2. WM. GEIPEL & CO.

We have submitted the letter of Messrs. Geipel & Co. to Mr. Denny, from whom we have received the following reply:

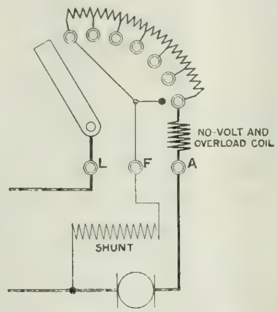
TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have to thank you for sending me a copy of Messrs. Geipel & Co.'s letter, and I have to say in reply to them that:

1. "No-voltage release" is the term generally used to denote a release which operates on the cessation of current. I agree with Messrs. Geipel that it is a misnomer, but it is a misnomer so universally applied that an attempt to correct it (unless made by some great authority in the electrical world) savours rather of pedantry.

2. A motor connected up according to the diagram given in your article of April 30th *would* start, but I agree with Messrs. Geipel that it would be unsatisfactory for starting a heavy motor on load, and for these circumstances I do not recommend it. I thought this was so obvious that the accompanying diagram was unnecessary, but I send it now for Messrs. Geipel's information.

3. It is rather out of my province to criticise the Carpenter Enamel Rheostat Co.'s device of 1895, which is, I believe, quite a good thing in its way. It is *not* "practically the same



CONNECTIONS FOR COMBINED NO-VOLT AND OVER-LOAD RELEASE.

arrangement" as my device, however: the principle of combination is similar, but I claim no invention for it. I claim, and have protected, a method of putting that principle to work.

I may add, in conclusion, that in experimenting and using my device I have not damaged any motors or starters.—I am, &c.,

Waltham Cross, June 7. C. W. DENNY.

DIESEL ENGINES IN SMALL GENERATING STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your readers will probably agree with the editorial note at the foot of Mr. Boot's letter which disposes of his quibble. Mr. Boot appears to read letters as carelessly as he writes Papers, for my letter in your issue of the 21st inst. stated that Messrs. Handcock and Dykes were the first to advise the use of Diesel engines for electricity supply work. The point is, that to them is due any credit for being the first to utilise the advantages of Diesels; my personal share in the matter is small.

It may be interesting to know that Leatherhead has not had steam for two years, and the Hindhead Company rely entirely upon their Diesels. With regard to accumulators, probably it will not be long before the Chichester Company finds it necessary to instal a battery.

At Tunbridge Wells, with a coal cost of over 1d. per unit, Mr. Boot had an excellent opportunity for pioneer work with Diesels in reducing generating costs.—I am, &c.,

Generating Station, Leatherhead, June 3. H. LESLIE DIXON. (Engineer and Manager.)

THE TECHNICAL ASPECT OF THE "G.B." SYSTEM OF ELECTRIC TRACTION.

On Monday evening last a lecture on this subject was delivered at the East London College by Prof. J. T. Morris. Mr. W. H. Patchell presiding.

The lecturer first described briefly the principle and method of operation of the "G.B." surface-contact system, which he had already dealt with in a previous lecture some 18 months ago, and showed a number of slides illustrating the construction of the track at Lincoln. The effective force of the contact piece in connection with the stud had been found to be at the beginning of its stroke about 0·8 lb., and at the end of its stroke it was about 0·6 lb. or 0·5 lb.

He then referred to recent improvements in the system and the causes of live studs, as mentioned in Mr. Stanley Clegg's Paper read before the Institution of Electrical Engineers.* There were,

* THE ELECTRICIAN, January 15, 1909, p. 526.

undoubtedly, faults in the system, yet it contained the elements of success, and it was, to the lecturer's mind, a great pity that the system had not been persevered with sufficiently to have brought it to a successful issue in the case of the Mile End-road. As regards the troubles experienced in the Mile End-road, these were due to explosions caused by leaky gas mains, to cross-covers and live studs. The actual facts, so far as he could ascertain, in connection with the last mentioned trouble, were that one horse had died from results of injuries received through an electric shock, and one horse and a pony received serious shocks.

He then considered the methods which had been advanced, in connection with Mr. Mordey's reports to the London County Council, for getting rid of live studs. With current leaking from the stud through the mud to the rail, arcs were set up between the conductor and the contact piece, so that, allowing for the drop in pressure across the arc, from 300 to 400 volts pressure might exist between the top of the stud and the rail. The arcs could be got rid of by two methods, (1) the resistance method, in which the arc was shunted by a low resistance and immediately extinguished, and (2) the condenser method. Mr. Mordey had recently shown that by putting a condenser of suitable capacity across the arc the latter would be instantly extinguished. The same effect would also take place if the condenser were put across the resistance in series with the arc, *i.e.*, between the stud and the rail. The lecturer could not offer a complete explanation of this action of the condenser, but experiments that had been carried out at the East London College threw considerable light on the phenomenon.

The key to the solution was probably that the arc was an unstable phenomenon, particularly for currents of such small values as 1 and 2 amperes, and oscillograph records showed that the voltage was more rippling in character than the current. Also, short arcs were much more unsteady than long ones. If, instead of a condenser, a fuse was placed in parallel with the arc the latter was not appreciably affected. Also, if the fuse were placed, like the condenser, in parallel with the series resistance no effect took place. This seemed to show that if the arc was to be extinguished it was necessary to have something which would cause oscillations in the circuit, and not merely to give the circuit an electric blow.

A number of experiments were shown by the lecturer with condensers connected between the stud and the conductor, both before and after an arc had been started, and also with the condensers across the resistance in series with the arc. He also showed the effect of putting a resistance in series with the condenser. The effect of the resistance was to make the results more uncertain, and in some experiments carried out at the College the following results were obtained:—

Overall Voltage 480. Arc Voltage 120. Capacity 1 mfd. Current 0·75 amperes. Arc Length 5 mm.

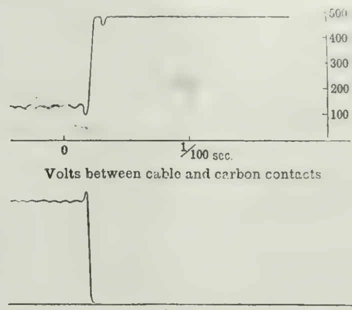
Condenser across arc.		Condenser across resistance.	
Resistance.	Extinction.	Resistance.	Extinction.
Zero	Certain	Zero	Certain
90 } 110 } ohms	Doubtful	50 ohms	Doubtful
Over 120 ohms	Fails	Over 60 ohms	Fails

These results related to a condenser of 1 mfd. capacity. Similar experiments had been carried out with condensers of greater capacities. Thus, with a 20 mfd. condenser a resistance of 230 ohms caused a doubtful condition of the arc, instead of 110 ohms, as in the table above for a 1 mfd. condenser. There was, doubtless, some relation between the two cases, and he hoped to follow the matter up.

Investigations had been carried out by means of a high-frequency Duddell oscillograph, and a number of visual records obtained were shown. Typical ones are illustrated in the diagram herewith. It relates to a case where the pressure between the mains was 480 volts and the volts across the arc 120. At the instant the arc was extinguished by the condenser the pressure across the contacts rose within a period of $\frac{1}{1000}$ of a second to the normal voltage, but on some occasions a slight momentary fall in pressure was indicated at the instant of connecting the condenser, as shown in the diagram, and also on certain occasions a slight fall of potential immediately after the arc had been extinguished. In regard to the current, a slight kick was usually observable on connecting the condenser, as illustrated herewith. The results obtained did not clearly indicate the reason for the arc extinction, but possibly that was due to the fact that the oscillograph would not record oscillations of sufficiently high frequency.

In conclusion, he thought it was an unfortunate thing that the second example of the "G.B." system should have been put down in a road which carried such a large amount of traffic as did the Mile End-road, and any system put down there ought to be a well-tried system, but once it was started it should have been carried through to a successful issue. As far as he could see, he was convinced that the "G.B." system had in it the elements of success, and if it was installed in some place where the conditions were a little more favourable than in the case in question—and he would also add, where the company had a free hand to put the system in as they pleased—he was convinced that the system would be a success.

A vote of thanks to Prof. Morris was proposed by Mr. W. H. Patchell, who drew the lecturer's attention to the difference in the sound when the condenser was connected (1) across the arc and (2) across the resistance in series with the arc. In the former case the "break" was silent, but the "make" was noisy, whilst in the latter case he noticed a noisy "break" and a silent "make."



Amperes

Prof. Morris, in reply, said, with regard to working the condensers across the resistance, he had found that there was a difference if the condenser was charged and if it was not charged. If one used a condenser charged to exactly the same voltage as that across the resistance one would expect no extinction of the arc. Experiments showed that a discharged condenser was more effective in extinguishing the arc than one which was charged.

FINANCIAL ORGANISATION AND ADMINISTRATION.

We have received the following communication from Mr. H. Faraday Proctor, city electrical engineer of Bristol:—

Considerable interest will be felt as to the conclusions come to at the forthcoming meeting of the Institute of Municipal Treasurers and Accountants in relation to the above matter. It is a very open secret that a set of regulations has been drawn up under the auspices of the above-named institute, and that some wicked persons have given a degree of publicity to the same which was scarcely desired by the originators at this stage.

To appreciate fully the effect of the proposals and the importance of the financial officers who are responsible for the drafting of the same, the rules should not have been written in the third person. If each treasurer or accountant to a municipality would undertake to circularise these draft regulations amongst the different committees and his brother officers—after having them reprinted in the first person, inserting his own name wherever necessary—general opinion would be speedily obtained, although it is feared that the said officer would scarcely feel gratified at the results from a personal point of view.

A few of the regulations would then read as follows:—

I AM THE "FINANCIAL OFFICER."

Separate annual estimates of capital and revenue accounts shall be submitted to MY COMMITTEE by every committee of the Council, in such form, and under separate headings, as MY COMMITTEE may prescribe. The preparation of the estimates shall be by the various heads of departments in consultation with ME.

I shall present the draft estimates to the various committees for approval, and furnish MY COMMITTEE with a copy thereof.

I shall bring up to MY COMMITTEE the annual estimates approved by the various committees.

In considering the capital estimates, MY COMMITTEE shall have regard to the maximum amount which, *in* THEIR *opinion*, the Council should seek to borrow in the year.

No liability exceeding £50 shall be incurred (by any committee) without the express sanction of the Council, except in the case of committees acting in pursuance of statutory or specially delegated powers of expenditure.

It shall not be in order to submit estimates to the Council through any committee other than MY COMMITTEE, except in cases of urgency, or where the Council is under statutory obligations to proceed.

No recommendation or proposal involving expenditure on capital account shall be submitted to the Council until an estimate is submitted by MY COMMITTEE to the Council.

THE HEADS OF DEPARTMENTS SHALL SUBMIT TO ME the contractors' detailed account and measure bill for MY examination and comparison with the contract, specifications and bills of quantities, also a statement showing the additions and deductions on the contract (if any), and the final certificate of the heads of departments or architect, as the case may be, is not to be issued until this has been done.

THE HEADS OF DEPARTMENTS SHALL FURNISH ME WITH PARTICULARS OF ALL ESTIMATES AND TENDERS.

The whole of the account keeping relating to stocks and stores, works accounts and cost accounts shall be under MY SUPERVISION AND CONTROL, and all statements of costs shall be compiled by and issued from MY department.

The accounts of all committees shall be submitted BY ME to MY COMMITTEE for examination and recommendation to the Council for payment.

MY COMMITTEE shall settle disputed accounts for goods supplied, work done or charges made.

No proposal dealing with new or existing sources of revenue shall be submitted to the Council until a report on the financial bearings of the proposal is submitted by MY COMMITTEE.

I shall at all times make any suggestions which may occur to ME as likely to effect economy without impairing efficiency.

I shall attend all or any of the committees of the Council as may be required.

Considered in this form, one can readily appreciate the desire for secrecy until such time as the treasurer representing finance could present himself in all his glory to receive the adoration and homage of the heads of the minor departments representing law, order, light, learning, &c. It is difficult to find the link connecting the various committees and the heads of departments, since the heads of departments have to submit particulars of their estimates and tenders, "contractors' detailed accounts and measure bills," to the great EGO, and the great EGO in turn presents the draft estimates to the various committees for approval.

It is not in order for any committee, other than the Financial committee, to submit to the Council estimates or any recommendation or proposal involving expenditure on capital account. Since the chief officers do not submit particulars to their committees, and the committees may not submit a proposal to the Council, why have committees—could not the great EGO do it all?

It is really almost impossible to conceive that any strong men would allow themselves to form part of a committee having such restricted powers as the financial officers propose. It is apparent that the human element has been ignored in drawing up the regulations. Whilst it cannot be supposed for a moment that the heads of all the great trading departments (to say nothing of the other officers) would allow the control of their department to be taken out of their hands, or consent to be under the obligation to submit all their estimates and proposals to another officer, it needs no very strong imagination to picture the lively time the poor financial officers would have under such conditions in collecting and retailing information regarding the various technical departments with the assistance—or otherwise—of their respective managers.

NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION.

We have received from the Secretary of this Association (Mr. F. B. O. Hawes), a pamphlet setting out its aims and objects, the method of organisation, the work hitherto accomplished by the Association, and other matters. The Executive committee, of which Mr. H. H. Berry (Messrs. Berry, Skinner & Co.), is the present chairman, is elected annually, and is composed of eleven representative men of the manufacturing branch of the electrical industry.

The pamphlet points out that only by a large membership can the association hope to continue effectually to carry out the duties it was originated to perform. Its real raison d'être is in the opportunity it affords for the ready settling of trade disputes, abuses, &c., in the convening of urgent meetings, either for the manufacturing trade as a whole or any section of it, and in the promotion of schemes that will be beneficial to electrical manufacturers. By joining the association the individual policy of a member is in no way interfered with.

OBJECTS OF THE ASSOCIATION.—The pamphlet states that the objects of the association are: "1. To promote and protect the interests of electrical manufacturers and others dealing in or supplying electrical goods in the United Kingdom of Great Britain, and for the consideration and discussion of all questions affecting the electrical manufacturing trade.

"2. To give the Legislature and public bodies and others facilities of conferring with, and ascertaining the views of, persons engaged in the electrical manufacturing trades, as regards matters directly or indirectly affecting that trade, and to confer with Government, municipal and local authorities and public bodies generally.

"3. To originate and promote improvements in the law, and to support or oppose alterations therein, and to effect improvements in administration, and for the purposes aforesaid to petition Parliament, and take such other steps and proceedings as may be deemed expedient.

"4. To diffuse among its members information on all matters affecting the electrical manufacturing trade, as may seem conducive to any of these objects.

"5. To obtain more favourable terms and rates from railway companies, shipping companies and other carriers for the conveyance of goods.

"6. To encourage the settlement of disputes by arbitration, and to act as or nominate arbitrators and umpires on such terms and in such cases as may seem expedient.

"7. To promote creditable displays of British electrical machinery, appliances and fittings, and drawings of the same at great national and international exhibitions."

It is claimed that the association has been successful in (1) obtaining from the Railway Clearing House redress of certain grievances due to the faulty classification of electrical apparatus, and in altering terms under which electrical goods are carried by the various railway companies; (2) in rectifying the irregular and unsatisfactory manner in which electrical goods were hitherto classified by the Customs under imports and exports, and in obtaining a re-arrangement of such classification, giving a truer analysis of the Board of Trade returns; (3) in negotiating and rectifying a number of unfair clauses in specifications issued at various times by municipal and other bodies (including the clauses relating to the shortening of the period for retention money and the abolishing of the non-returnable fees formerly in vogue in certain instances); and (4) by employing an expert who deals with the fire policies issued by the tariff companies it has saved its members a considerable amount.

It is also claimed that it has put a stop to the holding of numerous small local exhibitions, and that it has assisted in promoting thoroughly representative exhibitions. It has successfully convened meetings for the benefit of a number of sub-sections, for discussing and dealing with questions affecting their particular interests; and it has been instrumental in uniting the various sections of the trade for simultaneously raising prices when necessary. It has arbitrated (free of expense) in case of trade disputes, and settled such questions without having to resort to legal procedure; it has made advantageous arrangements with the British Traders' Association, whereby members can obtain reliable information concerning the financial status of any firm, and the free collection of their overdue accounts; it circularises its members directly it receives any authentic information regarding fraudulent firms; and it has been instrumental in abolishing the objectionable practice of giving Christmas boxes, &c.

The association has formed a benevolent institution for the benefit of the brain workers engaged in the electrical industry generally, and collected funds which have put it on a sound financial basis. (Particulars of this fund were given in THE ELECTRICIAN for May 7, p. 143.)

A branch of the Association is to be started in the North of England shortly.

WIRELESS TELEGRAPH CLASSES.

Dr. R. Mullineux Walmsley, principal of the Northampton Polytechnic Institute, Clerkenwell, London, forwards some particulars regarding what is probably the first examination paper ever set upon the subject of "Wireless Telegraphy" at the close of a full sessional course by an expert on the subject. This course was given at the Northampton Institute by Dr. J. Erskine Murray during the past session, and we learn that 83 per cent. of the students attended the final examination and that the average of marks obtained was 68 per cent. The following is the examination paper:—

WIRELESS TELEGRAPHY.

Monday, May 17, 1909. 7:30 to 10.

Answer six questions only. Give sketch diagrams wherever possible.

1. Explain the difference in the course of the current in wire and wireless transmission from place to place. Show differences in slope of lines of force passing over sea, soil with ground water, dry rock.
2. Distinguish between damped and undamped or uniform alternating currents, and describe shortly apparatus for producing high-frequency currents of each type.
3. Describe the various types of high-frequency currents obtainable by varying the conditions in an "arc" generator of high-frequency current.
4. Describe various types of detectors of high-frequency current and explain why ordinary telegraphic instruments are not sufficient.
5. If it be required to determine the direction from which signals are coming or to make the transmission a maximum in a given direction, what types of aerial and station apparatus should be used?
6. Name some types of instrument suitable for high-frequency current measurements. Describe a method for the measurement of the frequency of a current. If a circuit has capacity—0 2 mfd., self-induction = 5.000 cm. and negligible resistance, find its natural frequency.
7. How can the resonance curve of a circuit be obtained? What can be deduced from it? What is the effect of inserting extra resistance?
8. Show diagrammatically different methods of coupling two circuits. Explain the type of current produced when a spark circuit is closely coupled to a secondary circuit in tune with it.
9. State the conditions necessary for the transmission of articulate speech in wireless telephony, and describe shortly the apparauts required.

THE TRACKLESS TROLLEY.

The report of the sub-committee recently appointed by Leeds Corporation to inspect and report upon the various systems of railless trolley traction on the Continent has been issued.

The committee consider that by avoiding the heavy expenditure required in the installation of ordinary tramway traction, the railless trolley method of conveyance offers considerable possibilities for general feeders in suburban and inter-urban districts to tramway systems, and is quite capable of supplying a sufficient service for thinly populated districts on a reasonably economic basis. They recommend that a system of railless traction should be adopted at Leeds, for the district between the city and Farnley, instead of constructing electric tramways, and that, if necessary, powers be obtained to carry this into effect. The committee do not make any suggestion as to which of the three systems inspected (the Mercedes-Stoll, the Filovia and the Max Schiemann) is the best form of traction. They believe that with some adaptations and improvements a selection can be made of a form which will serve the purpose of the Corporation.

The vehicles employed in all these systems do not differ greatly in general appearance from the single-deck motor omnibus, except that they are provided with a means of collecting current, such as a "fishing-rod" from the roof to the source of supply, much as the ordinary electric trams are worked from overhead cables. The principal difference between the various systems is in respect of the arrangement for keeping the two shoes on to the two cables. In Vienna the vehicles carry 12 passengers seated, an additional 12 are allowed to stand, even on the platforms both front and back of the car. The entrance for passengers is at the driver's end, and he is quite able to attend to all the duties of a conductor as well as driver. The committee were particularly struck with the smoothness and comfort of riding, the spring base of the truck being well arranged. The brakes are ample, and spraggs are fitted to prevent running backward if stopped on a hill. The motors are each 20 H.P., and form the hubs of the back wheels, current being collected from the supply cable by means of a pair of wheels running on the top of the wire, a similar pair of wheels transferring the used current to the return. A weighted pendulum slung from a frame carrying these two pairs of wheels keeps them well pressed upon the wires, and the current is conveyed to the motors, not by a "fishing-rod," but by a pair of cables which allow the car to pass to any part of the road.

The cost of the chassis in the Mercedes-Stoll system is about £550, without body; the cost of the overhead construction about £1,690 per mile, and the working expenses per car-mile 4·52d., as follows:—

Current	0·40d.
Tyres (total load 4·2 tons)	1·33d.
Wages (driver only employed)	1·20d.
Depot expenses	0·26d.
Taxes, management, insurance	0·80d.
Repairs, renewals, painting cars and equipment	0·53d.

The method of collection of current works very smoothly, with an entire absence of noise. The principal apparent disadvantage lies in the possibility of the collector becoming detached from the overhead wires by collision or other cause, and falling to the ground, which might occasion considerable damage and delay, as its removal or replacement on the wires requires two men with special poles.

On the Filovia system, in operation at Milan, the cars carry 30 passengers. A framework carrying two pairs of wheels—one pair in contact with each overhead cable—is employed to maintain the circuit. It is similar to that used in the Mercedes-Stoll system, except that it is pressed by a "fishing-rod" or "boom" against the undersides of the cables. There are two direct-current motors of 10-12 H.P. each, and working cost per car-mile works out to 5·645d. as follows:—

Cost of energy	0·415d.
General expenses	0·594d.
Rubber tyres renewal	2·160d.
Wages and salaries	1·400d.
Maintenance of vehicles and line	0·620d.
Repairs of vehicles	0·456d.

The route inspected (owned by a private company) was $4\frac{1}{2}$ miles long. The vehicles were able to reverse and manœuvre without the trolley being removed, and to take heavy gradients over bad and muddy roads without difficulty, vibration or noise. The practicability of the Filovia type of railless traction considerably impressed the committee. The cost of overhead construction was estimated at only £750 per mile, but only wooden poles were used, which had been found to be very serviceable.

The Max Schiemann system was seen working at Mulhausen, Germany. The contact with the pair of cables was maintained by means of a "fishing-rod," carrying at its extremity a pair of sliding shoes. The overhead construction was similar to that of the systems previously described. The vehicle carries about 15 passengers seated, and the front wheels only have rubber tyres, so that there is considerable vibration and noise. The single motor drives on to the front axle, making the steering comparatively heavy. The design of this type of vehicle is stated to be undergoing radical modification. The weight of the present empty car is 2 tons $16\frac{1}{2}$ cwt.

On neither of the three systems have many hitches been reported, and as to the wear and tear of the roads, the committee understand that, owing to the comparative lightness of the vehicle, the surface of the road suffers less than in the case of a service of cars carrying their own petrol or other engines.

At the meeting of the Council on Wednesday the chairman of the Tramways committee (Mr. Smithson) moved the adoption of the report, and said the committee were agreed that one of the three systems recommended ought to be given a trial in Leeds, and the route to Farnley had been selected for the experiment. The Town Clerk thought that it would be necessary to get an act of Parliament passed before the experiment could be tried. That would prevent anything being done this year, but in the meantime the committee could determine which of the systems would be best.

The resolution was adopted.

THE EMPIRE PRESS CONFERENCE.

The delegates representing the Press of the British Empire, who are at present assembled in this country with the object of discussing various questions of imperial importance, have paid especial attention to the question of the cost of telegraphic communication between different parts of the Empire.

At a meeting held at the Foreign Office on Monday, Lord Crewe (who presided) expressed his sympathy with the aims of the Conference on the question of cheapening and extending telegraphic communication, and Mr. Stanley Reed ("Times of India," Bombay) proposed that a committee of overseas delegates should be formed to report to the Conference on the subject of cheaper cable rates within the Empire at a future session, to be held on June 25. An amendment to include on this committee four representatives of British newspapers was agreed to, and the Hon. Theodore Fink stated that it was evidently the determination of the Conference to come to an understanding as to what was the full assistance which the Home and Colonial Governments were willing to give to the Press of the Empire in connection with the development of intercommunication. Mr. Sydney Buxton (the Postmaster-General) expressed the view of the Department on the subject, and pointed out that the whole matter was one of pounds, shillings and pence. He agreed that it was impossible for the Press to take advantage of the elaborate system of coding of which the commercial world was able to reap the full benefit, and he thought, therefore, that the question of special rates for the Press, in order to place them on an equality with the business man, a subject worthy of consideration. To a certain extent the inequality had been met, and he thought they all should recognise that some of the cable companies had endeavoured to meet the difficulty by a large reduction in Press rates. The British Post Office, he desired to point out, had been very liberal in respect to its treatment of the Press, and its sympathy had been on a cash basis He was inclined to think that, as regarded the British Press, the Post Office had been rather too liberal. Before the Conference met he had been in communication with the various cable companies interested in order to see how far they would be likely to meet the views of the Conference on this subject. Naturally they would not commit themselves, nor had he asked them to do so. But they had to recognise the existence of the cable companies, and also the fact that cable companies, like newspapers, were commercial bodies, and had done great service for the Empire. He understood the companies to say that if they were assured that the result of a reduction of rates, say to 1s. or 6d. a word, or whatever it might be, would produce a considerable amount of business, they would be willing to consider the matter favourably. That was what the Conference must consider. The cable companies pointed out that at the present moment the total amount spent on Press telegrams was not great, and formed a very small proportion of the total expenditure of newspapers.

The Hon. H. LAWSON ("Daily Telegraph" London) said, in supporting the motion, that the question of cable rates did not concern only the Dominions and India, but also to an even greater extent the British, and particularly the London Press. Communication must be by cable, and Press messages could not be sent in cipher. It was impossible to send them by code. Only recently he had tried to have Press communications sent in cipher, and the attempt was a dismal failure. Code messages being useless for newspaper purposes, it was essential that news should be written at length, and it must come by cable, because in the present age people would not wait for the mails. The means by which the required reform must be accomplished were alternatively by a reduction in cable rates, by an increase of competition, by an increase of subsidy, or by a combination of all three.

Following is the text of the original motion as carried: "That this Conference regards it as of paramount importance that telegraphic facilities with the various parts of the Empire should be cheapened and improved, so as to ensure fuller intercommunication than exists at present, and appoints a committee to report to the Conference at its reassembling on June 25 as to the best means of obtaining this object."

The original motion was finally passed, and a standing committee was established to study the question of an Imperial News Service, and to take measures to secure a reduction of the rates of transmission, the committee to consist of the following members: Sir Hugh Graham ("Star," Montreal), Mr. R. Kyffin-Thomas ("Register," Adelaide), Mr. F. W. Ward ("Telegraph," Sydney), Mr. Thomas Temperley ("Richmond River Times," Bathurst), Mr. J. O. Fairfax ("Morning Herald," Sydney), Mr. George Fenwick ("Otago Daily Times," Dunedin), Mr. A. F. Lawson ("Mail," Madras), Mr. Mark Cohen ("Evening Star," Dunedin), Mr. J. S. Brierley ("Herald," Montreal), Mr. P. D. Ross ("Evening Journal," Ottawa), Mr. John Nelson ("Times," Victoria, B.C.), Mr. R. Philipson-Stow ("South African News," Capetown), Mr. G. H. Kingswell ("Rand Daily Mail"), Mr. F. Crosbie Roles ("Times of Ceylon"), Mr. Stanley Reed ("Times of India," Bombay), Hon. Surendranath Banerjee ("Ben-

galee," Calcutta), the Hon. H. L. W. Lawson ("Daily Telegraph"), Mr. Moberly Bell ("The Times"), Mr. J. S. R. Phillips ("Yorkshire Post"), Mr. Ernest Parke ("Morning Leader").

Mr. P. D. Ross ("Evening Journal," Ottawa) moved "That for the achievement of better and cheaper electric communication in the Empire it is one of the essentials that there should be State-owned electric communication between the British Islands and Canada across the Atlantic Ocean, and also State control of electric communication across Canada between the Atlantic and Pacific cable services." If his proposal were carried into effect it would result in a great reduction in the cable rates to Australia. It had been estimated that a State-owned Atlantic cable would reduce the rate to Canada from 25 cents to 5 cents a word. There would be a corresponding decrease in Press rates.

Sir Hugh Graham said the only basis for an improved service was a cheapening of the rates. If that could be got from the cable companies, well and good; but if not, they would lay their cables, and he had an assurance that money would be forthcoming for that purpose.

Mr. Austen Chamberlain, M.P., said: Recent years had seen a great improvement in the transmission of news from one part of the Empire to another. He thought that communications had reached a point of development and even of cheapness where they served the purpose of rapidly supplying information of great and striking events, whether of matters of rejoicing or for sorrow. But that was not enough. It did not give that constant daily news which enabled men living widely apart to feel themselves in constant touch with each other. The question needed the co-operation of instructed public opinion throughout the Empire, of all the Governments and their treasuries, and of the Cable Companies. He hoped that, whatever was decided, the Cable Companies, which had been the pioneers in this work and had rendered great service in the past, would not be ungenerously treated. But the cable companies must make up their minds that the times were changing, that fresh needs were arising, that the service which satisfied in the past could not satisfy in the future, and, if they were wise, they would be the first to study how they could meet these new necessities, and avoid burdening themselves with a publicly-owned and publicly-supported competition.

Mr. Phillips ("Yorkshire Post") suggested that matters of Imperial interest should be sent over the cables from either side largely at the cost of the Governments concerned, while messages dealing with matters of commercial or social concern should be sent entirely at the expense of the newspapers themselves.

Mr. T. Temperley ("Times," Richmond River, Australia) strongly advised the nationalisation of inter-Empire cables.

Consideration of Mr. Ross's motion was then postponed until June 25.

PARLIAMENTARY INTELLIGENCE.

London County Council (Tramways and Improvements) Bill.—The Select Committee of the House of Commons which has been considering this bill for some time decided, on Wednesday, to approve the scheme for the extension and reconstruction for electric traction of the horse tramways from Tooley-street through Dockhead to Woolwich. The Committee decided that the County Council must keep the terminus at Tooley-street and carry out certain widenings at Dockhead.

The scheme for the reconstruction for electric traction of the present Highgate cable tramway was next considered. The proposed expenditure on this line is £57,850, including widening. The Committee passed the proposal yesterday (Thursday).

Accumulator Motor Cars for Railways.—The increasing interest which is being taken in accumulator traction will doubtless be enhanced by a report on the subject due to Herr A. Giesler, engineer of the Palatinate railways. On these lines it appears that electrically-operated motor cars have been in use for some years, and a report on their performance has now appeared in the "Bulletin" of the International Railway Congress. As early as 1900 seven accumulator cars were in service, four on the standard-gauge and three on narrow-gauge lines. The latter have since been withdrawn, owing to tramway extensions in the districts concerned. The cars now used are operated over seven routes, with an average length of 17½ miles, among them being the round trip between Ludwigshafen and Worms, a distance of 27½ miles, and the journey from Neustadt to Schifferstadt, 11 miles. The average consumption of energy is about 32 watt-hours per ton-mile. Over a period of seven years the eight-wheeled cars spent on the average rather less than 12 per cent. of their total working time in the repair shops. This figure shows a certain advantage over the steam locomotive, the average period during which locomotives were under repair in the whole of the German Empire amounting to 18·01 per cent. during 1905. The entire working cost amounts to about 7d. per car-mile.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Edison & Swan United Electric Light Co. (Ltd.) require a commercial manager; must have had thorough training and experience and be fully qualified to take charge of the sales organisation. Applications to the Chairman of the Company, 36, Queen-street, London, E.C. See advertisement.

The Governors of the Heriot-Watt College, Edinburgh, invite applications for the position of assistant lecturer in electrical engineering as from Sept. 6 next. Salary £130 per annum. Further information from Prof. Baily at the College. Applications must be lodged by June 21.

A demonstrator and assistant in the laboratory is wanted in the department of electrical engineering of the Glasgow and West of Scotland Technical College. Salary £100 per annum. Applications by June 24 to Prof. Magnus Maclean, from whom further particulars may be obtained.

The managers of the Technical College, Dundee, invite applications for the position of lecturer in electrical and mechanical engineering. The person appointed will have full charge of the electrical department, and must be competent to take the senior branches of mechanical engineering. Salary £350. Applications to the Director of Studies, Technical Institute, Dundee, by June 15.

The Council of King's College (University of London) invite applications for the position of professor of physics. Applications by June 14. Particulars from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

The Governing Body of the South Western Polytechnic Institute (London) invite applications for the post of head of the mechanical engineering department. Commencing salary £350–£400. Applications to the Secretary by June 22.

Croydon Education committee invite applications for the post of principal of the polytechnics. Salary £300, rising to £350. Forms from the Clerk, Catherine-street, Croydon. Applications by June 26.

At the University of Manitoba, Winnipeg, Canada, there are required a lecturer in civil engineering (salary $2,500) and demonstrators in physics and chemistry ($1,000 each). Applications to the Registrar by July 1.

Mr. J. L. Sutherland, late of the tramway power station, has been appointed station superintendent of Coventry electricity works.

Mr. R. Smith, mains superintendent at Worcester, has been promoted to the position of chief assistant engineer and mains superintendent at £140 a year, and Mr. E. Page has been made station superintendent at £120 per annum.

Mr. Thos. N. Riley, M.Sc. (Vict.), B.Eng., A.M.I.E.E., of the Aston Manor Technical School, has been appointed engineering master (mechanical and electrical) at Plymouth Science, Art and Technical Schools.

Scholarships.—West Riding (of Yorks.) County Council offer four technical scholarships (of the value of £60 per annum) to residents within the administrative area of the West Riding, and available for courses of instruction in connection with engineering (mechanical or electrical), metallurgy, dyeing or other approved industry. The scholarships are intended for young artisans who already have a suitable amount of mill or workshop experience, and the awards will be mainly based on the results obtained at examinations of the Board of Education and of the City and Guilds of London Institute. Particulars may be obtained from the Education Department (Technical Branch), County Hall, Wakefield.

Argentina.—The "Review of the River Plate" states that the Cia. de Luz Electrica de la Provincia de Buenos Aires have acquired the San Fernando electricity supply undertaking from Messrs. Varela & Cuneo.

Australasia.—In a report to Sydney City Council on the working and further development of their electricity undertaking, the consulting engineer (Major Cardew, of Messrs. Preece & Cardew) states that the development has been more rapid than he anticipated, the output now being over nine million units per annum, instead of four million. Instead of 600 kw. of plant, 2,000 kw. is installed. He recommends the erection of a fuel conveyor at an estimated cost of £6,000. This is calculated to save 1s. per ton of coal.

Major Cardew also approves the proposal of the city electrical engineer (Mr. H. R. Forbes Mackay) to put in 4,000 kw. horizontal shaft turbines, but he does not recommend the installation of a 400 kw. turbine

set for running auxiliaries, as he considers one of the existing reciprocating sets could be made available for the purpose. He thinks there is now no doubt that for 4,000 kw. units, where suitable condensing facilities exist, turbine plant is cheapest in first cost and maintenance. He does not advise further extension of overhead e.h.t. conductors in Sydney, nor, unless under special circumstances, in the suburbs, as, in his view, the risks and losses inherent in that form of transmission more than outweigh the financial advantage.

Sydney Lighting & Power Co. have come to agreements with the Echuca Shire Council to supply electricity for lighting in Rochester, and with the Rochester Waterworks Trust for supply of the current for electric pumping.

Battersea (London).—The Lighting committee have prepared a scheme for providing consumers, at an estimated cost of £1,500, with arc lamps and motors, and the wiring of premises therefor for cash or on the hire purchase system.

The Electrical Trades Union has written to the committee protesting against the proposal that the wiring work should be carried out by contractors.

Brighton.—At the meeting of the Council last week the accounts of the electricity department (an abstract of which appeared in our last issue) were adopted.

Councillor German, who moved that the accounts be approved, said he thought their policy in transferring the generating station to Southwick had been fully justified. The two items upon which the greatest economy was to be effected by the change were in coal and wages. In 1905, the last year they did all the work at North-road coal cost them £23,205, but last year at Southwick, although the output was a good deal more, the total cost had fallen to £15,520, and the price then was not so favourable as at present. In 1905 wages were £6,655, but last year the amount was £5,340. Total works cost in 1905 was 1·14d., but last year it had been reduced to 0·79d. per unit.

Burslem.—Sanction to a further loan of £7,535 for extensions of the electricity works has been applied for by the Council.

Chichester.—The official inauguration of the electricity works of the Chichester Electric Light & Power Co. (Ltd.) took place on 3rd inst. The ceremony was preceded by a luncheon which was given by the consulting engineer of the company (Mr. Horace Boot, M.I.E.E.), and among those present were the Rev. Chancellor H. M. Davy, J.P., who had been invited to perform the inaugural ceremony, Mr. E. Symons (a director of the company), Mr. C. Stewart (representing Messrs. Johnson & Phillips, the contractors), Mr. J. W. Loader Cooper (town clerk), Mr. F. J. Lobley (city surveyor), Mr. R. V. Weare (resident engineer to the company), &c.

Darlington.—An unopposed inquiry was held here last week into the application of the Council for permission to borrow £3,900 for extension of plant at the electricity works.

Darwen.—The Council have authorised the purchase of a 15 h.p. electric motor for the municipal weaving shed.

Domestic Electricity.—An important undertaking in connection with the supply of electricity for all domestic purposes is that which has been initiated at Preston by the National Electric Supply Co. This company have recently revised the scale of charges for supply, and have established extensive showrooms where a vast array of plain, ornamental and art fittings, a varied assortment of culinary and heating utensils, a wide range of small motors for small users, and a multiplicity of accessories are shown to best advantage. We have before us a series of photographs of the showrooms, and these indicate that the company have laid themselves out for a really good display. A venture of this kind is worth doing well—in fact, it must be badly done unless it is well done, and the National Electric Supply Co. at Preston seem to have organised and carried out a display which must bring the many advantages of electricity for a large variety of purposes prominently before the public of the extensive district which the company caters for.

Eastbourne.—The borough electrical engineer (Mr. J. K. Brydges) has been authorised to obtain quotations for water-softening plant of 1,000 gallons per hour capacity.

Eccles.—The Electricity committee are considering a proposal to purchase their fuel according to the number of heat units generated instead of by weight. Tenders are being invited for the erection of water softening and purifying plant.

Electric Lighting Acts (Amendment) Bill.—Islington (London) Council have decided to petition against this bill in order to obtain (if possible) a modification of clause 1, so that electricity supply undertakers authorised by provisional orders made under the clause should not be under further liability than that which is imposed by the common law in the case of persons exercising statutory powers and duties.

Hackney (London) Council have decided to request the members of Parliament for the borough to vote for the excision of Lord Avebury's amendment to clause 15.

In reply to an inquiry by Southwark Council, the Board of Trade state that they are advised that the bill as amended in the House of Lords will not override or limit any special provisions in local acts empowering local authorities to supply electrical fittings, &c.

Fatality.—An inquest was held at Bridlington on Friday into the death of Edward Dickens, electrical engineer, who was killed on the 3rd inst by falling through the glass in the roof of the Grand Pavilion, Prince's-parade, Bridlington.

Mr. A. C. Dickens said deceased was his son, and he had arranged to meet him at Grimsby that day. They were there fitting up a ship with an electric lighting installation. He had a business at Northampton, and had opened a branch at Bridlington.

Mr. E. R. Matthews (borough engineer) said that from foot marks on the plate glass in the skylights of the pavilion it was clear that decesaed had been walking on the glass without a hold of the ridge. On one of the panes there was a mark of a boot having slipped, and the deceased had apparently fallen heavily upon the next pane and crashed through into the hall. He need not have gone near the glass, but it being ¼ in. thick and rough surfaced it might have borne a man of his weight had he not slipped and fallen. No one could have gone over the glass without the gravest risk of being killed.

A verdict of accidental death was returned.

Financial Organisation and Administration of Municipal Undertakings.—At the last meeting of Poplar (London) Council the Electricity committee reported that they had received a communication from the Municipal Tramways Association, forwarding a copy of "Draft Regulations for Financial Organisation and Administration," which were to be brought forward at the meeting next week of the Institute of Municipal Treasurers and Accountants. Though these regulations had been drawn up without consultation with the heads of municipal trading departments, it was understood that an attempt was being made to get them approved by the L.G. Board.

The committee recommended—

That the L.G. Board be urged to arrange that the views of chairmen and chief officers of municipal trading departments be ascertained before effect is given to the proposals, based on the report of the Departmental committee of the Board on Accounts of Local Authorities, or otherwise, so far as such proposals affect municipal trading undertakings.

Hampstead (London).—24 of the public incandescent gas lamps are to be converted to electric lamps, the estimated saving being 4s. 6d. per lamp per annum.

Holland.—The Noord-Zuid-Hollandsche Tramweg Maatschappij (Amsterdam) is increasing its capital by £270,000 for the conversion of their tramways to electric traction and for other improvements. The prospectus (in Dutch) relating to the issue of capital and giving particulars of the proposed works can be seen at 73, Basinghall-street, London, E.C.

India.—It has been decided to carry out a scheme prepared by Mr. J. W. Meares for the electric lighting of Shillong by means of current generated by water power at an estimated cost of R.1,75,000.

At Shalimar and Kidderpore (Calcutta) power houses have been laid down and winding engines, each with a 200 h.p. motor, for hauling wagons on and off the Hooghly ferry are under construction.

Italy.—Two electric elevators are to be erected on the Caracciolo and Assereto bridges in Genoa harbour at an estimated cost of £120,000.

Leeds-Bradford Tramway Service.—A through tramway service between Leeds and Bradford was inaugurated on Monday.

At present the cars are to run every quarter of an hour from five in the morning up to noon and every 10 minutes afterwards, the running time being an hour for the complete journey. The through service has been made possible by the use of the Spencer-Dawson adjustable axle on the cars, which enables a car to run directly off the 4 ft. 8½ in. gauge of the Leeds lines on to the 4 ft. gauge of the Bradford lines.

Linking up London Electricity Supply Undertakings.—In our issue for May 14 we announced that at a joint conference of representatives of the municipal and company-owned electricity supply undertakings, the principle of linking up, as authorised by the London Electric Supply Act, 1908, was agreed upon. 12 Councils and nine companies were represented at that conference and a consultatives committee of 12 (six company and six municipal representatives) appointed to draw up the rules of procedure. The municipal representatives are: Councillors W. J. Stapleton (Hackney), H. R. Vorley (Islington), H. B. Barge (Poplar), J. F. Harwood (Shoreditch), H. H. Gordon (Stepney) and E. R. Debenham (Marylebone). The joint secs. are Mr. H. B. Renwick (for the companies), and Dr. H. Mansfield Robinson (for the local authorities).

L.G. Board and Workhouse Contracts.—A memorandum has been issued by the L.G. Board to Poor Law Guardians pointing out

That it is desirable in the interets of good administration and economy that persons wishing to tender for the supply of goods should have every facility for obtaining information as to the kind and quality of goods

needed, and that such persons or their agents should be allowed to take away patterns or samples wherever this can be arranged.

London Chamber of Commerce. At a special meeting of the Council on May 27, Mr. Charles E. Musgrave (assistant secretary) was appointed secretary of the Chamber in the place of Mr. Kenric B. Murray, who retires after over 27 years' service as secretary.

Loughborough.—Mr. John F. C. Snell has presented his report on the present position of the electricity supply undertaking.

In the report Mr. Snell stated that the plant on the whole appeared to be working satisfactorily, although it was not of a type he himself would have recommended. No economy could be effected in the staff. An unnecessary outlay on mains was originally made and the charge for public lighting should be increased. The average rate per unit sold was too low, consequently every additional lighting consumer, at the equitably higher rate paid for lighting, was a step towards the self-supporting stage. The present practice of the Gas and Electricity committee governing both the gas undertaking and the electricity undertaking was condemned as being unfair to the members of the committee, to the ratepayers and to the departments governed. An independent Electricity committee was recommended. Although the lighting rates were sound, a revision of the power rates was necessary, and to continue the existing scale must cause loss of revenue. In a supplementary report, Mr. Snell advised the Corporation to continue for the time being the present scale of charges for power. He was unable to suggest any immediate remedy for the present position, and the only possible future remedy was a growth of output of higher priced units, together with an economy of the severest kind in the costs of production, and a careful scrutiny of every addition to capital expenditure.

At Wednesday's meeting of the Council a further report of the Gas and Electricity committee on the supplementary report received from Mr. Snell was considered. It was proposed that the two reports of the committee, with the recommendations contained therein, be adopted.

It was moved as an amendment that the recommendation of the committee that the electricity undertaking should be placed under the control and management of a separate standing committee, as advised by Mr. Snell, be not adopted, but that the control of the undertaking by the Gas and Electricity committee as at present constituted, be continued, and the amendment was carried.

With respect to Mr. Snell's recommendation that all the accounts of the electricity department should be kept by the engineer and manager, on which point the committee asked for an expression of opinion, it was resolved that the accounts be kept by the borough accountant, as at present.

It was also resolved that the recommendation of the committee that the Highway committee, instead of being charged a lump sum to cover the total cost of lighting and maintenance for street lighting by electricity be charged 2½d. per unit for energy supplied, plus actual cost of maintenance and repair of lamps be referred to the Highway committee for consideration.

Longton.—The Council have rescinded their resolution to apply for sanction to a loan of £2,580 for extensions of the plant at the electricity works, and the expenditure is to be met out of reserve fund.

Market Harborough. The Council have applied for a further extension of time for carrying out their provisional order.

Mexico.—The British Vice-Consul at *Monterrey* (Mr. J. B. Sanford) reports that the electricity supply undertaking which started supply in 1890 and which has been acquired by a Canadian firm is, with the tramways and the waterworks and sewerage system, to be taken over by the Monterrey Railway, Light & Power Co. (Ltd.), which has been registered in London with a capital of £1,000,000. The electric power station is to be remodelled and will in future supply current for the tramways as well as for lighting.

Vice-consul J. F. Lynch at *Saltillo* calls attention to the steps which are being taken in his district to produce vegetable wax from the candelilla plant which grows there and in other northern states of the Republic. The botanical name of the plant is pedilanthus pavonis euphorbiacer, and it grows from 3 ft. to 5 ft. high in the shape of stalks without leaves or thorns. The wax is at present used for candles, phonograph and other records, &c., and it is said that "tests which have been made for its adaptability for insulation of electric wires have been very successful."

Middlesbrough.—The Council have decided to ask for sanction to a loan of £18,922 (not £10,000 as previously intended) to provide for extensions of cables for three years.

New Submarine Telegraph Cable.—The Telegraph Construction & Maintenance Co.'s cable steamer "Colonia" is about to leave the Thames to proceed to Newfoundland for the purpose of laying about 300 miles of cable for a new line of communication between St. John's (Newfoundland) and New York.

Oldham.—An unopposed inquiry was held here last week into the application of the Council for permission to borrow £8,000 for mains, £1,000 for house services and £1,250 for meters.

Presentations.—On 2nd inst. Mr. J. W. Beauchamp, deputy manager of Sheffield Corporation electric supply department, was the recipient of several articles of Sheffield plate subscribed for by the staff and employés as a token of esteem and goodwill, the occasion being Mr. Beauchamp's departure from Sheffield to Tunbridge Wells to take up the position of resident electrical engineer.

In making the presentation the general manager (Mr. S. E. FEDDEN) referred to the good work Mr. Beauchamp had done during his 8½ years' service with the department, and on behalf of the staff congratulated him very heartily upon his appointment to a higher position, and wished him every possible success in his new undertaking.

At the West Ham electricity offices on 29th ult. Mr. A. Hugh Seabrook, the engineer and manager, who was recently appointed to a similar position at Marylebone, was presented with a silver tea tray.

Mr. GILBERT expressed the regret of the staff at Mr. Seabrook's approaching departure, but at the same time congratulated Marylebone on obtaining him as their engineer and manager. From the beginning of his career at West Ham the whole department had progressed at every point. The meter, the mains and the stores departments had all grown abnormally, and they had worked with the smallest possible friction; that result was mainly due to Mr. Seabrook's admirable overseering.

The sales manager (Mr. HOLMES) said that most of them had had, at different times, to work under different managers, but under no manager had they received such tactful consideration as they had under the chief who unfortunately was now going from them. Mr. Seabrook had had at his finger-tips every detail of the whole department.

Mr. Smith and Mr. Tombs having spoken, Mr. Gilbert formally made the presentation.

In acknowledging the gift, Mr. SEABROOK said he did not feel that he deserved anything like the valuable recognition they had given him that night. The past 3½ years had been rough and tumble to a great extent, but those who had survived the reorganisation and alterations could be considered as men who had been tried in the fire and not found wanting. He felt perfectly certain that wherever he went he should never again have the opportunity of being associated with a staff more competent or more capable of hard work than the staff of that department. They had achieved a measure of success; they had supplied customers at about the lowest prices in the country, and extended the supply of material and apparatus to them. But the work could never be a success except by the hearty co-operation of a thoroughly capable staff, and he had endeavoured in the annual reports he had presented to the committee to let them know, as far as he could, in what high regard he held his staff. He had never allowed any sentiment to interfere with the management of the undertaking, but he hoped he had not gone too far in that direction. He thanked them very heartily indeed for their very kind present.

Personal.—Mr. J. H. C. Brooking, A.M.I.E.E., M.I.M.E., has been appointed general manager of the St. Helens Cable & Rubber Co., of Warrington.

Mr. O. H. Bishop, for many years sales manager of the Edison & Swan United Electric Light Co., has resigned his position with the company, in order to take up other work, particulars of which we hope to announce shortly.

Roumania.—Mr. Consul Wardrop states in his report for 1908 that there are 3– miles of electric tramways working at Bucharest, 12½ at Jassy, 8¾ at Galatz and 11¼ at Braila. It is proposed to construct about 25 miles of new lines at Bucharest, and the Municipality are endeavouring to find capital.

St. Annes-on-the-Sea.—The Electricity committee recommend the Council to reduce the charges for supply of electric current for power, heating and cooking. It is proposed to charge for the first 100 units 2½d. per unit, second 100 units 2d. and all current over 200 units 1½d. per unit. A proposal to reduce the charge for lighting by 1d. per unit was not adopted.

Salford.—The Electricity committee are negotiating for the supply of electrical energy to the Broughton Copper Co. (minimum annual consumption 350,000 units), and to the Unity Rubber Co. (200,000). Application is to be made for sanction to a further loan of £6,500 for a booster, switchgear, cables, conduits, &c. Altogether £13,000 is to be spent to provide for next winter's anticipated demand, half being defrayed out of the depreciation and renewals fund.

South Africa.—The "British and South African Export Gazette" states that Capetown Municipality are about to place orders for 450 tubular steel electric light poles, eight transformer pillars, two 10 kw. transformers and 700 double-channel steel cross-arms. An electric hoist will shortly be required for the Cinderella Deep, and electric street lamps, mechanical stokers, fuel economisers, coal and ash-conveying plant, automatic combustion and temperature recorders will shortly be wanted by Johannesburg Corporation.

A company has been formed to promote a scheme for the construction of an electric mono railway between Johannesburg and Pretoria.

The Transvaal Government have recently appointed a Commission to inquire into the desirability of the establishment of large electric power companies in the Transvaal, and the probable effect of such companies on the Witwatersrand gold and coal industries, the Central South African railways, agriculture and irrigation, the employment of labour, &c. Also into the attitude of the State to such companies.

Southend-on-Sea.—The formal opening of the Cliff bandstand took place on 29th ult.

The opening ceremony was performed by the Mayoress (Mrs. Ingram) in the presence of a numerous company, including the Mayor (Ald. J. C. Ingram, J.P.), the chairman of the Entertainments' committee (Councillor E. J. Taylor), Aldermen Brightwell, Martin, Berry, &c.

Several novel electrical devices have been installed at the bandstand, including a series of eight flambeaux round the eaves of the stand and a row of concealed lights whose rays shine from the gutterings on to the eaves. The light from four arc lamps is thrown on to the stand from the four corners of the enclosure in which the stand is situated and the colour of the lights from these is changed every quarter of an hour. The enclosure, which is about an acre in extent, is surrounded by a series of festoons of white electric bulb lamps, surmounted at the apex of each festoon with a cluster of coloured finial lamps. The ribs of the roof of the bandstand are prettily illuminated with frosted pearl lamps.

Southwark (London).—Estimates are to be obtained for installing and maintaining a battery of 1,540 ampere-hours capacity for 15 years at an annual inclusive charge of £308. The cost of building a battery room is estimated at £900.

Spain.—In an interesting report on the trade of the district of Seville, the British Consul gives a list of imports into that country, incluidng (1) incandescent electric lamps, (2) arc lamps, (3) arc lamp carbons, (4) wires and cables, and (5) dynamo-electric machinery. Of (1) Germany has the entire monopoly and imported 6 cwts in 1908; of (2) Germany imported 3 cwt., Belgium 9 cwt., United Kingdom 56 lb.; of (3) Germany imported 15 cwt. and Belgium 12 cwt.; of (4) Germany 67 tons, Belgium 48 tons, France 3 tons; and of (5) Belgium imported 116 tons, Germany 49 tons, France 3 tons, United Kingdom 2 tons. The U.K. thus imports 2 tons 56 lb. =4,536 lb. out of a total of 67,576 lb. or, say, 7 per cent.

Mr. Consul A. Keyser's report on the trade of the Seville district for 1908 states that a German company has so far enjoyed a practical monopoly of providing electric power for Seville and is now completing large works on the Prado de San Sebastian to supply three phase and continuous current. Another electricity supply undertaking (the Hidro Electrica del Guadiaro) is being established to supply power in the district and will generate its current by means of the falls in the Ronda mountains. Mr. Keyser thinks that there should be opportunities for the supply of British electrical plant when this undertaking is in a position to compete with the existing works.

Dynamos imported in 1908 included 49 tons from Germany, 116 tons from Belgium (these being also of German origin), 27 tons from France and 2 tons from the United Kingdom.

The electric tramway is to be extended to Chiclana as soon as the construction of the Barcas steel bridge (for which a Spanish firm has the contract) is completed. The tramways are operated by the Spanish branch of the Thomson-Houston Co. and the cars in use were made in Zaragosa.

Sunderland.—In moving approval of the accounts of the electricity department for the past year (abstracted in our last issue), the chairman of the Electricity committee (Ald. W. W. Bruce) stated at the Council meeting on Wednesday that this was the first year they had had to report a decrease in the output.

If, however, the undertaking had been owned by a private company a dividend of 5 per cent. would have been declared and £5,000 carried to reserve. There were indications that shipbuilding was beginning to revive, and he hoped they would in the near future show a balance on the right side. It was intended to use the machinery at Dunning-street as a reserve plant.

Taunton.—On Tuesday the Council decided, on the recommendation of the Electricity committee, to adopt the following scale of charges for electric current for lighting: Up to 25 units per quarter, 6d. per unit; 500 units, 4½d.; 1,000, 4d.; over 1,000, 3d.; and for arc lamps outside business premises, 2d. per unit.

Telegraphists' Cramp.—Instructions have been issued by the Postmaster-General on the question of compensation under the Workmen's Compensation Act to persons suffering from what is known as telegraphists' cramp. The P.M.G. expresses the desire that all such cases shall be treated with the utmost consideration consistent with the interests of the service, and retirement will not be enforced as long as any reasonable alternative remains. There should be, the P.M.G. considers, no great difficulty in giving most affected officers employment on duties which do not involve the use of telegraph instruments. It is not intended that permanent preferential treatment should be arranged, but rather that the officers should be transferred to situations in which their manipulative disabilities will not be likely to stand in the way of their prospects of advancement. Officers will be required to rank at the foot of the new class on transfer, but, subject to the limits of the authorised scales, they will not suffer reductions of pay, provided they do their best to qualify in the new duties and make reasonable progress.

The P.M.G. has had under consideration the questions whether any steps can be taken to prevent the appointment of persons likely to be affected with cramp and as to how to prevent cramp among appointed officers.

United States.—The Southern Pacific Railway Co. are equipping a large power house at Fruitvale, Alameda County, to supply current for working electrically the present steam lines in the cities on the east side of the Bay of San Francisco. The plant will be of 10,000 H.P.

The Great Western Electric Power Co. finished in December last the work, on which they have been engaged since 1906, of making a tunnel 3 miles in length through a mountain, for conveying the entire waters of the Feather river to the electric power plant which the company are erecting at Las Plumas and which will be of 144,000 H.P. The project has already cost £2,000,000. The company will supply power to the Cowell Cement Works, Contra Costa County, by an overhead line 150 miles in length.

British Vice-Consul Mortimer states that there are nearly 700 miles of electric tramways in the City of Los Angeles (Cal.) and on the suburban lines the cars run from 40 to 60 miles an hour.

Uruguay.—The "Review of the River Plate" states that the public electric lighting of Monte Video is to be increased by the addition of 1,000 arc lamps.

The Uruguayan Legislature have approved a bill intended to give an impetus to the dairy industry and which exempts from import duty boilers, motors and other electrical machinery and apparatus for lighting and for motive power for butter factories and creameries which, with the machinery, &c., are also exempt from property and licence taxes for 10 years. A national exhibition of milk products is to be held next year.

Wakefield.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £615 for transformers.

Watford.—The Council have received sanction to a loan of £4,952 for extensions of the electricity works.

Wireless Telegraph Notes.—It is announced from Berlin that the German airship Gross II., while in flight, succeeded in establishing wireless telegraph communication with the earth.

Elaborate arrangements are being made by the British Admiralty to establish wireless telegraph stations along the coasts of the United Kingdom. In cases where private enterprise has been unable, from economical reasons, to establish stations on a sufficiently large scale the Admiralty are stated to be acquiring these stations and organising them in a thoroughly effective manner. A regular system of naval wireless stations at sea, extending along the coast, where training in wireless telegraphy in the Navy can be given, is being organised.

It is announced that the P. & O. Steam Navigation Co. has decided to instal wireless telegraph equipments on board some of their fine vessels trading with Australasia and New Zealand, the first vessel to be fitted up being the "Marmora."

Wireless Telephone Notes.—It is announced that an interesting series of experiments have been carried out by the French cruiser "Condé" with the wireless telephone system invented by two French naval lieutenants whose work in this direction has previously been mentioned in our columns (MM. Colin and Jeance). The "Condé" was successful, it is stated, in establishing communication with the shore up to a distance of over 100 miles. The land station was at Toulon.

Workhouse Lighting.—The Guardians of South Dublin Union last week decided to appoint a committee to discuss with the clerk of works the question of the number of lights required and that tenders be invited for lighting and heating the workhouse premises.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Accrington.—The total revenue of the electricity department for the year ended March 31 was £16,067. 9s. 7d., and the expenses were 8 338, leaving a gross profit of £7,729.

After paying interest and sinking fund charges (£5,187) there was a net profit of £2,542, of which £500 has been appropriated for the installation of rented wiring on consumers' premises, £293 for the purchase of meters and motors, and £684 for superseded plant. The balance to the credit of revenue account (£064 14s. 1d.) has been transferred to depreciation and renewals fund, which now stands at £2,422. The capital expenditure is £71,644, against £68,858. There are 550 consumers, representing 59,852 8 c.p. lamps connected. 2,972,612 units were sold, including 1,973,280 for lighting and power, 38,818 for public lighting and 960,514 for traction. The working expenses were 0·673d. per unit, against 0·87d.

Aldershot.—The total revenue of the electricity department for the year ended March 31 was £4.178. 7s. 5d., including £474. 9s. 2d. from public lighting.

Total expenses were £2,336. 18s. 6d., including £1,484. 8s. 5d. for generation and £440. 0s. 3d. for management. Gross profit was £1,841. 8s. 11d., and after paying interest and the instalments of money borrowed, the balance is £183. 13s. 8d. The equivalent of 14,908 8 c.p. lamps are connected. 224,771 units of current were sold (an increase of 17,709 units) of which 186,673 were for private and 38,098 for public lighting, and the average price obtained was 1·43d. for private supply and 2·72 for public supply. Total works costs were 1·68d. (against 1·69d.) per unit and total costs 2·33d. (2·33d.).

In moving the adoption of the accounts, the chairman of the Lighting committee (Mr. Calvert) stated that he hoped members would regard with considerable pleasure the favourable report the engineer (Mr. F. Garside) had been able to present. The undertaking was in a very healthy position. Not only was it working at a profit, but it was adding year by year to the Council's assets. £22,000 had been expended on the undertaking.

Bexhill.—The Council have approved the accounts of the electricity department for the year ended March 31.

Total income was £9,751. 15s. 9d., and expenses £5,113. 15s. 6d., leaving gross profit £4,641. 0s. 3d. After paying interest and sinking fund and placing £220. 9s. 1d. to depreciation, there was a net profit of £536. 6s. 10d. The total capital expended is £64,165. 19s. 11d., an increase of £3,127 over 1908. 558,137 units were sold (373,601 for private lighting, 184,136 for public lighting, and 400 by contract); there are 53 arcs and 304 incandescent pillars for public lighting, and the maximum supply demanded was 457 kw. During the year metallic filament lamps were adopted for street lighting, and the annual cost was reduced by about £300. An additional 500 kw. Belliss-Westinghouse generating set, a Babcock & Wilcox boiler and chain-grate stokers, induced draught plant, &c., were installed. The works costs have been reduced and the total costs were 2·19d. per unit, against 2·26d.

Blackpool.—The revenue of the electricity department for the year ended March 31 was £35,638. 11s. 4d., including £18,609. 5s. 7d. from sale of current for private lighting and power, £9,966. 6s. for current supplied to the tramways department, £1,043. 1s. 4d. for current supplied to the Blackpool, St. Annes and Lytham Tramways Co., and £6,019. 18s. 5d. revenue from public lighting.

The expenses amounted to £16,377. 8s. 10d., and included £9,732.19s.1d for generation, £1,575. 17s. 1d. for distribution, £1,498. 16s. 1d. for management and £1,417. 15s. 10d. for rent, rates and taxes. The gross profit was £19,760. 12s., and after paying interest and sinking fund (£12,505. 14s. 1d.) the net profit was £7,254. 17s. 8d., of which £4,000 has been transferred to general district fund, and the balance (£3,254. 17s.8d.) to reserve. 3,815,392 units were generated; 1,314,774 units were sold by meter for private lighting and power, 265,916 units were supplied to the public lamps, 1,471,670 were supplied for traction, and 377,696 were used on the works. The maximum load occurred on Sept. 12, and amounted to 2,584 kw.

Bury (Lancs.)—For the year ended March 31 the income of the Electricity department was £17,089. 3s. 8d., including £16,727. 2s. 9d. from the sale of electric current.

Working expenses were £8,098. 10s. 8d., gross profit £8,990. 13s. After meeting interest, sinking fund contributions, &c., the net profit was £2,914. 10s. 10d. The total capital expended is £93,592. 18s. 2d., an increase of £2,100. 17s. 5d., but the outstanding loan is £72,042. 3,255,116 units were sold (1,536,943 to private consumers, 1,623,603 to the tramways department and 56,814 for the public lamps). There are 36 arc and 21 incandescent lamps for public lighting, and the maximum supply demanded was 1,695 kw.

In the report of the engineer and manager (Mr. S. J. Watson) it is stated that 28 additional consumers, representing an equivalent of 15,098 8 c.p., were connected to the mains during the year, including 66 additional motors (of 496½ h.p.). These figures represent substantial increases on the 1908 figures, and the total number of motors connected is 275, of an aggregate of 20,26½ h.p. Up to the present the electric drive has been adopted in over 30 distinct industries, and this number is being constantly added to. In the list supplied by Mr. Watson there are 73 local engineering firms, 18 woodworkers, 14 printers and 18 cotton and woollen mills using electric power, while there are also a large number of fans, lifts, cranes, pumps, &c., connected to the mains. The total costs were 1·03d. against 1·02d., generating costs being 0·57d. against 0·58d. The average price obtained was 1·25d. per unit, against 1·34d. The combined load factor for lighting and power increased from 19·9 to 20·9 per cent. A new generating station is being erected at Chamber Hall.

Colchester.—The accounts of the electricity department for the year ended March 31 show net profit £269. 7s. 1d., after deducting a deficiency of £22 on the previous year's working.

In moving the adoption of the annual report and accounts of the electricity department, the chairman of the Electricity committee (Mr. Barritt) said the result of the past year's working had been satisfactory. There was a small decline in the revenue (about £13), and there was a reduction in the number of units supplied for power and traction, but the sales to ordinary lighting consumers had increased in spite of the extended use of metallic filament lamps. The reduction in cost of coal, due largely to the use of mechanical stokers, was £1,739. Gross profit was £5,949, increase £1,301. Interest and redemption amounted to £5,081, increase £407. 9s. 6d. There had been appropriated for the reduction of suspense account £741, increase £455. They had written off prepayment installations the sum of £403, and off mechanical stokers £337, the money for both purposes being found out of revenue; and they had expended £56. 11s. 11d. in the purchase of arc lamps for hire. The reserve fund stood at £1,857, and the department proposed to reduce that amount by paying therefrom £501, then carrying to the credit of reserve the net surplus of the year. The reserve would then stand at £1,603. 13s. 10d.

The accounts of the tramways department were also presented and disclosed a deficit of £3,940. The chairman of the Tramways committee stated that general maintenance and repairs had cost £113 less, and maintenance of cars £482 less; but overhead equipment, trolley wire, &c., cost £319 more. Traffic revenue had been reduced about ¼d. per car-mile.

Leigh (Lancs.)—The total income of the electricity department during the year ended March 31 was £7,767. 5s. 11d.

Total expenses were £4,807. 11s. 1d. Interest absorbed £1,273. 6s. 1d. and sinking fund and repayment of loans £1,326. 8s. 9d., leaving a net profit of £360. 0s. 2d.

The report of the borough electrical engineer (Mr. A. T. Smith) states that, notwithstanding the extended use of metal filament lamps, the consumption of current increased by 8·9 per cent. There are 399 consumers, representing 20,360 8 c.p. lamps (and including 174 motors of 1,085 h.p.) connected to the mains. The maximum load was 440 kw. and the load factor 20 per cent. The total generation and distribution charges were 1·34d. per unit, against 1·26d., and the total costs were 2·30d., against 2·25d.

Lincoln.—The accounts of the electricity department (of which an abstract appeared in our last issue) have been adopted by the Corporation.

The output for the year ended March 31 was 1,718,612 units (460,782 for private lighting, 63,775 for public lighting, 106,151 for power, 915,116 to Messrs. Clayton & Shuttleworth and 172,788 for traction), an increase of 264,790. The increase in the demand for current for public and private lighting has been affected by the general use of metallic filament lamps. The increase in lamp connections was 4,438 equivalent 8 c.p. lamps (2,133 for lighting and 2,305 for power) making the total connections equivalent to 68,772 8 c.p. Works costs were 0·899d., against 1·058d., and total costs 1·454d., against 1·671d. per unit.

The tramways department has also had a successful year, working expenses being 5·60d. per car-mile run, against 6·10d. in 1907-8. Total receipts for the year were £6,104. 5s. 10d., and expenditure was £3,648. 2s. 10d., leaving gross profit £2,456. 3s. After paying interest and sinking fund, there was a deficit of £98. 1,516,658 passengers were carried and 156,190 car miles run.

In the report of the city electrical engineer (Mr. Stanley Clegg) it is stated that there was a saving in all items of expenditure, and about £82 was chargeable to the direct upkeep of the G.B. system. The amount was in excess of last year's costs, but was explained by the fact that the stud heads throughout the track, which had got rather worn, had been lifted and packed up so that they should now last another year or 18 months and give the five years' life he (Mr. Clegg) estimated for them. He had taken the average working costs of 75 other municipal tramways on the overhead system for the year 1908, and he obtained an average of 6·37d. per car-mile run, as total cost, and at Lincoln they were 0·77d. below that average, an improvement of 0·56d. upon last year. Mr. Clegg states that Lincoln now takes 20th place on the list of municipal tramways with low working expenses per car-mile.

Morley.—The report of the borough electrical engineer, Mr. J. E. Ellis, for the year ended March 31 states that the gross profit was £279. 11s. 4d. against £1,087 for the previous year, and after providing for payment of £2,078. 12s. 8d. for interest and sinking fund charges (against £2,004. 10s. 5d.) there was a net deficit of £1,799. 1s. 4d. In view of the almost general use of metal filament lamps the Electricity committee have decided to increase the price of current from lighting for 4d. to 5d. per unit.

New South Wales Tramways.—In the report of the Chief Commissioner of N.S.W. Government Railways and Tramways (Mr. T. R. Johnson) it is stated that the revenue of the tramways (which are mainly electrical and have a length of 148 miles) for the past quarter was £285,099, increase £20,781 compared with corresponding period of 1908.

The expenditure was £215,661, increase £19,375. 48½ million passengers were carried, an advance of 3½ millions. The percentage of expenditure to earnings was 75·63. During the quarter seven extensions were opened for traffic, adding 14 miles 13 chains to the system.

Sunderland.—The traffic revenue for the year ended March was £60,223. 19s. 4d., and the total income £60,425. 12s. 7d. (9·83d. per car-mile), a decrease of over £8,500.

Traffic expenses were £17,408. 4s. 6d., general expenses £5,168. 7s. 2d., general repairs and maintenance £3,842. 5s. 3d. and power expenses

£12,432. 5s. 2d., total £38,851. 2s. 1d., leaving a balance of £21,574. 10s. 6d. After paying interest (£8,127. 4s. 10d.) and income tax (£846. 12s. 7d.), the balance (£12,974. 11s. 1d.) was carried to appropriation account. Sinking fund absorbed £9,775. 10s. and £2,117. 15s. 4d. was placed to reserve and renewals, the balance being absorbed by various small payments. 14,857,779 passengers were carried and 1,474,900 car-miles run. The percentage of working expenses to receipts were 63·35 and the average fare per passenger was 0·972d.

Swansea.—The net profit on the past year's working of the electricity department was £1,748. 3s. 3d., and with £789. 15s. 3d. from 1908 the disposable balance is £2,157. 18s. 5d.

In a discussion on the accounts the chairman (Mr. A. Sinclair) stated that the receipts from the sale of current for power were £7,847, and that branch was the sheet anchor of the undertaking. There are 1,379 consumers, an increase of 217.

Warrington.—The total income of the Electricity department for the year ended March 31 was £16,057. 12s. 11d., and working expenses were £9,318. 2s. 10d., leaving a gross profit of £6,739. 10s. 1d.

After paying interest (£2,851. 7s. 10d.) and sinking fund (£3,110.17s.1d.) there was a net profit of £942. 12s. 8d., a decrease of £1,271 compared with 1908. The number of units sold was 2,866,566, including 1,986,302 to private consumers, 78,250 for public lighting and 509,110 for traction. The works costs came out at 0·560d. per unit against 0·607d., and the total cost 0·774d. against 0·809d. The sale of current for lighting has been affected by the use of metallic filament lamps and the demand for power has been retarded by depression in trade. Reductions in the charges for current for power and lighting have been made and are having a beneficial effect in introducing new consumers.

Wednesbury.—The total units sold by the electricity department during the past year were 223,708, against 176,406 in 1907-8.

The revenue were £2,086 and the expenditure £1,648, leaving a balance of £438. The report states that the increased profit anticipated during the current year, due to the economies effected in generation by reason of the new plant, will be sufficient to pay the interest and sinking fund charges (£718) in respect of the new loans raised to carry out the changes in the system of generation. Owing to the progress of the undertaking, further plant will shortly be required to meet increased demands for power and lighting. The equivalent of 23,020 8 c.p. lamps is connected to the mains.

West Bromwich.—The annual report and accounts of the Electricity department were adopted at the last meeting of the Corporation.

The number of units sold for traction were 922,516 (against 1,010,878 units in 1907-8), for lighting 287,222 (223,457), for power 700,543 units (421,900), public lighting 101,704 units (against 108,655, the total sales being 2,011,985 units (1,824,887). The increase in the sales for power was the largest experienced in any year since the inception of the undertaking, due to the reduced charges adopted. There was a net increase of 20 consumers during the year, making a total of 328, representing 55,284 8 c.p. (including 142 motors of 1,300 H.P.) connected to the mains. The total loan debt is £67,421. 15s. 8d.; capital expenditure amounting to £2,369. 5s. 4d. was incurred during the year, bringing the total expenpenditure to £73,609. 2s. The total revenue was £13,596. 5s. 7d.; and the annual expenses £6,740. 5s. 11d. (against £6,914. 16s. 3d.), leaving a gross profit of £6,855. 19s. 8d. (£6,056. 12s. 4d.) After paying interest, sinking fund, &c., the net profit is £2,412. The department has on hire 71 motors (of 412 H.P.), 97 arc lamps, a number of Nernst and other lamps, and 114 complete installations.

Worcester.—The total income for the year ended March 31 was £16,699, expenses £6,863, gross profit £9,835.

After paying interest (£4,412) and sinking fund (£5,263) the surplus was £160. The receipts for current have been affected by the adoption of metallic filament lamps, but the year's result is considered satisfactory. There has been a good increase in the number of consumers and in the demand for current for power. Works costs were reduced from 0·889d. to 0·795d. per unit sold and the total costs from 1·128d. to 1·011d.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Belfast Tramways and Electricity committee invite tenders for supply, delivery and erection of feeder panels for lighting switchboard. Specification and forms of tender, &c., from the city electrical engineer, Mr. Thos. W. Bloxam, Corporation Electricity Works, East Bridge-street, Belfast. Tenders with the Town Clerk, City Hall, Belfast, by noon, June 26. See also an advertisement.

Bedford Corporation invite tenders from boilermakers for the supply and erection of one 30 ft. by 8 ft. Lancashire boiler, with steam pipe work and superheater. Specification and form of tender from the borough electrical engineer, Mr. R. W. L. Phillips, A.M.I.E.E., Electricity Works, Cauldwell-road, Bedford. Tenders by noon, June 26. See also an advertisement.

Tenders are invited for the supply of a 15 ton overhead travelling hand crane to the city of Melbourne, Victoria. Tender forms, conditions, &c., from the agents of the City Council, Messrs. McIlwraith, McEacharn & Co., Proprietary (Ltd.), Billiter-square Buildings, London, E.C. Tenders to the Chairman of the Electrical Supply committee, Town Hall, Melbourne, by 2 p.m. of August 4. See also an advertisement.

Devonport Corporation Electricity committee invite tenders for the supply of stores for the 12 months ending June 30, 1910, including d.c. meters, paper-insulated cables, rubber-covered wires, flexibles, cutouts and lubricating oils. Particulars and forms of tender from the borough electrical engineer (Mr. J. W. Spark), Newport-street, East Stonehouse, Devon.

The Electricity committee of Stepney (London) Borough Council, invite tenders for the supply during the period ending June 30, 1911, of ampere-hour meters, demand indicators and time switches, and arc lamps. Tenders to the borough electrical engineer and manager, Mr. W. C. P. Tapper, 27, Osborn-street, Whitechapel, E., by noon June 14.

Salford Electricity committee invite tenders for the supply, delivery and erection at the Corporation electricity station, Frederick-street, Pendleton, of a battery booster and switchgear. Specification and form of tender from the borough electrical engineer, Mr. Victor A. H. McCowen, M.I.E.E. Tenders to the Chairman of the Electricity committee, by noon of Monday, June 14.

London County Council want tenders by 11 a.m. June 22 for the roadwork and platelaying of the authorised tramways in Southwark-street and Blackfriars-road and on the Victoria-embankment east of John Carpenter-street. Specification, &c., from the Chief Engineer, County Hall, Spring-gardens, S.W.

London County Council require tenders by 11 a.m. June 22 for the supply and fixing at Greenwich generating station of steam, exhaust, feed and drain piping, valves, &c., and cast-iron condenser water piping, valves, &c. Forms from the offices, Spring-gardens, London, S.W.

Burslem Corporation require tenders by noon June 29 for a 600 kw. steam generator, or (alternatively) a 600 kw. turbo-generator (450 volts), condensing plant, water tube boiler and switchgear. Specifications from the Electrical Engineer.

Dudley Guardians want tenders by 10 a.m., June 18, for supply and erection of 10 H.P. motor, shafting and belting in the workhouse laundry. Specification, &c., from the Clerk, St. James'-road, Dudley.

Whitehaven Harbour Commissioners require tenders by 10 a.m., July 20, for lighting the harbour, quays, &c., electrically or otherwise. Particulars from the Harbour Master.

Eccles Electricity committee want tenders by 10 a.m., June 21, for supply and erection of water softening and purifying plant. Specifications, &c., from the Borough Electrical Engineer.

Ipswich Corporation want tenders by June 23 for one year's supply of rubber insulated wires, and paper insulated lead sheathed cables. Specifications from the Chief Engineer.

Halifax Tramways and Electricity committee want tenders by June 18 for supply of lead-covered paper-insulated cable. Particulars from the General Manager, Skircoat-road, Halifax.

Felixstowe and Walton Council want tenders by noon, June 21, for cooling tower and tank, water softener and ventilating shaft. Specifications from Mr. R. P. Wilson, 66, Victoria-street, London.S.W

Gravesend Electricity committee require tenders by July 3 for the supply and erection of an automatic stoker.

Maidenhead Corporation invite tenders for the supply of a 150 kw. direct-driven Diesel generator. Tenders by noon of 23rd inst.

Tenders are invited for the supply of 150 relays (non-polar) to the Postmaster-General's Department in the State of New South Wales. Tender forms and general conditions may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply of a branching multiple magneto switchboard to the Postmaster-General's Department in New South

WALES. Tender forms and specification may be obtained at the Commonwealth Office, 72, Victoria-street, London, S.W.

Chinese Contracts.—In our Contracts Open pages there will be found an invitation from the Chinese Government, through its representatives, for sealed proposals for the erection and completion of a group of buildings to be used as a Bureau of Engraving and Printing in Peking, China. It will be noted that the plans and specifications are on file at, amongst other places, the Chinese Consulate-General, 88, Fenchurch-street, London, E.C. Tenders from European contractors must be filed with the Chinese Legation at Washington, D.C., not later than July 15th next. The conditions of the contract are instructive.

TENDERS RECEIVED AND ACCEPTED.

The following tenders have been accepted by Salford Corporation for annual supplies :—

Liverpool Electric Cable Co., rubber-covered cable : Electric & Ordnance Accessories Co., switches and fuses ; J. H. Tucker & Co., cut-outs ; H. R. Mansfield, stoneware conduits ; Albion Clay Co. stoneware conduits and pipes, cable protectors and cable bearers ; Key Engineering Co., fibre pipes ; Howard Asphalte Troughing Co., asphalte bridges ; A. Grenier & Co., W. T. Glover & Co., cables ; Veritys, motor starters ; British Thomson-Houston Co., carbon filament glow lamps ; W. T. Henley's Telegraph Works Co., Callender's Co., L. Andrew & Co., Baxendale & Co. and Ross & Co., cable accessories.

Hackney (London) Council have accepted the following tenders :—

British Insulated & Helsby Cables, disconnecting network boxes, meter boards, and resin ; W. T. Henley's Telegraph Works Co., linen tapes and hessian tapes ; General Electric Co., yellow flame arc lamp carbons ; Doulton & Co., troughing ; W. Lucy & Co., straight-through joint boxes, buried network boxes, dead-end and house service boxes, service fittings and glands, fuse boxes, service tee boxes, frames and covers, &c. ; Sykes & Sugden, fuse boxes ; British Electrical Trades' Supply & Bitumen Co., box compound ; J. Smart & Son, pitch compound ; and Sloan Electrical Co., arc lamp carbons.

Stockport Council have accepted the following tenders :—

Frank Pearn & Co., boiler feed pump, £138 ; H. Parkes, ironwork for overhead bunkers, £25. 7s. 2d. ; Brecknell, Munro & Rogers, two trolley standards at £5 each and 12 sets of ball races £1. 7s. 6d. per set ; Edgar Allen & Co., loop points, £14. 5s. ; Horner & Co., taking out two cross-overs and laying new one, £137. 10s. ; J. & W. S. Briscoe, relaying loop at Gatley terminus, £52. 7s. 8d. ; John Spencer, tramway poles light, £3. 18s. each, medium £5. 0s. 3d., heavy £6. 11s. 3d.

Sheffield Tramways committee have accepted the tender of W. H. Allen, Son & Co. for dismantling No. 1 condenser, and for supply and erection at the Kelham Island power station of a surface condensing plant for £1,933. The Electric Light committee have accepted the tender of Edgar Allen & Co. for main feeder cable, and an order has been placed with W. T. Glover & Co. for 50 tons of electrolytic copper wire and 50 tons of lead at current prices.

Hackney Electricity committee received tenders from 10 firms (three foreign and seven British) for underground cables.

The three lowest tenders would work out at the following prices for one year's supply : Union Cable Co., £3,288. 17s. ; Aubert, Grenier & Co., £3,392. 4s. 10d. ; British Insulated & Helsby Cables, £3,537. 15s. 4d. Having considered all the circumstances, the committee recommended the acceptance of the tender of the British Insulated & Helsby Cables.

On Monday York Corporation approved the recommendation of the Tramways committee to accept the tender of Dick, Kerr & Co., at £78,827 for the construction and electrical equipment of tramways in the city.

Swansea Council have accepted the tender of the Electric & Ordnance Accessories Co. for motors at £240, and that of Brook, Hirst & Co. for starting switches at £70.

Sheffield Corporation have accepted the tender of John Walsh (Ltd.) for the installation of telephones, &c., at the new buildings at Lodge Moor hospital.

Rotherham Council have accepted the tender of Halley's Engineering Co. at £685 for supply of a motor tower wagon.

Warrington Council have accepted the tender of the St. Helens Cable Co. for supply and laying of cables at £692.

Babcock & Wilcox have received an order for a boiler and chain grate stoker for Johannesburg municipal electricity department.

Farnworth Council have accepted the tenders of Cowans Limited for circuit-breakers and the British Westinghouse Co. for cables.

The Postmaster-General's Department, Brisbane, Queensland, have accepted the tender of British Insulated & Helsby Cables for Leclanché zincs.

Sale by Auction. Mr. Robert H. Ruddock, 71, Fleet-street, London, E.C., announces for sale on Thursday, June 17, at one o'clock, the nearly new plant, machinery and stock of the Automatic Engineering Co., 152, Clarence-road, Clapton, London, N.E. The sale includes a quantity of modern automatic machine tools by Brown & Sharp, A. Herbert (Ltd.), Cincinnati Machine Tool Co., Flather Mfg. Co., Owen Machine Tool Co. and Bradbury & Co. In an advertisement on another page some of the items to be offered are set out, and all further particulars can be obtained from the auctioneer, from Messrs. Howard Howes & Co., 27, Clements-lane, London, E.C., and from Messrs. Ranger, Burton & Frost, 17, Fenchurch-street, London, E.C.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

An advertisement contains particulars of some electrical engineering plant (including two 110 H.P. d.c. Siemens motors, with starter, &c., one 105 H.P. single-phase motor, two 4 H.P. electric capstans, one 2-ton electric derrick crane and one 5 H.P. electric locomotive) which is for sale.

Business for Sale. Messrs. Josolyne, Miles & Co., 28, King-street, Cheapside, E.C., advertise for sale, as a going concern, the manufacturing electrical engineering business of Messrs. Laing, Wharton & Cunnington, 7, Great Newport-street, W.C.

Patents Development.—The proprietors of patents No. 2,274/1904 relating to "Improvements in Telegraphic Transmitters," and No. 5,944/1902, relating to "Improved Telegraphic Systems," are desirous of entering into arrangements by way of licence and otherwise for exploiting the same in this country. Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

The proprietors of patents No. 13,427/1906, for "Dynamo Electric Machines," and No. 8,575/1905, for "Incandescent Vapour Lamps," also desire to enter into arrangements for their exploitation in this country. Apply to Messrs. Herbt. Haddan & Co., 31 & 32, Bedford-street, London, W.C.

Meter Contracts.—Edinburgh and Glasgow Corporations have placed orders with the British Thomson-Houston Co. for part of their yearly requirements in mercury meters. The B.T.-H. mercury meter it will be remembered, has a characteristic curve which closely approximates a straight line from the lowest load to full load, the meter starting easily with a load equal to one half per cent. of its rated capacity. These meters have also the highest possible ratio of torque to weight, and there are no hysteresis errors and other troubles, owing to their being no compounding.

CATALOGUES, &c.

SIEMENS GLASSWARE.—Messrs. Siemens Bros. Dynamo Works have ready a new list giving details of their latest designs of glassware. The opening pages deal with a variety of new and select designs of glass shades suitable for high-voltage tantalum or other metal filament lamps which can be obtained in various types of finish at remarkably low prices. A number of shades are also illustrated suitable for low-voltage tantalum and other metal or carbon filament lamps of low voltage in opal, satin or crystal etched finish. Special shades, suitable for all classes of interior decorations and electric light fittings are also listed. Messrs. Siemens Bros. have special facilities for obtaining highly artistic glassware in large quantities, and can place on the market glassware of exceptional value. The publication under review is of particular interest to the trade and also to electrical consumers, and those interested in the purchase of glassware should obtain a copy, which will, we learn, be sent free to any address on request.

WILLANS' TURBINES.—Last week we described in THE ELECTRICIAN the progress which Messrs. Willans & Robinson were making in the turbine field, especially with regard to the vacuum turbine. They have now issued a pamphlet dealing with the machines of the Willans-Parsons type, which are by this time well known to our readers. The pamphlet gives a general and fully illustrated description of the various types of this machine now made. Illustrations are also given of the shops at Rugby, where these turbines are made, and of some finished machines in operation at the works of various firms.

THE "BOUVERIE" INDICATING BELL PUSH.—The Sun Electrical Co. have placed on the market a new type of bell push, which is described in a pamphlet we have recently received. This push contains a buzzer which vibrates as long as the bell is ringing, so that a reliable indication of the working of the installation can easily be obtained.

Elliott's Instruments.—The various types of instruments made by Messrs. Elliott Bros., of Lewisham, S.E., are by this time too well known to call for special reference to them individually, but it is, all the same, interesting to note that the firm have just issued a binder which contains a number of pamphlets dealing with all their standard goods. These lists cover a very wide range, as they deal with such widely different items as switchboard and optical instruments of various kinds. Not long ago we drew attention to Messrs. Elliott's enterprise in placing a micrometer on the market. It must not be thought that this launching out into a new line in any way means that they have abandoned any of their other well-known goods, for these all appear to be as much in demand as ever.

Telegraph and Electrical Instruments.—We have received from Messrs. Snell & Tinsley, a fully illustrated catalogue dealing with the various instruments made by them. These include condensers, duplex balancing apparatus for telegraph work, potentiometers, voltboxes, standard cells, Wheatstone bridges, resistance coils, galvanometers, wattmeters, transformers and clocks. Each type of instrument made by this firm is fully illustrated, and described in the catalogue, which should be in the hands of everyone interested in telegraph work.

"Key" Lead-covered System of Wiring.—As is well known, in a lead-covered system of wiring there is a tendency for any moisture present to creep along the insulation of the cables. This disadvantage is, it is claimed, avoided by using the "Key" patent joint boxes. These are fitted with terminal blocks, to which all connections can be made without the use of soldering iron being necessary. The Key Engineering Co. in the pamphlet describe and illustrate the various advantages of and equipment connected with the system.

The O.S. Wiring System.—Messrs. Siemens Bros. & Co. have issued a neat pamphlet dealing with this excellent wiring system. A perusal gives a good idea of the advantages claimed for the O.S. methods and this way of placing it before their clients has much to recommend it.

Fittings for Holophane Glass.—In a list issued by Messrs. Julius Sax & Co. particulars are given of their fittings for use with "holophane" glassware. In their design attempts have been made to obtain artistic merit without sacrificing efficiency of illumination. Such glassware as this practically becomes necessary when metallic filament lamps are used, owing to the glare of light when these new lamps are left totally uncovered. We commend readers who are interested in this subject to visit the showrooms of Messrs. Julius Sax & Co., and personally inspect the various fittings there displayed.

"Acme" Time Meters.—The "Acme" Meter Co. have sent us a number of pamphlets dealing with the saving in current consumption that can be effected by using their meters on tramcars. The pamphlets contain opinions of a number of tramway managers on the value of meters on cars, a list of tramways using "Acme" time meters, an article on bonus systems, specimens of the cards used, and price lists containing details of the two types of time meter.

"Leuconium" Lamps.—The Stearn Electric Lamp Co. have issued a pamphlet giving prices and other details of their "Leuconium" metal filament lamps of both the ordinary and "Nevaout" types. Reductions in price have recently been made in these lamps.

Motor-starting Gear.—Mr. Geo. Ellison, of Birmingham, has earned a good reputation for his well-designed starting gear for motors, and in a recently-issued pamphlet he deals with the question of automatic release starting gear for alternating-current motors. Full details of the way in which this apparatus works are given.

Pelton Wheel Governors.—Mr. Percy Pitman, of Acton, London, forwards a copy of a circular dealing with his hydraulic governor. The way in which this apparatus is worked is described and illustrations are given.

Steel Wings.—The Steel Wings Wind Turbine Co., of Westminster, send us descriptive pamphlets of their new wind turbines for electric lighting and power work. The turbines embody several new features in the application of wind to the production of power. It is claimed that high efficiency is obtained, and the cost is much lower than in any similar type of windmill at present on the market.

Simplex Metallic Filament Lamps.—Simplex Conduits have ready a sheet showing reductions in the standard prices of their metallic filament lamps.

Tramway Economies.—Messrs. Chamberlain & Hookham are issuing a pamphlet dealing with meter questions, especially as regards their installation on tramcars.

Hawkes Electric Baths.—From Messrs. O. C. Hawkes has come to hand a circular dealing with their new electric baths. The booklet includes a description of a cabinet bath, which can be used for a variety of purposes. In design, construction and general finish it embodies, it is claimed, all the latest improvements on this class of article, and we recommend a perusal of the circular to all those interested in the subject.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during May, 1909, and (*b*) during the current year from Jan. 1 to May 31, with the increases or decreases compared with the corresponding periods of 1908:—

Electrical machinery (*a*) £37,295 (decrease £21,400), (*b*) £191,223 (decrease £93,597); telegraph and telephone cables (*a*) £8,512 (decrease £1,257), (*b*) £40,870 (decrease £16,593); telegraph and telephone apparatus (*a*) £14,594 (increase £892), (*b*) £75,121 (decrease £13,330); other electrical wires and cables, rubber insulated (*a*) £3,804 (decrease £2,853), (*b*) £21,826 (decrease £11,626); with other insulations (*a*) £7,516 (decrease £1,602 (*b*) £45,377 (decrease £6,218); carbons (*a*) £8,700 (decrease £4,455), (*b*) £54,765 (decrease £19,218); glow lamps (*a*) £23,563 (decrease £2,045), (*b*) £185,234 (increase £82,799); arc lamps and electric searchlights (*a*) £915 (increase £553), (*b*) £8,545 (increase £6,982); parts of arc lamps and searchlights (other than carbons) (*a*) £6,124 (increase £2,873), (*b*) £22,246 (decrease £109); primary and secondary batteries (*a*) £2,832 (decrease £1,710), (*b*) £21,113 (decrease £198). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £85,469 (decrease £11,986), (*b*) £517,969 (increase £15,769).

Exports.—The exports of electrical machinery, material, &c. (*a*) during May, 1909, and (*b*) during the current year from Jan. 1 to May 31, and the increases and decreases compared with the corresponding periods of 1908, are as follows:—

Electrical machinery (*a*) £105,649 (increase £9,989), (*b*) £579,814 (increase £23,421); telegraph and telephone cables (*a*) £41,545 (increase £8,829), (*b*) £187,279 (decrease £36,912); telegraph and telephone apparatus (*a*) £28,952 (increase £11,504), (*b*) £94,577 (increase £26,381); other electrical wires and cables, rubber insulated (*a*) £21,346 (decrease £5,149), (*b*) £110,160 (decrease £9,323); with other insulations (*a*) £24,872 (decrease £386), (*b*) £104,795 (decrease £8,201); carbons (*a*) £890 (decrease £120), (*b*) £3,361 (increase £186); glow lamps (*a*) £7,068 (increase £2,183), (*b*) £29,599 (increase £10,123); arc lamps and searchlights (*a*) £1,381 (decrease £2,968), (*b*) £8,445 (decrease £1,223); parts of arc lamps and searchlights (other than carbons) (*a*) £1,250 (increase £258), (*b*) £7,544 (increase £1,269); primary and secondary batteries (*a*) £7,800 (increase £2,800), (*b*) £46,201 (increase £23,813). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £162,784 (increase £12,744), (*b*) £739,093 (increase £5,271).

BANKRUPTCIES, LIQUIDATIONS, &c.

A meeting of creditors of the Electrical Works & Development Co. (Ltd.) will be held on June 28 at Messrs. Barnes, Dunn & Boughton's, 52, Gracechurch-street, London, E.C.

Mr. E. H. Hawkins, 4, Charterhouse-square, London, E.C., has been appointed trustee in the bankruptcy of Charlotte Rix, "the person or one of the persons trading as Bridgewater & Wright," electrical engineers, 78, York-road, London, N.

Conduit & Insulation Co. (Ltd.) (in Liq.).—Notice is given that a second and final dividend of 3s. 3d. in the £ (making in all 8s. 3d. in the £) has been declared in the matter of the liquidation of the Conduit & Insulation Co. (Ltd.). The estimated receipts were £6,118. 3s. 11d.; the total realised was £2,578. 4s. 10d. Of this amount, law costs, auctioneer's charges, hire of room, postages and liquidator's remuneration absorbed £641. 3s. 1d., and unsecured creditors received £1,962. 3s. 2d. Any further particulars can be obtained from Mr. C. J. March, liquidator, 23, Queen Victoria-street, London, E.C.

COMPANIES' MEETINGS AND REPORTS.

ANGLO-PORTUGUESE TELEPHONE CO. (LTD.) The report for 1908 states that steps have been taken to safeguard the company from any serious consequences arising from fluctuations in exchange during the current year. The gross revenue was £42,048, of which operating, management and general expenses absorbed £22,517, and royalties to the Portuguese Government £1,323, leaving gross profit £18,208. After providing for interest (£2,433), sinking fund (£1,167) and income tax (£532) the net profit was £14,075, added to £3,745 brought forward. The directors recommend a final dividend of 5 per cent. (tax free), making 8 per cent. for the year. £5,000 is put to reserve and £4,820 carried forward

ARON ELECTRICITY METER (LTD.)—At the meeting on Wednesday the chairman (Mr. Hugo Hirst) said that, roughly speaking, all the figures referring to trading on the debit side of the profit and loss account were double those of the previous financial period, as were also the gross profits, which this year represented £34,000, against £17,000 for the preceding half-year. After payment of the 7 per cent. dividend now recommended

by the directors, there would be now only 6 per cent. in arrear for preference dividends. With a continuance of business such as they had enjoyed for the past three or four years the time was drawing very near when the holders of ordinary shares would commence to take their share in the yearly results. They were at present commencing additional buildings at their factory in Schweidnitz, and they had to build new premises in Paris, where their business was showing great progress. They had extended their electric clock business in Germany, which required additional capital, and they had pushed on the taximeter business, which had absorbed nearly £10,000 additional capital. The outlook was very reassuring, and they hoped to reap in the near future the benefit of those extensions. Since the formation of the company they had spent nearly £70,000 in the improvement of their land, buildings, machinery, &c., and they had written off nearly three-quarters of that added sum. Allowing for depreciation, half of that amount, therefore, could be reasonably considered to have been used for the reduction of goodwill and patents, and if to that amount be added the £19,000 reserve which they had put aside, the item for goodwill and patents, which in former years was so much discussed, stood in their books at a perfectly reasonable amount. Taximeters were not generally sold outright, they were hired out. That meant an immediate demand on capital for the purpose of stock, while the benefits came back over a number of years. A company had been formed in Brussels (in which they held two-fifths of the capital) for hiring out taximeters in Belgium. The latter company had already received orders for several hundred instruments, which had partly been delivered and which were in service in Brussels. The taximeter business might be a large factor in the future, though he would like it to be understood that that department had not yet contributed to the profits. They had to thank for those their old Aron Meter business. They had now a line of instruments in direct and alternating clock and motor meters, in two-rate meters, in accumulator meters, pre-payment meters, and, in fact, in every kind of instrument suitable for any conditions required by electrical industry. Thanks to the skill of Prof. Aron and his staff, they could compete favourably with every type, and with any other make offered in any part of the world. Sir James Pender seconded the motion for the adoption of the report and accounts, which was carried unanimously.

KALGOORLIE ELECTRIC TRAMWAYS (LTD.) At the meeting last week Mr. A. H. P. Stoneham said he thought the terms they had got from the power company for the supply of power were fair. If it were not for the question of renewals they would be able to recommend a dividend, but with the renewal question looming ahead they felt it was necessary to retain the surplus profits for building up a fund against the time when the renewals became due.

LEAMINGTON & WARWICK ELECTRICAL CO. (LTD.)—At the meeting last week the directors' report stated that capital expenditure during the year was £779. The accounts showed a credit balance of £5,372 from the tramways and electricity supply, and sundry receipts amounted to £42. Deducting £1,354 for expenses and interest, and £350 provision for renewals, the balance was £2,265, making, with £139 brought forward, £2,405. After paying preference dividend, and 2 per cent. dividend on the ordinary shares for the year (£1,351), £282 remained to carry forward.

TAUNTON ELECTRIC TRACTION CO. (LTD.)—The revenue for 1908 was £2,301. 0s. 9d., compared with £2,438. 1s. 4d. in 1907; expenses were £2,036. 18s. 10d., against £2,009. 7s. 1d. Deducting expenses (including £200 to renewals fund) the surplus is £35. 19s. 11d., added to £32. 16s. brought forward. These amounts are carried forward. Arrangements have been made with the British Electric Traction Co. for the financing of the Rowbarton extension, and a contract has been let for the construction of the permanent way. Taunton Corporation has agreed to make a substantial reduction in the price of electric energy as soon as the extension is opened for traffic.

UNITED ELECTRIC TRAMWAYS OF MONTE VIDEO (LTD.)—The report for the year ended March 31 states that the conversion of the whole of the company's lines from animal to electric traction was completed during the year. Including various extensions, there is now a total of 80 miles of single track in operation. A further extension to Colon of about 3½ miles will be opened as soon as the necessary crossings under the Central Uruguay Railway have been completed. Additional rolling stock and plant for the power house has been provided to meet pressing needs. The profit and loss account, after providing for administration expenses and charging £35,107 for interest, shows a credit balance of £49,469 added to £11,963 brought forward. After writing off various amounts, setting aside £2,100 for sinking fund and transferring £10,000 to a renewals and contingency account and paying interim preference dividend, the directors now recommend payment of the dividends on the 6 per cent. cumulative preference shares and 5 per cent. on the ordinary shares, carrying forward £11,118.

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

EATON TELEPHONE DISINFECTOR CO. (LTD.) (103,275.)—Reg. May 28, capital £500 in £1 shares, to carry on the business of manufacturers and suppliers of contrivances and appliances for use in connection with telephones, &c. Private company. First directors are H. Cohen and F. L. Cohen. Reg. office, 36, Jewin-street, E.C.

F. A. WILKINSON & PARTNERS (LTD.) (103,232.)—Reg. May 26, with a capital of £500 in £1 shares, to acquire from F. A. Wilkinson the benefit of certain existing inventions for improvements in and relating to services for electric heating and wiring for houses and the like, to develop and turn to account the same, and to carry on the business of electricians, electrical, mechanical and general engineers, makers of and dealers in electrical apparatus, &c. Private company. F. A. Wilkinson is the first director. Reg. office, 53, Leighton-road, West Ealing.

MORTGAGES AND CHARGES.

BRITISH TUNGSTEN LAMP CO. (LTD.)—Particulars of £4,000 debentures created April 22 have been filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future, excluding uncalled capital. No trustees.

ELECTRICAL CONTRACTS & MAINTENANCE CO. (LTD.)—Particulars of £1,000 debentures created April 23, 1909, have been filed, the amount of the present issue being £600. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

ELECTRO-MECHANICAL BRAKE CO. (LTD.)—Further charge on freehold property at West Bromwich, dated May 19, 1909, to secure all moneys due or to become due from the company to the Metropolitan Bank of England and Wales up to £1,000.

RECEIVERSHIP.

LOWDEN ELECTRIC LAMP CO. (LTD)—F. Geoghegan, F.C.A., ceased to act as receiver or manager on May 25.

LIMITED PARTNERSHIP.

C. F. H. NIGHTINGALE & CO.—Reg. June 2, heating, electrical, sanitary and general engineers, &c., 19A, Harrington-road, South Kensington, S.W. Partnership for seven years from June 2. General partner, C. F. H. Nightingale, The Rest, Melfort-road, Norbury; limited partners, J. H. Robinson, Oulton, 40, Sydenham-road, Croydon, contributing £100 respectively.

CITY NOTES.

MEMORANDA (June 10).—Bank rate 2½ per cent. (since April 1 1909). Price of silver, 24 5/16d. per oz. Consols 84—84⅛ for money and 84 1/16—84 3/16 for account. Consols Pay Day, July 1; Stock and Shares Continuation Days, June 23 and July 12; Ticket Days, June 24 and July 13; Pay Days, June 11 and 25; Mining Shares Carry Over Day, June 22.

Prices of Metals (London).—*Copper*, cash, 60½; three months 61⅜. *Lead*, English, 13½—13⅞; foreign, cash, 13¼; three months, 13 7/16—13⅝; *Spelter*, cash, 22—22⅛; three months, 22⅛—22⅜. *Tin*, English, 133½—135½; foreign, cash, 134⅛ three months, 134⅝—135½. *Iron*, Cleveland, cash, 48/8 and three months, 49/4. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—The directors have declared a dividend on the ordinary shares of 10 per cent. per annum (less tax) for the half-year ended March 31, making, with the interim dividend of 6 per cent. already paid, a dividend of 8 per cent. for the year.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and register of holders of the 5 per cent. first and 4½ per cent. second debenture stock will be closed from 17th to 30th inst., inclusive.

COMPANIA DE ELECTRICIDAD LUZ Y FUERZA DE JUNIN (ARGENTINA). This company's profits for 1908 were $30,612 (m.n.) after writing off $26,387 for amortization of machinery and station accounts, a dividend of 6 per cent. was declared.

COMPANIA INDUSTRIAL DE ELECTRICIDAD DEL RIO DE LA PLATA.—This company made a profit during 1908 of $91,255 (gold), and a dividend of 9 per cent. has been declared.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—Final dividends of 3s. per share on the preference and 5s. 6d. per share on the ordinary shares are announced.

INDIA RUBBER, GUTTA PERCHA & TELEGRAPH WORKS CO. (LTD.)—The directors announce an interim dividend of 2½ per cent. (3s. per share), tax free, on the ordinary shares for the half-year.

SAO PAULO TRAMWAY, LIGHT & POWER CO.—This company has declared a quarterly dividend of 2½ per cent., payable July 1.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed June 16 a special settling day in £100,000 5 per cent. prior lien debenture stock of the *Brush Electrical Engineering Co. (Ltd.)* and 20,000 £10 fully paid 6 per cent. cumulative preference shares of *Hurst, Nelson & Co. (Ltd.)*.

TRACTION & POWER SECURITIES CO. (LTD.)—The profit for 1908 was £20,948, added to £4,826 brought forward. The directors have transferred £20,000 to investment reserve account, leaving £5,775 to be carried forward.

WESTERN TELEGRAPH CO. (LTD.)—The directors have declared the third quarterly interim dividend of 3s. per share (tax free) for the year ending 30th inst., being at the rate of 6 per cent. per annum. The transfer books will be closed from 17th to 23rd inst. inclusive, and the dividend will be payable on 24th inst.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Amount.	Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 31¶	2,516	...	52	70,744	− 334
Airdrie	„ 23	231	+ 6	21	4,532	− 72
Anglo-Argentine	June 3	39,881	+ 4,523	22	867,798	+ 49,029
Ayr Corporation	„ 5	315	+ 20	3	828	− 81
Baker St. & Waterloo Ry.	„ 5	3,490	+ 520	22	73,600	+ 6,525
Barnsley	May 28	173	+ 1	21	3,470	− 98
Barrow	„ 23	220	− 8	21	4,361	− 298
Bath Electric Trams, Ltd.	June 2	1,112	+ 319	22	15,223	+ 569
Birmingham Corporation	„ 5	7,435	+ 781	10	63,197	+ 1,629
Birmingham & Mid.	May 21	801	− 20	20	16,028	+ 98
Blackburn Corporation	June 2	1,421	+ 183	10	11,722	+ 242
Blackpool and Fleetwood	„ 5	1,442	+ 966	...	...	...
Bolton Corporation	„ 6	2,434	+ 58	10	23,271	− 38
Bombay	May 6	R39,700	+ R2,055	18	R693,785	+ R17,409
Bournemouth Corporation	June 2	2,031	+ 532	9	15,442	+ 732
Bradford Corporation	May 29	4,834	+ 15	9	41,241	+ 764
Brighton Corporation	June 6	1,248	+ 312	10	9,134	+ 1,013
Bristol Trams & Carriage	„ 4	7,245	+ 1,991	2	12,779	+ 2,471
Burnley Corporation	„ 5	1,403	+ 168	10	12,991	+ 471
Burton Corporation	„ 6	318	+ 17	10	2,576	+ 11
Bury Corporation	„ 5	1,314	+ 152	†10	11,652	− 52
Calcutta Tramways Co.	„ 5	R48,000	+ R2,822	22	R1,092,234	+ R95,294
Camborne-Redruth	„ 5	185	+ 50	23	2,723	− 20
Cardiff Corporation	...	...	...			
Cavehill	May 28	102	− 1	21	1,482	− 167
Central London Railway	June 5	5,919	− 607	22	121,612	− 12,608
Charing C., Euston & H'stead	„ 5	4,520	+ 1,200	22	85,545	+ 14,865
Chatham & Dist. Lt. Rys.	„ 3	1,175	+ 289	22	16,728	+ 1,545
City & South London Rly.	„ 6	3,219	+ 103	22	71,686	+ 1,011
City of Birmingham	May 28	2,903	− 4	21	56,706	− 603
Colchester Corporation	June 2	231	+ 67	...	...	...
Cork Electric Trams Co.	„ 3	501	− 30	22	8,441	− 928
Croydon Corporation	„ 4	1,985	+ 366	‖9	14,407	+ 816
Devonport & Dist. Trams	May 23	373	− 77	21	7,686	− 1,370
Dover Corporation	June 5	270	+ 51	10	1,918	− 62
Dublin & Lucan Railway	„ 4	202	+ 63	22	2,702	+ 269
Dublin United	„ 4	6,290	+ 451	22	111,860	+ 1,508
Dudley-Stourbridge	May 28	802	+ 13	21	15,593	− 233
Dundee Corporation	June 2	1,263	− 49	†3	3,052	− 215
East Ham Council	„ 5	1,234	+ 541	§9	9,823	+ 1,848
Exeter Corporation	„ 4	690	+ 351	10	3,569	+ 704
Gateshead & Dist. Trams	May 28	1,011	+ 60	21	20,546	− 29
Glasgow Corporation	June 5	18,127	− 561	‡1	13,691	+ 1,297
Glossop Trams	...	...	...	...	...	...
Gravesend—Northfleet	May 28	203	...	21	3,900	− 145
Great Northern & City Rly.	June 5	1,362	− 151	22	33,323	− 4,000
Gt. Northern, Piccadilly, &c.	„ 5	5,745	+ 410	22	127,295	+ 8,160
Greenock & Port Glasgow	May 23	617	+ 42	21	10,334	− 63
Hartlepool Tramways	„ 23	263	+ 5	21	4,312	− 103
Hastings Elec. Trams Co.	June 3	1,333	+ 349	22	18,716	− 95
Hong Kong	„ 5	$8,205	+ $992	22	$180,351	+ $12,573
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation	„ 5	2,697	+ 223	9	23,714	+ 380
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	„ 2	175	+ 27	9	1,212	− 66
Ipswich Corporation	„ 5	533	+ 85	10	3,672	+ 201
Isle of Thanet Co.	„ 5	902	+ 310	§27	11,675	+ 736
Jarrow	May 28	125	+ 25	21	2,270	+ 217
Keighley Corporation	June 3	2.0	+ 47	9	1,589	+ 93
Kidderminster & District	May 23	97	− 5	21	1,812	− 71
Kilmarnock Corporation	June 5	151	+ 2	3	455	− 54
Lanarkshire Trams Co.	„ 3	1,232	− 132	22	26,487	− 1,716
Lancashire United	„ 2	1,162	+ 41	22	27,539	+ 138
Leamington	May 23	173	+ 9	21	3,157	+ 216
Leeds Corporation	June 5	8,001	+ 1,165	10	61,560	+ 3,614
Leicester Corporation	„ 5	2,688	+ 280	...	...	...
Leith Corporation	„ 5	615	+ 87	3	1,892	+ 191
Lincoln Corporation	„ 5	142	+ 28	10	1,252	+ 81
Liverpool Corporation	May 29	10,879	− 200	‖21	222,569	− 1,616
Liverpool Overhead Rly.	June 6	1,537	+ 125	23	30,103	− 1,997
Llandudno & Colwyn Bay Ry	...	...	...	...	...	...
*London County Council	May 22	35,840	+ 362	§7	265,696	+ 20,210
London United	June 5	9,655	+ 1,812	‖25	125,698	− 5,519
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	„ 5	251	+ 39	9	1,763	− 35
Manchester Corporation	„ 5	17,199	+ 1,574	10	144,661	+ 2,921
Mersey Railway	„ 5	1,931	+ 82	22	43,246	+ 1,328
Merthyr	May 23	213	− 3	21	4,239	+ 2
Metropolitan Dist. Railway	June 5	10,246	+ 1,118	22	215,693	+ 19,697
Metropolitan Elec. Trams	May 23	6,683	+ 537	21	119,713	+ 12,547
Middleton	„ 28	318	− 33	21	6,578	− 328
Nelson Corporation	June 5	159	+ 5	†10	1,357	− 40
Newcastle-on-Tyne Corp.	...	...	...	...	...	...
Newport (Mon.)	„ 5	833	+ 132	10	6,663	+ 177
Northampton Corporation	„ 4	666	+ 174	§10	4,634	+ 166
Oldham, Ashton & Hyde	May 28	574	− 17	21	11,403	− 775
Oldham Corporation	June 6	1,823	− 212	10	20,290	− 1,075
Perth (N.B.) Corporation	„ 2	165	+ 5	§2	390	− 24
Perth (W.A.) Elec. Trams	„ 4	1,332	− 26	23	31,974	− 84
Peterborough	May 28	120	− 5	21	2,178	− 114
Portsmouth Corporation	...	...	...	...	...	...
Potteries	„ 28	1,891	+ 131	21	36,832	− 1,001
Preston Corporation	...	...	...	...	...	...
Rotherham Corporation	June 3	801	+ 190	9	5,724	+ 98
Rothesay	May 28	131	− 23	21	1,805	− 42
Salford Corporation	...	...	...	...	...	...
Sheerness	„ 28	52	− 3	21	920	− 120
Sheffield Corporation	June 6	6,325	+ 514	§10	53,172	− 16
Singapore Trams	„ 5	$9,517	− $33	22	$311,251	+ $2,023
South Metropolitan	May 28	934	+ 48	21	15,035	+ 282
South Staffs	„ 28	817	− 36	21	17,035	− 919
Southend Corporation	...	...	...	...	...	...
Southport Tramways	„ 28	274	− 150	21	5,118	− 26
Stalyb'dge, Hyde, &c., Jt. Bd.	June 5	933	+ 128	§9	7,522	+ 40
Sunderland Corporation	„ 6	1,399	+ 221	10	10,938	− 74
Sunderland District	„ 2	651	+ 140	31	13,883	− 230
Swansea Trams	May 28	917	− 6	21	18,670	+ 441
Swindon Corporation	...	...	...	...	...	...
Taunton	„ 28	39	− 1	21	735	− 69
Tynemouth and District	„ 28	227	+ 21	21	3,185	− 58
Tyneside Trams Co.	June 2	548	+ 118	22	8,952	+ 786
Wallasey District Council	„ 5	1,116	+ 179	§9	8,925	+ 642
Walsall Corpn.	„ 5	659	+ 104	22	11,157	− 718
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	May 27	2,425	+ 224	8	19,191	+ 1,614
Weston-super-Mare	„ 28	107	+ 18	21	1,153	+ 170
Wolverhampton Co.	„ 28	401	− 38	21	8,308	− 914
Wolverhampton Corpn.	June 1	1,302	+ 449	22	16,137	− 533
*Worcester	May 28	277	+ 4	21	5,184	− 4
Wrexham	„ 28	94	− 8	21	1,948	− 67
Yorkshire W.R. Trams	June 6	1,676	+ 279	23	26,031	...
Yorkshire Woollen District	May 28	943	+ 9	21	18,102	− 472

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. ¶ Plus 5 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shre.	Last Dividend	Name.	Price Wed. June 9.	Rate % Yield-ed. £ s. d.	Dividend Due.	Business Week to June 9. High-est.	Low-est.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½—10	6 0 0	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞—10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼—10¾	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101—105	4 5 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½—4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93—96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½—9	5 11 0	March	8¾	..
5	3/6	Do. 7 per Cent. Pref.	8—8½	4 2 0	Mar, Sept	..	—
St.	4%	†Cent l Elec. Sup. Co. 4% Guar. Db. Stock	97—100	4 0 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—4⅛	5 11 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4⅝—4⅞	4 12 0	Feb, Aug	4[illegible]	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93—101	3 19 0	Jan, July	..	—
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	99½—101	4 0 0	..	100[illegible]	100⅛
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾—4¼	5 8 6	Jan, July	8⅞	..
5	2/6	Chelsea Electric Supply Ord.	3⅝—4⅛	4 9 3	March	4[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102—105	4 7 6	June, Dec	10[illegible]	103½
10	7/0	City of London Electric Lighting Ord.	10½—11	5 10 0	Feb, Aug	[illegible]	10⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾—12½	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121—123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101—104	4 6 6	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1¾—2¼	—	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3⅝—3⅞	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅝—8⅞	5 15 6	Feb, Aug	[illegible]	8½
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞—11⅛	5 8 0	Mar, Sept	10[illegible]	10[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	106—109	4 2 9	Jan, July	103[illegible]	105½
St.	4½%	Do. Second Deb. Stock	100—103	4 7 6	May, Nov	101½	101½
5	3/6	Folkestone Electricity Supply Co. Ord.	4½—5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5—5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97—100	4 10 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7½—7¾	5 10 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7⅝—7⅞	5 5 0	Feb, Aug	7½	—
5	6%	Do. 6 per Cent. 1st Pref.	5⅝—6⅛	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97—100	4 0 0	..	—	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98—101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85—89	5 1 0	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞—2¼	3 6 8	Mar, Sept	2[illegible]	..
5	8/0	Do. 6 per Cent. Pref.	5⅛—5¼	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92—96	4 3 6	Jan, July	—	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅜—4¾	5 16 0	April, Oct	..	—
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾—5⅛	4 7 6	Jan, July	5	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107—110	4 2 0	June, Dec	—	—
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85—88	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95—98	4 12 0	June, Dec	..	—
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4¾—5	4 2 1	Feb, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	84—86	5 5 11	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅝—4¾	2 13 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞—5⅛	5 0 0	Feb, Aug	—	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99—101	4 0 0	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99—101	4 19 0	..	—	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91—93	4 17 10	Jan, July	—	..
10	8/0	Notting Hill Electric Ord.	11½—12½	5 12 0	March	—	..
5	4/6	Oxford Electric Ord.	6—6½	5 8 0	March	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94—97	4 2 6	Jan, July	..	—
5	5/0	St. James' & Pall Mall Elec. Ord.	9—9½	5 5 0	Feb, Aug	9⅛	..
5	3/6	Do. 7 per Cent. Pref.	7—7½	4 13 6	Feb, Aug	7½	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	83—90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	⅝—⅞	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 8 0	April	—	..
St.	..	Do. 5% 1st Mort. Stk. Red.	102—104	..	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	—	..
1	0/8⅝	Do. 7 per Cent. Cum. Pref.	1[illegible]—1[illegible]	5 7 0	Feb, Aug	..	—
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100—103	4 7 6	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	⅝—1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2—2½	10 0 0	April, Oct	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80—84	5 7 3	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	9[illegible]—9½	5 5 0	Mar, Sept	9[illegible]	9[illegible]
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛—5½	4 11 0	Jan, July	5⅛	5[illegible]
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	97—99	4 1 0	Jan, July	98¼	97½
1	..	Bath Elec. Trams Pref. Ord.	¼—⅜	..	April	[illegible]	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	86—91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89—92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8¼—8¾	6 17 4	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½—8¾	4 11 5	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100—101	3 19 2	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅞—1[illegible]	..	June, Dec	[illegible]	..
10	3/0	Do. 6 per Cent. Cum. Pref.	2⅝—3⅜	8 13 0	Feb, Aug	..	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	90—94	5 6 3	April, Oct	93	90⅛
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68—72	6 5 0	May, Nov	68½	..
St.	3½%	Central London Ordinary Stock	65—67	5 4 9	Feb, Aug	65[illegible]	65
St.	4%	Do. 4 per Cent. Pref. Stock	85—87	5 12 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	50—52	4 15 0	Feb	51	..
100	4%	Do. 4 per Cent. Debs.	102—104	3 16 6	Jan, July	103½	103
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92—94	4 5 0	Jan, July	93⅛	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾—5¼	4 15 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97—101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	32½—33½	4 9 6	Feb, Aug	34	33½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110—112	4 9 0	Feb, Aug	110¼	110½
St.	5%	Do. (1895)	103—105	4 11 0	Feb, Aug	.	..
St.	5%	Do. (1901)	103—105	4 15 0	Feb, Aug	104	—
St.	5%	Do. (1903)	93—96	5 4 0	Feb, Aug	101	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99—101	3 19 0	May, Nov	95½	—
10	6/0	Dublin United Trams. Ord	—	4 15 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Pref.	13—14	4 5 9	Feb, Aug	12½	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	½—¾	..	Feb, Aug	[illegible]	—
10	..	G. Northern, Picc. & Brompton 4% G.Pf	8½—9	—	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94—95	4 3 6	Jan, July	96	95½
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2—2½	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	83—87	5 3 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	6½—6	8 8 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6¾—7¼	7 13 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	87—89	5 1 11	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞—1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	57—62	6 9 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9[illegible]—11[illegible]	5 18 6	Feb, Aug	10[illegible]	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91—93	5 7 6	Jan, July	9[illegible]	91½
10	..	Liverpool Overhead Railway Ord.	[illegible]—1	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	5—6	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	83—84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2—3	10 10 0	Jan, July	2¼	2[illegible]
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	70—74	5 8 0	Jan, July	..	..
St.	—	Mersey Con. Ord. Stock	1—2	—	Feb, Aug.	—	—
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April	[illegible]	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	[illegible]	—
St.	4½%	Do. 4½ per Cent. Deb. Stock	98—100	4 10 0	Jan, July	99½	98
St.	3%	Metropolitan Railway Consolidated	34½—35½	1 5 9	Feb, Aug	35	38
St.	3%	Do. Surplus Lands Stocks	69—71	4 4 6	Feb, Aug	70	—
St.	3½%	Do. 3½ per Cent. Preference	89—91	3 17 0	Feb, Aug	91	..
St	3½%	Do. 3½ per Cent. "A" Preference	83—84	4 3 6	Feb, Aug	83½	82½
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82—84	4 3 6	Feb, Aug	82½	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	93—95	3 13 3	Jan, July	95	94

In calculating the yield allowance has been made for accrued interest but *not* for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share.	Last Dividend	Name.	Price Wed., June 9.	Rate % Yield-ed.	Dividend Due.	Business Week to June 9 Highest.	Lowest.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	9[illegible]	93
St.	..	Metropolitan District Railway Ord.	16¼—16¾	—	Feb, Aug	16[illegible]	16¼
St	..	Do. Extension Pref. (5 per Cent.)	39 —41	..	Feb, Aug	39½	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	68 —70	5 0 0	Feb, Aug	—	—
St	3%	Do. 3 per Cent. Conseltd. Rent-charge	78 —80	3 15 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	103 —106	3 15 6	Jan, July	...	..
St.	4	Do. Guar. Stock 4 per Cent.	89 —92	4 7 0	Mar, Sept	..	...
St.	6	Do. 6 per Cent. Perp. Deb. Stock	141 —143	4 3 9	Jan, July	...	..
St.	4	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	...	...
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	[illegible]	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db.	84 —88	5 14 0	Jan, July	..	..
..	..	Undergd.E.Rys.Lond. Inc.bds.with coup.3	37 —39	..	June, Dec	37¾	..
..	..	Do. 5% Prior Lien Bonds	101 —102	4 18 0	..	..	..
—	4½	Do. 4½% Bonds with coup. 3	89 —91	4 19 0	..	90½	89¾
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	—	—	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	86 —90	5 0 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	—	..	..	[illegible]	..
1	0 7½	Do. 6% Cum. Pf.	[illegible]	6 17 0	April, Oct	[illegible]	¾
1	2/4	Babcock & Wilcox Ord.	4 —4[illegible]	4 11 0	April, Oct	4[illegible]	4[illegible]
1	0/7½	Do. Pref.	1⅛—1½	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅜—7⅞	6 9 0	July, Feb	..	...
5	3/0	Do. 6 per Cent. Pref.	6½—6⅞	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thomson Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	½—¾	..	Feb, Aug	[illegible]	¾
100	..	Do. 6 per Cent. Prior Lien Debs ord.	97 —99	6 1 0	..	[illegible]	9[illegible]
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	40 —41	9 2 0	Jan, July	...	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1st Deb.Stock	43 —48	9 8 0	Mar, Sept	..	..
St	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.	9⅝—10½	7 3 9	Jan, July	10¼	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5½—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106 —107	4 4 0	Nov, May	106⅞	..
1	1/0	†Castner-Kellner Alkali Co.	1⅜—1[illegible]	6 16 0	May, Nov	1[illegible]	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —105	4 4 0	Feb, Aug	104[illegible]	..
1	0/7½	Chadburn's (Ship) Telegraph Ord.	1⅛—1[illegible]	7 10 6	March ..	..	..
..	0/7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1⅜	5 13 0	April, Oct	..	..
1	0/5½	Consolidated Electrical Co.	[illegible]	5 4 0	August ...	—	..
1	1/0	Consolidated Signal Co.	1½—1[illegible]	7 15 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	..	..
5	3/0	*Crompton & Co. (Nos. 1 to 85,000)	1 —1½	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	95 —98	5 2 0	Jan, July	..	—
1	0/7½	Davis & Timmins	¾—1⅛	..	Mar, Sept	..	..
5	2/0	Dick, Kerr & Co. Ord.	1[illegible]—1½	8 0 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1[illegible]	4 16 9	Sept	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	½—½	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	70 —76	5 6 8	June, Dec	71	70
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	[illegible]	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 3 0	Jan, July	..	..
5	..	Electric Construction Co.	[illegible]	..	Jan, July	..	..
5	3/9	Do. 7 per Cent. Cum. Pref.	⅞—1½	11 4 0	July	1[illegible]	1[illegible]
St	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59 —63	6 7 0	Jan, July	60	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅜—7⅝	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	16 3	Henley's Telegraph Works Ord.	11⅞—12⅛	6 2 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —6	4 3 6	Feb, Aug	5	..
St	4½%	† Do. 4½ per Cent. 1st Mort. Deb. Stock	104 —106	4 5 0	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Wrks.	14½—15¼	6 10 0	Feb, Aug	..	..
10	..	Do. 5 per Cent. Cum. Pref.	10⅜—11	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	99⅝	—
1	..	National Elec. Construction Co.	½—1	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—½	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	¾	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅜	—	—	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	..	..
10	24/0	Telegraph Construction & Maintenance	32½—34	5 6 0	Mar, July	32½	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd. Ord.	2 —2[illegible]	4 9 9	..	2[illegible]	2[illegible]
1	0/6	Do. 5 per Cent. non-Cum. Preference	1[illegible]—1[illegible]	4 8 0	..	1[illegible]	..
St	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	110⅜	..
St	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 17 6	June, Dec	..	..
100	4½%	† Do. 4½ per Cent. 2nd Mort. Deb. red.	102½—104½	4 6 0	June, Dec	104⅛	103
100	5%	† Do. 5 per Cent. 3rd Mort. Debs Scrip.	104½—106½	4 14 0	..	105⅜	..
10	5	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	—	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2[illegible]—3[illegible]	9 2 0	Apr, Oct	3[illegible]	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	78	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	94 —96	5 3 6	June, Dec	..	..
St.	15/0	Anglo-American	57 —59	5 12 0	F,My,Ag,N	58½	57½
St.	30/0	Do. Preferred	99 —100	6 0 0	F,My,Ag,N	101[illegible]	98⅝
St.	3 0	Do. Deferred	15 —16⅛	2 9 8	F,My,Ag,N	17⅛	15[illegible]
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91 —93	4 6 0	Jn,Ap,Jy,O	91⅞	91[illegible]
10	6/0	Cuba Submarine Ord.	[illegible]	6 1[illegible] 0	Feb, Aug	8[illegible]	8¾
10	10/0	Do. Preference 10 per Cent.	17 —1[illegible]	5 11 0	Feb, Aug	..	—
5	2/0	Direct Spanish Ord.	2½—3⅛	5 15 0	April, Oct	—	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9	5 9 0	April, Oct	—	..
St.	4½%	Do. 4½ per Cent. Deb.	100 —102½	4 8 0	Jan, July	..	.
20	4 0	Direct United States Cable	1[illegible]—13½	6 8 0	Ja,Ap,Jy,O	12[illegible]	12½
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.	101 —103	4 7 0	June, Dec	..	..
St	6/0	Eastern Ordinary	132—135	5 4 6	Ja,My,JyO	135	132
St	17 6	Do. 3½ per Cent. Pref. Stock	85½—87	4 0 6	Ja,My,JyO	87	86½
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 16 0	May, Nov	104¼	103[illegible]
St	6/6	Eastern Extension	1[illegible]—14½	6 14 0	Ja,Ap,Jy,O	12⅜	12¼
St	4%	Do. 4 per Cent. Deb. Stock	102½—103½	3 16 6	Feb, Aug	102	..
..	4%	Eastern & S.Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	—	..
1	[illegible]	G. N. of Copenhagen, with Coupon 76..	27 —28	6 8 0	Jan, July	28[illegible]	..
..	4½	Halifax & Bermuda 4½% 1st Mt. Db.(red.)	101 —103	4 7 6	June, Dec	..	..
..	[illegible]	Indo-European [illegible]	61½ —62½	5 15 9	May, Nov	...	..
..	$1	Mackay Companies Common	76 —82	4 16 0	Ja,Ap,Jy,O	—	..
..	$1	Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	¾—1	..	April	..	
1	4%	Pacific & European Te.4% Guar. Dbs.(red.)	100 —102	3 18 0	June, Dec	.	—
2½	1 3	West Coast of America	1⅛—1⅜	4 12 0	May	1[illegible]	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	...	..
10	..	West India & Panama	⅝—1	..	May, Nov	⅝	—
10	6/0	† Do. 6 per Cent. 1st Pref.	8¾—8¾	6 17 0	May, Nov	..	—
10	[illegible] 0	Do. 6% 2nd Pref. & 1/-/ on acc. of arrears	8 —9	6 13 6	May, Nov	..	—
100	5%	Do. 5 per Cent. Debs.	102 —104	4 16 6	Jan, July	—	..
10	5/0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	14⅛	1[illegible]
St	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	102½	10[illegible]
...	4%	Western Union Telegh. $1,000 4% Bonds	93 —95	4 6 0	..	..	..

Share.	Last Dividend	Name.	Price Wed., June 9.	Rate % Yield-ed.	Dividend Due.	[cut off]
		TELEPHONES.		£ s. d.		
100	$8	Amer. Teleph. & Telegh. Cap. St.	141 —145	5 10 0	..	
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98⅛—100½	3 19 6	Jan, July	
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	
5	3 0	Chili Telephone	8 —8⅜	4 16 9	August ..	
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	
1	0/6	Do. 5 per Cent. Pref.	[illegible]—1[illegible]	5 7 0	May, Nov	
St.	6%	National Co. Pref. Stock	107 —108½	5 10 6	Feb, Aug	1
St.	6%	Do. Def. Stock	121½—123½	4 17 6	Feb, Aug	1
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11	5 9 0	Feb, Aug	1
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11	5 9 0	Feb, Aug	
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5[illegible]—5[illegible]	4 5 9	Feb, Aug	
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	
1	1/0	Oriental	1[illegible]—1[illegible]	5 7 6	April, Oct	1
1	0 7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1[illegible]	4 17 6	April, Oct	
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100 —102	4 8 0	Jan, July	
5	3/0	United River Plate	6⅝—7⅛	6 11 6	July	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	June, Dec	
St.	4½%	Do. 4½ Deb. St. Red.	101 —105½	4 5 0	Jan, July	
		FINANCIAL INVESTMENT, &c.				
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜—3⅝	8 5 0	Jan, July	
10	2 0	Globe Telegraph & Trust	10⅝—11⅛	5 8 0	SpDcMrJu	1
10	3/0	Do. 6 per Cent. Pref.	12¾—13¼	4 10 6	SpDcMrJu	13
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.				
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅜—6⅞	4 14 0	April, Oct	6
5	5/0	Do. 10% Non-cum. 2nd Pref.	9⅜—9⅞	5 2 6	Jan, July	9⅞
St.	4%	Do. 4% Deb. Stock	91 —93	4 3 6	June, Dec	91
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 0	Jan, July	..
5	3 6	Brisbane Electric Trams. Invest. Ord.	5⅞—6[illegible]	4 19 0	May	6[illegible]
5	2 6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	5
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	105 —107	4 4 0	Jan, July	..
St.	8%	British Columbia El.Ry.Df. Ord.	143 —147	5 6 9	Mar, Sept	..
St.	6%	Do. Pref. Ord. Stock	123 —127	4 14 6	May, Nov	125½
St.	5%	Do. 5% Cum. Perp. Pref. Stock	109 —112	4 9 0	Jan, July	110½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..
100	4½%	Do. Vancouver Power Debs.	102 —105½	4 5 9	Jan, July	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	99½—100½	4 4 6	—	100
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98½—100½	4 19 6	Mar, Sept	99
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96 —100	6 0 0	Feb, Aug	91⅞
5	2/0	Calcutta Tramways (1 to 137,610)	4⅜—4¾	4 14 9	Mar, Sept	4[illegible]
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅜	4 18 0	Jan, July	4
1	4½%	Do. 4½ 1st Deb. Stock (red.)	100 —103	4 7 0	Jan, July	101
St.	..	Cape Electric Tram Shares	⅜—⅝	..	..	⅜
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅜—5⅞	4 5 6	F,My,A,N	5⅞
St.	4%	Do. 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	92½
100	5%	†Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	82 —85	5 17 6	June, Dec	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	95 —98	5 2 0	Feb, Aug	95⅞
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	89 —93	5 7 6	Jan, July	91
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 11 6	Jan, July	69
5	1/0	Lisbon Elec. Trams. Ord.	[illegible]—1[illegible]	4 14 0	July	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1[illegible]	4 16 0	Jan, July	—
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	89 —91	5 7 0	Jan, July	—
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	92 —95	5 5 0	Jan, July	—
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	94 —97	5 2 6	Feb, Aug	—
100	$1½	Mexico Trams Co. Com. St.	142 —145	3 9 0	..	151½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92 —94	5 6 3	..	95½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6		104
1	1/0	Perth Elec. Trams Ord	⅝—⅞	6 13 0	May ..	..
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	—
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5⅞	5 2 0	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	100 —102	4 8 0	..	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	97 —99	..	..	99
..	5%	Do. 30 yr. Gold Bnds.	95 —98	5 4 0	..	96⅞
100	5%	Do. 50 yr. Mt. Bnds	84 —86	..	..	87⅛
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	155 —157	6 10 9	..	157
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	96½—98½	5 1 6	June, Dec	98½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.				
5	3 0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5⅞	5 11 0	Mar, Sept	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	9⅞
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95½—97½	4 12 6	Jan, July	96½
5	3/3	Calcutta Elec. Supply Ord.	6[illegible]—6[illegible]	6 0 3	April, Oct	6⅜
100	$1½	Canadian Gen. Elec. Co. Com. St.	120 —123	5 11 0	..	123½
100	$3½	Do. 7% Cm. Pf. Stock	120 —122	..	..	122½
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —101	4 19 0	Jan, July	..
500	5%	Elect. Development Co of Ontario	88 —90	5 11 0	..	89½
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1½—2	..	Feb, Aug	..
St.	5%	Do. 5 per Cent. Deb Stock	89 —92	5 8 0	Jan, July	—
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	88 —91	5 10 0	Jan, July	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	..
10s	4	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	[illegible]
1	0/1½	Do. 6 per Cent. Cum. Pref.	½—[illegible]	8 6 0	April, Oct	[illegible]
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	81—83½	5 16 0	..	88
St.	$1	Mexican Lt. & Power Co. Com. St.	72 —74	6 2 0	—	77
500	5%	Do. 5% 1st Mort. Gold Bnds.	87—90	5 12 0	..	91
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	126 —129	4 13 0	F,My,A,N	127½
1	1/1½	River Plate Electricity Co. Ord.	1⅝—1⅞	5 6 8	April	1[illegible]
1	1 2½	Do. 6 per Cent. non-Cum. Pref	1[illegible]—1[illegible]	5 1 0	May	..
St.	6%	Do. 5 per Cent. Deb. Stock.	103 —107	4 13 6	Jan, July	105
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅝—6⅛	5 6 6	April, Oct	..
100	$1	Shawinigan Water & Power Co. Ca	96 —98	4 2 0	—	96⅞
..	5%	Do. 5 per Cent. Bds.	107 —109	4 11 6	Jan, July	108
St.	4½%	Do. 4½ Per. Con. Mt. Db St.	96 —98	4 12 0	—	97⅛
..	6%	Victoria Falls Power Co. Pref.	[illegible]	5 7 6	Jan, July	[illegible]

* In [illegible] the [illegible] allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote the

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NOTES.

An Electrical Industrial Association.

ELSEWHERE our readers will find an importan t letter by Sir WILLIAM PREECE on the desirability of forming The Electrical Industrial Association, whose object would be to deal with general questions affecting the industry, to provide a common platform on which such questions could be discussed, and to impress the general and financial public with the huge commercial interests represented by the Industry. We may mention that some time ago this question was put before the editors and proprietors of the principal electrotechnical journals, and Sir WILLIAM was approached in the hope that he would see his way to take the initiative in such a movement. As might have been expected, Sir WILLIAM was found to be entirely sympathetic to the idea. Subsequently there was formed a committee, who worked along somewhat similar lines. We are now glad to note that Sir WILLIAM has obtained the consent of the Lord Mayor to the holding of a meeting at the Mansion House to consider what steps shall be taken to give the movement such a start as its importance demands. We feel that nothing but good can come of a movement of this kind, and that no man would be welcomed more readily than Sir WILLIAM PREECE as the head of such an association. This body would not be in conflict with any other society; indeed, we feel that other bodies should welcome it, and we might even suggest that the Institution of Electrical Engineers, when in their new home, might extend their hospitality to the new-comer The British electrical industry, though strong technically, is lamentably weak on the commercial side. We, hope, therefore, that the industry, and all who are interested therein, will give their unanimous support to the movement, for unanimity in a matter of this kind is urgent, and it should not be difficult to sink minor differences or points of view for the common good.

The Telefunken and Lepel Wireless Systems.

IN this issue we give a fairly full abstract of a recent lecture by Count ARCO, wherein he announces to the world the wide ambitions and the working details of the new Telefunken system. The new system possesses as its principal novelty a spark-gap which is much sub-divided and strongly cooled. In such a spark-gap the electrical oscillations have a very short life, because the gap quickly ceases to be bridged by hot conducting gases, and thus the primary circuit does not exercise that action and reaction which gives rise to the beating pair of wave-lengths that usually arise in coupled circuits. To get rid of this doubleness of wave-length is a praiseworthy feat, and is probably of some considerable importance technically; yet at this moment we do not venture to share in all the exultant hopes of the lecturer as to the supersession of other methods of wireless telegraphy by the new Telefunken system, but shall await the expression of opinion by ordinary purchasers and users of the Telefunken apparatus. From the description of this plant given by the lecturer, it will be seen that the apparatus has been developed with great scientific insight and technical skill, so that the whole "practicalisation" of WIEN's idea of exciting secondary oscillations by a primary impulse forms another tribute to German knowledge and thoroughness.

APART from the question whether the new-born system is a real workable improvement on the deceased Telefunken system, the whole subject is of great interest in view of the conflict that has arisen between Baron VON LEPEL and the Telefunken Company. VON LEPEL emphatically declares in our columns this week that the principal novelty in the new Telefunken system—that is to say, the

much cooled spark-gap round which all the other details of the new system circle—is in point of fact an intentional copy of a method invented and developed by himself. We have referred to this matter in previous issues. VON LEPEL now supports his assertions categorically by historical details that must be allowed to possess the force of evidence. Indeed, readers of ARCO's own lecture will perceive that the Telefunken engineers were admittedly following VON LEPEL's lead in their development of the Wien idea. Count ARCO's point is, no doubt, that the Telefunken Company, starting from VON LEPEL's ingenious method of cooling a low voltage discharge, have arrived at a method of cooling and damping a high voltage discharge, which, regarded as a method of generating electrical oscillations, is different in its scientific rationale from the process of VON LEPEL. Whether this difference is fictitious or real may have to be looked into by the Courts, and can only be properly settled by adequate experimenting. Meanwhile we think that those who are following the present quarrel will agree that VON LEPEL's parallel plate discharger was the germ of the Telefunken improvements, and will sympathise with him if he endeavours to secure the fullest fruits of his happy invention.

Hull Telephone Accounts.

THERE are now very few municipal telephone undertakings in existence in this country, but two or three have withstood the almost inevitable fate of falling into the hands of either the Postmaster-General or the National Telephone Co. One of these undertakings is at Hull, or, to be quite exact, Kingston-upon-Hull, and accounts have recently been issued showing a profit on the year's working. The net profit shown is £1,040. 9s. 5d., but it is doubtful whether this sum can be regarded in any sense as a true indication of the year's working. Fortunately it has not been used for the relief of rates, but although carried to a reserve fund, the latter only amounts to £2,311. 12s. 6d. for a total capital expenditure of £57,854. 14s. 8d. This might be good enough were adequate provision made for depreciation, but this item, so serious in telephone undertakings, does not appear to receive any particular attention; and, moreover, in the capital account we notice an item of £964. 8s. 8d. for preliminary expenses, which can scarcely be regarded as an asset. We fear that were private undertakings run on these lines the result would be disastrous before very long, and if this is so for private enterprise it should apply equally to municipal work, which should be run as far as possible on true business lines.

Personal.—Prof. H. A. Wilson, F.R.S., of King's College, London, has been appointed Professor of Physics in McGill University, Montreal.

Government Grants to University Colleges.—The report of the Advisory Committee on University Colleges in Great Britain has been issued. A number of recommendations (which will be given in our next issue) are made as to grants and the standard of education in such institutions.

Cable Interruptions.	Date of Interruption.
Dakar—Conakry	May 13, 1909
Tangier—Cadiz	May 19, 1909
Cayenne—Salinas	June 7, 1909
Paramaribo—Cayenne	June 8, 1909

American Institute of Electrical Engineers.—The twenty sixth annual convention is to be held at the Hotel Frontenac, Frontenac, Thousand Islands, N.Y., from June 28th to July 1st. Thirty-two Papers are to be read, and the presidential address will be delivered by Mr. Louis A. Ferguson.

Royal Society.—Among the Papers read at the meeting yesterday afternoon were the following: "On Electrostatic Induction through Solid Insulators," by Prof. H. A. Wilson, F.R.S.; "The Passage of Electricity through Gaseous Mixtures," by Mr. E. M. Wellisch; "The Co-efficients of Capacity and the Mutual Attractions or Repulsions of two Electrified Spherical Conductors when close together," by Dr. Alexander Russell; and "On the Effect of Previous Magnetic History on Magnetisation," by Prof. E. Wilson and Messrs. G. F. O'Dell and H. W. K. Jennings.

Street Lighting at Southampton.—We understand from Mr. H. F. Street, borough electrical engineer at Southampton, that, following a report by him, the Highways and Lighting Committee recommended the Council to change 430 gas standards from gas to electricity. This report was confirmed by the Council last week. Everybody seems pleased with the alteration, as the improvement is most noticeable and, further, will be effected at a small saving to the ratepayers. Many of the councillors agreed to the change as they were supporting their own undertaking, but the public paid more attention to the better light given by electricity.

Measuring Small Currents of High Frequency.—In a Paper read recently by Prof. R. Arnò before the Société Internationale des Electriciens, the author described an instrument for measuring telephone currents and periodic currents generally of high frequency and very feeble intensity. The instrument contains a magnetic system with a vertical axis subject to the action of two rotary fields, equal but revolving in opposite directions. A coil coaxial with the magnetic system carries the current to be measured. The action of this coil changes the hysteresis lag, in proportion to the intensity and the frequency of the current, within certain limits. There results a variation of the hysteresis of the magnetic system and a deflection is obtained. The rotary fields are in general produced by two sets of coils, one in series with an ohmic resistance and the other with a self inductance or capacity. By means of a movable coil in each field the instrument can be brought to the zero point.

City and Guilds of London Institute.—The annual report of the Council shows that the number of students taking the diploma and special electrical engineering courses at the Central Technical College continues to diminish. Thus, in the session 1907-8, the number was 113, compared with 126 in 1906-7 and a maximum of 160 in 1904-5. The reduction in the number of students attending the electrical department is mainly due to the transfer of first-year students to the Royal College of Science. The number of students receiving instruction in electrical engineering was, however, 302 in 1908, compared with 348 in 1907, the average number of hours attended per week per student being 7 and 8·3 respectively in the two years. Last year 23 students of the College obtained the degree of B.Sc. (engineering) of the University of London, 21 in honours and 2 pass. The total number of internal students of the University who have taken their degree from the Central Technical College is now 81, out of a total of 164 conferred by the University in engineering since 1903, the first year of the examination. There were 184 registered internal students of the University attending the College in 1908, whilst at present the number has increased to 210. At the Technical College, Finsbury, 76 day students took the electrical engineering course in 1907-8, compared with 87 in 1906-7 and a maximum of 110 in 1902-3, 33 students obtaining certificates. The number of evening students in the electrical department in the 1907-8 session was 19 for the complete course and 125 for special lectures, the figures for the previous session being 15 and 131 respectively, whilst in 1905-6 they were 31 and 157.

Wireless Telegraphy at Sea.—Once more has wireless telegraphy come to the assistance of the shipwrecked crew and passengers of a great liner. Losing her way in a dense fog off the Western Isles, the Cunarder "Slavonia" ran ashore on

Largento Point, just off the island of Flores, early on the morning of June 10th. Owing to the rocky nature of the coast the island has no direct connection with the cable system of the Europe & Azores Telegraph Co., but this connection is being provided by means of wireless stations. The "Slavonia" was furnished with a complete Marconi equipment, and the persistent working by Mr. Stanley Coles, the operator in charge of the installation on the "Slavonia," was successful in establishing communication with the North German Lloyd vessel "Princess Irene," which was steaming 180 miles to the south of Flores. The "Princess Irene" went to the spot indicated by the wireless message and proceeded to take off the whole of the passengers, the crew being landed at Flores. There were in all 410 souls on board the "Slavonia." Shortly afterwards a gale suddenly sprang up, and the "Slavonia" became a total wreck. Mr. Coles worked hard for 13 hours to obtain his success, and shares with his friend, Mr. John Binns, the hero of the "Republic," the honour which belongs to men who have done their duty well and successfully in positions of danger. Wireless telegraphy has indeed proved a blessing at sea, and the future has much honour in store for those in charge of such installations. Mr. Coles, who is only 19 years of age, is a Devonian.

After leaving Flores, on her way to Gibraltar, the "Princess Irene," on passing Ponta Delgada, where the Europe & Azores Telegraph Co. have a wireless station erected, communicated details by wireless of the mishap to the "Slavonia," which were immediately sent to all interested over the company's cables. The service thus rendered included a number of private messages to friends of the rescued passengers.

The Electrical Contractors' Association.—The annual dinner of this association was held on Monday last in the King's Hall, Holborn Restaurant. A large number of members and friends attended, and consequently there was a very successful evening.

The toast of "The Institution of Electrical Engineers" was proposed by Mr. G. Harland-Bowden, who made some mention of the scheme which was under consideration for the examination and certification of electrical workmen.

Mr. W. M. Mordey, President of the Institution of Electrical Engineers, who replied to this toast, gave a *résumé* of the principles on which the work of the Institution of Electrical Engineers was carried out. Its purpose was to deal with scientific, engineering and professional questions, and not with the trade or commercial side. He mentioned that, as the result of the labours of a committee which had been sitting for some time, a code of rules for professional and business etiquette would be completed during the next session, and the Articles of Association, next time they were altered, would allow more effective powers to the Council for dealing with members who did not adhere to a proper standard in this respect. The subject of Wiring Rules was the next matter touched upon by the speaker. He said that the new edition would deal with cheaper methods of wiring, which he hoped would open up a great field for enterprise. The question of examination of candidates requiring admission to the Institution of Electrical Engineers was also under consideration. Mr. Mordey again referred to the controversy regarding the state of electrical trade in this country and in Germany, and again reiterated his remarks showing that the state of the electrical industry in this country was not so bad as it might seem at first sight.

Mr. J. S. Huddlestone, of Messrs. Siemens Bros. & Co., then proposed the toast of "The Electrical Contractors' Association," to which Mr. E. C. Wallis, the president, responded. The toast of "The Cable Makers' and Kindred Associations" was proposed by Mr. Leonard G. Tate and responded to by Messrs. J. Taylor, C. McArthur Butler and H. H. Berry. An excellent programme of music was also provided.

A Modern Railway Problem: Steam v. Electricity.—At the Royal Institution on Thursday, June 10th, Prof. W. E. Dalby delivered the second of his series of two lectures on the above subject. The locomotive, he said, had to be considered from the point of view of design, and the problem which designers had before them was to make the best compromise between two mutually antagonistic conditions—viz., those for steady running, and those for starting and acceleration to the running speed. An ideal engine for hauling an express train at a high uniform speed on the level was not the ideal engine to start such a train, or to accelerate it to the running speed, and vice versa. He had found, by referring to the curves of train resistance, that suitable dimensions for a locomotive employed to haul 300 tons on the level at 50 miles per hour were 30 sq. ft. of grate area, 1,800 sq. ft. of heating surface and a single pair of driving wheels loaded to 18 tons. The boiler was large enough to produce sufficient energy for the purpose. Besides the general relations between tractive force, indicated horse-power and speed, starting also had to be considered, and this involved two points: Firstly, the amount the locomotive could pull when starting, and, secondly, how long it would take to change the speed of the train from zero to full speed. The lecturer also stated that the amount of energy required to run a stopping service was almost double that required to run a fast service, although the running speed was the same. This was the case both in steam and electric traction. Electricity, however, was at an advantage, owing to the ease with which the energy corresponding to the running speed could be imparted to the train, and this could not be done in any practicable manner with steam traction. If the conditions of service required quick acceleration and frequent stops the inevitable conclusion was that the steam locomotive could not compete with the electric motor. The lecturer then drew attention to other advantages which the electric motor possessed over the steam locomotive. One of these was that with electric traction the size of an existing terminal station arranged for steam locomotives was virtually much increased by the substitution of electric traction, owing to the time lost in shunting the locomotive being saved. It was evident, however, that for fast main line traffic with few stops, where the time required for acceleration was negligible in comparison with the total running time, the steam locomotive was the best commercial means that could be used.

ARRANGEMENTS FOR THE WEEK.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

MONDAY, June 21st.

7:30 p.m. Reception and conversazione at the Town Hall, Albert-square, Manchester, by the Right Hon. the Lord Mayor (Ald. E. Holt).

TUESDAY, June 22nd.

10:30 a.m. Meeting at the Municipal School of Technology, Whitworth-street, Manchester. Presidential Address by Mr. S. L. Pearce. Paper on "Cheap Units," by Councillor A. Sinclair.

1:15 p.m. Luncheon in the Large Hall, Town Hall, Manchester.

2:45 p.m. Visit to Stuart-street, Dickinson-street and Bloom-street generating stations of the Manchester Corporation.

WEDNESDAY, June 23rd.

10 a.m. Meeting in the Small Concert Hall of St. George's Hall, Liverpool. Papers on "The Influence of Metallic Filament Lamps on the Electrical Industry and on Street Lighting," by Mr. E. E. Hoadley; and "Modern Cable Systems," by Mr. E. M. Hollingsworth.

1 p.m. Luncheon at the Exchange Hotel, Liverpool.

2:30 p.m. Visit to Lister-drive Generating Station.

4:30 p.m. Visit to R.M.S. "Mauretania."

THURSDAY, June 24th.

10 a.m. Meeting in the Municipal School of Technology, Whitworth-street, Manchester. Papers on "Steam Turbines from the User's Point of View," by Mr. A. S. Blackman; and "Notes on Condensing and Water Cooling Plants," by Mr. E. Lunn.

1 p.m. Luncheon at the Midland Hotel, Manchester.

2:30 p.m. Visit to the British Westinghouse Co.'s Works, Trafford Park.

7 p.m. Annual Dinner of the Association at the Midland Hotel, Manchester.

FRIDAY, June 25th.

10:30 a.m. Annual General Meeting at the Municipal School of Technology, Whitworth-street, Manchester.

1 p.m. Luncheon at the Midland Hotel, Manchester.

2:30 p.m. Visit to the Salford Electricity Works at Frederick-road, Pendleton.

FRIDAY, June 25th.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: (1) "A Transition Point in Zinc Amalgam," by Prof. Carhart; (2) "A Method of producing an intense Cadmium Spectrum, with a proposal for the use of Mercury and Cadmium as Standards in Refractometry," by Mr. T. M. Lowry, D.Sc., F.C.S.; (3) "On the Measurement of Wave-length for High Frequency Electrical Oscillations," by Mr. A. Campbell, B.A.; (4) "An Electromagnetic Method of studying the Theory of and solving Algebraical Equations of any Degree," by Dr. A. Russell and Mr. J. N. Alty; (5) "The Sine Condition in relation to the Coma of Optical Systems," by Mr. S. D. Chalmers; (6) "Exhibition of a New Fery Thermo-electric Calorimeter," by Dr. C. V. Drysdale; (7) "An Instrument for measuring the Strength of an Intense Horizontal Magnetic Field," by Mr. F. W. Jordan, B.Sc.; (8) "On a Method of determining the Sensibility of a Balance," by Prof. Poynting, F.R.S., and Mr. G. W. Todd, M.Sc.; and (9) "The Balance as a Sensitive Barometer," by Mr. G. W. Todd, M.Sc.

THE NEW TELEFUNKEN SYSTEM.*

BY COUNT ARCO.

A great change has been taking place during the last few years in the domain of wireless telegraphy, with the result that improvements have been made in two directions—namely, an increase in the range and a considerable improvement in the certainty of working, with which also is included a greater freedom from disturbance. Both improvements have arisen from work that has been done in the United States, and both are due to two very simple technical facts. The first is the abolition of the coherer as a detector in the receiver circuit and its replacement by an integrating detector. The other is the increase in the impulses in the secondary spark in the sender. The beginning of these changes was about five years ago, when the Telefunken Company, in the years 1903 and 1904, shortly before the amalgamation of the Slaby-Arco and Braun-Siemens systems, fitted up a number of ship stations. Leyden jars were used for senders, and the spark-gap was placed in the oscillation circuit, which was directly connected with the aerial and fitted with the well-known Braun method of coupling. The receiver was a recording apparatus on the coherer principle. This apparatus was tried by various American experimenters, including Shoemaker and de Forest. It reduced the exciting capacity by one-sixth and raised the frequency in the secondary about 10 times. At the same time the direct current with which the Leyden jars were charged was increased by about three or four times. At the receiving station the coherer was replaced by an electrolytic detector and a telephone receiver, forming the Schloemilch cell. The range of this apparatus was about 700 km. to 800 km., as compared with 150 and 200 km. with the old arrangement. This record was broken in February, 1907, by a Telefunken station maintaining communication over a distance of 2,400 km.; and since the beginning of 1907 the Telefunken Company has, with few exceptions, used a high-spark frequency, and has thereby reached very great ranges with small mast heights. An arrangement, due to Pfund, in which the standard apparatus was modified by the introduction of a strongly ventilated spark-gap, and by the connection of the choking coil between the machine and indicator, enable a close coupling between the machine and indicator to be obtained, so that the spark frequency rose from between 20 and 30 to about 300 per second. By this arrangement, also, practically the whole of the machine energy was obtained in the exciting circuit, while about 20 per cent. of it was turned into oscillation energy in the aerial. The reliability of this apparatus was increased by the receiver, which contained no movable parts—a great improvement on the coherer.

The author then discusses the methods employed by Elihu Thomson in 1900 and Tesla† in 1894 for the generation of high-frequency oscillations. In these, in spite of the slight damping of the oscillations, it is quite correct to speak of continuous wave trains as being obtained. This name, "continuous trains of waves," has, however, become misunderstood at times. For instance, the Marconi station at Clifden, which works with his new method of generation, by no means sends out undamped oscillations, for it has two standard coupled waves, and, like the old method of spark generation, shows a large damping of the energy transmitted.

Turning to the question of generating oscillations by means of the arc, the author deals with the work of Poulsen in this field, and shows that the expected increase in efficiency could not be obtained, as the oscillations generated by the arc vary in amplitude and in frequency, so that the receiving operation is not different from that with damped waves.‡

The author at the beginning of 1908 was able to generate, by means of the arc lamp, oscillations of a third kind, in which the inconstancy usually present in this arrangement was at last overcome. To do this the capacity of the arc lamp circuit was made very large, the self-induction small and the circuit was coupled as closely as possible with the antenna. The oscillations then transmitted had practically the same frequency and damping as the secondary circuit. An accurate tuning between the exciting and excited circuit is, however, not necessary, and any alteration in the frequency is thereby overcome. We were satisfied with this arrangement for about a month, when we discovered our present system, which is described in this lecture.

* Abstract of a lecture before the Verband Deutscher Elektrotechniker at the annual meeting in Cologne. Abstracted from a full account in the "Elektrotechnische Zeitschrift," 1909, Nos. 23 and 24.

† Martin. "The Invention of Nicola Tesla," pp. 209 and 306.

‡ Reference is also made to the following Papers in this connection: Dr. C. Schapira, "Über den Wirkingsgrad der Hochfrequenzlampe mit unterteiltem Lichtbogen." Graf Arco, THE ELECTRICIAN, Vol. LXIII. Fleming, THE ELECTRICIAN, Vol. LIX., p. 270, *et. seq.* Diesselhorst, "Analyse Elektrischer Schwingungen mit dem Glimmlicht Ozillographen." Ver. der Deutschen Phys. Ges. IX., 14.

A short explanation of the phenomena in two coupled circuits is necessary before referring to the work of Wien. The exciting circuit contains a spark-gap, while the second is electrically tuned, and closely coupled with it. The exciting oscillation has a large amplitude and dies rapidly away, the energy being after a few oscillations wholly transferred to the secondary circuit. A re-transfer then begins from secondary to primary until all the energy is for the second time contained in the latter. This occurs several times, and an oscillograph of the phenomena due to Dieselhorst is shown in the upper part of Fig. 1. The lower curves show the effect when the primary circuit is "quenched" after the energy has all left it for the first time.

In December, 1906, a discovery of the highest importance to those interested in "wireless" work was made by Prof. Max Wien, and was described by him in the "Physikalische Zeitschrift."* In this he made some observations which formed the beginning of our method of generating slightly damped electric waves. He carried out some researches on two closely coupled oscillation circuits, using the Bjerknes method and a resonance circuit, the primary of which contained a very small spark-gap. By means of this arrangement he found, not the usual two coupled waves, but in general three waves, as shown in Fig. 2. His explanation is as follows:—

"The reason for these three oscillations may be considered to lie in the fact that the resistance of the very small spark-gap increases suddenly, so that the oscillations in system 1 die away very soon,

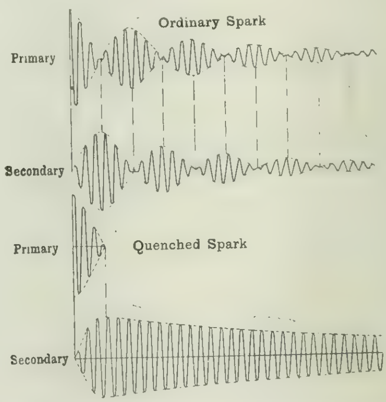


FIG. 1.—OSCILLATIONS IN INDUCTIVELY-COUPLED CIRCUITS.

and only those in system 2 remain. These oscillate as a single uncoupled system within their own frequency and damping. Perhaps it might be possible in this way to obtain slightly damped oscillations."

As soon as I read this article I repeated the tests, and these were so successful that I attempted to modify the idea for technical purposes. My attempts were for a long time unsuccessful as regards the reliability of working, until Rendahl proposed the adoption of a spark-gap immersed in mercury vapour. A very high efficiency was thereby obtained, but in spite of this the method could have no practical application, as the lamps had a very short life, over 150 of them being tried; and, in spite of many attempts, no success was achieved.

About this time Prof. Wien made another communication to the "Physikalische Zeitschrift"† on the subject of the "Stosserregung," and especially as regards their measurement with large spark-gaps and loose coupling. Rendahl, however, showed in a subsequent issue of this journal‡ that the method of Wien described above had a very low efficiency compared with that of the old spark methods, and still lower compared with the mercury vapour lamp. He also showed that the maximum energy obtainable with small spark-gap methods was too small, and the inconstancy of the oscillations was too great for the method to be used in practice. With this statement of Rendahl's I must disagree. In March, 1908, the last difficulty in the process disappeared, as we then succeeded in obtaining the "Stosserregung" by means of a direct-current arc lamp, and a decision had to be come to between the two methods of generation.

About this time, however, a third idea came up for consideration. For after two years' work attempting to make the Wien arrange-

* No. 23, 1906, p. 872. † No. 2, 1908, p. 51. ‡ No. 6, 1908, p. 203.

ment reliable we obtained in March, 1908, our new system of singing sparks. A great deal of credit for this system is due to Herr Rendahl. To him, also, is due the new name of "quenched" sparks for the Wien arrangement, which Wien himself called "hissing" sparks. A harder task is the proper naming of the arrangement known by Zenneck and others as the "Stosserregung." This method is shown in Fig. 3. It contains a closed oscillatory circuit which is connected to a source of direct current through an interrupter. The characteristic of this method is the presence of only one oscillating system, and it is at present much used for measuring purposes. For telegraphic transmission the energy is much too small, as the charging voltage depends on the interrupter, which must, of course, work sparklessly. At first this method of generation had a coupling of 16 per cent. and gave about six half oscillations. It had, therefore, to be very accurately tuned on the secondary side. When, however, the idea of the "Stosserregung" is taken up, these six half

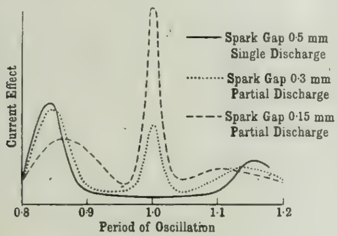


FIG. 2.

oscillations have to be combined into one blow. Zenneck defines a good sender for "Stosserregung" by saying that the oscillations in the primary system must be quenched after the first period and after the primary system has given up all its energy to the secondary system. For this reason the Wien arrangement belongs naturally to this class; but in spite of this there arises the question whether it could be called a "Stosserregung" pure and simple. The arc lamp with a large primary condenser is much more a "Stosserregung," as the quenching can be obtained after the second half oscillations, and tuning between the two circuits is hardly necessary. Other similar arrangements mentioned in the lecture are those of Lepel and the Badische Anilin- & Soda-Fabrik, about the latter of which little is known, while the first has been lately described in THE ELECTRICIAN.*

The author then goes on to describe the various details of the "singing spark" system, the theory of which is given by Wien in the "Jahrbuch für Drahtlose Telegraphie und Telephonie."† The reason for the sharp quenching lies in the fact that the heat conductivity of the short spark-gaps is small. This phenomenon is used twice, once in generating a single small damped train of waves, and secondly to obtain a sharp and regular frequency of sparking. Such

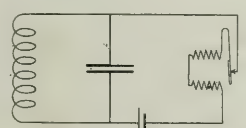


FIG. 3.

a high frequency is only possible with an ordinary spark-gap when a strong air blast is used,an arrangement which means a considerable loss in energy. It can be obtained with quenched sparks quite as accurately as in the mercury vapour lamp, with which apparatus von Simon first obtained a high-spark frequency. Further, in this way a larger range can be obtained by using a quantitative detector. If these impulses are made to follow each other very regularly, this form of sending energy causes, if such a detector is used, a rhythmic movement of the telephone membrane in the receiving station, and gives a clear musical tone. Such an arrangement should, perhaps, be called "singing quenched sparks," but we have adopted the simpler name of "singing sparks."

Turning to the arrangement of the sender, this consists of an exciter circuit in which is placed the quenched spark-gap. A tuned aerial system is connected with this, the coupling between the two being close enough to allow of the energy passing over as quickly as possible, but loose enough to allow of quenching after the first oscillation, so that none but the first oscillation in the secondary need be taken into account. For this reason a coupling from 15 to 20 per cent. is used in most cases. The damping of the transmitted waves with umbrella or T antennæ is about 0·08 to 0·1 when the latter are working with their fundamental oscillation, but only 0·05 to 0·03 when waves of from three to four times as long as the fundamental are being sent out. Such small numbers can, however, only be obtained when special care is taken to reduce all losses to a minimum.

Anyone who has worked with oscillations of so low a damping will agree that it is very difficult to obtain from the behaviour of the resonance circuit without the help of a resonance curve, an idea as to whether constant amplitude oscillations or very slightly damped oscillations are being used. In practice the difference in resonance between these two is scarcely noticeable. In quenched spark generation, on the other hand, the condition of the spark-gap has no influence on the frequency of the secondary circuit, and it need not, therefore, be regulated. The frequency is absolutely constant, and the resonance can be fully utilised. On account of the very small antennæ damping, auxiliary circuits have up to the present been used between the generator and the antennæ, as recommended by Stone and Wien. These have been tried exhaustively in the laboratory, but have not yet been introduced into practical working. The damping of the auxiliary circuit must, in order that it may work advantageously, be not more than one-tenth of that of the antennæ, or a maximum of 0·01 to 0·005. This is, however, hard to obtain, and we have not yet succeeded in doing so.

The rapid adjustment of the apparatus to work with different wave-lengths, which is necessary at the present time, gives rise to a number of by no means small difficulties as compared with the simple

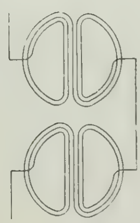


FIG. 4.

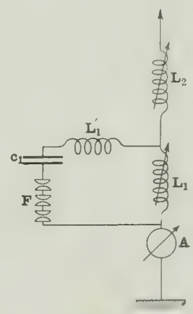


FIG. 5.

arrangement with which we worked. The sender has not only to be capable of using a number of wave-lengths over the greatest possible range, but these have to be continually altered between wide limits and over a large wave scale. For altering the wave-length two arrangements are used—*i.e.*, either altering the condenser, or the inductance coil, or both may be combined. Having regard to the inductive relations, the inductance coil is the easiest to alter, and an apparatus known as the variometer is now used in wireless telegraphy for this purpose. One of these apparatus, capable of dealing with a considerable amount of energy, has now been successfully built, and will be placed on the market for sending purposes. This variometer consists of a fixed and movable circular plate. On both of these are placed windings which can be connected in either series or parallel, as shown in Fig. 4. If the discs are so arranged that the fields of the four coils can be added together the self-induction is a maximum, while in the opposite position the self-induction becomes a minimum. A continual variation between these limits gives the various values. Such a variometer, which can be altered through an arc of 360 deg., and by changing over the windings from parallel to series gives a self-induction of 1 to 16, is due to Rendahl.

To obtain any desired wave-length in both oscillation circuits by means of such a variometer is an easy matter, but it is harder to arrange the sender to work equally over all wave-lengths and at the same time to obtain good quenching. Rendahl has overcome this difficulty in the simplest way by the arrangement shown in Fig. 5. In this the exciting circuit is made up of a condenser C_1, the spark-gap F and the coupling variometer L_1. The poles of this circuit are connected through a hot-wire instrument to earth, and through the counterpoise to an antennæ; a variometer, L_2, is also connected in the circuit. If C_2 is the capacity of the antennæ and L_1 the total self-induction in the exciter circuit, it can be both theoretically and

* Vol. LXIII., p. 174, *see also* p. 376 of this issue.
† Vol. V., p. 473, *et. seq.*

practically shown that for any desired wave-length which can be obtained by altering the variometer the coupling remains constant, and that the coupling factor is given by the relation $\sqrt{\frac{C_2}{C_1}}$. This relation works out at 1 to 25 for a 20 per cent. coupling. In reality it is best for the coupling not to be kept quite constant, for with short waves and with the quenching arrangement very short it should be somewhat looser. This is obtained in the simplest way by connecting in the exciting circuit a constant, and, in relation to L_2, a very small self-induction, L_1', which is not used for coupling purposes. So long as L_1 is also small, L_1' appreciably affects L_1, and the coupling is loosened. For larger values of L_1, L_1' may be neglected and the coupling is closer.

For a constant primary capacity the wave-length could be increased four times, say from 500 to 2,000 metres, by using the variometer described above. With rather more complicated construction it could be altered five times, say from 600 to 3,000 metres. If it is desired to increase this range, the variometer must either be removed or be combined with a variable capacity. In the last case the antenna, of course, must also be changed, as the change in capacity will also tend to change the most suitable coupling. A change in the antenna is generally necessary, as for a certain length of wave, say from four to five times the fundamental, the antenna oscillations will become too small. This has, rather extraordinarily, been forgotten in arc lamp methods, for the author has heard that as long a wave as desired can be obtained from any antenna with a sufficient amount of energy. In this case, why not connect the antennæ direct to the pole of the alternating-current generator ?

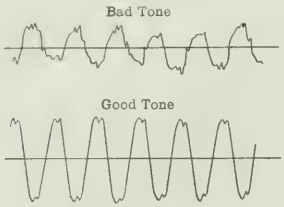


Fig. 6.

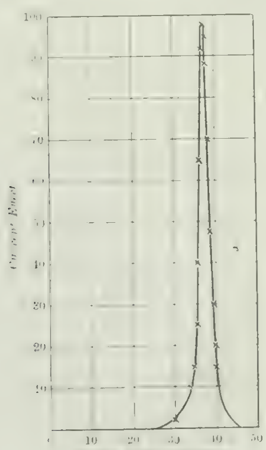


Fig. 7.

As regards the current for feeding the exciter, as large a number of impulses as possible is desirable for well-known reasons. Direct current is, therefore, an advantage. Against this, however, there are many disadvantages, of which, perhaps, the greatest is the arcing tendency, the high voltage, which in a sender of about 4 kw. capacity is necessary for the good operation of the spark-gap, and complications in the receiver on account of the difficulty of regulating the spark frequencies. This last condition requires the use of alternating currents of standard frequency, although even here a number of impulses may be generated by partial discharges. Amongst the well-known advantages alternating current possesses one other—viz., the tendency to arc in the spark-gap which is present with direct current, and, in spite of inductive and other resistances, is not quite avoided, in this case entirely disappears. With alternating current of standard frequency matters are so arranged that for each change in current direction a whole series of partial discharges take place. As shown in the upper curve of Fig. 6, a current curve taken on the oscillograph in the secondary transformer circuit, there are three partial sparks per oscillation. These periodic impulses may give rise to a very large sender energy, but are, in spite of this, of very little use in the ordinary acoustic receiver. For instance, our test station at Nouen worked for a long time on 150 periods per second, and with about 2,000 impulses in the same time. At the receiving end the energy could not be collected in the telephone, except by changing it by means of a detector into rectified currents. The irregular and quick impulses generated only small amplitudes in the membrane. A special transformation of energy had, therefore, to be effected at the receiving end by means of an interrupter, or some apparatus of that description. The more frequent the impulses the less audible they are in the receiving telephone, and are, therefore, more suitable for telephony and less suitable for telegraphy, except by using the receiving arrangement described above, which, however, has its unpleasant side.

For practical purposes, especially as regards the receiver, it is most suitable to use an impulse frequency of from 500 to 2,000 by the employment of alternating current with the same frequency, so that one discharge takes place per alternation. The regularity is then so great that the noise of the spark gives out a clear musical tone, as shown in the lower diagram in Fig. 6.

With an alternating current of frequency between 500 and 1,000 the generation of sending sparks is very good and this arrangement should be tried. I do not know, however, whether it is possible to obtain such a good sound by using vapour lamps. The clearness of the tone plays a considerable part in the utilisation of the energy and freeness from disturbance in the receiver.

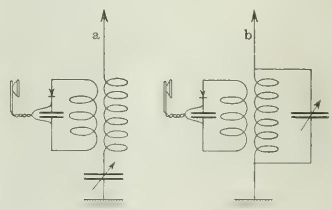


Fig. 8.

The generator current is transformed to charge the exciting capacity, and is stepped up from 4,000 to 70,000 volts, according to the size of the station. This operation can be carried out by an ordinary transformer or by an induction coil. Both have their advantages and disadvantages, and the efficiency of both is about the same. In the larger stations an induction coil is used, and in the smaller a transformer. It should be remarked that the very low efficiencies of induction coils which are found in Röntgen ray and laboratory work do not occur here. This is owing to the fact that they are correctly proportioned to the back E.M.F. from the capacity and themoderate voltage.

Coming now to the high-frequency apparatus and exciting circuit, the principal problem was the quenched spark-gap itself, and here numerous difficulties were met with, the principal of which was the generation of a series of regular sparks. The sparks passed generally between the middle points of the electrodes, so that an arc was set up and the electrodes wore away, thereby throwing out the oscillations. This trouble was overcome by the adoption of ring-shaped electrodes whose surfaces, between which the sparks passed, were polished. The spark occurred at one place only, but never at the middle, and was then forced, as in the horn arrester, to the edge of the ring. On the way it was quenched. In order to keep the electrodes at quite a small distance apart the space between them was filled with an insulating material, such as mica, and by this means, also, air was satisfactorily excluded. With this arrangement, however, large quantities of energy could not be used, as a limit was soon reached ; the spark-gap then got out of hand, and had to be removed every half hour or so for cleaning purposes. Examination showed that the surface was pitted. This energy limitation has now been overcome, so that any desired amount can be converted into oscillations, and it does not appear that any further increase will give rise to difficulties. A modification was made in the series

spark-gap, the total energy being distributed between several gaps in series, so that none were unduly stressed, in proportion to the amount of energy being converted.

The material used in the spark-gap is of even greater importance as regards sharp quenching, efficiency and reliability. Iron, zinc, brass and aluminium are all quite unsuitable for the purpose. The best materials are copper and silver—*i.e.*, metals with specially good heat conductivity—and only with these substances can a sharp quenching be obtained, even with couplings of 20 per cent. and upward. Close coupling is necessary for the energy to be quickly distributed and for the spark-gap to be instantaneously unloaded and cooled ready for the next discharge. For the same reasons, as regular discharges as possible are to be recommended, for then the cooling time is best employed. A large number of spark-gaps give rise to no complications, as they need not be inspected more than once every few weeks ; and, further, a very simple regulation of the sender energy is obtainable by cutting out one or more of the spark-gaps or by inserting a resistance in series with them. A very small proportion of the full-load energy, say one-hundredth or less, may thus be used, when short distances have to be traversed, without altering the sound of or damping the oscillations.

Rapid quenching of the sparks can be effected more accurately when the energy in each spark-gap is relatively small, and when the spark distance is kept short. Hydrogen* may be used instead of air for enclosing the gap, an arrangement which allows longer gaps to be employed, if desired, and reduces the energy consumed. It may be noted that it is possible to obtain a single oscillation from a coupled sender with an ordinary spark-gap by submitting it to a strong enough blast. This was shown by Pichon in 1907, who succeeded in obtaining from a 5 mm. spark and a 20 per cent. coupled sender a single wave by submitting the gap to a very strong blast of nitrogen. This arrangement is, however, very inefficient.

There is as little trouble with the capacity as there is superfluity of it with the spark-gap. The rapid quenching in the primary circuit makes it unnecessary to consider any small losses in the latter, and low-efficiency paper condensers have been used without any difficulty. No trouble is experienced from edge discharge, as the short primary waves only slightly ionise the surrounding atmosphere.

The damping of the exciting circuit with ordinary spark-gaps is, in fact, generally considered from the wrong standpoint. Unloaded gaps are measured to find the energy transmitted, and a decrement of 0·2 is allowed for the antenna. This factor should, however, have a value between 0·08 and 0·03, as shown by the resonance curve in Fig. 7. Under these circumstances, the value of the reduction which should be made in the unloaded exciter damping is not so large as is generally thought. For instance, with an old type of sender, the rather low damping on no load of 0·35 was obtained, yet this sender was able to communicate with ships over distances up to 950 miles, using only 1·5 kw. in the primary. It was, therefore, very efficient in practical working, and the only points that need be considered are safety in operation and the reduction of the space occupied by the apparatus to a minimum.

Owing to the sharp quenching of the exciter a hitherto unknown economy is obtained in the generation of the high-frequency oscillations. The efficiency of a 2 kw. generator with a frequency of 500 is about 75 per cent., that of the induction coil about 80, and that of the high frequency exciter 85 per cent., so that the overall efficiency is 50 per cent., or, without the machine, 65 to 70 per cent. In a larger equipment, such as an 8 kw. station, it is naturally higher. Compare these results with those obtained in the spark method with an efficiency of 20 per cent., and with those of the arc with an efficiency of 10 to 15 per cent. ! This increase in efficiency is of especial importance, in portable stations, as less weight and volume are necessary for the same output.

The arrangement of the secondary circuit was much more difficult, as the energy remains in it for a long time, and its damping must be proportioned to that of the transmitted wave. A choice had to be made between the old Braun and the "Zwischenkreisschaltung" arrangements. The latter† possessed great electrical advantages, but required a strongly damped antenna, which oftens means an increase in the mast height. The Braun arrangement was, therefore, adopted in conjunction with slowly-transmitting slightly-damped antennæ, especially as this arrangement was more suitable for receiving.‡ But on the other hand, a number of difficulties had to be considered in this connection, for a slightly-damped antenna only imposes a smaller damping on the discharge, and, in order not to make the antenna efficiency too low, all damping losses must be reduced to a minimum, including those due to earth current and silent discharges. A special set of equipment has been designed for this purpose, including insulators and improved antenna material. Further, the resistance losses in the antenna transformers have been greatly reduced. For this purpose very fine copper wires with a maximum diameter of 0·07 mm. have been used in the windings, a number of which are connected in parallel and insulated from each to other to give the necessary low antenna resistance. Low resistances are a necessity for high antenna currents, and in the latest 2 kw. stations, with an antenna capacity of 1,000 cm., a current of 13 amperes is obtained with a wave-length of 1,000 cm. and an antenna resistance of 6 ohms. The antenna coils consist of 480 single wires connected in parallel. In the 8 kw. station the capacity is 2,000 cm., the current 35 to 40 amperes for the same wave-length, and the resistance is 3 ohms. Over 3,000 wires are used in winding the coil. All the wires must be equally loaded, a condition which is obtained by using wires of equal ohmic and inductive resistance.

* "Uber Funkenstrecken für Stosserregung." By A. Espinosa de los Monteros. "Jahrbuch d. drahtl. Telegraphie und Telephonie," Vol. I., p. 480.

† "Physikalische Zeitschrift," No. 2, p. 50, 1908.

‡ "Annalen der Physik," Vol. XXV., p. 446.

To alter conveniently the antenna wave-length, a part of these windings is used as a variometer, while the rest can be cut out by steps, so that wave-lengths varying over a very wide range can easily be obtained. On the other hand, in the older methods, if the wave-length was increased to more than one and a half times the normal, the range decreased rapidly. Altering the length of the coils, too, resulted in an increase in the spark-gap losses, owing to the increase in the number of oscillations. In the quenched spark system, however, after the first oscillation, the primary circuit is cut off from the oscillations, and there is no increase in the losses.

Turning to the receiver, a choice of detector and its connection is limited by the energy form of the sender, and falls with singing sparks into three main classes.

The first condition is a very rapid impulse frequency with a relatively small maximum voltage, allowing long ranges to be obtained even with short antennæ. For this purpose only such detectors as electrolytic cells, and especially the so-called contact detector, which works as a rectifier and without a relay, need be considered. The more rapid the impulse frequency and the shorter the pauses the lower the maximum voltages in both sender and receiver, the more unsuitable is the coherer, the limit to this being reached with undamped waves of small amplitude.

The author then reviews the development of the contact detector, paying special attention to the work of Braun and to that of Wien* and Austin.† The Poulsen ticker arrangement is also referred to.

The second condition is the singleness of wave and small damping of the transmitted oscillations. In the earliest coupled senders the energy was divided about equally between the waves, and attempts to tune both sender circuits failing, the receiver was tuned on one, usually the shorter, wave. This arrangement meant a certain loss of energy, and possessed other disadvantages—disadvantages which are overcome in the new sender by the suppression of the coupled wave and by a decrease in the damping. Increased tuning and resonance is thereby obtained. These two advantages possessed by the quenched spark method mark a great advance. The small damping permits the use of a loose coupling between the receiving antenna and a minimum damped secondary circuit, from which at each oscillation a definite amount of energy is sent to the detector. The coupling was formerly so loose that no wave was noticeable at the receiving end, so that the energy from the single wave was very well picked up. In spite of the view that still looser coupling should be employed, it has been made close in the singing spark system, and the arrangements shown in Figs. 8A and 8B have been adopted for short and long waves respectively.‡ Dr. Kiebitz has shown in this connection that neither sensitiveness nor freedom from disturbance are sacrificed by directly transfering the antenna energy to the receiver. On the other hand, the loose receiver coupling recommended by Mandelstan and Brandes§ is not as successful against atmospheric disturbances as was hoped.

Only one method of preventing disturbances is possible—that is to give the sender an individuality, and to allow it to work directly on to an induction coil. It is very disadvantageous to have any transformation of the receiver energy which shall reduce or alter the individuality of the sender. In the so-called calling apparatus which is now being placed on the market, and which is designed to close a local circuit by means of the detector current and cause a bell to ring, we use a certain selectiveness . The apparatus consists of a moving-coil instrument having a sensitiveness of 10^{-7} amperes per scale division. Owing to the pointer moving there occurs at intervals of 10 seconds a good contact, which closes the local circuit. Atmos-

* "Physikalische Zeitschrift," 1902, p. 69.

† "Bulletin" of Bureau of Standards, Vol. V., p. 158.

‡ German Patent No. 136,641.

§ German Patent No. 191,478.

pheric disturbances and short-lived impulses of any kind do not move the point from its zero position, but a series of impulses lasting from 10 to 20 seconds puts it in operation.

The third distinguishing characteristic of the singing spark system is the very fine individuality of the sender. The musical sound of the spark, in fact, gives each sender a distinguishing mark other than the wave-length and the damping. A great advantage is that the signals are transmitted as clear musical sounds, and although attempts to do this have often been made, they have never succeeded. This characteristic is the reason for the extraordinary results obtained with the new system, as it allows the signals to be clearly distinguished from atmospheric disturbances; a differentiation not possible with either the old spark or arc arrangements. And this differentiation is possible in the singing spark system, however large the disturbances are, even up to the breaking-down point of the detector.* The sender can be easily adjusted to transmit sounds slightly different from the standard, and, thanks to the adaptibility of both the ear and telephone in compassing a large scale, great variations in the frequency, say from 200 to 2,000, may be employed.

Attempts were made to obtain a better sound efficiency by the employment of both electrical and acoustic resonance, in accordance with the advice of Wien, but these were not successful. On the other hand, a very much better efficiency was obtained by the employment of the tuned telephone relay. The long-sought-for solution to the problem of a telephone relay has been simplified in this special case by the fact that the rhythmically pulsating detector current passes through the high resistance winding of an electromagnet, in whose field is a light armature with a period of oscillation corresponding to that of the required sound. Microphone contacts are placed against this armature, and these are connected with the winding of a second electromagnet and a local battery. A current of greater strength, but pulsating rhythmically with the first, is sent through this second winding, and communicated to a second armature with increased amplitude. By three such arrangements it is possible to raise the detector current from 10^{-8} to 10^{-2} amperes, and by this means a loud-speaking telephone or Morse instrument—connected, of course, through a suitable relay—can be used. Such a resonance relay increases not only the selectiveness, but also the sensitiveness.

With regard to the other advantages of this system the reader is referred by the author to the article which appeared in THE ELECTRICIAN for April 30, 1909.

The following are some data relating to the outputs of the present standard apparatus :—

Primary output. Kw.	Height of mast. Metres.	Range. Km.	Over land or sea.
1·5	20	200	Land
1·5	30	350	,,
1·5	45	550	Mountainous land
1·5	35	600	Sea
8·0	60	2,500-3,000	Level land
20·0	60	3,500-4,500	or sea

The above concluded the literary portion of the lecture, and the author then turned to demonstration. He showed by means of apparatus on the lecture table the operation of the resonance relay (Resonanzlautverstarker). Keeping the electric tuning on both sender and receiver constant, he altered the acoustic resonance over a range from one octave above to two octaves below the fundamental, and showed how the sound from the sender altered. The relations between the intensity and sharpness are the same in this case as with electrical tuning. The operation of the "Stosserregung" was further demonstrated by means of a pendulum similar to that used by Prof. Fleming at his recent Royal Institution discourse, and described on p. 332 of our last issue.

A 2 kw. quenched spark station delivering singing sparks was shown, an artificial antenna being used whose electrical dimensions were: Capacity $(C)=1,000$ cm., self-induction $(L)=51,200$ cm., fundamental wave $(\lambda_0)=450$ m., and damping $(\delta_0)=0·08$, or such as would be employed on a ship station with a T antenna. With such an antenna a wave range from 600 to 2,000 metres could be continuously obtained. The energy consumed in this arrangement was measured by a wattmeter in the transformer circuit, and a hot-wire ammeter in the antenna circuit. These gave readings of 1·5 kw. and 13 amperes respectively. Taking the dimensions given above, the antenna resistance works out at 5·3 ohms, whence the efficiency of the arrangement is 60 per cent.

The singleness of the wave and damping in the antenna was then shown by means of a wave measurer. The antenna was connected with a large detector, and the tuning and loudness of the oscillations could be distinctly heard. The quenched spark equipment was then removed and one producing the ordinary coupled waves substituted and the differences demonstrated. The easy regulation of the spark-gap was also commented on.

The lecture then continues: "I concluded my lecture before the Schiffsbautechnischen Gesellschaft in December, 1907, with the question: Which is the method of the future? I called attention to the apparently successful production of a vapour lamp, and remarked that practice would have the last word on the subject. The vapour lamp has not yet made its appearance in practice, but has, in fact, received a knock-down blow by the introduction of Wien's method. In the course of only a year this new method has risen from laboratory beginnings to a workmanlike and well-tested equipment, which appears to work extraordinarily well in practice. At powers of about 1 kw., measured but now after one year's working, and without the principle of the arrangement being altered in any way, a 50 kw. station has been constructed, by means of which as much as 30 kw. can be delivered to the antenna as oscillatory energy. This station will shortly be erected and tested at our Nauen experimental station. 6 kw. delivered to the antenna allows a range of 3,000 km. to be covered, so that 30 kw. predicates a range of many thousand kilometres, and the conversion of the ether into the earth's space vector."

* Kiebitz, "Elektrotechnische Zeitschrift," 1909, p. 222, THE ELECTRICIAN, Vol. LXIII., p. 99.

THE LEPEL WIRELESS TELEGRAPH SYSTEM.

BY BARON VON LEPEL.

I should like to make the following remarks on the recent publications of Count Arco in THE ELECTRICIAN, and in the German technical and daily press, regarding the new system of singing sparks, and especially on Count Arco's lecture at Cologne on June 4th.*

In reply to the letter of the Lepel Wireless Syndicate published in THE ELECTRICIAN on May 14, 1909, Count Arco also published a letter in the issue of May 21, 1909, in which he stated that the Manager of the Syndicate, Capt. A. Simpson, had no right to remark, owing to his ignorance of the Telefunken patents, that the singing spark system was a serious infringement of the patent rights of the Lepel Wireless Syndicate. I know Count Arco's statement to be quite untrue on

Extracts from translation of E. Von Lepel's German Patent No. 24,757. Filed August 20, 1907. Laid open April 12, 1909.

Claim 1. Generator for the production of rapid electrical oscillations from direct or alternating current, consisting of two electrodes between which an electrical discharge takes place, and with which one or more oscillating circuits are connected in parallel: characterised by the fact that the working surfaces of both electrodes, of which the negative must be metallic, are parallel to one another and are separated by a gap which is small in comparison with their area.

Claim 2. Generator according to claim 1 characterised by an arrangement to prevent the discharge travelling to the edge of the electrodes, consisting of an annular layer of a suitable insulating material, preferably paper, between them.

Extracts from translations of the Telefunken Company's German Patents.

No. G. 27,483. *Filed August* 20, 1908. *Laid open April* 13, 1909.

Patent claim . . . consisting of two electrodes pressed against each other with intermediate insulating material, characterised by the fact that at the ends of the insulating material the distance of the electrodes is greater than in the sparking space.

2. Spark-gap according to claim 1 characterised by a ring-shaped sparking space.

No. G. 27,164. *Filed June* 23, 1908. *Laid open April* 13, 1909.

Claim 1. Disposition of two modifications (?) of the Wien process of producing electric oscillations (hissing spark) gap in which several spark-gaps are connected in series, characterised by the fact that the electrodes of the spark-gap, which consist of not easily volatilised heat-conducting material, are in the shape of plates and are at or about the same distance from each other for an area, which is considerable in comparison with the spark-gap.

No. G. 28,198. *Filed May* 16, 1908. *Laid open April* 13, 1909.

Claim . . . characterised by the fact that the spark-gap is enclosed so as to be as far as possible air-tight.

Specification. The invention relates to a spark-gap for the Wien process and differs from known forms by the fact that all access of air to the spark-gap is impossible. This has the effect of making the sparks much more regular, which is probably chiefly due to the fact that the sparking surfaces can be oxidised only to a very limited degree. Such a spark-gap in which the electrodes are made of copper will, after having been worked for hours, hardly show a suspicion of oxidisation.

* Abstracted on p. 370 of this issue.

account of the practically simultaneous publication in April, 1909, of the master patents of both the Telefunken Company and the Lepel Wireless Syndicate.

Count Arco incorrectly stated that we had no knowledge of the Telefunken patents, and he denied any knowledge of our German specifications, so that I am compelled to reproduce the corresponding parts in both specifications. (*See* page 374).

The identity of both arrangements is clear, and it only remains to remark that the application of the Telefunken Company was made about a year later than mine. Coming now to the development of the system, as explained by Count Arco, at Cologne, on June 4th, he goes back a long way and makes the statement that American stations have employed very high spark rates for many years. But the Telefunken Company thought that the messages had been picked up under specially good receiving conditions, and, therefore, attached no importance to these facts. Count Arco then gives an account of the work which was carried out by the Telefunken Company with mercury vapour lamps by Rendahl, and shows that the company had for a long time experimented with the "Stosserregung," when in 1908 occurred a great change in direction on the part of the Telefunken staff.

In December, 1906, was published by Prof. Wien the properties of a very powerful discharge which could be obtained from very short spark-gaps. Researches were made on these, and their very great advantages for wireless telegraphy amply demonstrated. After this publication, which as remarked by Count Arco, occurred in December, 1906, it was still a long journey to the design of an arrangement by which a simple and technical apparatus could be obtained for transforming a large amount of energy with a good efficiency; and Count Arco says that the first researches of the Telefunken Company in this direction were abandoned; until suddenly, in March, 1908, the Telefunken Company were blessed with enlightenment.

The above is, very shortly, what is laboriously stated by Count Arco in his lecture in proving, in advance, an alibi for the Telefunken Company against all later assaults on their position.

It is interesting to note here that Count Arco remarks, "besides this, other methods of generation have been proposed, which appear to employ the 'Stosserregung' by means of an arc lamp (Zenneck, Leitfaden der drahtlosen Telegraphie)—*viz.*, the methods of the Badische Anilin & Soda-Fabrik and that due to Lepel. About the first nothing is known, while about that of Lepel some details have appeared in different daily papers. It appears to employ an arc immersed in hydrogen and playing between two very close metal surfaces, by which practically continuous oscillations are obtained in the secondary circuit."

I feel myself pledged to quote Count Arco's lecture at this place, because by it a fierce light is thrown on his outspoken *mala fides*, for he by this time must have known of the publication of our German patent specification. I will now go on to certain important points in the development of the history of my system. As a result of early researches on the conductivity of thin, badly-conducting sheets, I obtained in November and December, 1906, a very simple arrangement for generating electric oscillations, and brought it to a sufficient state of perfection that I was able to show the very primitive arrangement to Count Arco. In January, 1907, he came at my invitation to my residence in Berlin, after I had first bound him over to strict secrecy. I possess correspondence with him from which it appears that he paid repeated visits with his then chief of laboratory staff, Mr. Rendahl. Numerous tests were carried out by them to investigate my arrangement, which I had, unfortunately, shown them, with the result that the Telefunken Company entered into negotiations for the purchase of the invention.

Both Count Arco and Mr. Rendahl considered, as I did, that the phenomenon was not suited for arc but for spark working. And they agreed with me that the arrangement would work as well with direct current as with alternating current, and that by connecting several apparatus in parallel, as well as by using high voltages and series connection, very large amounts of energy could be safely generated. The Telefunken Company had only an interest in my invention as regards its use in wireless telephony, for which only small amounts of energy have to be used. They also considered that practically continuous oscillations were unsuitable in wireless telegraphy, because the use of a coherer was impossible with them, and a good effect could not even be obtained with a telephone receiver. Even with the Poulsen ticker, under the most suitable conditions, an integration of at most 50 oscillations were obtainable.

My work was, therefore, confined from that time to direct current at a pressure of 220 volts I ordered in the Telefunken shops a very simple, but, unfortunately, a very inaccurate, apparatus with a ring spark-gap, with which exhaustive tests were supposed to have been made in the Telefunken laboratory shortly before Easter, 1907, and always under Count Arco's vow of secrecy; in reality, a test was made which lasted about an hour and when I inquired of Count Arco as to his opinion on the result he stated that this arrangement was quite sufficient to convince him of the unsuitability of the system for wireless telephony, as the tone was "coloured" when receiving.

In this experiment I used two very large ring shaped metal electrodes which were planed as level as possible, and whose surfaces were placed as nearly as possible parallel at a distance apart of something in the neighbourhood of $\frac{1}{10}$ mm. Tests were also made with polished electrodes, using between them a thin layer of Venetian turpentine. At this time Count Arco asserted that he had doubts as to the validity of my patent, as it dealt simply with the subject of a new spark-gap. I, therefore, continued working with my arrangement and communicated confidentially the improved apparatus thus obtained to Poulsen in June and September, 1907. In September, 1907, I sent, with the new system and with very good results, the first news over a long distance, namely, between Lyngby and Esjberg, using Poulsen's mast, and with his ticker as a receiver. The direct current used in this case was $1\frac{1}{2}$ amperes, the terminal voltage being 440 volts, the distance covered being about 160 miles. The hearing was good and the tuning obtained was equal to that with the Poulsen apparatus. A single wave about 1,000 metres long was transmitted. I showed Poulsen two things in the laboratory; first, that the damping of the oscillations in an artificial antenna could be varied, as desired, over the widest limits by altering the damping of the antennæ, and, second, that the generation of the oscillations was possible with my apparatus both with and without the employment of a ring of paper between the plates. Equal energy and sharpness of tuning was obtained in both cases, and there was merely an improvement in the constancy of the oscillations, by placing a ring of insulating material between the plates. I was thus able to disprove Poulsen's objection that the hydrogen obtained from the paper was necessary for the generation of the oscillations.

As, however, I could come to no working arrangement with the Poulsen Company I determined to work privately, and used a fairly old station at Reinickendorf, near Berlin, and a second station placed at Brunswick. At this station in January, 1908, I first showed my arrangement to the chief of the Wireless Telegraph Section of the Prussian army. Until June, 1908, I carried on tests over long distances, for instance, between Berlin and Norddeich, about 312 miles, with the Poulsen ticker as receiver. I then first succeeded, in conjunction with Dr. W. Burstyn, in putting into practical operation the receiving arrangement designed by him. From this moment our system took up an independent position.

Since 1908 the Telefunken Company had for many months an almost daily opportunity of over-hearing the working of our station at Reinickendorf, both telegraphing and telephoning, and to acquaint themselves with the constancy of the wave-length and the singularity of our oscillations. For this reason further negotiations were undertaken with the Telefunken Company in March, 1908, which resulted in Count Arco refusing to guarantee the amount of secrecy required by my partners and myself, which was demanded on account of the state of our patent specification. At this time Count Arco informed me that he had often heard our signals at Furstenbrunn, a trial station of the Telefunken Company.

Last September I came to England with two stations, and worked here for three months under the auspices of the War Department with Capt. Evans at Aldershot. Soon afterwards these stations were purchased by the British War Office, and the Lepel Wireless Telegraph Syndicate, Limited, with offices in London, was founded; the first step towards a

wider publicity being thus made. Up to this time the work had been carried on by me with the kind and able help of Dr. W. Burstyn and General von Gayl. The first of these introduced, besides the receiver mentioned above, a number of important details and improvements into the new system. On account of the small number of the staff which has been working on my system its development has naturally been relatively slow. This development was undertaken in the direction of obtaining not only a suitable system for wireless telegraphy but also for telephony, a fact which has led me, after certain tests with alternating current, to return, as regards energy generation, to direct current. My idea was to use as far as possible voltages under 500 volts, thus obtaining a cheap system over moderate distances. I have succeeded, in fact, without a series arrangement, in obtaining an apparatus which is cheap and which embodies all practical requirements. For the further development of alternating-current working the necessary laboratory staff has been obtained and a method of generating oscillations by alternating current is contained in our patent.

Besides this I have made another very considerable step, for I have succeeded by the simplest methods in transmitting a musical note in our direct-current stations. This note is very clear and strong, and possesses many advantages over that generated by alternating current. Two of these can be set down here. The tone can be altered as quickly as need be over the whole acoustic scale, and no complicated and costly machinery is necessary to do this. In order to obtain an idea of the efficiency of this latest improvement, I may inform you that the chief of the Royal Wireless Station at Scheveningen has written me that the competent staff there heard a few days ago "God Save the King," which we were playing at our Slough station by means of an electric piano. This apparatus can, of course, be also used for alternating current. Tests are now being carried out on long-distance work, and I shall be pleased to describe these later.

I therefore think that, under the limitations which are necessary when publishing an article in the technical Press, I have made it clear that the new Telefunken system is not an accidental but an intentional copy of my system, and I will, in conclusion, ask Count Arco the question whether it is unknown to him that his own engineers designate the so-called new Telefunken system as "Die Lepelei."

THE LEPEL WIRELESS TELEGRAPH SYSTEM.

BY J. ERSKINE-MURRAY, D.SC.

As a considerable amount of misconception appears to exist as to the function of the generator in the Lepel system, I was recently requested by the Lepel Syndicate to make a series of experimental measurements which should determine definitely the character of the discharge through the gap between the electrodes. This experimental investigation is not yet complete in all its details, but as decisive results have been obtained on the points of major importance it is unnecessary to delay publication of the latter; further details being reserved for a later communication.

1. The electrodes between which is the gaseous section of the primary high-frequency circuit are metal plates about 8 cm. in diameter. The upper plate, which is usually of brass or some similar alloy when direct current is used, is cooled by contact with a metal tank through which water circulates. The lower plate is usually of copper and is itself a hollow box through which water is passed continuously. As the air gap between them is, I find, under ordinary working conditions only about 0·05 mm. the conditions are favourable to an extremely rapid cooling of the gas heated by the discharge. Prof. Fleming, in his article on "The Telefunken or Quenched Spark Discharger" in last week's issue of THE ELECTRICIAN, states that the gap between the plates in the Telefunken type is 0·25 mm.; hence the Lepel generator, in which the gap is only one-fifth part of this, is probably four or five times as efficient as a spark quencher—*i.e.*, is much less likely to permit of the formation of an arc.

2. I have seen a high-frequency current produced with this generator without the use of a paper, or any other diaphragm. The difficulty then is that the discharge is apt to run to the edge of the plates, where it becomes at once an inactive arc. Paper is better than mica to prevent this happening on two accounts. Firstly, mica, if fused by the discharge, becomes conductive, and secondly, the fact that the paper burns away very slowly ensures that the discharge passes gradually from point to point of the electrodes, constantly taking place at fresh and cool parts of their surfaces.

Since the high-frequency current can be produced without employing any diaphragm whatever, it is clear that the action of the Lepel generator does not depend on the presence of a hydrogenous atmosphere between the electrodes.

3. Experiment shows that a large alteration in the distance between the electrodes makes no appreciable difference in the frequency of the current.

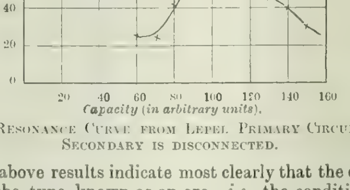


FIG. 1.—RESONANCE CURVE FROM LEPEL PRIMARY CIRCUIT WHEN SECONDARY IS DISCONNECTED.

4. The above results indicate most clearly that the discharge is not of the type known as an arc—*i.e.*, the conditions of its production are totally different from those obtaining in a Duddell or Poulsen generator. In addition to these we have the fact that the capacity in the primary circuit is a very considerable fraction of a microfarad while the inductance is extremely small.

5. The most conclusive proof, however, of the nature of the discharge is given by the resonance curves of Figs. 1 and 2, which show that the decrement of the oscillations in the primary circuit though the air gap is very large, amounting to about 0·6, even when no energy is being taken by the secondary. Under working conditions the value is, of course, considerably greater, owing to the inductive and conductive transfer of energy from primary to secondary, which increases the damping of the current in the primary circuits.

Thus resonance curves, taken from the primary circuit while it is giving out energy to the secondary, or aerial, circuit, by

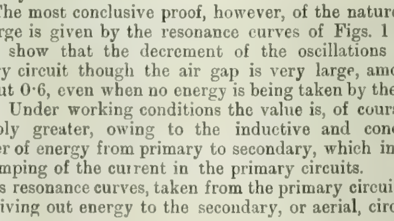


FIG. 2.—RESONANCE CURVE FROM LEPEL PRIMARY CIRCUIT WHEN SECONDARY IS DISCONNECTED. WAVE-METER MORE CLOSELY COUPLED THAN IN FIG. 1.

means of a sensitive wave meter, show considerably greater damping than is indicated by Figs. 1 and 2.

Prof. Fleming misunderstands the conditions of the circuit when suggesting that the gaseous section of the circuit is in series with the aerial. This is not so, since the main path of the high-frequency current is from the aerial through the primary circuit to earth and not through the air gap. This fact in part explains the exceedingly high efficiency of the apparatus as a converter of direct or low frequency alternating current to high-frequency current, for the path taken by the main high-frequency current is thus of negligible resistance.

We, therefore, come to the conclusion that the Lepel generator acts on the principle of impulsive excitation enunciated

by Prof. Wien; that the damping of the primary circuit is sufficient to attain this result, which is obtained by proper proportioning of the electrical dimensions of the circuit without the insertion of the additional energy-wasting resistance used by the Telefunken Company for this purpose, and that the use of a direct-current supply is in no way incompatible with the efficient production of a high-frequency current by this method.

RELATION OF LOAD FACTOR TO POWER COSTS.

At a recent joint meeting of the Chicago Branch of the American Institute of Electrical Engineers and the Western Society of Engineers, three Papers on this subject were presented, and abstracts of them are given below. The first was by Mr. E. W. Lloyd, of the Commonwealth Edison Co.

A great deal has been written regarding the bearing of the load factor in a given plant on the cost of producing and selling electricity, and it now seems to be generally accepted that this is the logical basis from which to consider the matter. In determining the load factor of a plant it becomes necessary to have maximum measuring instruments. For use on direct-current circuits such instruments have been developed and are both efficient and cheap; but for measuring the maximum on three-phase alternating-current circuits there is not available to-day a cheap and efficient instrument. In order, then, to carry on the practical business of selling energy at differential rates it is necessary, on three-phase systems, to establish a schedule of percentages, or to make tests from time to time of the maximum demand of any installation. We have adopted a schedule of percentages, compiled from actual readings taken from direct current installations. This has been used for two years, and we have found these percentages to be very close in a great majority of cases. This schedule is as follows:—

Installations under 10 H.P. where only one motor is used	85 per cent.
Installations under 10 H.P. where more than one motor is used	75 ..
Installations from 10 H.P. to 50 H.P., both inclusive, irrespective of the number of motors	65 ,,
Installations over 50 H.P., irrespective of the number of motors used	55 ,,

Out of 3,900 consumers of power, having installations aggregating 35,000 H.P., the average maximum was 53·5 per cent. of the connected motor load, and this was subdivided as follows:—

1 to 5 H.P.	2,900	customers	75·4 per cent.
6 to 10 H.P.	456	,,	64·5 ,,
11 to 20 H.P.	237	,,	64·7 ,,
Over 20 H.P.	307	,,	42·9 ,,

Maximum load conditions in factories in Chicago seem to be between 4:30 and 5 o'clock in the evening, regardless of the time of the year. Further, the maximum load condition in these plants does not always come at the time of the peak conditions of the central station. Of course, there is a point of high maximum in these plants at the time of the central station peak, but the highest maximum of the plant usually comes before the time of the central station peak.

There is considerable difference in the load factors of different industries. For instance the load factor for elevator service does not exceed 10 per cent., while that of refrigeration business is probably in the neighbourhood of 50 per cent. The average load factor of street railway systems is probably 35 per cent., whilst consumers of electricity having load factors exceeding 50 per cent. are very rare. It therefore seems reasonable to suppose that the load factors of central stations will not be much greater than this for some years to come. The load factor of any central station cannot exceed this figure until nearly all of the business of a community has been obtained, and where the diversity factor, due to the large number of different kinds of customers served, is such as to have more than ½ hour periods of maximum use.

The next Paper was read by Mr. C. A. S. Howlett, of the Western Electric Co.

The manufacturer's position in this question of load factor and rates is of supreme importance, especially as it applies to power rates. The cycle of operation may be considered as taking place as follows: The central station develops and adopts equitable power rates that encourage the use of motors; the manufacturers design and construct efficient and reliable motors and see that the customer makes a proper selection and installation; satisfied customers mean more business both for the central station and the manufacturer. The two vital elements that the manufacturer must consider are an efficient installation and, if alternating current, one with as high an average power factor as possible.

In determining the proper size of motors to instal in an industrial plant it seems to be the practice to take a portable motor as large as the largest that will be liable to be needed. The horse-power input is used as the basis and sometimes is multiplied by two for safe measure. In the case of a direct-current plant these large resultant motors operating at fractional loads tend toward a dissatisfied power user, and if the plant is using alternating current, such a condition tends towards a low power factor. For these reasons co-operation between the central station solicitor and the manufacturer's representative is earnestly recommended.

The third Paper was presented by Mr. J. M. S. Waring, of the Electric Storage Battery Co.

The author deals mainly with what is said to be a comparatively novel application of storage batteries. The total expenses of a power company may be divided into: (*a*) Fixed charges on equipment, including power house apparatus, transformers, transmission lines, &c.—namely, interest depreciation, taxes, insurance, &c. (*b*) Operating expenses made up of such items as fuel and feed water if it is a steam plant; oil, waste, incidentals, repairs and labour, including power house force, line men, &c. (*c*) Organisation expenses, including salaries of officials, clerks, solicitors, &c., office rents and such expenses. Power companies are realising more and more the necessity of adopting a form of rate which will do justice to all of their customers as well as to themselves, and the tendency to-day is the adoption of a form of rate which will pro-rate the total expenses of the operating company as equitably as possible among its customers. In order to accomplish this all fixed charges and fixed expenses should be divided among the customers in proportion to their maximum demand for power; then each customer pays the fixed charges and fixed expenses on the apparatus set aside for his use. Also, all variable expenses should be divided among the customers in proportion to the energy they consume in a fixed time. Of the various expenses under the headings (*a*), (*b*) and (*c*) referred to above, the only variables in the case of a hydro-electric plant are the repairs, oil, waste, incidentals, and probably only a small part of the power house force, all the other expenses being practically fixed and independent of the load factor. In the case of a steam plant, however, the variables would include oil, waste, incidentals, fuel, feed water, repairs and a larger percentage of the power house force than would occur in the hydro-electric plant. Therefore, in general, the operating expenses—that is, the variable charges—are a greater percentage of the total operating cost in the hydro-electric than in the steam plants. Now the total fixed charges of the plant divided by its kilowatt capacity will give the amount per kilowatt which each consumer should be charged for each kilowatt of his maximum demand. The total operating expense of the plant for a fixed period of time, divided by the kilowatt-hours output for that period will give the cost per kilowatt-hour of the actual operating expenses, exclusive of the fixed charges, and this amount plus the company's legitimate profit would be the kilowatt hour rate that the customers should pay for their energy consumption.

The author then considers a few existing tariffs. and shows that the equitable basis of rates or its equivalent offers an inducement to the purchaser of power to improve his load factor. The battery application to which the author has been leading up is that of a storage battery installed by the purchaser of power to reduce his maximum demand, and consequently his annual primary charge. From the latter's point of view, the battery proposition to be attractive must insure him a reduction in his annual power bills sufficient to pay the annual fixed charges and expenses incident to the battery, plus a fair return on the battery investment; or, in other words, the yearly fixed charges and operating expenses per kilowatt of the battery (meaning the total annual cost of the battery divided by the maximum number of kilowatts cut off the peak), must be less than the fixed charges and fixed expenses per kilowatt per year of the power company.

From the point of view of the power company, the improvement of their load factor by the purchaser's installation of storage batteries makes possible a greater energy output for a certain plant investment, and, therefore, a greater revenue since a part of the charge for power is at a fixed rate per kilowatt hour. It is evident that the value of the battery situation will depend: (1) on the breadth and shape of the peak; (2) on the power company's method of determining the peak; and (3) on the method of determining the fixed charges and fixed expenses per kilowatt.

As illustrations of how these items affect the battery situation, the cost of a battery to eliminate a certain triangular peak might be prohibitive, while a smaller battery to cut off less of the peak might prove a paying investment, for, due to the shortened base line, the cost of battery per kilowatt of peak would be

decreased as the size of battery is decreased. The power company's method of determining the peak has a distinct bearing. For instance, if the peak load of a railway is assumed to be the maximum one hour average load in one case, and the maximum five minute average load in another, the same size of battery might meet both conditions, and therefore cost the same, but it could reduce the peak more in the latter than in the former case, thereby effecting a larger return on the investment.

The power company's method of determining its fixed charges per kilowatt is also pertinent to the battery situation. In the case of a steam plant these charges can often be based on the overload rating of the generating units, while with a hydro-electric plant they can figure on very little, if any, overload capacity, as the generator would probably be installed with a continuous rating nearly equal to the water wheel capacity. If the charges are based on overload ratings, the reduction of a certain amount in the peak would result in less reduction in the consumer's bills than if based on continuous ratings.

ELECTRIC TRACTION ON RAILWAYS.*

XV.—THEORETICAL CONSIDERATIONS OF CATENARY SUSPENSION.

BY PHILIP DAWSON.

(*Continued from page 259.*)

It is due to the introduction of single-phase high-tension currents for railways that the catenary suspension has been developed. The suspension generally consists of one or two supporting wires, usually of stranded steel, suspended between structures and supporting the contact or trolley wire at intervals of from 6 ft. to 12 ft. by means of dropper wires. The object of such a suspension is to obtain as perfectly horizontal a contact wire as possible, and to combine with this great security against fracture with as little displacement due to changing weather conditions as circumstances permit. The collection of electric currents at high speeds without momentary interruptions and consequent arcing and pitting can only be effected by keeping the irregular motions of the collector bow within certain limits.

In the Zossen tests a smooth contact with high-speed running was obtained by employing vertical contact pieces on the three bows. The track over which these tests were made was practically straight, and it is very doubtful if the collector would have been satisfactory on curves with the inevitable side sway of the train. Since the irregularities of train motion in the vertical direction are far less than in the horizontal, the best results would be got with a perfectly horizontal trolley wire.

To obtain even an approximately horizontal wire by the ordinary tramway suspension would necessitate both very high mechanical tension in the wire itself and very short spans. Such a construction would be both expensive and very rigid, besides being subject to great changes of tension with temperature. The catenary suspension has the good points desired without the defects and, with care in design, can be made both very safe and subject to easy replacements and repairs without serious derangements of service.

The calculations involved in the design are somewhat troublesome, since a great many variables have to be taken into account. In all calculations the parabolic approximation can be safely used in place of the true catenary equation. Treating the catenary as a parabola is the same thing as saying that the weight per horizontal foot is constant instead of per linear foot. It will be seen at once that the error introduced by making this assumption with, say, a 6 ft. sag in a 40 yds. span is quite negligible.

The formulæ for the properties of a supported wire are as follows, using the parabolic assumption :—

$$f=\frac{a^2W}{8P}, \qquad P=\frac{a^2W}{8f}, \qquad l=a+\frac{8f^2}{3a},$$

where a=horizontal span,
l=true length,
f=sag at centre,
W=weight per unit length,
P=tension at lowest point.

Any units for weight and length apply, if used throughout, for all equations. The weight used in these calculations should be that of the whole suspended system (per unit length) and the sag that of the supporting wire. The case of the double catenary suspension will be met by using the vertical and not the actual sag of the wire in calculating tension, &c., the weight being half the complete suspension for each wire.

Effect of Temperature.—By using a considerable sag in the supporting wire the change in this sag for a given change in temperature becomes small. The equation connecting the sag in any wire with the change in temperature may be derived as follows :—

Let P, W, f, a have the values given above,
α=coefficient of expansion per degree Fahrenheit,
t°=any change in temperature in Fahrenheit degrees,
P_1=Any known tension corresponding to a prescribed value of a and f and l.
E=modulus of elasticity, pounds per square inch,
s=section of wire, in square inches.

Using the two formulæ given above for catenaries,

$$l=a+\frac{8f^2}{3a} \quad . \quad . \quad . \quad . \quad . \quad \text{(I.)}$$

and

$$f=\frac{a^2W}{8P}, \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(II.)}$$

we have

$$l=a+\frac{a^3W^2}{24P^2} \quad . \quad . \quad . \quad . \quad \text{(III.)}$$

Now consider a certain wire of known length, l, and then imagine it, first, heated through t° Fahrenheit and, second, having its tension reduced from P_1 to P by any means whatever. The change in length resulting from these two changes will be represented by the equation

$$\Delta l=l_1\left[t^\circ\alpha-\frac{(P_1-P)}{Es}\right]. \quad . \quad . \quad . \quad \text{(IV.)}$$

but $l_1=a+\dfrac{a^3W^2}{24P_1^2}$ and $l=a+\dfrac{a^3W^2}{24P^2}$.

The weight per unit length W can be considered constant, since a large change in P corresponds to an exceedingly small change in W.

Further $$\Delta l=l-l_1=\frac{a^3W^2}{24}\left(\frac{1}{P^2}-\frac{1}{P_1^2}\right).$$

Therefore $$l_1\left[t^\circ\alpha-\frac{(P_1-P)}{Es}\right]=\frac{a^3W^2}{24}\left(\frac{1}{P^2}-\frac{1}{P_1^2}\right),$$

or $$t^\circ\alpha=\frac{a^3W^2}{24l}\left(\frac{1}{P^2}-\frac{1}{P_1^2}\right)+\frac{(P_1-P)}{Es}. \quad . \quad . \quad \text{(V.)}$$

As this equation is a cubic for P, it will be simpler to assign values for P and solve for t°. For sags less than 5 per cent.

of the span the error of assuming l and a equal is less than 0·7 per cent. Making this assumption, we have

$$t^\circ a=\frac{a^2W^2}{24}\left(\frac{1}{P^2}-\frac{1}{P_1{}^2}\right)+\frac{(P_1-P)}{Es} \quad . \quad . \quad . \quad \text{(VI.)}$$

which is the equation usually employed for these calculations.

The following values for a and E apply for various metals :

Metal.	a per deg. Fahr.	E lb. per sq. in.
Copper (hard)	0·00000956	18,000,000
Brass	0·0000105	14,000,000
Iron	0·000006830	30,000,000
Steel	0·000006361	32,000,000
Aluminium	0·0000128	10,000,000

Now consider a double catenary suspension for which a=190 ft., W=1 lb. per foot.

Suppose maximum allowable difference of sag is 6 in., let us examine the allowable temperature change for various sags; and suppose that the wire is put up on the coldest day, say at 0°F. Putting the wire up with a 6 ft. sag the tension P_1 will be

$$P_1=\frac{a^2W}{8f}=\frac{190^2\times 1}{8\times 6}=753\text{ lb.}$$

If the wire is expanded by heat till the sag is 6 ft. 6 in. the pressure will be

$$P=\frac{190^2\times 1}{8\times 6{\cdot}5}=694.$$

Suppose the supporting wire is of steel (stranded) with a section of 0·095 sq. in. Taking E=32,000,000 and a =0·000006361, and substituting in formula (VI.)

$$t^\circ 0{\cdot}000006361=\frac{190^2\times 1^2}{24}\left(\frac{1}{694^2}-\frac{1}{753^2}\right)+\frac{753-694}{32{,}000{,}000\times{\cdot}095}$$

t°=79° for a 6 in. change in sag. For a 3 in. change t° =37°F., for a 4 in. change t°=52°F., showing that the sag increases a little more rapidly than the corresponding temperature rise. For a temperature rise of 100°F. the sag would be 7½ in.

The analysis which follows, though complete in itself, is based on the method used by S. Nicolaus, and published in the "Elektrotechnische Zeitschrift" in 1907, only adapted for English units and applied to catenary suspension for feeding railways.

Taking formula (VI.), already referred to, we have

$$t^\circ a=\frac{a^2W^2}{24}\left(\frac{1}{P^2}-\frac{1}{P_1{}^2}\right)+\frac{P_1-P}{Es}.$$

If we call w weight per unit length and unit and section, p tension per unit section, we have

$$w=\frac{W}{s} \quad \text{and} \quad p=\frac{P}{s}.$$

Therefore (VI.) can be written

$$t^\circ a=\frac{a^2w^2}{24}\left(\frac{1}{p^2}-\frac{1}{p_1{}^2}\right)+\frac{(p_1-p)}{E}.$$

Further, t° has been defined as a *rise* in temperature, so that, if we use actual temperatures T and T_1, we have $t^\circ=T-T_1$, and substituting in the equation given above we have

$$(T-T_1)a=\frac{a^2w^2}{24}\left(\frac{1}{p^2}-\frac{1}{p_1{}^2}\right)+\frac{p_1-p}{E}. \quad . \quad \text{(VII.)}$$

This formula represents the difference of two equations

$$T=\frac{a^2w^2}{24a}\left(\frac{1}{p^2}\right)-\frac{p}{Ea}. \quad . \quad . \quad . \quad \text{(VIII.)}$$

By the aid of this equation we can plot families of curves giving the relation of temperature sag and tension for any span. For steel, the weight of a section 1 ft. long and 1 sq. in. cross-section is 3·4 lb.

If p is tons per square inch,

$$p=0{\cdot}000190\frac{a^2}{f}.$$

For aluminium $\qquad p=0{\cdot}00065\frac{a^2}{f}.$

For hard-drawn copper $\qquad p=0{\cdot}000215\frac{a^2}{f}.$

Steel—

$$T=\frac{a^2w^2}{24a}\left(\frac{1}{p^2}\right)-\frac{p}{Ea}.$$

If we make p the tension in tons per square inch, w will be the weight in tons of a section of 1 sq. in. 1 ft. long.

E=14,300 tons per square inch,
a=0·000006361,

$$T=\frac{a^2}{p^2}0{\cdot}0151-p\,11{\cdot}0,$$

T=degrees Fahrenheit,
p=tons per square inch,
a=span in feet.

For aluminium—

$$T=\frac{a^2}{p^2}0{\cdot}000888-p\times 17{\cdot}3.$$

For hard copper

$$T=\frac{a^2}{p^2}\times 0{\cdot}0129-p\times 12{\cdot}9.$$

The results of applying the formulæ to steel—namely,

$$T=\frac{a^2}{p^2}0{\cdot}0151-p\times 11{\cdot}0,$$

$$p=0{\cdot}000190\frac{a^2}{f},$$

are here given. These involve the modulus and coefficient given above for steel, and the weight, which has been taken as 3·4 lb. for a section of 1 sq. in. 1 ft. long. Since these curves are worked out for a single catenary, certain modifications will have to be adopted for using them when this catenary has to support an additional load.

We will take the case worked out previously and show how to get the results by use of the curve sheets. We had the following :—

a=190 ft.
W=1 lb. per foot.
s=0·095 sq. in.
f=6 ft.

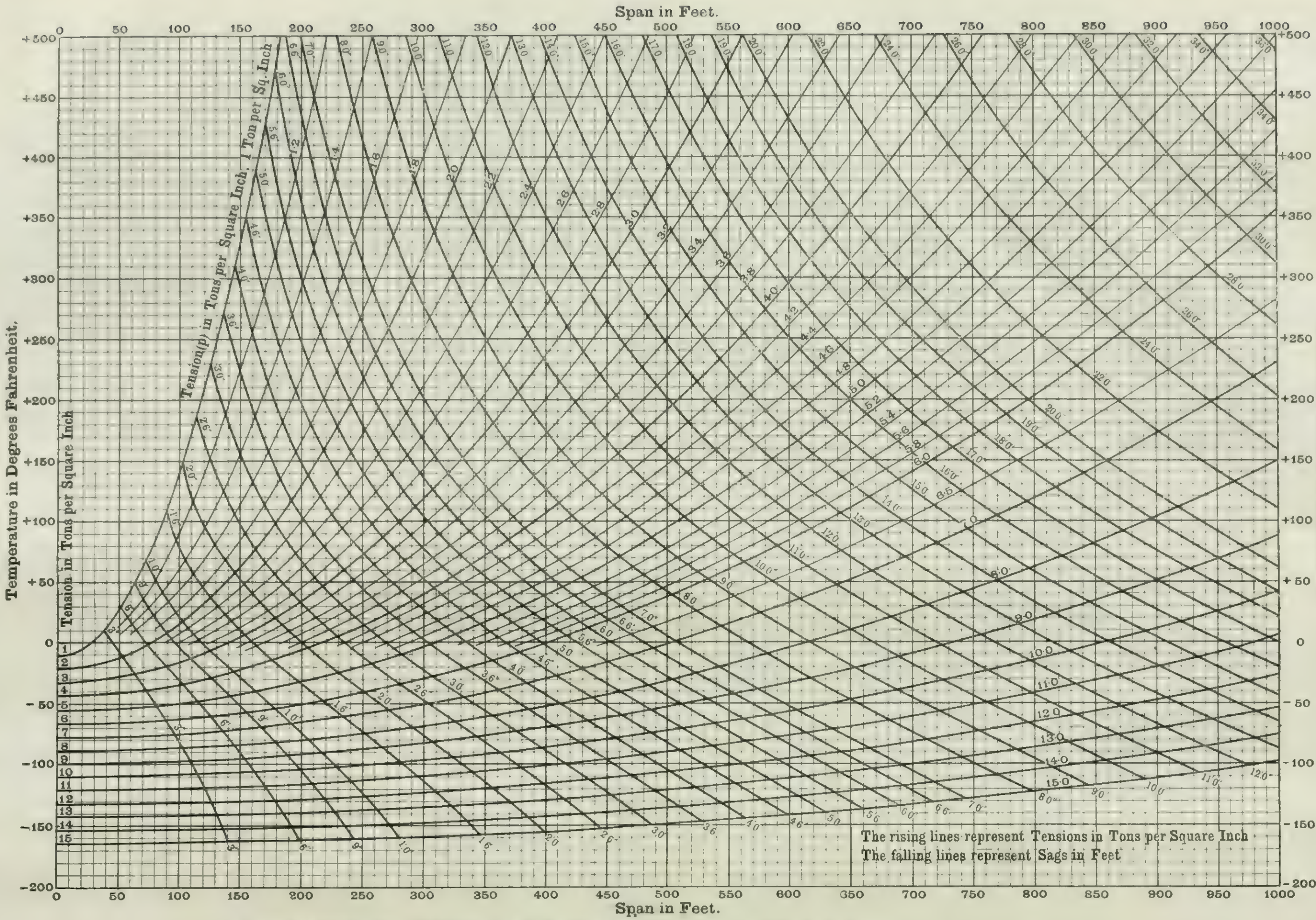
The true weight of 1 ft. of steel wire with a section of 0·095 sq. in. is 3·4×0·095=0·323 lb. With 1 lb. per foot, therefore, the factor K of total weight to weight of wire will be K=3·1. We can write, therefore, W=kw where w is the weight used in plotting the curves.

Now $\qquad P=\frac{a^2W}{8f} \quad \text{or} \quad P=\frac{a^2wk}{8f}.$

or we may write $\qquad P=\frac{a^2k^2w}{8fk}.$

Observing the last equation, we see that, by using the curves already plotted and substituting for the true value of a an increased value $a_1=ak$ and for f an increased value, $f_1=fk$, we shall find the true value of P.

K=3·1, a=190 and f=6.
a_1=590 and f_1=18·6.



EXAMPLE: A wire of section 0·095 supports 1 lb. per foot with a sag of 6 ft. and a span of 190 ft. If $K = \frac{\text{Weight of wire}}{\text{Total load}}$, K in this case is 3·1.

Multiply a and f by K and find the corresponding value of P. In this case 3·55 tons per square inch. Resulting change in sag if heated 100°F. will be $\frac{2}{K}$ ft. = $7\frac{3}{4}$ in.

Curves based on equations:

$$T = \frac{a^2\omega}{24\alpha}\left(\frac{1}{p^2}\right) - \frac{P}{E\alpha}, \text{ and } P = \frac{a^2\omega}{8f},$$

where a = span, f = sag, T = temperature, P = tension in wire, α = 0·000006361 per degree Fahrenheit, E = 32,000,000 lb. per square inch, ω = 3·4 lb. per 12 cubic in.

FIG. 1.—CURVES FOR STEEL CATENARIES.

Following the 590 ft. span ordinate up till it crosses the sag of 18·6 ft., we find the tension P to be 3·55 tons per square inch, which is the same value as we got before, only then it was in the form of 753 lb. per wire of 0·095

$$\left(\frac{753}{0{\cdot}095 \times 2{,}240} = 3{\cdot}54 \text{ tons per square inch}\right).$$

If the temperature should increase by 100° F., we can get the increase in sag by following the 590 ft. ordinate 100 deg. up from the 18·6 ft. sag. This gives a sag of 20·6 ft. The difference of 2 ft. must be divided by K or 3·1 to get the true difference. This gives $7\frac{3}{4}$ in., which is nearly the value we got previously (of $7\frac{1}{2}$ in.).

If the catenary here worked out had been put up with 3 ft. instead of 6 ft. sags the change in heating 100°F. would have been $11\frac{1}{4}$ in., and if a 2 ft. sag it would have been 12 in.; but the wire would have been under a tension of 10 to 11 tons per square inch. It will be seen that with the aid of this curve sheet (Fig. 1) any problem involving steel catenary wires can be solved.

The question of the expansions and contractions in the trolley wire itself is a far simpler one than that of the supporting catenary.

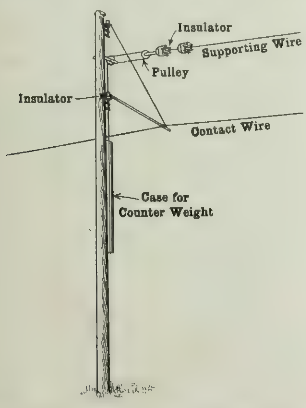


FIG. 2.—METHOD OF PROVIDING CONSTANT TENSION IN CONTACT WIRE.

The change in tension due to varying temperature is independent of the total length of wire employed, provided each point of the wire retains a fixed position. If some device for keeping the trolley at a fixed tension at all times were adopted the change in length is, of course, a constant fraction of the total length employed. For copper wire with a temperature range of 100°F. the change in length is 5·05 ft. per mile. The adoption of such a principle would involve certain (though not insurmountable) difficulties in the working of section insulators. A method of preventing the change in sag due to climatic conditions by keeping the tension of the contact wire constant has been adopted in Sweden. The accompanying sketch shows the arrangement (Fig. 2) as adopted by the Swedish State Railways.

(*To be continued.*)

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Agenda de l'Electro." 2nd year. (Brussels: "Electro." Fr. 3.50.

"Starkstromtechnik Taschenbuch für Elektrotechniker." Edited by E. v. Rziha and J. Seidener. (Berlin: Wilhelm Ernst & Sohn.) M.20.

SELECTIVE EMISSION OF INCANDESCENT LAMPS AS DETERMINED BY NEW PHOTOMETRIC METHODS.*

BY E. P. HYDE, F. E. CADY AND G. W. MIDDLEKAUFF.

The recent development of high-efficiency metallic filament lamps has aroused new interest in the measurement of the high temperatures of glowing metals, and has raised the question as to whether the high efficiencies are due primarily to the high temperatures at which the filaments operate or to selective radiation (*i.e.*, the distribution of energy in the spectrum of the radiating body at a given temperature is different from that of a black body at the same temperature).

A recent photometric study by the authors of the relative properties of metal and carbon filament lamps has led to the establishment of two new photometric methods by which a positive qualitative criterion may be had of relative selectivity of two radiating filaments. According to the first method, if one filament is maintained at some definite voltage or current—that is, at some definite temperature—and the voltage of a second filament is changed until the distribution of energy in the visible spectra of the two as determined by a spectrophotometer is the same, then if the two filaments had identical radiating properties the energy curves of the two would be identical throughout the entire spectrum, and the temperatures of the two filaments would probably be the same. If this were the case, the ratio of the energy in the visible spectrum to the total energy radiated would be the same for the two filaments. Now, the energy per second radiated in the visible spectrum can be measured by determining the number of lumens, and the total energy per second radiated can be determined by measuring the watts supplied to the lamp, since there is no convection and very little conduction. If the radiating properties of the two filaments were identical, the number of lumens per watt under the above condition would be the same for the two filaments.

According to the second method the two filaments are brought to the same distribution of energy in the visible spectrum in the same way as that employed in the first method. If, now, a determination is made for each filament of the percentage change of candle-power in a specific direction—equivalent numerically to percentage change in flux—corresponding to 1 per cent. change in watts supplied to the lamp, these two coefficients of change of candle-power corresponding to 1 per cent. change in watts would be the same if the radiating properties of the filaments were identical. Conversely, if the two coefficients are different, one filament must be radiating selectively with respect to the other.

In the actual use of these two methods the determination of the agreement in the visible spectrum of the energy curves of the two filaments had been made, not with a spectrophotometer as described above, but by means of a colour match in an ordinary Lumner-Brodhun contrast photometer. If one lamp is maintained at a definite voltage and the voltage of a second lamp is changed until the colour of the light radiated by the two lamps is the same, as observed in the photometer, it has been found that the spectrophotometric curves of the two filaments agree excellently. The colour-match method is simpler and perhaps even more exact than the spectrophotometric method, provided there is no strong selectivity within the visible spectrum.

By the use of the above two methods it has been shown qualitatively that there is a decided difference in selectivity between various filaments. It is not possible, however, to determine the exact amount of the difference without knowing the true temperatures, for the determination of which there is at present no known accurate method.

By making an assumption which has been found to be true for platinum, and which, although probably correct for most metals, has not been demonstrated to be true, it is possible to form an idea of the direction in which the difference in temperature will occur, and to place a lower limit on the effect of selectivity in partly accounting for the high efficiency of the metallic filament lamps.

If we imagine a radiating body which tends to exaggerate in its emission the energy of the shorter wave-lengths—that is, a body which emits a larger proportion of its total radiant energy in the visible spectrum as compared with a black body at the same temperature—it is probable that this property of selective emission would obtain in the visible spectrum also, so that the emission in the blue would be relatively larger than the emission in the red as compared with the emission from the black body at the same temperature. If this assumption, which would seem to be true for platinum, is true for tantalum, tungsten and osmium, then the values recorded

* Abstract, from the "Electrical World," of a Paper read before the New York Section of the Illuminating Engineering Society.

in the last column of the tables give, in every case, the lower limit of the effect of the selectivity on the efficiency of the filaments.

Table I.—*Average Values obtained at Voltages corresponding to a "Colour Match" with the Standard Lamp at 75 volts.*

Types of filament.	Red black-body temps.	Relative change in c.p. for 1 per cent. change in watts.	Flux per watt.
Untreated carbon..................	1,420 C.	1·00	1·00
Helion	1,405	1·00	0·97
Treated carbon.....................	1,395	0·97	1·06
Gem	1,400	0·98	1·05
Tantalum	1,340	0·83	1·28
Tungsten	1,345	0·79	1·49
Osmium..............................	1,390	0·80	1·85
Table II.—*Values with Standard Lamp at 100 volts.*			
Untreated carbon..................	1,680° C.	0·86	3·85
Helion	1,650	0·85	3·85
Treated carbon.....................	1,645	0·84	4·15
Gem	1,650	0·84	4·0
Tantalum	1,570	0·72	4·35
Tungsten	1,555	0·71	5·25
Osmium..............................	1,610	0·69	5·9
Table III.—*Values with Standard Lamp at 125 volts.*			
Untreated carbon	1,890 C.	0·76	9·0
Helion	1,850	0·75	9·2
Treated carbon.....................	1,855	0·74	9·5
Gem	1,855	0·76	9·4
Tantalum	1,765	0·65	10·0
Tungsten	1,740	0·67	11·5
Osmium..............................	1,800	0·65	12·5

The results of an investigation on various filaments using both methods are given in Tables I., II. and III. The standard lamp was a 110 volt carbon lamp consuming 3·5 watts per candle. The values given in columns 3 and 4 are in terms of arbitrary units so taken that for the untreated carbon filament at a colour match with the standard lamp at 75 volts, the value in each case is unity.

If there were no selectivity, the lumens per watt would be unity for every type, and the coefficient of percentage change in candle-power for 1 per cent. change in watts would be the same for each type. It should be noted that as some of the measurements were made under unfavourable conditions, the numerical results are not insisted on to a high degree of accuracy, although the general conclusions are definitely established.

The order of the filaments is that of their relative selectivity, and it is significant that this order is the same by both methods and for the three arbitrary temperatures of the standard lamp at which measurements were made. The helion filaments which were used were old, and they may have lost the silicon deposit, which fact may account for their position in the table.

THE ELECTRIFICATION OF STEAM-DRIVEN NON-REVERSING ROLLING MILLS.

We give below a short account of the discussion which took place at the meeting of the Leeds Local Section of the Institution of Electrical Engineers when Mr. W. F. Mylan read his Paper on this subject. An abstract of this Paper appeared in our issue of May 21.

Mr. W. Hartnell, in opening the discussion, said that the economies shown in the Paper were not solely due to the electric drive—some had arisen from its substitution in place of steam gear that was rather antiquated. The ropes used were convenient, but involved a loss of, say, 7½ per cent. of power. Cut gear wheels were now obtainable of large size. At a works near Birkenhead for re-rolling steel rails successive sets of rolls were driven by electric motors and gear wheels. At the Prescot works of the British Insulated & Helsby Cables (Ltd.) the sets of rolls used both for aluminium and copper were driven through gearing by electric motors. A steam engine must be capable of exerting the maximum torque required on the rolls, which involved an expensive outlay. An electric motor that would take a 100 per cent. overload for a short period was, in comparison, inexpensive, and the capital outlay to supply the power was provided at the generating station. The steam engine required a large and expensive flywheel to assist it to overcome the short overload. The flywheel of the motor revolving at a much higher speed, and assisted by the great overload capacity of the motor, was much smaller. The capital to be sunk to drive rolls by electric motors was, therefore, not only much less than that required for a steam plant, but as the rolls were practically idle most of their time the annual charge for interest and depreciation per ton of metal rolled must be much less when electric motors were used to do the same work. Steam plant for direct driving reversing rolling mills was especially costly. As an instance, an engine at Sheffield of 8,000 H.P. with three cylinders made only a few revolutions backward and forward each time an ingot of steel was rolled. They were all agreed as to the advantages of electrical driving; if, however, the Sheffield manufacturers were desirous of coming on to the Corporation supply, would the authorities be prepared to deal with, say, at least 30,000 H.P. ?

Mr. C. A. Ablett thought that the author had rather under-estimated the number of rolling mills which were driven electrically on the Continent of Europe, as the speaker knew that one firm alone had installed nearly 200 motors for driving non-reversing rolling mills, the aggregate power being nearly 200,000 H.P., and he believed that the total number of non-reversing rolling mills on the Continent of Europe which were electrically-driven was nearly 400. With regard to the list of firms which had adopted electrical driving, he could add about 10 additional names of English firms, showing how rapidly the electric driving of rolling mills was being adopted. As the question of reversing rolling mills had been raised in the discussion, he mentioned the equipment for a large reversing rolling mill which was being built for a plant near Middlesborough. The mill motor would give about 10,000 H.P. under normal conditions of operation, and was supplied by a flywheel converter set, and as this flywheel served to neutralise the variations in load, the motor which drove the flywheel converter set had a capacity of only 1,800 H.P., and under normal conditions would be taking considerably less power than that from the power house. The question of economy had also been raised, and it was of interest to mention a large electrically driven reversing rolling mill, which had been recently set to work in Germany, where the motor was capable of giving 10,000 H.P. at 30 revs per min., and was, he believed, the largest reversing rolling mill motor in the world. The firm who owned this mill stated that the adoption of the electrical drive had saved them one shilling in the ton rolled compared with the previous steam engine, and had enabled the output to be increased 30 per cent. With reference to the figures given in the Paper, he pointed out that when the units per ton rolled for a given section were stated, the elongation should also be stated, as when the section was rolled from a large billet the power taken was naturally more than when it was rolled from a small one. As to the figures for the channels, he thought these should read 1½ in. by ¾ in. by 2 in., and not 0·02 in. as given. It would also be interesting if the size of the 800 lb. billets from which the angles were rolled was given, and also the size of the billets for the above mentioned channels. The same remark also applied to the figures for the sheets. In referring to the slip regulator, it was mentioned that this was employed with an alternating equipment, and that the resulting effect was the same, and independent of the electrical characteristics of the installation. He took it this meant that the result was the same as with a compound wound motor, but he pointed out one very important difference; in both cases the speed of the motor must fall by some value up to 10 per cent. in order that the flywheel effect might be beneficially utilised, and while this fall in speed could be attained with the compound wound motor without any loss of power, in the three-phase motor, a loss of power was necessarily involved. In the near future, however, a method of obviating this difficulty with the three-phase motor might find application. In further reference to the question of the automatic slip regulator, both with the alternating-current motor and with the direct-current motor there were two characteristic ways of obtaining the necessary variation in speed, to enable the stored energy of the flywheel to be beneficially utilised in neutralising the peaks of the load:—(*a*) Permanent slip regulation might be adopted in the case of the direct-current motor by providing compound winding, and in the case of an alternating-current motor by providing resistance in the rotor circuit. (*b*) Automatic slip regulation might be provided in the case of the direct current motor by relays which altered the resistance of the shunt field, and in the case of the alternating-current motor by an arrangement which automatically inserted resistance in the rotor circuit as the load increased. The characteristic features of these two methods were: with the permanent slip regulation considerable variations in current, about the mean value, must take place, because it was the variation in current which caused the variation in speed, and in this system the variation in speed was usually not very great. Where automatic slip regulation was provided, the current always remained at practically constant value, corresponding to the mean value of power required, because the automatic slip regulator when not actually in operation might be regarded as being in a state of balance, and a very small variation in current was sufficient to upset the balance and bring it into operation. In this case, however, the variations in speed might be very great. It was sometimes stated that the use of the automatic slip regulator enabled the losses which occurred in the slip resistance of a three-phase motor to be reduced, but practical experience had shown that no appreciable reduction could be effected. It was also mentioned that the time taken to extract the energy from the flywheel was usually considerably higher than the time required to return the same. It might perhaps be said in general that the conditions of rolling mill driving were such that the time taken by the pass was considerably shorter than the interval between passes in many cases, so that more time was available for the flywheel to regain its stored energy, but he did not think it was justifiable to make any general statement that apart from the conditions imposed by the process of rolling the flywheel required a longer time to regain its stored energy than to give it up. When the permanent slip resistance was used it would be found that if the rate of giving up and regaining stored energy be plotted against the time, logarithmic curves were obtained somewhat similar to those of the heating and cooling of an electrical machine; but in spite of this it could be found in every

case that the flywheel could regain the stored energy in the intervals between the passes in order to reduce as far as possible the variations in power required from the motor. He was entirely in agreement with the author as to the desirability of using liquid controllers for starting three-phase motors, but if a liquid controller was used with a large direct-current motor, he feared that considerable trouble would occur due to the electrolysis of the plates, and also due to the electrolysis of the liquid considerable quantities of oxygen and hydrogen might be liberated, which would prove to be dangerous.

Mr. A. J. Cridge added some particulars of another mill to the list given by Mr. Mylan. The motor was supplied from the Sheffield Corporation's mains, and was 350 H.P., 2,000 volts two phase, 50 periods, running at 490 revs. per min. The motor drove three sets of rolls, two by rope and one by belt transmission. A 4 ft. pulley on the motor was belted to a 10 ft. pulley on the 8 in. mill, and a 4 ft. 6 in. pulley was roped to a 14 ft. pulley on the two 10 in. mills. He was informed that roughly 30 to 40 tons of ingots of various sizes passed through the mill daily with an average consumption of 1,000 or 1,100 units per day, so that the power used worked out at from 25 to 30 units per ton. These figures relating to the mill did not seem to be in agreement with those investigated by the author. He asked the author to give some more information as to the method of controlling the speed of rolling mill motors by cascade connections, and also about flexible couplings.

Mr. E. S. Saunders also referred to the figures for units consumed per ton, which seemed excessive. The author stated that the freedom from stalling was largely due to the smooth running of the electrical equipment, and that when a tendency to stall occurred, the motor slowed down, extra energy was obtained from the flywheel and from the line, automatically tending to get the material through the rolls. The freedom from stalling was really due to the enormous torque which could be obtained instantaneously from motors. He wished to advocate as far as possible the abolition of gear and ropes between the motor and the mill. He noticed that in the table given in the Paper, there was not a single instance of a direct-coupled mill. There was no real objection to designing a motor to run at almost any speed required, and direct driving was the most efficient way to drive a mill, and need not necessarily involve extra capital cost. Each case required individual consideration. He agreed with Mr. Hartnell that 7½ per cent. of the power was constantly running to waste in cases where a rope drive was adopted; and if there was a double reduction gear probably quite 10 per cent. was wasted. The author stated that a motor required little attention, and with emergency devices for stopping it was not necessary to have an attendant standing by continually. This evidently referred to emergency pushes. Everyone would be aware of a case in Sheffield where a steam driven mill was fitted up lavishly with these emergency devices. One day the engine commenced to gain speed, eventually running away and bursting its flywheel with disastrous results. Not one single man had the common sense to use the emergency stops. Such an occurrence could easily be guarded against with electrical drives by means of automatic circuit breakers.

Mr. T. Harding Churton considered that the relative advantage of direct drive and driving through gear was mainly a question of expense. In the case of driving by gear, whether by ropes or otherwise, a relatively high speed motor might be employed, which was both more efficient in running and less expensive in capital outlay. Against these advantages was to be set the power lost in the gear, but this might be entirely balanced by the difference in the relative efficiencies of the high speed and low speed motor. As to the efficiency of rope driving, he thought that the 7½ per cent. loss mentioned was higher than it should be for a well-designed drive. The three-phase induction motors mentioned in the Paper were all of the wound rotor type, whereas in the speaker's opinion the machine with the short-circuit rotor was pre-eminently suitable for this kind of work, wherever its use was permissible on the supply system.

Mr. H. E. Yerbury asked the author why there were only three direct-current motor installations and 26 two and three-phase systems mentioned in the table, and whether there was any special reason for this apart from the supply connections. In comparing the relative efficiency of steam engines and motors the author had compared instances where inefficient steam plant was installed before the change.

Mr. W. F. Mylan, in reply, said they did not claim that electricity was the "great save-all" for it was not. There were certain cases and certain conditions where electricity would lose money instead of making it, and as electrical engineers they ought to be the first to recognise this. He was glad Mr. Hartnell called particular attention to auxiliaries, because it was so remarkable to see the way in which the material was handled round a rolling mill, without being touched by human hands. There were times when the rope drive was the most suitable arrangement one could adopt. Reversing mills had been mentioned, but this was a subject which wanted separate treatment; unfortunately they had only a few examples to refer to. The whole question of units consumed per ton rolled was undoubtedly determined by the size and nature of the ingot at the commencement of rolling, and the total elongation required. He was afraid he had been a bit misleading in his remarks on the subject of slip regulator. What he really intended to point out was what energy was obtained from the flywheel in both cases, irrespective of the method adopted to get it. With regard to the question of taking out and return of energy from the flywheel, the time required to return the energy to the flywheel was determined either by the maximum demand, which could be made on the line, or the maximum load which the motor would stand. There had been comparatively small progress made in regard to motors connected in cascade in this country. He knew one instance where these motors were being used in connection with a small winder. He expected to see a large number of such combinations installed in the near future. It was possible to run at full load and full speed, or half load and half speed, with a high efficiency and comparatively good power factor. He agreed that the absence of stalling was also due to the fact that a motor had in itself a very large capacity for overload, and it was due to the combination of this, and of the smooth running of the equipment, that one got such freedom from stalling. On the question of direct-coupled motors, as mentioned by Mr. Saunders and Mr. Churton, it was not entirely a question of capital expenditure. Under certain conditions it was practically impossible for the manufacturer, at any rate at the present time, to build a satisfactory slow speed alternating-current motor. That was a serious objection not only from the point of view of those firms that had their own power stations, but from the point of view of the public supply company. In Sheffield the supply authorities refused to allow a motor whose power factor was below their standard to be connected at all. With regard to the use of short-circuited rotor machines, if Mr. Churton would supply such a machine of large size which would start up against full load, or above, and drawing a reasonable current from the line, he should be very pleased to sell them and watch them operate. Mr. Yerbury had raised the point about the number of alternating-current motors which were used. That was, to a certain extent, due to the load conditions and it must be remembered that in the majority of cases the power plant was installed before the application of the power to the rolls. Also the majority of the supply companies selling current in bulk, now gave an alternating-current supply.

A BALLISTIC TEST FOR INDUCTANCE.

BY GISBERT KAPP.

Fig. 1 shows a well-known method for the determination of the inductance of a coil by ballistic galvanometer. The battery B supplies current to the coil L to be tested, an amperemeter, A, and a resistance, *ab*, with sliding contact, which is so adjusted that the galvanometer G shows no deflection as long as the switch S remains closed. R is a high resistance put

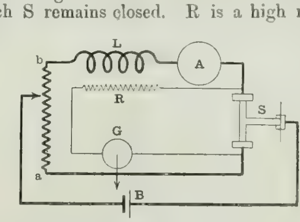


Fig. 1.

into the galvanometer circuit in the usual way. On opening the switch the battery becomes detached and the coil discharges through the galvanometer, the deflection of which is a measure for the flux in L that has vanished when the battery circuit was opened. This method is perfect in theory, but very difficult to carry out in practice. It can only give accurate results if the switch S breaks both its contacts absolutely at the same moment. A special type of switch working with almost mathematical precision is thus required, and this must be tested before use in the following way: L is replaced by an inductionless resistance and the contacts of the switch are so adjusted that on opening it G shows no deflection. To overcome the drawback of having to employ a special switch, which has to be adjusted each time, I have devised the arrangement shown in Fig. 2, and found it to work quite satisfactorily. It has the advantage that no special apparatus is required, the switch S being of the usual type. Also in this case a sliding contact, *f*, is used to supply current to the two halves of the circuit, one half containing the coil to be tested and an ammeter, A. The sliding contact is so set that the galvanometer with S closed shows no deflection. In this case the points *a* and *c* have the same potential and the whole system is nothing else than a Wheatstone bridge in balance, the arms being *ag*, *gc*, *cf* and *fd*. If, now, S be opened the coil L discharges through two parallel circuits—namely, RG and *cd*—and the galvanometer shows a deflection which is a measure of the flux that has disappeared in L. At first sight it might seem that the deflection would be very small, since the resistance in the galvanometer circuit is very much larger than that of the parallel branch *cd*, but by a suitable choice of the various resistances it is possible to obtain sensibly the same deflection as with the method of Fig. 1. The branch *cd* forms virtually

B

a shunt to the galvanometer, and to explain the apparent paradox that this shunt (although of very small resistance in comparison with R) does not sensibly diminish the quantity of electricity passing through the galvanometer, it is only necessary to remember that the total quantity of electricity set in motion by the disappearance of the flux through L is not a constant (as would be the case if a condenser were to take the place of L) but a variable quantity, which itself depends on the resistance of the discharge circuit, being the larger the smaller r. There is, however, a limit to the permissible reduction of r—namely, the fact that the time constant L/r of the discharge circuit must remain reasonably small, otherwise the fundamental condition under which the use of a ballistic galvanometer is permissible is no longer fulfilled. To test this point we need only take, with the same current in A, but whilst gradually reducing r, a series of deflections. As long as r remains sufficiently large these deflections will all be equal, but as soon as r is reduced beyond the permissible point we notice a reduction in the deflections.

As long as r is made larger than this value, experimentally found, the method gives correct results.

The theory of the method is as follows. Let

ρ = resistance of the branch agbLAc,
r = resistance of the branch $cfda$,
R = resistance of the branch cRGa,
L = inductance of coil and ammeter in henrics,
b = ballastic constant of the galvanometer,
θ = deflection on interrupting the current I amperes,
i = momentary value of current flowing through L,
i_1 = momentary value of current flowing through r,
i_2 = momentary value of current flowing through R.

$$i = i_1 + i_2.$$

$$i = i_2\left(\frac{r+R}{r}\right)$$

$$-L\frac{di}{dt} = i\left(\rho + \frac{rR}{r+R}\right)$$

$$-L\frac{di}{dt} = i_2\left(\rho + \frac{rR}{r+R}\right)\left(\frac{r+R}{r}\right)$$

$$-L\int_I^0 di = \left(\rho + R\frac{\rho}{r} + R\right)\int_0^\infty i_2\,dt,$$

$$LI = \left(\rho + R\frac{\rho}{r} + R\right)b\theta, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

since $\int_0^\infty i_2 dt$ is the total quantity of electricity that has been discharged through the galvanometer, and that is given by the product of the ballistic constant b and the deflection θ.

In comparison with the resistance of the galvanometer circuit the resistance of the branch abc is infinitely small, so that the first term in the bracket of equation (1) may be neglected. It is also in most cases possible to make r fairly large, say, 100 or more times as large as ρ, so that the second term in the bracket would affect the result by something less than 1 per cent., and this correction can be estimated from an approximate knowledge of the resistances ρ and r. If we write R for the resistance of the galvanometer circuit thus corrected, we get a very simple equation for L, namely,

$$L = \frac{R}{I}\theta b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The method of Fig. 2 may be applied with advantage to the determination of the hysteretic loop of laminated iron samples made up in ring form. I limit the application to laminated samples because, as is well known, solid samples are not very suitable for a ballistic test of any kind. Owing to eddy currents in the solid section, the flux through it does not follow instantly any change in exciting force, and the result is a disturbing creep of the galvanometer, which renders the observation of its deflection uncertain. I also limit the application to samples in closed ring form, because with a sample having butt joints an unknown amount of exciting force is required to overcome the magnetic reluctance of the joints, and although the observation would give the total area of the hysteretic loop correctly, the loop itself would appear sheared over, and thus not give the true relation of **H** and **B**. If, then, the sample must be prepared in the shape of a closed ring, it becomes necessary to wind it by hand, and for the old method of testing two coils must thus be wound—one the pilot coil for connection to the galvanometer circuit and the other the exciting coil proper. The advantage of the new method of testing lies in this, that only the exciting coil need be wound, thus reducing the labour of preparation for the test. Fig. 3 shows the arrangement of the test, the lettering corresponding with that of Fig. 2. Since the current is occasionally reversed an ammeter with central zero must be used. I found it convenient to employ a Siemens milliampere meter and to use its own shunt and a spare shunt, ga to make up the resistance ρ. M is a main current regulator supplied from a battery and D is a rheostat for fine adjustment of the maximum value of the exciting current for each setting of M. It is also useful for making sure that the time constant of the circuit is kept sufficiently low for the particular galvanometer used. C is another rheostat for taking intermediate points of the loop. The resistances of M, D and C need not be known. The resistances of cd and of the circuit agc need only be known approximately to make the correction in R previously explained. For taking the **H**-**B** relation the switch s remains closed, but for taking the complete hysteretic loop, C and s must be worked in the well-known manner. The galvanometer is provided with a damping key as usual. The measurement includes the inductance of the ammeter, and to eliminate that a plug is attached to the coil, so that it may be short-circuited and the inductance of the ammeter be determined separately. I have, however, found this inductance with a shunted Siemens instrument to be extremely small.

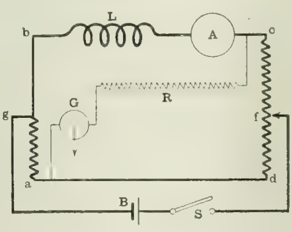


Fig. 2.

The theory of the test is as follows: Let, in addition to the symbols used previously,

n = the number of turns of the exciting coil,
l = the mean length of the ring in centimetres,
A = its cross-sectional area filled by iron in square centimetres,
B = the induction,
ϕ = the total flux passing through A;

then
$$\phi = AB,$$

$$n\frac{d\phi}{dt}10^{-8} = i\left(\rho + \frac{rR}{r+R}\right),$$

$$\int_{\phi'}^{\phi} d\phi = \frac{10^8}{n}\left(\rho + \frac{rR}{r+R}\right)\int_{i'}^{i} i\,dt,$$

$$i = i_2\left(\frac{r+R}{r}\right),$$

$$i' = i'_2\left(\frac{r+R}{r}\right),$$

$$\phi - \phi' = \frac{10^8}{n}\left(\rho + R\frac{\rho}{r} + R\right)\int_{i'_2}^{i_2} i\,dt,$$

$$\mathbf{B} - \mathbf{B}' = \frac{10^8}{An}Rb\theta, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where R is the corrected value of the galvanometer circuit resistance as above explained. The value of **H** is found in the usual way from

$$\mathbf{H} = \frac{0{\cdot}4\pi n i}{l}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$\mathbf{H}' = \frac{0{\cdot}4\pi n i'}{l}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

If only the **H-B** curve, but not the complete loop, is required, we close switch s and knock over the reversing switch. This gives

$$\mathbf{B}' = -\mathbf{B},$$
$$\mathbf{B} = \frac{10^8}{2An} Rb\theta. \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The **H-B** curve can then be drawn from the observations (4) and (6).

To test the accuracy of this method I have made observations with sample rings with pilot coils, one set of observations in the usual way by connecting the pilot coil to the galvanometer,

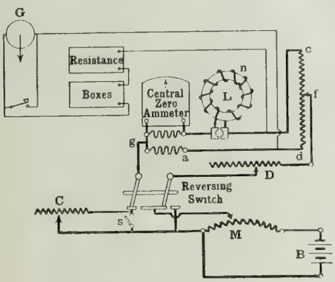


FIG. 3.

and another set by discarding the use of that coil. The two sets of observations agreed. The periodic time of the galvanometer employed was a little over six seconds, its resistance 34 ohms, and the total resistance in the galvanometer circuit was varied between 1,000 and 20,000 ohms. The resistance r was about 38 ohms, and that of the branch agc about 0·3 ohm. The correction for R was thus about 0 8 per cent.

SIEMENS CONTINUOUS-CURRENT MOTORS AND GENERATORS.

Siemens motors and dynamos and their characteristics are by this time so well known to readers of THE ELECTRICIAN that the following particulars of a new class of continuous-current machine recently

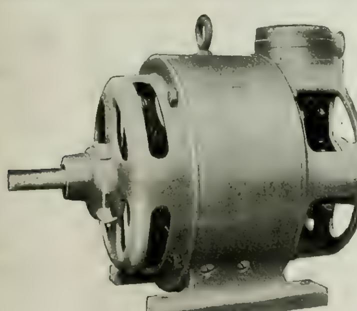


FIG. 1.—PROTECTED TYPE MACHINE.

designed and placed on the market by Messrs. Siemens Bros. Dynamo Works (Ltd.) will doubtless be of interest, embodying as it does improvements on the older class of work. These machines are made in three types, viz., protected, ventilated and totally enclosed. Fig. 1 shows a standard protected type machine, the ventilated type being illustrated in Fig. 2. The latter is shown with perforated metal covers, but single or double gauze covers are fitted when required. The totally-enclosed type is similar to the ventilated type, with the exception that the covers are of solid instead of perforated metal.

These machines are capable of dealing with 25 per cent. overload for half an hour or 40 per cent. overload for three minutes without undue sparking or overheating. For continuous running, the temperature rise, as measured by thermometer, does not exceed 70°F. for protected type machines, 80°F. for ventilated type with perforated metal covers, and 90°F. in the case of ventilated type with gauze covers, or totally-enclosed machines. All machines are designed to run at all loads with fixed position of brushes. The magnet frame, which is circular and of cast iron, is fitted with end shields, which can be turned through an angle of 90 deg. or 180 deg., thus rendering the machine equally suitable for fixing to the floor, wall or ceiling. The main poles are laminated and bolted to the frame, commutation poles, when fitted, being of solid wrought iron in the smaller sizes and laminated in the larger sizes. The arma-

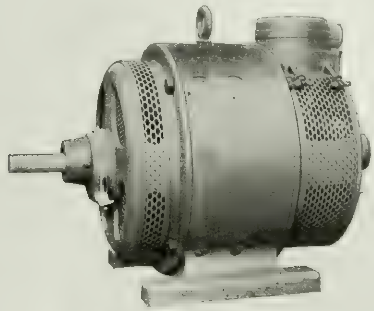


FIG. 2.—VENTILATED TYPE MACHINE.

ture is slotted and drum wound ; the core plates are keyed direct to the shaft, and held in position by two end flanges. Particular attention has been paid in the design to secure thorough ventilation. The field coils are former wound for the smaller machines and wound on bobbins for the larger sizes ; in all cases they are heavily insulated from the poles and the frame as a safeguard against earthing by abrasion. The commutator is built up of hard-drawn copper segments insulated from one another by mica. Carbon brushes are employed, and in order to ensure efficient commutation and to reduce to a minimum any possibility of overheating at the commutator, each brushholder is provided with two brushes. A consider-

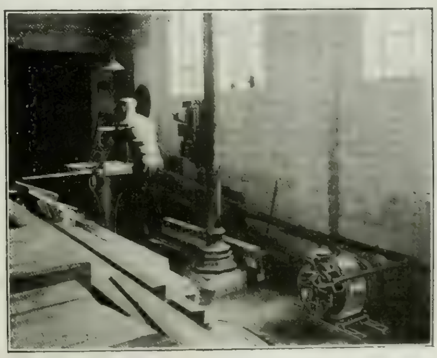


FIG. 3.—SIEMENS F.C. MOTOR DRIVING CIRCULAR SAW 3 H.P. AT 460 VOLTS, 1,100 REVS. PER MIN.

able number of these machines have already been installed to perform widely differing duties, for which they have been found to be eminently suitable. An interesting example is shown in Fig. 3, which illustrates a 3 H.P. motor driving a circular saw.

College Electric Railway.—According to the "Electrical World" Clemson College, the State Institution of South Carolina, proposes to build a short electric line from the college to Calhoun, for the purpose of making a close and direct connection with the nearest railroad main line. The new road will be used for both passenger and goods service.

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SYSTEMS OF CHARGING.

Provided that services can be installed at a low cost, small consumers offer many opportunities for the extension of electricity supply. In a recent issue we referred to the possibility of discarding maximum demand indicators for such consumers; a still further step in the reduction of capital outlay per service is to do away with meters altogether and to charge a fixed sum per lamp per quarter for all energy supplied. Although such a system possesses a few obvious drawbacks, encouraging, as it does, the wasteful use of electrical energy and a reduction in the number of lamps installed, it is attractive to a certain class of small consumers, who appreciate the fact that the cost of lighting is a fixed amount. As an instance of the possibilities of securing business on these lines, and of the popularity of the scheme in certain cases, it is interesting to learn from the "Electrical World" that the Marshall Light, Heat & Power Co., which operates in a town of 6,000 inhabitants, has obtained no less than 92 small consumers on the above basis during the three months following the introduction of the fixed rate system. The charge which has been introduced by the company is $1 per month for four 25-watt tungsten lamps, 20 cents additional for each lamp up to seven, and then 15 cents for all further lamps required. The lamps are sold to the consumers at list price, and as attention is drawn to the fact that a

wasteful use of energy involves unnecessary lamp renewals, the comparatively high price of tungsten lamps encourages the consumers to make use of the current economically. If higher candle-power lamps or carbon lamps are afterwards employed, meters are installed. It is stated that the system was introduced as an experiment, and in view of its apparent popularity the results after a more extensive trial will certainly be watched with interest by other engineers.

At the recent Missouri Electric Light Convention the question of fixed rates was discussed in connection with a Paper on "Equitable Rate Making," and a considerable divergence of opinion was shown to exist as to the desirability of such a system. The heavier electric light bills in the winter, as compared with the summer, was stated to be a common source of complaint where meters are installed; and whilst some speakers instanced cases where consumers paid a larger amount on the fixed rate system than when on the meter basis, others mentioned instances where the adoption of meters led to improved results. In view of the steady reduction in fuel consumption per kilowatt-hour during recent years, it must be remembered that the fixed rate system of charging can now be more easily justified than when the fuel consumption formed a considerable item in the total cost of production of electrical energy, and those stations with low fuel costs can the more safely experiment in the direction of a fixed rate for a certain class of small consumers.

In this country the introduction of metal filament lamps has caused greater attention to be paid to the present systems of charging for electrical energy, and it would seem desirable that the efforts of engineers should be devoted rather to the encouraging of consumers to maintain their previous consumption of electrical energy by a more liberal use of electric light and electric appliances than to keeping up the revenue obtained from lighting consumers by increasing the price per unit. In this connection we do not doubt that a fixed charge depending on the number of lamps installed, together with a low price per unit for energy consumed—or a high price for a certain minimum number of units, with a low price thereafter—would be found to give satisfactory results in the majority of cases; whilst for small private houses, with lighting only, the charge for energy might be omitted and a slightly higher fixed charge made.

We may mention that an interesting modification of the system in which the charge is based on the number of lamps installed seems to be in vogue in Detroit and other American towns. It applies only to residential consumers and is known as the "Dow" system. The consumer is charged a high rate for a certain number of units per room, without regard to the number of lamps connected, and additional units are then supplied at a low rate. A strong point of this system is that it does not discourage consumers from installing lamps in cellars, &c., where the lamps are infrequently used, and it has been pointed out that a maximum demand based on the number of rooms is as likely to be correct as when based on the number of lamps. The system has certainly the merit of simplyfying the process of inspection, which is always raised as an objection against systems based on details of a consumer's installation.

There is no doubt that central station engineers have now a good selection of alternative tariffs, and it only remains to put these seriously to the test of actual working.

REVIEWS.

Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Practical Calculation of Transmission Lines. By L. W. Rosenthal. (New York: McGraw Publishing Co.) Pp. x+93. $2 net.

The author intends this book to be a practical help in the rapid and accurate calculation of transmission lines, and "the arrangement of the formulæ, tables and text has been directed solely by the needs of the rapid worker." As power lines are not such common things that there is any necessity for getting out designs at the rate of, say, a dozen per diem, the advantage of great speed in this kind of work is not very obvious; and if speed can only be bought at the cost of abandoning all original thought and argument, and simply following blindly the rules and tables worked out by the author, most engineers will be satisfied with less speed and prefer to work in their own old way, suiting means to a definite end, and keeping a clear grasp of the subject at each step. But then the author says that the old way is not so good as his. I quote verbatim: "The alternating current division presents a new and original method for the solution of these problems. It is the only method known to the author which determines the size of wire directly from the volt loss in the line, and it also possesses unique features of scope, accuracy and simplicity." This is a large claim, and the reader will naturally be anxious to know what these unique features of the author's method are. As far as I am able to make out they consist in the suppression of all mathematical and generally applicable arguments, and the substitution of a host of special factors for which long tables are given. Unfortunately the author does not show what the scientific significance of his factors is. He simply gives formulæ in which "heat factor," "resistance factor," "temperature factor," "wire factor," "capacity factor," "reactance factor," and so on occur and tables for the numerical value of these factors, without, however, a single word of explanation what the factor is or why it should be in his formula. In most cases a reader well acquainted with the subject can, by analysing the formula, make out the physical meaning of any particular factor, but it is like the solution of some puzzle question, and certainly not the way to work rapidly. In one case, namely the wire factor, I have not been able to puzzle out its inner meaning. I gather that it depends on the frequency, the power factor, the diameter of the conductor, and the distance between two conductors, but how these various quantities can be combined into one factor is not shown. Apparently the author thinks it quite superfluous that an engineer should know at each step of his calculation what he is doing. All that he requires is, that the person using his book should follow blindly the instructions. Here is a sample: "The true power factor of the source is obtained by the following method. Formula (61) is solved for K'_0 using the apparent power factor of load for K. The value of t'_0 corresponding to K'_0 is noted from Table XIV., page 39, and substituted in formula (45) for the reactance factor. The true power factor at source is then obtained from Table XIV., by finding K_0 corresponding to t_0". Apparently the author is under the impression that engineers hitherto have arrived at the voltage required at the generator end of the line by simply adding algebraically the impedance voltage to the voltage required at the delivery end, for by two vector diagrams on page 30 (the only diagrams found in the whole book), he labours the point that the addition must be vectorial.

Some terms used by the author are a little vague. Thus he speaks of relative resistance, without explaining what he means by this term. In working through one of his examples the reader, after a little trouble, finds that relative resistance is not a resistance at all, but the ratio of two resistances. Also the term rail impedance is used in a novel way, or at any rate the formula given has not the dimensions of an impedance. On page 86 we find "Impedance per mile of one T rail, bonded and installed

$$=0{\cdot}8\sqrt{\frac{\text{cycles per second}}{\text{pounds per yard}}}$$

The dimensions of this quantity in the electromagnetic system are $M\ {-}L^{3}T^{-1}$ whereas the dimensions of an impedance are LT^{-1}. What the author calls an impedance is therefore not the quantity which is commonly understood by this term.

This book illustrates a tendency in modern literature which is not good. I do not mean to say that a reader, once he has mastered the author's factors and worked through his examples, could not by following his instructions get accurate results in ordinary cases, but this attempt to teach designing by receipt in the style of a cookery book, and the consequent impression that an engineer need not base his work on fundamental scientific principles, must sooner or later lead to failure.

GISBERT KAPP.

La Télégraphie Sans Fil. By ALBERT TURPAIN. 2nd edition. (Paris: Gauthier-Villars.) Pp. xi.—386. Fr.19.

The scope of this work, of which this is the second edition, is rather wider than the title—"Wireless Telegraphy"—would imply. The work deals with a variety of applications of electromagnetic waves and rapid electrical oscillations. Of course, there are not many ways of producing high-frequency oscillations, even, say, for purely medical purposes, that have not been used in wireless telegraphy, so none of the contents of the book seem beyond the ken of the radio-telegraph engineer.

The scheme on which the book is constructed is as follows: Successive chapters deal, in order, with the history of electric waves and of the means of detecting them, the methods of producing electrical oscillations, the early methods of wireless telegraphy, the various "systems" concocted up to date, the methods of making the chief high-frequency measurements, the various attempts at syntonic telegraphy, and a general account of odds and ends of information about large power stations. The book then proceeds to chapters on wireless telephony, on telegraphy by waves along wires, on telemechanism, and on high-frequency apparatus of many sorts. This arrangement has grown up out of that of the first edition. It works out rather badly. There is much repetition, many matters being discussed under various headings in different chapters, and there is much scattering of discussions that ought to have been massed at one place.

The book has several features that distinguish it from others on wireless telegraphy. One is the very complete treatment of apparatus for making sparks, which takes up the whole of the second chapter. The list of apparatus begins with the Holtz machine and passes to the transformer and high-tension alternator. In connection with the inductorium is an elaborate account of current interruptors, mechanical and electrolytic. Another feature worthy of special mention is the chapter on telegraphy by means of electric waves along wires. This method is, of course, the author's own child. It consists in using (for land stations, at any rate) overhead wires to direct the waves—that is to say, the waves are to be propagated along wires instead of hemispherically. The sending and receiving apparatus are to remain much the same as in telegraphy without communicating wires; but, says our author, transmission by this method would be much more economical than hemispherical transmission. A variety of schemes is given for diplex, duplex and quadruplex telegraphy by this method, but to the present writer they did not appeal convincingly. One other noteworthy item of the volume is the collection of published researches on electric storms, carried out by wireless telegraph recording apparatus. Unhappily, these researches are very few in number and do not tell us much of the laws or even of the causes of the "atmospherics," so troublesome in wireless telegraphy.

The volume contains much careful criticism of general wireless telegraph affairs and prospects. For instance, the arc method of generating oscillations is dissected, and sound reasons are advanced against its wide adoption. But, broadly speaking, the author is rather harsh on all systems of wireless telegraphy, especially as regards communication over great distances. He pours ridicule on the idea of spending many kilowatts at a sending station in order to waggle a telephone diaphragm feebly at the other side of an ocean, and he holds the opinion that the daily costs of a large wireless telegraph station will much outweigh the interest charges and upkeep of a cable doing the same work. In forming this opinion, however, he has probably underestimated the repairs bill of a cable company, and has, no doubt, been influenced by his leaning towards his own proposals of Hertzian telegraphy *with* wires.

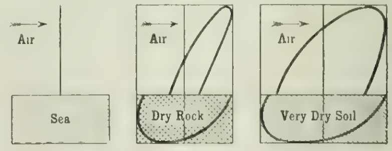
W. H. ECCLES.

RESEARCHES IN RADIOTELEGRAPHY.*

BY PROF. J. A. FLEMING, D.SC., F.R.S.

(*Continued from page 351.*)

It should be clearly understood that when a wireless telegraph antenna is in operation, it sends out into the surrounding space a nearly hemispherical electric wave which spreads out in all directions. There are five causes which weaken the wave as it travels outwards:—(1) The distribution of the energy continually over a larger and larger area. The wave amplitude diminishes inversely as the distance, and the wave energy inversely as the square of the distance. This is proved theoretically from first principles by Hertz's equations, and has been confirmed experimentally by the experiments of Messrs. Duddell and Taylor, and of Prof. Tissot. (2) There is a certain absorption of energy due to the ionisation of the atmosphere by daylight and to other causes, but this is only detectable over long distances, and for the present moment we shall neglect it. We include, however, under this head obstructions due to special atmospheric conditions, electrical or material. (3) There is a diminution due to earth curvature which is operative only over long distances. (4) There is some reduction of intensity which results from obstacles—such as hills, trees,—especially from cliffs of ironstone or conductive rocks, due to distortion of the electric field. (5) Lastly, there is the weakening due to the dissipation of energy by the penetration of the waves into the surface over which they travel.



A — ρ = 1 ohm/metre cube. K = 80.

B — ρ = 100,000 ohms per metre cube, K = 2 – 3.

C — ρ = 10,000 ohms per metre cube, K = 1 – 3.

ρ = Resistivity. K = Dielectric constant.

FIG. 3.

We shall consider the last-named cause alone at the present moment. Dr. Zenneck has discussed mathematically, in a very interesting Paper, the effect of the conductivity and dielectric constant of the terrestrial surface, soil or sea, on the propagation of a plain electric wave over it, assuming the radiation to be from an ordinary vertical antenna, and the electric force therefore normal to the earth, and magnetic force parallel to it. The result is to show that there are, broadly speaking, three cases to consider. First, supposing the surface material to be a good conductor, then the wave moves over the surface and penetrates a very little way into it. The electric force in the air over the surface is a purely alternating force vertical to the earth's surface, and the magnetic force is an alternating force parallel to it, and there is very little subterranean electric or magnetic force (*see* Fig. 3A). This is realised approximately or most nearly in the case of radiotelegraphy over sea water. Secondly, let the earth be assumed to have a very poor conductivity and not a very large dielectric constant, then analysis shows that the electric force in the air has two components, one perpendicular to the earth's surface and one parallel to it, and the resultant is an alternating and a rotating force, the direction of its maximum value being inclined to the surface and leaning forward (*see* Fig. 3B). The wave front therefore slopes forward. Also there is a subterranean electric force, showing that the wave is penetrating into the soil, and there is therefore dissipation of energy owing to the conductivity of the soil as the wave travels over the surface. This case is realised when the wave travels over land composed of dry soil having a small dielectric constant. Thirdly, let the earth be a very poor conductor, having a small dielectric constant from 2 to 3, and a specific resistance, of about 10,000 ohms per metre cube. For example, very dry earth or sand. Then the investigation shows that the electric force in the air has two components, one parallel to the earth's surface and one perpendicular to it differing in phase, and the resultant is

* Lecture (slightly abbreviated) delivered on June 4th before the Royal Institution.

represented by the rotating radius of an ellipse, the maximum value or major axis of which is inclined forward in the direction of the wave motion (*see* Fig. 3c). At the same time there is some penetration of the wave into the earth and consequent dissipation of energy.

Dr. Zenneck has considered the case of electric waves 1,000 ft. in wave length, and has represented the final result by some interesting curves. He defines the effect of the absorption of energy by the soil by stating the distance in kilometres at which the wave amplitude would be reduced by the effect of this absorption to $0{\cdot}367 = 1/\epsilon$ of its amplitude at the sending station, altogether apart from the weakening due to the spreading of the waves out in a hemisphere, which we may call the spherical or space decrease. These curves are plotted to abscissæ representing the specific resistance of the soil (*see* Fig. 4). You will see from this diagram that when a plane electric wave having the above wave-length is propagated over sea water, it would have to travel 10,000 kilometres before its amplitude would be reduced in the assigned ratio; and over fairly dry soil, about 100 to 1,000 kilometres; but over very dry soil, having a small dielectric constant, only about 1 to 10 kilometres. Also you will notice that the curves rise up again for still higher resistivities. This, of course, is as it should be. All the practical cases lie between two ideal extremes: the case of an infinitely perfect conducting earth, in which case the waves would not penetrate into it at all; and the other case, an infinitely perfect non-conducting earth, in which the wave would penetrate into it, but would suffer no dissipation of energy. This theory is quite in accordance with practical experience in radiotelegraphy. Every receiving apparatus associated with an antenna of a certain height and kind must be subjected to waves

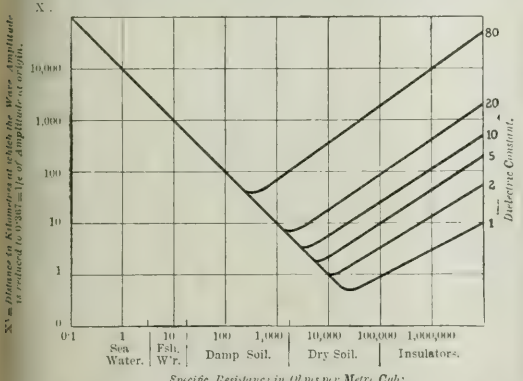


FIG. 4.—CURVES SHOWING THE DISTANCE IN WHICH ELECTRIC WAVES 1,000 FT. (300 METRES) IN LENGTH HAVE AMPLITUDE REDUCED TO $1/\epsilon$ BY TRAVELLING OVER VARIOUS SURFACES. (Dr. Zenneck)

of a certain minimum amplitude to give any appreciable signal. For all lower amplitudes that particular receiving arrangement is perfectly deaf. Now it is a matter of common experience that with a given radiotelegraphic apparatus and antenna, it is possible to receive signals for greater distances over sea water than over dry land, and that if the soil is very dry, the distance may be cut down very considerably indeed. This is not due merely to the difficulty of making what the telegraphists call a good earth at the sending station, it is due to the absorption of the wave by the earth for the whole distance which extends between the two stations. Hence, also, it is a common experience that when particularly dry weather is succeeded by wet weather, the radiotelegraphic communication between two stations on land is considerably improved.

In another Paper, Dr. Hack has shown that even underground water is an advantage in facilitating radiotelegraphic communication. Since a shore station must always be established on shore for communication with ships, it is in consequence generally the custom to select a site for that station as near as possible to the coast, and to take pains to get a very good conducting connection between the foot of the antenna and the soil, and also if necessary between the antenna earthplate and the sea. Fessenden has suggested for this purpose the use of what he calls a wave chute, which is merely a metallic network extending some distance outwards from the antenna in cases where this antenna is established in the centre of towns or dry districts.

Dr. Zenneck has also given a series of curves which show in a remarkable manner the reduction in wave amplitude due to both distance and surface absorption, calculated for waves of 1,000 ft. in length, and for various coefficients of absorption (*see* Fig. 5). Thus, for example, if we are propagating plane waves 1,000 ft. long over a surface which by itself would reduce the wave amplitude to 0·367 of its initial amplitude in 1,000 kilometres, then, when we consider the decrease by distance as well, we have to take account of the fact that this last cause reduces the wave amplitude at 1,000 kilometres to 0·001 of that which it is at 1 kilometre distance. I have represented in Fig. 5 some of Dr. Zenneck's curves. The dotted line shows the decrease of amplitude by distance alone, and the firm lines that due to distance and terrestrial absorption in various cases. We are able to see from them the large effect due to travel over large distances of very dry soil. Thus, for instance, if the absorption is such as to cut down the amplitude in the ratio of 1 : 0·367 at 1,000 kilometres, then at a distance of 3,000 kilometres the amplitude of a wave of 1,000 ft. in length would be cut down in the ratio of 3,000 to 1 by distance alone, but in the ratio of 60,000 to 1 by distance and terrestrial absorption combined.

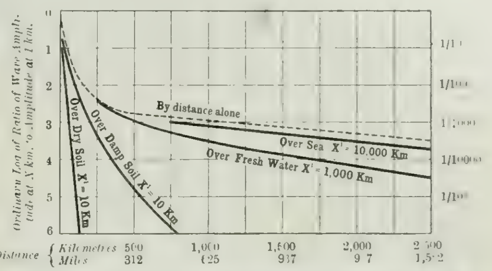


FIG. 5.—CURVES SHOWING DECREASE IN WAVE AMPLITUDE WITH DISTANCE FOR WAVES 1,000 FT. IN LENGTH. (Dr. Zenneck).

An important matter is the question of the influence of wave length on this absorption. It can be shown from theory that an increase of wave length reduces the energy dissipation by the earth. Thus, in certain cases, increasing the wave length from 1,000 to 10,000 ft. increases the range of effective communication 100 times. This agrees with practical experience. The absorption is also determined by the decrement of the wave train being greater the larger the decrement.

One practical deduction to be made from this investigation is that the reduction in wave amplitude which takes place when the wave moves over very dry soil is as much due to small dielectric constant of the material as to high resistivity. We see also that the wave front is very far from being vertical when the waves travel overland, and hence it is an advantage in that case for the receiving antenna to slope away from the direction in which the waves are travelling or

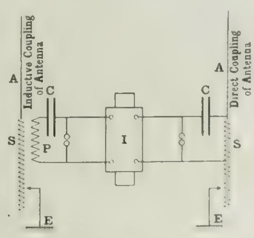


FIG. 6.

from the radiant point. Lastly, it points to the advantage of a long wave for overland working. Generally speaking, then, we find that electric wave telegraphy is conducted with much greater ease over sea than over dry land, the reason being that the dielectric constant is large and the conductivity of sea water is sufficient to prevent much penetration of the electric wave in the sea, and therefore there is not much dissipation of its energy by absorption due to the surface over which it travels. We have here an instance of economy in Nature. Over sandy deserts, where we can, if need be, put up telegraph posts and wires, radiotelegraphy has had some natural difficulties placed in its way, but on sea, where connection between moving stations is the important matter, and telegraph posts are impossible, special facilities seem to have been afforded us for conducting it.

The next point to be noticed in connection with the antenna is the means adopted of setting up the oscillations in it. The universal custom at present is to excite oscillations in a reservoir circuit consisting of a condenser and an inductance by means of the spark or arc. If the spark method is used, then the condenser is one of relatively large capacity, and the inductance is kept small. If the capacity is measured in electrostatic units, and the inductance in electromagnetic units, the ratio of capacity to inductance may be something of the order of 5:1 or even 20:1. In this case the condenser is charged by means of an induction coil or transformer, and discharged across a spark-gap, and this discharge consists of intermittent trains of electric oscillations with a periodic time equal to the free natural period of the oscillatory circuit. These discharges are made to succeed each other from 50 to 600 times a second, by using an induction coil with an appropriate interrupter, or else an alternator and a transformer. If the arc method of exciting the oscillations is employed, then the ratio of capacity to inductance must be much smaller and the oscillations are excited in this circuit by

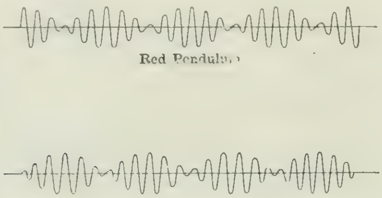


Fig. 7.

a continuous current arc worked with a voltage from 200 to 400 volts or more, the arc being traversed by a strong magnetic field and generally being placed in a chamber kept free from oxygen. The oscillations set up in the condenser circuit are then persistent or unbroken. The oscillations are excited in the antenna by coupling it inductively or directly with the condenser circuit (*see* Fig. 6). If the former method is employed, then an oscillation transformer is used consisting of two coils of wire, one coil being inserted in the condenser circuit and one in the antenna circuit, and according as these coils are near or far apart, they are said to be closely or loosely coupled. These two circuits have then each their own natural period of electric vibration, like tuning forks, and they have to be

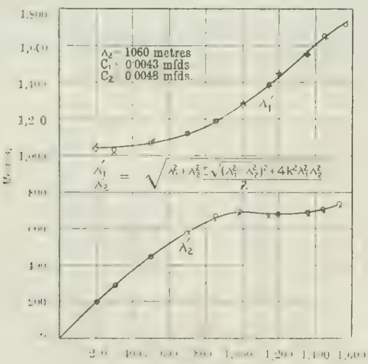


Fig. 8.—Pierce's Experiments on Inductive Coupling.

adjusted to syntony. It is well known that under these conditions oscillations set up in one circuit immediately create oscillations of two frequencies in both circuits. This action can be easily illustrated by two pendulums which are of the same length and are hung side by side on a loose string. If one pendulum is set swinging, it imparts little jerks to the other and sets the latter in motion, but to do this the first must part with its own energy, and hence is gradually brought to rest. Then the operation is repeated in the reverse direction (Fig. 7). Hence, each pendulum is alternately swinging faster and slower than its ordinary rate, and may be said to possess two rates of vibration. The same thing happens in the case of two closely coupled syntonic electric currents. If one circuit has free oscillations set up in it, the action and reaction of the circuits generates oscillations of two frequencies. Accordingly, when an antenna circuit is coupled to a condenser circuit, we have oscillations of two frequencies set up in it, and waves of two wave-lengths radiated from the antenna. The presence of these two waves can be detected either by measurements made with the cymometer or by an oscillograph vacuum tube. In the first case all that is necessary is to place a cymometer in proximity to the antenna and vary its oscillation constant. It will be found that there are two settings of the handle for which the Neon tube glows brightly, and the scale of the instrument will indicate the wave-lengths of the two waves respectively. Some

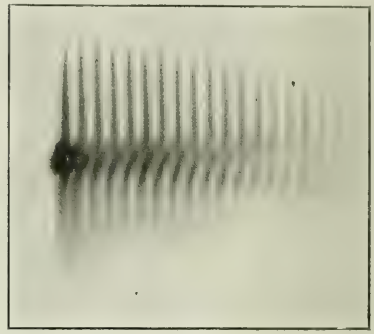


Fig. 9.—Oscillogram of Damped Oscillation (Antenna not connected) taken with the Gehrcke Oscillograph Vacuum Tube.

instructive measurements of this kind have been made by Prof. W. G. Pierce in a recent research, and he has shown that the wavelength given by the formulæ which can be deduced from the theory of the operations are in agreement with actual measurements (*see* Fig. 8). Another striking confirmation can be obtained by the oscillograph vacuum tube, invented by Dr. Gehrcke of the Reichsanstalt, Berlin. This consists of a glass tube having two strip electrodes in it nearly touching, which are made of nickel or aluminium. The tube is filled with pure nitrogen and exhausted to a pressure of about 10 mm. to 20 mm. If such a tube has a high voltage applied to its terminals a glow light extends along the electrodes, the length of which varies with the E.M.F. Hence, if the tube is connected to a circuit in which an oscillatory discharge is taking place, the


Fig. 10.—Oscillogram of Secondary Oscillation (Antenna connected) taken with Gehrcke Vacuum Tube.

glow light along the tube will rapidly extend and contract. If the electrodes are examined in a revolving mirror, making from 50 to 100 turns a second, the images of the glowing electrodes corresponding to each oscillation will be separated out, and if the oscillations are persistent or undamped, we see a series of short bright lines alternately above and below a central line. If, however, the oscillations are damped, then we see in the mirror a train of images each decreasing in length (*see* Fig. 9). On applying such an oscillograph vacuum tube to the circuit of an inductively coupled antenna, and examining in a revolving mirror the image of the electrodes, they will be seen to present an appearance as in Fig. 10, taken from photographs kindly given me by Herr Hans Boas, of

Berlin. These oscillograms indicate that there are two oscillations present of different frequency, producing an effect similar to beats in music. Owing to the difference in frequency, the oscillations alternately reinforce and extinguish each other throughout the period, and as this type of oscillogram is only obtained with an inductively coupled antenna, it is a proof that in such a case there are two oscillations present of different frequencies. A similar result has been obtained by Prof. E. Taylor Jones with low-frequency oscillations in coupled inductive circuits by means of an electrostatic oscillogram of his own invention. Looking at these photographs, it will be seen that each represents a single train of damped oscillations gradually dying away, but that in each train of oscillations there is an alternate waxing and waning of the amplitude, which indicates that there are two superimposed oscillations of different frequency. Accordingly, in the case of wireless telegraph antennæ inductively coupled, we have in general two waves radiated of different lengths, and either of these can be made to affect suitably tuned receiving circuits. These waves have different damping and different maximum amplitudes.

One of the disadvantages of close inductive coupling is, therefore, that we must divide the energy given to the antenna between two waves of different length. As the receiving antenna is generally only tuned to one of these wave-lengths, we then capture and absorb only the energy conveyed by the waves of that wave-length. To meet this difficulty it has been the custom to employ a feeble coupling between the circuits of the oscillation transformer, so as to generate waves of only one wave-length. The objection then arises that the energy conveyed to the antenna is much reduced. It is, however, possible, as I have shown, to duplicate the receiving circuits so as to capture the energy of both the waves, even with close coupling of the transmitter transformer (Fig. 11).*

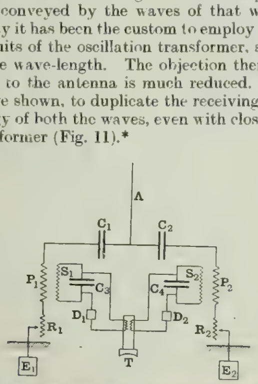


FIG. 11.—METHOD OF UTILISING WAVES OF BOTH FREQUENCIES EMITTED BY INDUCTIVELY-COUPLED TRANSMITTING ANTENNA.

A method of creating feebly damped oscillations has, on the other hand, recently been developed, generally known in Germany as Wien's method, or the method of quenched sparks, which is based on the fact that if we can quench or stop the spark in the condenser circuit after the first few oscillations, the oscillations of the antenna then take place freely and with a single frequency. The principle which underlies this method is the well-known fact, to which particular attention was called by Prof. M. Wien, of Danzig, in 1906, that the damping effect of very short sparks is extremely large. Hence, if we form a spark-gap consisting of a large number of very small spark-gaps in series, say 10 gaps each of 0·3 mm., and if we keep the spark surfaces cool, then not only can no arc form between these surfaces, but the condenser spark is immediately quenched. Moreover, if we supply this spark-gap, either from a high-frequency alternator or from a low-resistance transformer, we can produce as many as 2,000 sparks per second. A form of discharger† for this purpose has been devised by the experts of the Wireless Telegraph (Telefunken) Company, of Germany, which consists of a series of copper discs or copper boxes cooled with water, the flat surfaces of which are placed in contiguity, but separated by very thin rings of mica. The interspaces between the boxes is not more than $\frac{1}{25}$th part of an inch, and 10 or 12 of these boxes are placed in series. The row of boxes takes the place of the ordinary spark balls, and is connected to the secondary terminals of a transformer, fed by a high-frequency alternator, and also connected to an oscillatory circuit. When the transformer is in action it produces a very large number (1,000 or more) oscillatory discharges of the condenser per second, each of which has a large initial amplitude, but quickly dies out. The inductively or directly coupled antenna hence receives a very large number of impulses per second, each of which sets up in it free electrical oscillations of one definite period. Such a multiple gap disc discharger used in the manner described appears to operate on quite different principles from the single pair of discs with interposed paper ring which Von Lepel has employed. From the description and mode of connection of the Von Lepel discharger this last appears to act in virtue of the production of an arc discharge in the manner of the Duddell or Poulsen arc. During a recent visit to Germany I was permitted to see a discharger of the multiple disc type, with which remarkable radio-telegraphic results have been obtained in economy and efficiency of work.

In connection with spark telegraphy, it has lately been clearly seen, that much can be done by attention to details of construction to increase the number of oscillations in each wave train in the case of spark apparatus—in other words, to lessen the damping by obviating energy losses in all parts of the apparatus. It is not a matter of indifference what kind of glass we use in Leyden jars or what form of stranded wire we employ in oscillation transformers, or type of spark discharger. By appropriate selection of apparatus we can considerably increase the number of oscillations in damped trains of small amplitude, and therefore increase the possibilities of utilising the principle of resonance.

(*To be continued.*)

* Since the delivery of this lecture my attention has been drawn by Mr. J. Hettinger to an article by himself in the "Electrical Engineer" of October 26, 1906, in which he describes an almost identical arrangement devised by him for capturing both the waves of an inductively-coupled transmitter, and refers to a prior invention for the same purpose by Dr. G. Seibt.

† *See* THE ELECTRICIAN, June 11, 1909, p. 332.

THE POSITION OF THE ELECTRICAL INDUSTRY.

Our readers will remember that some time ago we referred to the steps that were being taken to organise an influential committee to take into consideration questions affecting the electrical industry, with a view to forming an association which would deal with these questions in a manner to bring them prominently forward for discussion. Another object of the proposed association was to devise a common platform upon which all the various sections of the industry could be called together to discuss questions affecting the general interests. Some progress was made, and a small committee took the matter up on the lines recommended by a small provisional committee of the Editors and Proprietors of a number of the Electrical Journals, one of these recommendations being that Sir William Preece, K.C.B., should be asked to accept the presidency of such an association.

The committee duly approached Sir William Preece, and we learn from Sir William that negotiations have reached a stage when a letter which he has addressed to the committee may be published, and will prove of general interest. This letter is as follows :—

3, Queen Anne's Gate, Westminster, S.W.
May 20, 1909.

DEAR SIRS: I very much regret the unavoidable delay in communicating to you my views in regard to the question of establishing some organisation which is able to protect the general, commercial and financial interests of the electrical industry of this empire. I agree with you that while the technical development of the electrical industry is well provided for by the Institution of Electrical Engineers and its allies, there is a pressing and immediate need for some organisation whose aim should be to impress the general and financial public, and especially Parliament, with the vast commercial interests represented by the industry. There are two important questions involved :—

Firstly.—The broad Imperial industry affecting both home and colonial markets now deeply depressed by ignorance of its growth and its wide capabilities and extent. It is virtually closed to development by the practical impossibility of obtaining capital on fair conditions. Money that flows freely to our colonies and to foreign countries cannot be obtained for our home demands, except on exorbitant and almost prohibitive terms.

Secondly.—The local home industry is dependent on mutual self support, mutual confidence between master and man, and broad business-like relations between the wholesale and retail elements and between buyer and seller.

For the *first* purpose, my view is that we should solicit the Lord Mayor to invite to a meeting in the Mansion House our leading banking and financial authorities to consider the want of confidence that exists between capital and home industry, the causes for this very evident and unsatisfactory condition, and the remedies. Indeed, I have seen the Lord Mayor, and he has consented to this proposal.

For the *second* purpose, we require an association which, supported by existing societies, will bring the public voice to bear upon their representations, so as to enable deputations to Government departments, and witnesses before Royal Commissions and Parliamentary Committees, to speak, not merely with the authority of experts, but with the force and weight of numbers from all sections of the industry.

The association must in no way savour of the nature of a trade ring or of a trust. Its general constitution embracing all sections of the industry in all parts of the country ensures this.

I am in full sympathy with any movement that is going to improve the present position of the electrical industry, and will always be pleased to give my cordial support to such efforts.

With regard to the suggestion that I should accept the presidency of such a body, I am quite willing to entertain the idea.

I would suggest for your consideration that it would be well to give the organisation a name which is calculated to express its objects, and the title I suggest is "The Electrical Industrial Association of Great Britain." With a strong and active council, representing all the various sections of the industry, and with the support of the existing institutions, I am sure that we will recover confidence and secure success. I am, Yours very truly,

(Signed) W. H. PREECE.

CORRESPONDENCE.

DIFFERENTIAL METHODS OF MEASURING HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Prof. Ernest Wilson's inquiry in your last issue, I may say that we have not applied our method to test materials possessing marked magnetic viscosity. Doubtless the method would fail under these conditions, though it is quite possible that the differential use of a fluxmeter would meet the case.

What we aimed at was the development of a method for quickly testing the ordinary grades of sheet iron in commercial use, and I think I am right in believing that magnetic viscosity is not usually exhibited in a pronounced degree in such materials. We certainly have found no evidence of it in the materials so far dealt with, although (keeping in mind the experiments of Prof. Ernest Wilson, A. Hoyt Taylor, and R. Jouaust on the subject) we have been on the outlook for viscosity from the very first, recognising that it would prove a bar to differential ballistic testing. We have also satisfied ourselves that the discrepancy in the results obtained with bundles, as compared with rings, is not due to anything of the nature of magnetic viscosity.—I am, &c.,

Manchester University, June 15. ROBERT BEATTIE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been much interested in the differences obtained by Dr. Beattie and Mr. Elton in testing ring and straight specimens of iron for hysteresis loss. About a year ago I carried out some tests in the laboratory of Messrs. Baldwins (Ltd.) at Wilden and obtained a somewhat similar result. In this case, however, the comparison was made between ring specimens and a magnetic square, as used by Searle ("Proceedings" Inst. Elect. Eng., December, 1904; THE ELECTRICIAN, Vol. LIV, p. 313). The rings were 11 cm. external and 9 cm. internal diameter, and the square was built up of strips 14 in. by $\frac{5}{8}$ in., with overlapping ends to form a square 13 in. sides. In the following table are given the results obtained for specimens differing greatly in their magnetic quality, but it will be seen that there is a practically constant proportional difference between the two methods of testing:—

Sample.	Loss at B = 4,000 100 cycles. Ring.	Square.	Loss by ring. / Loss by square.
A	0·42	0·385	1·12
B	0·52	0·45	1·15
C	1·61	1·44	1·11
D	1·95	1·76	1·11
			Mean 1·12

The winding of the square was such that the value for **H** to give the required maximum **B** was practically the same as for the rings, but the loop in the former case fell entirely inside that from the latter, giving the above differences of area.

The two sets of samples were in each case cut alternately from the same sheet before annealing and then annealed close together in the pot, so that all errors due to differences of composition or mechanical treatment should be eliminated.—I am, &c.,

Stourport, June 14. J. C. W. HUMFREY.

EARTHING OF THE NEUTRAL POINT OF THREE-PHASE GENERATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have just returned from a tour of some of the Swiss and Italian generating stations, and in view of the recent discussion in your columns on the above subject I took the opportunity of making some inquiries. I found that, in general, the neutral was insulated; in one case, however, considerable disturbances had been experienced and the neutral was earthed with beneficial results. In another case the neutral was insulated but permanently connected to one side of an ordinary horn arrester mounted on the top of each machine, the other side of the arrester being connected directly to earth; the gap was so adjusted that a spark would pass when the neutral rose above 6,000 volts to earth. The tension of the system was 11,000 volts between the lines. Each line was, in addition, protected by lightning arresters in the usual way. The engineer-in-charge told me that the apparatus worked well and the generators were in no way disturbed when the neutral flashed over to earth.—I am, &c.,

Karlsruhe, June 9. G. W. WORRALL.

THE WORK OF THE LONDON ARMY TROOPS R.E.

At the Territorial Sports which were held at Ranelagh on Saturday, the 12th inst., a special display, illustrating modern methods of telegraphic communication in the field, was given by the troops of this command, on two of the polo grounds adjoining the arena. The force which consisted of detachments from the Balloon, Wireless, Cable, and Air-line Companies under the command of Major J. J. F. O'Shaughnessy of the London Cable Telegraph Company, R.E., was supposed to be the Telegraph Head Quarters of a Division encamped 10 miles from its Army Corps Head Quarters at Elmer's End, with which constant communication was maintained by wireless telegraphy; while communication with the various Brigades and Subcommands of the Division was maintained by the Air-line and Field Cable sections by means of D.C., S.C. and Vibrator Telegraph sets, and telephones controlled from a portable central exchange.

Frequent ascents were made by a captive balloon which was used as an observation post from which reports were transmitted by telephone to the Division Head Quarters.

The portable wireless set which was kindly lent by the Lodge Muirhead Co., consisted of a light wagon on which was mounted a 60 ft. telescopic aerial pole which, despite the unfavourable weather conditions, was quickly erected after arrival on the ground. Perfect communication was maintained with Elmer's End with an expenditure of from 50 to 60 watts, obtained from a light portable accumulator mounted on the wagon. The display was inspected by Colonel Sir Edward Ward, Permanent Under Secretary of State for War, Lieut-General Sir Henry Mackinnon, Lieut.-General Baden-Powell, and other distinguished officers, who all expressed their approval of the efficient and practical manner in which the work was carried out. The smart work of the Air-line detachment, under Lieut. Gunton, and the brilliant manner in which the cable section "paid out" and "reeled up" field cable at the "gallop," were specially commended.

In the arena the driving competition for six horse teams and wagons, open to all Territorial Engineers, was won by a team from this Corps.

The London Army Troops, R.E., commanded by Lieut.-Colonel A. Bain have an establishment of approximately 600 officers and men, and although the Corps was only formed last July, they have been up to full strength since February last, and have now got a waiting list of over 200 technical men who are anxious to join.

The equipment of the Air-line and Cable Companies is nearly complete; but the Wireless and Balloon Companies have not been so fortunate in obtaining equipment from the authorities. The former have obtained most of their practice instruction at the fixed stations of the Lepel Co., and with portable sets kindly lent by the Lodge-Muirhead Co., while the Balloon Company have only had a few stores issued to them for instructional purposes.

THE EUREKA CLOCK.

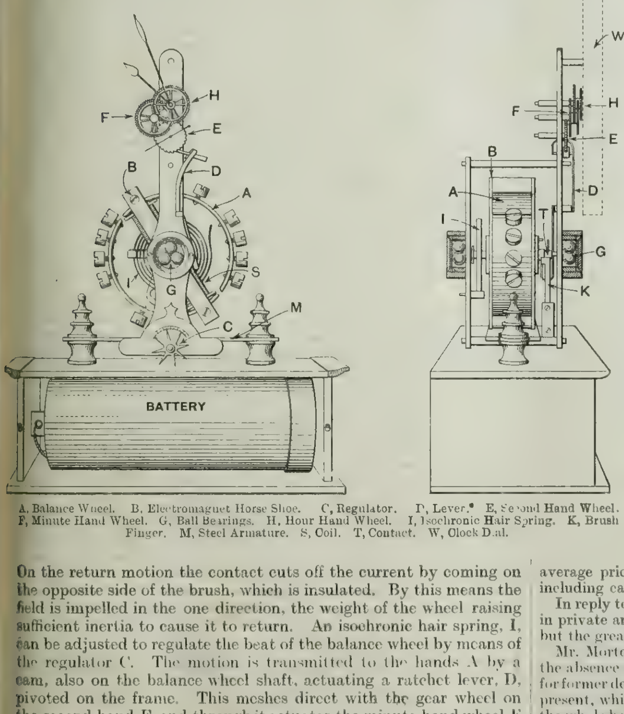
Ever since the days of King Alfred, when history tells us time was recorded by notches on candles, we have had more or less reliable methods of recording the flight of time. Until a few years ago the operation of clocks was entirely mechanical, and of recent years very fine specimens of work of this description have been made, both for exhibition purposes and also for the wear and tear of everyday use.

With the rapid strides made by electricity, a number of applications of this source of energy have been made with a view to actuating clocks, and at the present day we have various systems by means

of which the hands of a clock dial are actuated by an electric circuit connected up to a master clock. We have recently seen, however, another type of electric clock, which is in itself electrically operated, and which, it is claimed, is absolutely accurate and reliable. At the same time this clock is complete, and entirely independent of outside sources for its actuating power.

The Eureka clock, which Mr. Sigismund Kutnow had the honour of showing the King the other day, is a very simple and at the same time substantially made piece of apparatus. Its very simplicity emphasises the ingenuity shown in its construction, and an explanation of the drawings shown will further convince those interested of the very few moving parts, which is in itself a great feature.

A compensated balance wheel, A, is mounted on ball bearings, G, and, with the exception of the electromagnet B, is exactly similar to the balance wheel to be found in most watches at the present day. The magnet B consists of two steel strips connected across as the top by means of a screw with the bottom ends forming the pole-pieces. The field coil S lies between the pole-pieces, and consists of many windings of enamel insulated wire. This in itself is interesting from the fact that for the first time small enamel insulated wire has been made and used in this country. The pole-pieces are free to rotate over a steel armature, M. A contact in the balance wheel shaft rubs the brush finger K intermittently, and when the wheel rotates in one direction contact is made with the battery on one side of the brush.



A, Balance Wheel. B, Electromagnet Horse Shoe. C, Regulator. D, Lever.* E, Second Hand Wheel. F, Minute Hand Wheel. G, Ball Bearings. H, Hour Hand Wheel. I, Isochronic Hair Spring. K, Brush Finger. M, Steel Armature. S, Coil. T, Contact. W, Clock Dial.

On the return motion the contact cuts off the current by coming on the opposite side of the brush, which is insulated. By this means the field is impelled in the one direction, the weight of the wheel raising sufficient inertia to cause it to return. An isochronic hair spring, I, can be adjusted to regulate the beat of the balance wheel by means of the regulator C. The motion is transmitted to the hands A by a cam, also on the balance wheel shaft, actuating a ratchet lever, D, pivoted on the frame. This meshes direct with the gear wheel on the second hand E, and through it actuates the minute hand wheel F and the hour hand wheel H. All these wheels are perfectly free, and only carry strain when the actuating motion takes place. The current for working this clock is obtained from an ordinary standard dry cell, and it is guaranteed for at least 1,000 days continuous working. The current consumed works out at about $6\frac{1}{2}$ amperes per year, both by calculation and actual test. The clock need not be stopped even for changing the battery, as the momentum of the balance wheel is sufficient to carry on the motion while the old battery is disconnected and the new one put in circuit.

The factory where these clocks are made in London is being run in the most up-to-date way. Every part of the clock is made to standard size, so that interchangeability of the various parts is assured, and at present all the clocks are being made the same size. Not the least interesting feature at the works is a museum, in which is shown the various attempts at making electric impulse clocks which now seem fair to prove successful.

THE CHARGE FOR ELECTRIC POWER AT WEST HAM.

On Tuesday Mr. H. Ross Hooper, M.Inst.C.E., resumed his inquiry at Stratford Town Hall, London, E., into the application of West Ham Council for permission to borrow £51,600 for electricity supply purposes. The inquiry had been adjourned for further particulars to be prepared as to certain items of expenditure, and of certain contracts into which the department had entered. The application included £15,612 over expenditure on a previous sanction, and £8,612 already expended on the present application.

Mr. A. H. Seabrook, borough electrical engineer, said they asked for the maximum period for repayment of the excess expenditure amount. He thought amounts of £23. 13s. 9d. for temporary connections, £727 for cleaning a disused sewer to be used as a culvert for their cable to Silvertown, and £66 for making good Great Eastern-road after the bursting of a pipe, were proper items to be charged to capital expenditure. In putting in a new transformer only the difference in the cost of the new transformer against the old one was charged to capital account. Practically the whole of the additional work, for which £25,272 was applied for, had been carried out. Their maximum load last winter was 6,100 kw. They had entered into a contract with Bruce Peebles & Co. for changing the 1,200 kw. sets from single phase to two phase, which had already been done with the two 600 kw. sets. This would make the whole four sets better than when they were put in. The total capacity of the station was 11,400 kw. The Council contemplated applying for a further £3,000 for mains and £2,000 for services. They were applying for £18,515 for transformers. The expenditure for transformers for the year ended March last was £2,594, which left £16,000 for the three succeeding years. That would be necessary, as they were transferring the transformers from stock to capital, as suggested by the Inspector.

Mr. Elvey Robb (for the India Rubber, Gutta Percha & Telegraph Works Co., Silvertown) asked why overdraft due to bankers (£40,000) had been altered to moneys due to treasurer in the current accounts, and the Inspector said discussion of that could be deferred for the moment.

Mr. C. H. Patterson, borough treasurer, said with regard to sinking fund on the excess expenditure, sums had been set aside, pending permanent borrowing, on the whole of the capital expenditure until March, 1909. £1,657 had been charged to the undertaking as the sum set aside pending permanent borrowing. That was only on the expenditure, not on the full sanction. Asked by the Inspector to deal with the overdraft on revenue account (£39,157. 5s. 4d.), Mr. Patterson said the balance shown on the balance-sheet consisted of sundry debtors, reserve fund invest- ments, stores on hand, motors on hire, arc lamps, &c., on hire, and cash in the engineer's hands, total £53,426, against which were sundry creditors, consumers' deposits, reserve fund and balance of net revenue account, total £14,269, the difference being the balance of £39,157.

Mr. Seabrook said the supply of energy at 0·37d. per unit which had been given was justified by the fact that the bulk of the increased units sold last year (4,000,000 units) was at 0·37d., and there was a net improvement in the accounts of £8,500, the net profit being £3,853, against a loss in the previous year of £4,670. In addition to that, the whole of the Silvertown supply, which was $5\frac{1}{2}$ million units during the year, was at the average price of 0·43d. Capital charges were 0·457d., and total costs, including capital charges, were 0·977d.

In reply to Mr. Elvey Robb, Mr. Seabrook said there had been decreases in private and public lighting supply, a small increase in traction supply, but the greater proportion of the increase was in power supply.

Mr. Morten having objected to questions by Mr. Robb as to whether the absence of monthly reports from the borough treasurer could account for former deficits, the Inspector said, in discussing an application like the present, which included some £25,000 for new works, of which practically the whole had been carried out, they could not be confined to the accounts of one year.

Mr. Seabrook said he could not say whether the borough treasurer suggested that the power supply was being given at too low a price. He believed a member of the Council alleged that they were supplying below cost price. In certain of the minutes he was reported as having said the principle of fixing the price for a consumer was that he should pay his proportion of the capital charges and running expenses. He applied that principle in making out the charge of 0·37d. He could quite understand that Mr. Robb was annoyed that there was not a big loss on the last year's working. The contract for the supply at 0·37d. was for five years. It was not made by the Committee upon a formal estimate from him specially prepared for the occasion; the information he gave them on that occasion was chiefly verbal.

Mr. Robb went into a calculation, assuming 100 per cent. load factor and maximum load of 6,100 kw., and taking last year's capital charges (£29,511) and an output of 53,200,000 units, arrived at a capital cost of 0·133d. per unit.

Mr. Seabrook said that did not necessarily apply to the 0·37d. supply.

He had not the figures before him showing the details of the cost per unit. Coal cost about 0·2d.

Mr. MORTEN objected to giving the particulars, as he said it would be equivalent to giving the reasons for the contracts, which should be private.

Mr. ROBB said the undertaking, which had a capital of nearly half a million, was only rated last year at £114, whereas the India Rubber Co. contributed over £7,000 a year to the rates. The Corporation's electricity undertaking showed a surplus of £3,000 last year, but this low rating destroyed the apparent surplus.

The INSPECTOR supported Mr. Robb's demand for a statement of the details of the cost per unit. He said Mr. Robb had made his calculation on 100 per cent. load factor, and the only justification that had been put forward for the price of 0·37d. was that the undertaking had shown a profit last year. What it would do next year, or had done in previous years, was not taken into consideration, and money was now being asked for in respect of plant and mains to give that supply.

Mr. MORTEN said they were subjected to an amount of investigation which would ruin any company. It was impossible for any Corporation to carry on a successful business under such conditions.

Mr. ROBB said all he wanted was that Mr. Seabrook or Mr. Arthur Wright should show that the undertaking was being run on sound lines from an engineering and financial point of view. It was a sloppy method to say "because there is a slight surplus in our accounts the price of 0·37d. is a proper price."

Mr. SEABROOK, in reply to Mr. Drucker (who appeared for six firms of electrical contractors in the borough), said it was true the Corporation carried on a wiring installation department and a sales department in competition with contractors who were ratepayers. Seeing that the Corporation possessed the powers, he advised that they should exercise them. It had frequently been the case that such departments had been worked at a loss, but he did not think it could be said that the West Ham Corporation undercut the local contractors. He would be one of the first to stop anything of the kind if there were a loss, as there would be no sense in carrying it on.

The INSPECTOR said he thought it was a fair thing to ask that an account of the trading of the department should be produced. It might be a small matter to the Corporation, but a large matter to certain ratepayers.

Mr. MORTEN having remarked that this department was not concerned in the present application for a loan, and Mr. ROBB having replied that it was concerned in the overdraft of £39,157, Mr. MORTEN and Mr. PATTERSON said they did not admit that there was any overdraft.

Mr. PATTERSON said he would see what could be done by the next morning towards preparing a statement of the trading of the sales department.

On Wednesday Mr. PATTERSON, in reply to Mr. Drucker, said he could not at once give the income of the fittings department with any degree of exactness or state whether the department was working at a profit or a loss. He could not say whether, apart from motors, there was a loss of £296. 17s. 7d. He did not admit that the accounts for the past year showed that to be the case. The accounts showed a net surplus on the hire of motors of £792. 13s. 4d., after deducting depreciation, but not establishment charges. He had not heard that any complaints had reached the committee that the department had sold material at prices lower than those of the manufacturers. There was a system of wiring premises under which the consumer repaid the cost in 10 years. That scheme was worked at a loss, and it had been discontinued. There was now a new scheme of "free" wiring which promised to give favourable results. Under the latter scheme 25 per cent. was paid down by the consumer and the whole cost was spread over two years.

Mr. H. H. HOLMES, manager of the sales department, said the department sometimes got prices from contractors and sometimes the department did the work. The orders were obtained before the quotations were obtained. If a contractor did the work the department made a profit on it. He could not say how many installations had been carried out by or under the department during the last 12 months. In each contract they worked out whether a profit had been made. They always showed a profit after taking the prime cost and a percentage of establishment charges, but there were other expenses, such as proportions of salaries of engineer and accountant, of which he could not give details until the borough treasurer had a statement made out. The department did not cut in at unremunerative prices in order to get jobs. They sold materials at the usual retail prices. He did not know that the prices of cable on a list issued by the department in January, 1908, were prices below those which other contractors could not buy, and at which cable could not be bought retail elsewhere. If that were so, the contractors were bad buyers. The department only bought and sold good cable. They did not work outside the borough. He admitted that they supplied and fixed a dynamo at the private house, outside the borough, of one of the largest consumers in the borough. The Committee had asked that working outside the borough should be stopped, as there seemed to be some doubt as to its legality.

Mr. TROUP, of Troup, Curtis & Co., ratepayers and electrical contractors in the borough, said good British made cable could not be sold at remunerative rates at anything approaching the prices in the Corporation's list. When his firm sent to makers for prices the figures they received were above those in the Corporation's list. No business could be done at those prices except at the ratepayers' expense. The department supplied to him cable alleged to be Siemens, but which turned out not to be Siemens. The department, on being challenged on this point, reduced the price from £1. 17s. 8d. to £1. 14s. 7d. They were in that instance selling German inferior material as good British cable. Nevertheless, the price at which it was supplied was too low.

Mr. PATTERSON, in reply to Mr. Robb, said he did not regard the surplus in the net revenue account for the year ended March last as a net profit, but as a surplus. The Abbey Mills station was abandoned about 1904. A loan of £1,503 was sanctioned in respect of a boundary wall, &c., for that station in 1899, and the money was raised. The work for which the loan was sanctioned was not carried out by the electricity department. The station still belonged to the department, and it received a rent from the department that used it. The money was not replaced until after the last inquiry, because the Council had not decided until then to abandon the scheme. The loan was returned to the Public Works Loan Board He denied that that £1,503 was used to reduce their overdraft or for any other purpose.

Mr. MORTEN said the item due to bankers in the Corporation's accounts did not mean an overdraft.

Mr. ROBB said, if that were correct, the Corporation had filed accounts containing statements which were false in fact.

Mr. MORTEN objected to questions by Mr. Robb as to where the borough treasurer got all the money which was stated to be due to him in the accounts, as that was the main question in an action now pending in the Chancery Division, in which action it was alleged that money had been borrowed *ultra vires*.

Mr. PATTERSON said the electricity undertaking was not assessed for rating as a whole until the current year. Previously the assessment was only £250 for mains. The present assessment was £12,900. At 9s. in the £ they would have to pay £5,625. He denied that the overseers (who were appointed by the Corporation) practically settled the assessment. The reserve fund of £2,017 was about ½ per cent. on the capital expenditure. That was not an adequate provision. If a reserve fund was to be used for the renewal of portions of the undertaking which might be worn out before the termination of the loans, the general basis of a reserve was usually taken as the difference between the sinking fund contributions and the depreciation. He was of opinion that if circumstances permitted it was desirable to write 10 per cent. per annum off motors. If they had written 10 per cent. off motors last year, instead of 6 per cent., it would have made a difference of about £470 or £480 in the surplus. He had been expecting the undertaking to be put into rating ever since he came there four or five years ago. He had called the Assessment committee's attention to it himself on more than one occasion with the knowledge of the other overseers. The assessment of £12,900 was under appeal. Assuming that they had to submit to that assessment, it would have turned the surplus of £3,853 in the last accounts into a deficit of some £2,000.

Mr. MORTEN read the Council's resolution, dated April 30, 1908, to abandon the scheme for boundary wall, &c., at Abbey Mills and return the money, which Mr. Patterson hoped would dispose of Mr. Robb's suggestion that he had attempted to deal with the funds in an irregular manner.

Mr. ROBB, addressing the Inspector on behalf of his clients, the India Rubber Co., said that was a company holding a very responsible position in that district. Their opposition was not actuated by any want of sympathy with the Corporation, but when they found the Corporation had entered into certain contracts at very low rates they thought it their duty to offer advice and criticism. Their engineer, Mr. Stuart Russell, went into the question whether current could be supplied at a price anywhere in the vicinity of 0·37d. with the prospect of the department paying its way. Mr. Russell was equally of opinion that all consumers should be debited with their proportion of capital and running charges. He arrived at the conclusion that a consumer's proportion of the standing charges should be in the same ratio as the ratio of his maximum demand to the maximum demand of the station, provided there was no diversity factor. The load factor of the consumer who got his supply at 0·37d. had not been disclosed. He was told the highest load factor, and that in the most favourable conditions (in collieries) was from 90 to 95 per cent., and, therefore, in assuming 100 per cent. load factor they were giving a margin to the Corporation, and there could be no diversity factor. Mr. Russell and Mr. Patchell had gone into the division of the standing and running charges, and when he called them they would show that there must be a considerable loss on a supply at 0·37d. The actual position of the undertaking had been concealed by a method which was unsound. He attached great importance to the rating question, as it had been shown that there had been neglect of duty. It was unsound finance for the undertaking to benefit at the expense of the general body of ratepayers. In evidence on a London power bill last year Mr. Seabrook had stated that extensions of plant at West Ham could be carried out at a trifle over £3. 7s. 9d. per kilowatt, and that the capital charges on the additional plant would not exceed 10s. per kilowatt per annum, and he seemed to adopt the line that only the cost of the additions should be considered in calculating the capital charges on supplies to additional consumers, and that the expenditure already incurred could be ignored, and yet in a discussion on a Paper at the Institution of Electrical Engineers he said the limit of economy seemed to have been almost reached by the Newcastle Co. with a capital expenditure of £33 per kilowatt.

Mr. MORTEN said Mr. Robb was wide of the mark in assuming that Mr. Seabrook meant new plant would only cost them slightly over £3. 7s. per kilowatt. What he meant was that the capital charges on the amount they would have to spend would be 10s. per kilowatt annually.

Mr. ROBB, continuing, said if one set of consumers paid full capital charges and others did not, it followed that the former were being penalised. Mr. Seabrook had said some portion of the loan for which sanction was now asked was to be applied to the reduction of the overdraft, or revenue balance or whatever it might be called, and as that was the important matter in the action Mr. Morten had referred to, and in

which his clients (the India Rubber Co.) were the relators, it would be improper that any moneys should be granted for that purpose before the trial of the action. It was doubtful whether a Corporation had the right to borrow on revenue account at all. In the accounts were amounts such as £50,000 odd on capital account and £39,000 on revenue account due to the treasurer. Where did the treasurer get the money? It was perfectly obvious that the sinking fund had been tampered with. If Mr. Morten or anyone else would get up and show him that that large amount could have been obtained from any other source than the sinking fund he would apologise at once in sackcloth and ashes. If a Corporation could borrow £40,000 on revenue account without any sanction it stultified the practice of the L.G. Board in authorising loans. One department could only lend to another department under the consent of the L.G. Board. Borrowing on revenue account was a thing unheard of. He took strong exception to the desire of municipal electrical departments to debit everything possible to capital and show a profit at any cost.

Mr. J. S. Huddleston, of Siemens Bros. & Co., said, in reply to Mr. Drucker, the cable produced, and which Mr. Troup had referred to, was not supplied by his company, and it was of inferior quality. He was manager of the cable department at Messrs. Siemens, and was absolutely sure the cable produced was not theirs. The strand was in a different lay and the rubber was of a different quality. He thought the cable produced was made on the Continent. Messrs. Siemens manufactured cable in Germany, but it was not exported to England. There was no possibility of Messrs. Siemens supplying their German made cable from their department over here. Their cable had three layers of rubber, and that produced had only two. It was neither the English nor the German make of Siemens cable.

Mr. Sidney Coxell, clerk to Messrs. Troup, Curtis & Co., said his firm did not write to the various cable makers for prices. They took the prices in the list issued by the Cable Makers' Association, and rang up and ascertained the discounts that would be allowed.

The examination of the witness was not concluded, and the inquiry was adjourned to July 5.

LEGAL INTELLIGENCE.

The King v. Justices of Devonport and others.

On Monday a Divisional Court (the Lord Chief Justice and Justices Jelf and A. T. Lawrence) heard arguments on a rule nisi, obtained by Devonport Tramway Co., prohibiting the Corporation and magistrates of Devonport from proceeding further with certain information and summonses which had been issued and were pending against the company.

Mr. J. A. Simon, K.C., and Mr. Lynden Macassey appeared for the company, and Mr. Danckwerts, K.C., and Mr. Courthorpe Munro for the Corporation.

It appeared that the tramway company were authorised by an act, passed in 1898, to construct tramways in the borough of Devonport, and by an act passed in 1902 the Corporation were authorised to construct other tramways in other parts of the borough. By agreement the Corporation consented to grant, and the company agreed to take, a lease of the Corporation tramways, and that agreement was scheduled to the act of 1902. The agreement provided for a lease, which was made, and under two of the covenants of the lease there were penalties. The company covenanted to provide such a service of tramcars as the Corporation thought reasonable in the public interest, but if the company did not provide such reasonable service a penalty of £2 a day was provided for. Another covenant was that the company should run workmen's cars to the satisfaction of the Corporation, at such hours as the Corporation might require. A penalty was provided. There was also a clause providing that if any differences arose between the Corporation and the company they should be referred to a Board of Trade arbitrator. The Corporation sued the company under the Summary Jurisdiction Act for the recovery of the two penalties referred to, and the company's case was that the penalties were not recoverable under the Summary Jurisdiction Act, but, if recoverable, were recoverable as liquidated damages.

Mr. Danckwerts, in showing cause against the rule, recited the facts, and said that the company gave notice to the Corporation that their financial position was such that they could not any longer run the Corporation tramways, and they purported to send to the Corporation a notice saying that after a certain date they would stop the working. They also sent them the rent for a period ending on the date at which they proposed to stop. The Corporation refused to accept the rent in full, but were willing to accept it on account. The company would not accept that and afterwards stopped running. The penalties incurred by the company for failing to run proper services of ordinary and workmen's cars were, according to the view taken by the Corporation, recoverable summarily. The grounds apparently on which the company got the rule nisi were (1) that these penalties were not recoverable summarily; (2) that under the lease there was an arbitration clause, and that, therefore, the magistrates had no jurisdiction; and (3) that the Corporation had re-entered. He submitted that none of those grounds had any foundation. Counsel said that the first point which arose was that there was a dispute which should have been settled by arbitration or by the Board of Trade. He asked where the difference could be. The company only objected because they had not money enough to carry out their duties and obligations. The notice to provide specified services of cars for workmen, the company had also been unable to comply with through financial disability.

For the Company, Mr. Simon, K.C., said he would address himself to two points—that the Act of Parliament did not justify the proceedings before the magistrates for recovery of penalties under the lease, and secondly that in any case the jurisdiction of the magistrates was ousted. The summons was, in terms, for a failure to comply with the provisions of the clause in the lease, to wit, that the company did not on the 17th of January provide such a service as was reasonably required by the Corporation in the public interest. The notice of January 4 was a requisition for certain services of cars which were set out in details. There was, therefore, abundant material for discussion as to what would amount to a reasonable service, more particularly when they bore in mind that the company had said it was an undertaking which was terribly unprofitable, and that, on the other hand, the Corporation were attempting to bring them to a position in which they would be compelled to sell their rights. He contended that a difference was not avoided merely by issuing summonses before the details of the difference were disclosed.

The Lord Chief Justice asked how the existence of a difference ousted the jurisdiction of the magistrates.

Mr. Simon said, as he understood it, if there were a difference, then the magistrates had no jurisdiction to enforce the penalty until that difference was determined. His clients said their finances debarred them from working the trams, and the Corporation had served them with an elaborate notice. To justify that they could only do so by saying that what they required the company to do was done in the public interest. The company said they could not work. The Corporation said the company must work, and delivered a list of what they wanted the company to do. They could only compel the company to do what was reasonable. On the question of imposing penalties you must have in view what it is they are required to do, and what they have failed to do. That is exactly what the Board of Trade will be asked to settle.

The Lord Chief Justice, in delivering judgment, said the rule applied for raised considerable difficulty. The main contention upon the first point was that the penalties which were sought to be recovered under the sections of the Act, and which were penalties to be recovered under the Summary Jurisdiction Act, were only penalties fixed by agreement, and not by lease. The two penalties in respect of which the summonses were issued were penalties for not complying with a notice of the Corporation. Dealing first with the penalty under sec. 8, his Lordship said that, in his judgment, the words "any penalty under the said agreement might be recovered in manner provided by the Summary Jurisdiction Act" did include the penalty under the lease. It seemed quite impossible to come to the conclusion that it was intended that there should be a summary remedy for penalties under the agreement, and no summary remedies for penalties under the lease. The penalty did not cease to be a penalty under the agreement, because ultimately the relations between the parties were fixed by a lease as distinct under the agreement. He thought, moreover, when they looked at the position of clause 11 that view would certainly strike them, because the summary jurisdiction was already there in one sense in regard to one set of trams. By the Act of 1898, provision had been made, by sec. 63, for running cheap trams, and by the section of the Act to which their attention had been called, there was to be recovery by summary jurisdiction. Upon the first point, therefore, Mr. Simon failed. On the second point he again had had difficulty, but it seemed to him that on the whole it was better for the rule to be discharged. One of his real difficulties arose because there were two sets of summonses. Dealing with the provisions under clause 8, which provided that the company should run such a service as was reasonably required by the Corporation in the public interest, and that any question which might arise as to the service of such cars might be determined on application by the company, or any body or person, to the Board of Trade, his Lordship said Mr. Simon had told them that he was in this difficulty, that the lines were not remunerative, and the receipts were small and the expenses heavy, and the question arose whether it was a reasonable service. Up to the time of the rule being moved there was no suggestion made by the company that there was any question to be determined under the last part of the section. Although some point might arise which would involve the question of what the real position of the company was, and how far the penalties ought to be sought to be enforced on their merits, having regard to the nature of the questions which had arisen, he was unable to say that there had been the existence of any preliminary question which must be determined before the magistrates had any jurisdiction. He therefore came to the conclusion that the rule must be discharged.

Mr. Justice Jelf and Mr. Justice Lawrence agreed, and the rule was accordingly discharged.

Child and Another v. Ward.

On Friday Mr. Justice Swinfen Eady heard this action to restrain Mr. Charles B. Ward from carrying on or being connected with the British School of Telegraphy (at 179, Clapham-road, London, S.W.), or elsewhere in the United Kingdom, and from being otherwise connected, either directly or indirectly as principal or otherwise, with telegraphic training in the United Kingdom for seven years from Sept. 1, 1904. It was stated that defendant originally owned the South London Telegraph and Commercial Training College (Brixton), which he sold to plaintiff (Mr. Child) in 1904. Plaintiff removed to Penywern-road, Earl's Court, renaming it the London Telegraph Training College, and selling it in 1907 to a company formed under that name. Defendant's assignment in 1904 contained a covenant which he was alleged to have broken by becoming the business manager, and assisting in telegraph tuition, at the school in Clapham-road, which belonged to his father and another person.

After hearing evidence Mr. Justice Swinfen Eady granted an injunction, following the language of the covenant, to restrain defendant from being directly or indirectly connected, as principal or otherwise, with

telegraph training at the British School of Telegraphy, 179, Clapham-road, or elsewhere in the United Kingdom, and from opening any other college for the teaching of telegraphy for a period of seven years from Sept. 1, 1904.

Hind v. Child.

At Bromley (Kent) County Court last week plaintiff sought to recover £29. 18s. 3d. under the following circumstances: Defendant sold to plaintiff a house which was stated to be wired for the electric light. Plaintiff took that to mean that the wires and fittings went with the house, and that in purchasing the property he also became the owner of the fittings. It turned out, however, that that was not so, and when the tenant of the house was giving up possession plaintiff was informed that the wiring was on the hire-purchase system from the Bromley Electric Light & Power Co., and before he could lay claim to them he had to pay £29. 18s. 3d., and consequently he claimed that amount. Plaintiff submitted that he considered there was a breach of contract on the part of defendant in not disclosing the fact that the wiring belonged to the company.

Judge EMDEN held there was no breach of contract. He did not suppose defendant knew of the wording of the particulars, which were usually drawn up by the solicitors acting for the property and the auctioneers. The absence of more words in the particulars, which would have shown that the wires belonged to the company, was an unfortunate mistake.

The action was dismissed.

Gould v. Lehwess.

In the Court of Appeal on Saturday, before Lord Justice Fletcher Moulton and Lord Justice Buckley, Mr. Gore-Browne, K.C., moved on behalf of defendant, for a stay of execution, on bringing £1,300 into Court, pending the hearing of an appeal. The case was reported in THE ELECTRICIAN for May 28.

After hearing Mr. Atkin, K.C., for the respondent, Lord Justice BUCKLEY said that the learned judge had granted a stay of execution on certain terms, and the Court would not interfere to alter that decision except upon a very plain case. The application must be refused.

PARLIAMENTARY INTELLIGENCE.

County of Durham Electric Supply Bill.—The Select Committee of the House of Commons on Unopposed Bills on Friday considered this bill, which contained a clause giving the company power to subscribe to the capital of, or to lend money to, undertakings which were prepared to take a supply of current from the company.

Mr. MOON (Speaker's counsel) asked what difference there was in allowing an electric power company such a clause and giving power to a railway company to subscribe towards the erection of factories along its route.

Mr. WEBB (parliamentary agent for the promoters) pointed out that railway companies did erect hotels and run motor services.

Mr. CALDWELL (deputy-chairman of the Committee) said what he feared was that the granting of such powers might result in money being allocated to schemes other than that for which it was subscribed.

Mr. C. MERZ (consulting engineer to the company) said that if they could find some capital it would often make all the difference as to an undertaking being started.

After discussion the Committee rejected the clause, but allowed the bill to proceed with respect to the linking up of the company's generating stations with those of the Newcastle-on-Tyne Electric Supply and the Durham & Cleveland Electric Power Cos.

London County Council (Tramways and Improvements) Bill. The Select Committee of the House of Commons which has been considering this bill for some time on Tuesday dealt with the proposal for the temporary construction, by agreement with the local authority, of a line across Hammersmith Broadway giving access to the White City.

After hearing evidence, the Committee allowed the clause giving the Council power to construct the tramway.

Electric Railway Bills.—The Committee of the House of Commons on Unopposed Bills has passed the preamble of the North-East London Railway Co.'s bill, which extends by one year the period for the construction of the line from the City to Waltham Abbey.

The Committee have also approved the Edgware and Hampstead and the Watford and Edgware Railways Bills, the object of each being to extend the time by two years for the construction of works and the taking of land.

Liverpool Corporation Tramways Bill.—This bill was considered by a Select Committee of the House of Commons on Tuesday and Wednesday. The bill authorises the construction of additional tramways, including an extension to Huyton. The L. & N.W. Railway Co. opposed this extension on the ground of opposition, but after hearing the evidence the Committee found the preamble proved.

The North-East Coast Institution of Engineers and Shipbuilders and the Institution of Engineers and Shipbuilders in Scotland.—A joint summer meeting of these two Institutions will be held at Glasgow on August 4th, 5th and 6th next. Papers will be read and excursions and dinners will also form part of the work.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant master for the science section is required at the Borough of Aston Manor Technical School, who must be qualified to teach electrical engineering (including laboratory instruction), mechanical engineering and mathematics. Commencing salary £150. Applications to the secretary (Mr. H. Norwood), Education Offices, Aston Manor, near Birmingham, by Monday July 5. See also an advertisement.

An instructor in electrical engineering (practical and theoretical) and electric wiring, and an instructor for electricity and magnetism, are wanted at the Borough of Kingston-on-Thames Technical Institute for the winter session, for one evening a week each. Salary 21s. and 15s., respectively per evening of three hours. Applications to Mr. H. T. Roberts by June 26. See also advertisement.

The Governors of the Heriot-Watt College, Edinburgh, invite applications for the position of assistant lecturer in electrical engineering as from Sept. 6 next. Salary £130 per annum. Further information from Prof. Baily at the College. Applications must be lodged by June 21.

A demonstrator and assistant in the laboratory is wanted in the department of electrical engineering of the Glasgow and West of Scotland Technical College. Salary £100 per annum. Applications by June 24 to Prof. Magnus Maclean, from whom further particulars may be obtained.

The Governing Body of the South Western Polytechnic Institute (London) invite applications for the post of head of the mechanical engineering department. Commencing salary £350-£400. Applications to the Secretary by June 22.

Croydon Education committee invite applications for the post of principal of the polytechnics. Salary £300, rising to £350. Forms from the Clerk, Catherine-street, Croydon. Applications by June 26.

An electrical engineer, familiar with the electrical and mechanical design of d.c. motors, is required. See an advertisement.

A working electrician is required, used to motors and water pumps, good estimator, &c. See advertisement.

A science master and principal is wanted for the Loughborough Technical Institute. Particulars from Mr. W. A. Brockington, Leicestershire Education Committee, 33, Bowling Green-street, Leicester. Applications by July 14.

A cable and wire drawing company advertise for representatives in the Midlands, Wales, South and West England.

Mr. C. G. Eley, senior charge engineer, in the 3rd class of Woolwich electricity department has been promoted to the 2nd class at £150 per annum; and Mr. Robert Scrivener, switchboard attendant, has been promoted to 3rd class at £90 per annum.

Mr. A. Howie, deputy electrical engineer at Wolverhampton, has been appointed deputy manager and chief assistant engineer of the Sheffield Corporation electric supply department.

Acton.—The Electricity committee have again considered their relations with the Metropolitan Electric Supply Co., which is supplying electricity in bulk.

Recently it was decided to increase the charge for electric current to private consumers and thereupon the secretary of the company (Mr. E. Cunliffe Owen, C.M.G.) wrote to say that when the company made the revised terms to the Council it had no idea that the selling prices of energy were to be raised. If the effect of the increases was to check consumption, the directors would probably consider themselves free to re-open the matter.

The committee recommend the Council to ask the company to enter into an agreement with them embracing the terms of its letter of Nov. 3 last.

Ashton-under-Lyne.—An unopposed inquiry was held on Friday into the application of the Council for sanction to borrow £2,040 for extensions of cables, &c.

Australasian Cable Service.—Various statements have been published from time to time both in Australia and in this country, concerning an alleged "arrangement" between some of the principal journals in Australia and the Eastern Extension Telegraph Co. These accounts has been described as a "monopoly" (a much abused expression, by the way). The statement was given particular prominence on this side in the "Manchester Guardian" on June 9, and has been answered by a reply from Mr. T. S. Townend, the well-known and respected London manager of the Australian Press

Association, who gives it an emphatic denial, and in doing so has the express permission of the manager of the Eastern Extension Co. in stating that there is not one word of truth in the assertion that any "arrangement" has been made between the Association and the company in this connection other than a business understanding which it is in the power of any person or group of persons to make. At the present time, when any stick is good enough with which to beat the telegraph companies, who operate successfully one of our few British industries, it is well that these indiscriminate statements, sown broadcast as they are, should be definitely disposed of.

Barnstaple.—The Albert Hall is to be wired for the electric light at a cost of £98.

Barton-on-Trent.—Last week the Council decided to apply for sanction for a further loan of £4,000 for extensions of the electricity undertaking.

Bath.—The Council propose to apply for a provisional electric lighting order for the Bath rural district.

The Council also propose to apply to the Board of Trade for an order that the powers of the Somerset & District Electric Power Co. shall cease as to the part of their area of supply within the city of Bath and any extended area in respect of which a provisional order authorising the supply of electricity may be obtained.

The Council have requested the local members of Parliament to use their best endeavours to secure the passing of the Electric Lighting Acts (Amendment) Bill in its original form and to oppose any amendments limiting the powers to be given, also that they support the insertion of a new clause prohibiting unauthorised persons from supplying electricity within authorised areas of supply.

Beckenham.—The Council have applied for sanction to a loan of £398 for the erection of coal bunkers and additions to economiser.

Bexhill.—The increase in salary of the electrical engineer (Mr. W. T. Le Feuvre) from £350 to £425 per annum by three annual increments of £25 each has been approved by the Council.

Brazilian Telegraphs.—In the message presented to the National Congress at Rio de Janeiro, on May 3, Dr. A. A. Moreira Penna, President of the Republic, said :—

The total length of telegraphs at the end of last year was 69,457 km. (about 43,063 miles), or 2,104 km. (1,304 miles), more than at the end of the previous year. Telegraphic communications between Belém and Manaos by the cable of the Amazon Telegraph Co. had continued subject to interruptions. It was proposed to revise the contract of the company in order to provide for the duplication of the cable, whereby the service would be greatly improved. The number of telegrams sent and received on the national lines had increased by 13 per cent. and the number of words by 23 per cent., showing that the reduction in price had had a good effect.

The Message continues :—

In addition to the three telegraphic companies whose cables land on the shores of Brazil, a concession was granted in 1908 to the Felten & Guilleaume A.G., of Cologne, for a cable which is to commence working within 3½ years from the date of the concession. In addition, the department has in view the installation of a radio-telegraphic station of high power on the island of Fernando de Noronha. Here also will be located a small station in communication with Pernambuco. Another wireless station is being erected on Babylonia Hill, Rio de Janeiro.

Brighton.—The electricity supply mains are to be extended to the workhouse in order to give supply for driving the bakery and laundry machinery.

China.—The Siemens-Schuckertwerke (Shanghai) have installed electric lighting plant at Kirin, including two Allen high-speed engines coupled direct to 165 kw. Siemens alternators (generating three-phase current at 5,000 volts with a periodicity of 50), and Borsig-Tegel (Berlin) boilers. The same company have a contract for the equipment of electricity works at Mukden, with a 350 B.H.P. Belliss engine, and a 250 kw. Siemens dynamo.

The Soochow electricity works, also equipped by the Siemens-Schuckertwerke, were recently opened. This installation includes three Krupp boilers, and two open type Schickau engines coupled direct to 175 kw. Siemens alternators generating three-phase current at 2,200 volts.

Mr. Consul Pitzipios' report states that the British Concession at Chinkiang was provided with electric light last summer by the Chinkiang Electric Light Co., a Chinese undertaking.

Cleckheaton.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £2,681 for extensions of the electricity supply mains, &c.

Cullompton.—Application has been made by a company to Devon County Council for consent to a provisional order for this district.

Ealing.—For outside arc lamps the charge for electric current has been reduced to 3½d. per unit.

Electricity in Horticulture.—It is announced that the German Emperor has adopted an electrical system for stimulating the growth of plants in the gardens on his estate at Dahlen, a few miles out of Berlin. Experiments have been carried out under the supervision of Dr. Hochstermann, to the satisfaction of the Kaiser's advisers, and "systematic experiments are now being made in order to find a cheap and simple method of charging the atmosphere."

Exhibition.—It was decided at a Congress of the South African National Union, on May 11, that "should a Union of the South African Colonies be accomplished, an international industrial exhibition should be held at Cape Town at the time of the opening of the South African Parliament."

Fife Tramways.—Kirkcaldy and Dysart Councils have approved the scheme for the extension of the Kircaldy tramway system to Dysart.

German East Africa.—A report of Mr. D. Young, British vice-consul, states that electric light is supplied in the capital (Dar-es-Salaam) by the Deutsche Ost-Afrikanische Eisenbahngesellschaft, at about 10d. per unit. Mains for street lighting (underground in the European and overhead in the native quarter) are being laid, the total capital cost of the public lighting being estimated at £6,000. The town of Tanga, however, is lighted by "spirit lamps." Dar-es-Salaam, Tanga, Bagamoyo and Pengani have local telephone systems.

Golborne.—The question of revoking the Council's electric lighting order has been deferred for a year.

Grays Thurrock.—On the recommendation of the Lighting committee it has been decided that the electrical engineer (Mr. E. D. Long) is not to undertake wiring work himself unless it should be found that the quality of the work done or of the prices charged by private contractors, militates against the interests of the electricity undertaking.

The salary of Mr. Long has been increased to £250 per annum.

Greece.—The report of Mr. Consul E. MacDonell states that the electrification of the tramways at Piræus has been pushed forward. 26 miles being in use, and 12½ miles projected. 120 cars (of Belgian make) are running and another 40 are to be added. The undertaking employs 750 persons.

Harrogate.—The Electric Light committee are preparing a scheme for extending and improving the street electric lighting arrangements.

Hemel Hempstead.—The application of the Chesham Electric Light & Power Co. for a provisional order will be supported by the Council.

Hindley.—The question of revoking the Council's electric lighting order has been deferred for 12 months.

Horse Show Illumination.—One of the features of the successful Horse Show at Olympia (London) last week was the brilliant manner in which the arena was illuminated. There were no less than 102 "Excello" arc lamps in use, and the effect, as may be conceived, was striking to a degree.

Ilford.—The charge for electric current to be supplied to the tramways department has been fixed at 1⅛d. per unit.

India.—The "Indian and Eastern Engineer" states that the Madras Port Trust Board have decided to enter into an agreement to take a supply of electrical energy from the Madras Electric Supply Corpn.

The hydro-electric power undertaking in the Native State of Patiala is expected to be in operation by the end of 1909. Capital expenditure is estimated at 10½ lakhs.

A scheme for the adoption of electric pumping at Bangalore City Water Works is under consideration.

Inquests.—On Friday an adjourned inquest was held at Birmingham into the death of Benjamin Cole, a blast furnaceman, of Sedgley, who died on a tramcar (which plied between Millfields and Sedgley) on May 21.

Deceased was stated to have boarded the car at 10:30 p.m. at Millfields. During the journey he was riding on the top of the car and became unconscious, and when the tramcar arrived at Sedgley a doctor pronounced life extinct. The inquiry had been adjourned to enable the Coroner (Mr. T. A. Stokes) to communicate with the Board of Trade, as it had been suggested that the man's death was due to electric shock. The Coroner also directed that the car on which Cole was found dead should remain at the depot at Sedgley till after its inspection by the Board of Trade representative.

The CORONER read a report he had received from Mr. A. P. Trotter, electrical adviser to the Board of Trade, who stated that a defect in an electrical conductor was found, causing the charging of the standard, but, in addition, a defect was found in the circuit of the warning red lamps. Mr. Trotter referred to the word "electrocuted" employed in the Coroner's letter, pointing out that electrocution was a name which had been given to a revolting form of capital punishment for condemned criminals in America, and had been adopted by sensational journals in this country as meaning death by electric shock.

The Coroner read regulation No. 11 of the Board of Trade model form of regulations for tramways, which Mr. Trotter had referred to, as follows: "The trolley standard of every double-decked carriage shall be electrically connected to the wheels of the carriage in such manner as either to prevent the possibility of the standard becoming electrically charged from any defect in the conductors contained within it, or, in the event of the standard becoming electrically charged, to give a distinctive and continuous warning signal to the driver or conductor. A signal may be a red lamp, or preferably an audible signal." The Coroner added that in this case the warning red lamps did not act.

ALFRED JOHNSON, conductor of the car, said his attention was called to the condition of the man, who was then in a state of collapse. He had one foot on the standard, and his back against a side rail. A passenger named Norton, who was also riding on the top of the car, told witness he had just had a shock, and, pointing to deceased, said: "It's electricity that is in this man." Directly afterwards witness tried the standard, but did not experience a shock.

Mr. W. A. FOSTER (for the Wolverhampton & District Tramways Co.) said Mr. Trotter made an inspection of the electrical equipment of the car on May 27, and it was then perfectly clear that there was a defect in an electrical conductor, to which fact the unfortunate man's death was no doubt due. The extraordinary position occupied by the man in having one foot on the standard and his back or head against the iron rail made the circuit complete. The voltage of the electric current was about 500, which in the ordinary way would not impart a shock sufficient to kill anybody. The car had been thoroughly overhauled at the company's works, and was started running again on 4th inst. He submitted that the accident was one which no ordinary human foresight could have prevented. It was the first fatality of the kind in the experience of the company, who did not deny liability.

The CORONER considered the warning red lamps should be frequently examined.

Mr. RICHARD W. CRAMP, general manager of the company, said the cable connected with the warning red lamps was concealed in the woodwork and insulated, and if, as in that case, the cable parted, the lamps could not act. It was impossible to say what caused the defect in the cable, but the mishap was one which no human foresight could prevent. It was the position of the man at the time of the leakage of electricity that brought about his death.

Dr. BALLENDEN, who had made a post-mortem examination, said there was no external burning, but the skin was covered with blisters from decomposition, which was very rapid. There was nothing in the condition of any of the organs to account for death.

A verdict that death was due to electric shock was returned.

On Tuesday an inquest was held on the death of John R. Pridden, an electrician, who was killed at the Imperial International Exhibition, Shepherd's Bush.

ARTHUR POWELL, electrician employed by the Witching Waves (Ltd.), one of the amusements at the exhibition, said that the waves were worked by 160 arms and cranks from a machine which was below the ground and was driven by electric power. On Saturday morning deceased was engaged in fixing and wiring the motors in an underground chamber. He had connected one motor, and was engaged on another. He was holding a wire above his head and with the other hand was using pliers, when his right foot, which was resting on a bank of clay, slipped. Deceased groaned, his head fell forward, and he died shortly afterwards. Deceased received a shock from a live terminal, with which he came in contact when he slipped. There were covers for the terminals, but they were not on at the time, and witness could not say who removed them.

Mr. L. FREEMAN, electrical contractor, who employed deceased, said that Pridden removed the covers of the terminals, which had to be taken off while he was doing the work, but which he ought to have replaced after the fuses had been extracted. Had he done that there would have been no accident.

The jury returned a verdict of "Accidental Death," and expressed the opinion that it was negligent on the part of Mr. Freeman not to see that deceased was quite safe before he commenced his work.

Leeds-Bradford Tramway Service.—The through tramway service between Leeds and Bradford is being well patronised. As stated in our last issue, the service was inaugurated on the 8th inst., and over 6,500 through passengers were carried in the first week.

Little Hulton (Lancs.)—The Board of Trade have sanctioned the transfer of the Council's electric lighting order to the Lancashire Electric Power Co.

London County Council.—On Tuesday a loan of £7,100 was granted to Stepney Council for electric lighting.

Anchoring of Track Rails.—It was agreed to expend £7,000 in respect of the anchoring of track rails on the Council's tramways during 1909-10

Maghera.—At a recent public meeting of ratepayers it was decided to enter into an agreement with Mr. Millar, of Maghera, for the public lighting of the district.

Manchester.—At the meeting of the Electricity committee on Wednesday the matter of the recent explosion at the Victoria-buildings was under consideration. After discussion it was agreed that the work of doing away with the old form of jointing should be pushed forward with all possible speed, so that by the end of the year the most modern methods of jointing will have been adopted throughout the city.

SPECIAL NOTICE.

NOW READY.——Vol. LXII. of "THE ELECTRICIAN" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

Metropolitan Association of Electric Tramways Managers.—A meeting of the members of this Association was held on the 11th inst., at the Metropolitan Electric Tramways Offices (Manor House, Finsbury Park, N.). There were present:

Mr. Blain (West Ham), chairman; Mr. Schofield (Leyton), Mr. Howard (Barking), Mr. Ullman (East Ham), Mr. Mittelhausen (Bexley Heath), Mr. Hammond (Metropolitan Electric), Mr. Mason (South Metropolitan) and Mr. Goodyer (Croydon), hon. secretary. Sir Clifton Robinson (London United) and Messrs. Bruce (L.C.C.), Balfour (Dartford), Coveney (Erith), Murray and Spurr (Walthamstow) were unable to be present.

The hon. secretary reported he had received various communications relating to metropolitan tramway matters since the last meeting, and it was decided that several of these should be followed up.

The visitors then inspected the company's offices, and a special car having been placed at their disposal they were conveyed to the Wood Green and Finchley depots, accompanied by Mr. A. H. Pott (the company's chief engineer) and Mr. A. L. Barber (secretary). At both depots Mr. Pott explained many matters of interest in connection with the working of the system. 25 new bogie cars (Brush bodies, Mountain & Gibson bogie trucks, and G.E. 67 equipment) were in course of erection at Finchley depot, and Mr. Pott pointed out several new features in connection with these. The party subsequently returned to Finsbury Park, where they were hospitably entertained on behalf of Mr. J. Devonshire, managing director of the company, who was unavoidably prevented from being present.

Mr. BLAIN, in moving a vote of thanks to Mr. Devonshire, took the opportunity of thanking Mr. Pott, Mr. Hammond and Mr. Barber for the arrangements made to enable the members to visit the company's extensive system, and stated that the members would look forward to having the opportunity later on of inspecting the company's repairing works now in course of erection at Hendon.

Mexico.—The contract authorising the Mexican Tramway Co. to carry out extensions and modifications of tramways in the City of Mexico appears in the "Diario Oficial," for May 15, which can be seen at 73, Basinghall-street, London, E.C.

North Eastern Railway.—The consulting electrical engineers (Messrs. Merz & McLellan) have presented a report to the directors of this company on the proposal to convert further portions of this railway to electric traction, including the Newcastle to South Shields, South Shields to Sunderland, and Sunderland to Newcastle sections. It is stated that the company will continue to employ the continuous current system.

Overhead Transmission Lines.—The Board of Trade have granted permission to the Fife Electric Power Co. to erect overhead cable from their works at Townhill, Dunfermline, to Beath Bleachfield. This cable is for supplying current to the tramways, and it will probably be extended into Cowdenbeath, for power and lighting, and ultimately to Lochgelly. Where the cable crosses a thoroughfare it will be placed under ground.

Penrith.—The official inauguration of the electricity works took place on the 4th inst. The generating plant comprises two 65 H.P. Crossley gas engines (driven by producer gas) coupled to two direct-current generators. There is also a storage battery of 120 cells of a capacity of 200 ampere-hours. There are already over 40 consumers. The works have been erected to the plans of Mr. J. W. Speight and the contractors for the equipment of the generating station were Messrs. W. P. Theerman & Co., while Messrs. W. T. Henley's Telegraph Works Co. supplied and laid the cables.

Plymouth.—At their meeting next month the Museum and Art Gallery committee will consider the system of electric lighting to be adopted at the new Museum and Art Gallery.

Presentations.—The staff of Messrs. Willans & Robinson have presented a fumed oak combination desk and bookcase to Mr. Frank Ridgers, who is leaving.

Kettering electricity staff have presented a Gladstone bag to Mr. B. S. Short, who is leaving for St. Albans.

Provisional Order Transfer.—Barton-upon-Irwell Rural Council give notice of intention to transfer their powers, liabilities, &c., under their 1906 electric lighting order to the Lancashire Electric Power Co., the pecuniary consideration being £432. 18s. The Council are to have the right to re-purchase the undertaking at the expiration of seven years from the date of the transfer, or any subsequent seven years.

Railway Combinations.—The Board of Trade have appointed a Departmental Committee to consider and report what changes, if any, are expedient in the law relating to agreements among railway companies, and what, if any, general provisions ought to be embodied for the purpose of safeguarding the various interests affected in future Acts of Parliament authorising railway amalgamations or working unions. Mr. Russell Rea, M.P., is chairman of the committee, the other members being Lord Robert Cecil, M.P., Sir Maurice Levy, M.P., Mr. G. H. Roberts, M.P., Lord Hamilton of Dalzell, Lord Newton, Mr. J. S. Beale, Mr. Alex. Siemens, Mr. Ernest Moon, and Mr. W. Temple Franks.

St. Pancras (London).—The Electricity committee has been considering the question of obtaining motors for lending to prospective consumers, and Messrs. Bruce Peebles & Co. and Cutting Bros. have agreed to lend motors to the electricity department for hiring purposes.

Salford.—An unopposed inquiry was held on Tuesday into the Council's application for sanction to borrow £2,200 for the electricity undertaking.

Smoke Prevention.—A new smoke preventer is about to be placed on the market by the Furnace Appliances Co., 9, Bedford-row, W.C., who state that very complete trials have been carried out during the past 12 months, which have shown that any class of fuel may be smokelessly and economically consumed with their apparatus. The company have also acquired the business of the British Fuel Economiser and Smoke Preventer, together with works, offices, &c., and will commence operations on July 1.

South Crosland (Yorks.)—The Council have asked Huddersfield Corporation to extend the electric supply mains to this district.

South Lancashire Tramways.—On Monday the South Lancashire Tramway Co. inaugurated a through service of tramways between Atherton, Tyldesley, Mosley Common, Worsley, Swinton, Walkden, and Farnworth. Through services were also established between Lowton and Bolton and between Clifton and Bolton.

Stretford.—A sub-committee of the Electricity committee is considering the question of the provision of a coal conveyor for the generating station. Tenders are to be invited for a motor tower waggon.

Telephony over Long Distances.—Several references have been made to a new telephone receiver and transmitter, the invention of two Swedish engineers, and it is now stated that the instrument has given satisfactory results in a trial between Paris and Stockholm, about 1,100 miles distance. The conversation was conducted via Berlin, the success of the experiment being, it is stated, in greatly improved conversation.

Turkey.—The report of Major C. H. M. Doughty-Wylie, Acting British Vice-Consul for the Province of Adana, states that a water power electricity supply undertaking has been inaugurated at Tarsus, and a scheme for supplying electricity in the towns of Adana, Tarsus and Mersina is under consideration. A mill at Adana, with 10,000 spindles and 180 looms, and employing between 800 and 900 hands, is lighted electrically. At Tarsus the proprietor of a mill with 22,000 spindles and 400 looms is asking for a concession to enable him to adopt driving by electricity (generated by water turbine driven generators), and also supply current for lighting the cities of Adana and Mersina.

Watford.—The Council have received sanction to a loan of £4,952 for extensions of the electricity works.

Whitwood (Lancs.)—The Council's electric lighting order has been extended for a year.

Wireless Telephone Notes.—It is gratifying to learn that promotion has promptly followed the excellent results which have attended the use of the improvements in wireless telephone apparatus invented by Lieuts. Colin and Jeance of the French Navy. Lieut. Colin has been promoted to the rank of Captain and Lieut. Jeance has been made an officer of the Legion of Honour. Reference was made in our last issue (p. 359) to the successful experiments which had been conducted between Toulon and the cruiser "Condé" over a distance of about 100 miles.

Wolverhampton.—The borough electrical engineer (Mr. C. E. C. Shawfield) recently prepared a report recommending the purchase of coal conveying plant, and mechanical stokers. The electricity committee approved the report and recommended the Council to carry out the work at an estimated cost of £870.

The recommendation was adopted by the Council on Monday.

Wood Green.—The Council have resolved not to erect electricity works, but negotiations are proceeding with the North Metropolitan Electric Power Supply Co. for a supply of electricity in bulk. Messrs. May & Hawes are acting as consulting engineers to the Council.

Woolwich.—The Council have conditionally consented to an extension on the overhead system of the tramway from Beresford-square to Nile-street.

Yardley.—On Wednesday the Tramways & Electric Lighting committee recommended—

That in view of the serious objections to the terms of the agreement with the City of Birmingham Tramways Co. raised by the reports of the consulting electrical engineer (Mr. C. H. Gadsby) and the consequent impossibility of framing a scheme for putting into operation the Council's electric lighting order based on such agreement which would be at all likely to meet with the approval of the Board of Trade and L.G. Board notice be given to the company terminating the agreement.

Cricket.—On Saturday, June 12, the annual cricket match between the "Robertson" and "Osram" and the General Electric Co. (Witton) clubs, took place on the grounds of the former at Mill Hill Park, and ended in a draw.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Batley.—The income of the electricity supply department for the year ended March 31, was £5,856. 3s. 3½d., including £2,363. 12s. 3½d. from the sale of current by meter, £2,887. 13s. 9d. from current sold by contract, and £400 for public lighting.

The expenses were £3,540. 17s. 10d., including £2,454. 11s. 5d. cost of generation; and the gross profit was £2,315. 5s. 5½d. After paying interest and sinking fund there was a deficit of £307. 18s. 8½d. 890,914 units were generated, against 936,578 in 1908; 462,030 units were sold by contract against 499,243; 230,866 to private consumers against 236,239. There are 25 arcs and 50 incandescents for street lighting. The total maximum supply demanded was 350 kw. for traction and 22,948 8 c.p. lamps for lighting and power.

Canterbury.—In moving the adoption of the accounts of the Electricity department for the past year, the chairman of the Electricity committee (Ald. Mason), stated at the Council meeting last week that the year's working had been most satisfactory.

The capital expended was £1,378, making the total £66,379, but they had repaid £17,415. The reserve fund was £3,037. The past year's revenue was £8,766, against £8,669, and the units sold showed an increase of 2 per cent. The expenses showed an increase of £68, and after provision for interest, income tax and repayment, the profit was £93, which, with £500 brought forward, had been carried forward. The profit was not large, but they had reduced the price of current to 4½d., and the introduction of metal filament lamps had affected the revenue.

The total income was £8,766. 0s. 11d., including £8,355. 16s. 6d. net from the sale of current for public and private lighting and power. The cost of generation was £2,616. 19s., distribution £402. 15s. 5d., management expenses £792. 9s. 3d., and with rents, rates and taxes, &c., the total working expenses were £4,689, 16s. 8d., leaving a gross profit of £4,076. 4s. 3d. After paying interest on loans, sinking funds, &c., there was a net profit of £93. 10s. 7d. 764,327 units were generated, and 291,761 units were supplied to private consumers for lighting, 159,083 for power and 213,407 for public lighting. There are 12 arc and 634 incandescent posts for public lighting, and the maximum supply demanded was 447 kw.

Hoylake.—The net profit on the past year's working of the electricity supply undertaking was £567.

Manchester.—On Wednesday the Electricity committee considered the annual report of the secretary (Mr. F. E. Hughes) and the abstract of the accounts for the year ended March 31.

The receipts from the sale of current amounted to £361,116, and with miscellaneous receipts the total was £367,240, against £384,602 for the preceding year. The working expenditure (including provision in 1908 of £40,000, and in 1909 of £21,495 for future renewals) was £205,534, compared with £219,358, leaving a gross profit of £161,706, against £165,244. After paying interest, sinking fund, &c. (£149,706) the net surplus is £12,000 (against £19,543), which has been handed over to the city fund in aid of the rates. The renewals suspense account amounted to £130,567 at the beginning of the year, and has since been increased by bank interest (£2,038) and a further contribution of £21,495 from revenue account, but certain abnormal expenditure, totalling, £18,848 chiefly for discarded plant, having been debited during the year, the account only shows a net increase of £4,685, leaving £135,252. The reserve fund at the beginning of the year stood at £13,854. During the year there has been charged to this fund £5,541 for land adjoining Stuart-street station, £1,651 for wages of permanent employés engaged on capital account and £707 being balance of legal charges incidental to the acquisition of warehouse property in Dickinson-street. After crediting £403 for interest, the balance is £6,358. During the year the L.G. Board granted additional borrowing powers to the extent of £81,244, making the total amount sanctioned £2,724,754. The capital outlay is £2,521,871. The reductions made in the prices of current for lighting at December, 1907, affected the income for the whole year, and represented a concession to lighting consumers of £16,341. Messrs. Siemens Bros. Dynamo Works have replaced the 750 kw. generators on the two Parsons tur-

bines, with satisfactory results, at Dickinson-street station. Owing to a strike Messrs. Richardsons, Westgarth & Co. were unable to complete their contract for the installation of two "contraflo" surface condensing plants in connection with the Musgrave engines by the autumn of last year; but the work is actively progressing, and will be completed this summer. A contract has been placed with the Tudor Accumulator Co. for the installation of a large storage battery, boosters, &c., as a result of which substantial economies in the coal bill are anticipated. As to the Stuart-street station, an order had been placed with the British Westinghouse Co. for two high-tension switchboards. A storage battery has been installed by the Tudor Accumulator Co. for auxiliary and excitation purposes, and the contract with the Blasberg Engineering Co. for the installation of two cooling towers has been completed. The works in connection with the contract for a second 6,000 kw. turbo-alternator, high-tension switchgear and four water-tube boilers, &c., will be completed this summer. A contract has been made with Mr. John Thom for sinking a bore-hole in Clayton Vale to obtain water for condensing and boiler feed purposes. Small extensions at certain of the existing Corporation distributing stations have been made during the year. Owing to depression in trade the number of distributing stations put down on consumers' premises for power supplies fell considerably below the number in the preceding year. The high-tension and distributing mains have been extended into Audenshaw and Droylsden, and a similar extension into Failsworth will be made this summer. When this latter work is completed, the whole of the districts whose provisional orders have been taken over by the Corporation will be receiving a supply of electricity. Over 14 miles of new mains were laid during the year. The total output from the three generating stations during the past year amounted to 88,766,232 units, compared with 82,752,989 units of the previous year, an increase of 7·27 per cent. The quantity accounted for was 73,715,884 units. The total mileage of main conductors laid equals 352 miles 256 yds., an increase of 13 miles 932 yds.

Norwich. The accounts of the electricity supply department were approved by the Council on Tuesday.

The Electricity committee's report stated that the increase in the number of units sold was only 11 per cent. compared with 29 per cent. for 1907 and 26 per cent. for 1906. For private lighting 1,853,908 units were sold (against 1,694,223 in 1907), public lighting 41,867 (against 41,867), and power 2,171,094 (against 1,925,432), a total of 4,066,869 (against 3,661,522). The total income shows an increase of £1,576. 4s., or 4½ per cent., while expenditure increased by £177. 5s. 10d. The balance was £1,398. 18s. 2d. in excess of last year, or £18,143. 0s. 10d. to carry to net revenue. There was an increase of £803. 2s. 11d. in the charges for interest and sinking fund, so that the net profit is £3,700.5s.10d £2,450 has been placed to depreciation fund; which, after allowing £500. 7s. 2d. for special expenditure in renewal of mains, and £350 as a further contribution in respect of wiring outlay carried out prior to 1902, now stands at £17,504. 15s. 9d. The total income was £37,189 (against £35,613); expenditure £19,046 (against £18,868). There are 4,425 consumers, representing the equivalent of 136,729 8 c.p. lamps connected, including 485 motors of 2,662 H.P. Further capital expenditure will be incurred in order to keep pace with the increasing demand for electrical energy.

Warrington.—For the year ended March 31 the gross profit on the tramways was £8,124. 8s. 11d., against £8,346. 0s. 4d. for the preceding year.

After paying sinking fund and interest charges the net profit was £2,370. 6s. 8d., against £2,579. 11s. 1d. The profit has been carried to reserve, which now amounts to £6,480. 3s. 10d. Passenger receipts were £19,320. 1s. 6d., compared with £19,782. 9s. 7d.

The gross profit on the electricity undertaking was £6,739. 10s. 1d., against £7,533. 9s. 5d., and after paying interest and loan charges (£5,796. 17s. 5d.) the profit was £942. 12s. 6d., against £2,213. 10s. 6d. The income from sale of current decreased by £1,153, and meter rentals by £140 owing to abolition of rents, but the work done for customers had realised £571, an increase of £219. Working expenses decreased by £382, but loan charges increased by £477. The reserve fund now amounts to £8,108. 9s. 1d.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited for supply of 18 transformers to the MELBOURNE (Australia) Municipal Council. Tender forms, conditions, &c., may be obtained from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co., Proprietory. (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by Wednesday, July 7. See also an advertisement.

BELFAST Tramways and Electricity committee invite tenders for supply, delivery and erection of feeder panels for lighting switchboard. Specification and forms of tender, &c., from the city electrical engineer, Mr. Thos. W. Bloxam, Corporation Electricity Works, East Bridge-street, Belfast. Tenders with the Town Clerk, City Hall, Belfast, by noon June 26.

BEDFORD Corporation invite tenders from boilermakers for the supply and erection of one 30 ft. by 8 ft. Lancashire boiler, with steam pipe work and superheater. Specification and form of tender from the borough electrical engineer, Mr. R. W. L. Phillips, A.M.I.E.E., Electricity Works, Cauldwell-rd., Bedford. Tenders by noon June 25.

Tenders are invited for the supply of a 15 ton overhead travelling hand crane to the city of MELBOURNE, Victoria. Tender forms, conditions, &c., from the agents of the City Council, Messrs. McIlwraith, McEacharn & Co., Proprietary (Ltd.), Billiter-square Buildings, London, E.C. Tenders to the Chairman of the Electrical Supply committee, Town Hall, Melbourne, by 2 p.m. of August 4.

DEVONPORT Corporation Electricity committee invite tenders for the supply of stores for the 12 months ending June 30, 1910, including d.c. meters, paper-insulated cables, rubber-covered wires, flexibles, cutouts and lubricating oils. Particulars and forms of tender from the borough electrical engineer (Mr. J. W. Spark), Newport-street, East Stonehouse, Devon.

LONDON County Council want tenders by 11 a.m. June 22 for the roadwork and platelaying of the authorised tramways in Southwark-street and Blackfriars-road and on the Victoria-embankment east of John Carpenter-street. Specification, &c., from the Chief Engineer, County Hall, Spring-gardens, S.W.

LONDON County Council require tenders by 11 a.m. June 22 for the supply and fixing at Greenwich generating station of steam, exhaust, feed and drain piping, valves, &c., and cast-iron condenser water piping, valves, &c. Forms from the offices, Spring-gardens, London, S.W.

BURSLEM Corporation require tenders by noon June 29 for a 600 kw. steam generator, or (alternatively) a 600 kw. turbo-generator (450 volts), condensing plant, water tube boiler and switchgear. Specifications from the Electrical Engineer.

BIRMINGHAM Corporation want tenders by June 30 for 12 months' supply of stores to the electric supply department, including electrical accessories, ironmongery, drysaltery, &c. Particulars from the City Electrical Engineer.

BRISTOL Docks committee want tenders for the supply and erection of cables, fittings, &c., in connection with electric lighting at Portishead Dock. Specification, &c., from the engineer (Mr. W. W. Squire), Cumberland-road, Bristol.

ACTON Council want tenders by 3 p.m. July 12 for 12 months' supply of lead-covered paper-insulated cables. Form of tender, &c., from Mr. M. J. Martin Blair, 130 Churchfield-road, Acton, W.

GILLINGHAM (Kent) Council require tenders by noon June 28 for coal for the electricity department. Specifications, &c., from the Borough Electrical Engineer.

WHITEHAVEN Harbour Commissioners require tenders by 10 a.m., July 20, for lighting the harbour, quays, &c., electrically or otherwise. Particulars from the Harbour Master.

CLACTON Council want tenders by noon June 30 for one year's supply of electricity meters, service and distributor cable and

troughing. Specification, &c., from Mr. H. W. Everitt, electricity works, Clacton.

Ipswich Corporation want tenders by June 23 for one year's supply of rubber insulated wires, and paper insulated lead sheathed cables. Specifications from the Chief Engineer.

Speed Indicators.—The Council of the Tramways and Light Railways Association have made arrangements, with the co-operation of some of their members who are owners of tramway undertakings, to make a series of trials of any speed indicators of merit that may be brought to their notice, as a useful addition to the ordinary equipment of a tramway car. The Council invite information from owners, inventors or manufacturers who may desire to take advantage of the opportunity. Communications to the Secretary, 35, Parliament-street, London, S.W. See also an advertisement.

Chinese Contracts.—In our Contracts Open pages there will be found an invitation from the Chinese Government, through its representatives, for sealed proposals for the erection and completion of a group of buildings to be used as a Bureau of Engraving and Printing in Peking, China. It will be noted that the plans and specifications are on file at, amongst other places, the Chinese Consulate-General, 88, Fenchurch-street, London, E.C. Tenders from European contractors must be filed with the Chinese Legation at Washington, D.C., not later than July 15th next. The conditions of the contract are instructive.

TENDERS RECEIVED AND ACCEPTED.

Stepney (London) Council have accepted the following tenders:—J. Every, eight feeder boxes, £89. 10s.; W. Cottis & Sons, 11 distributing boxes, £125. 10s.; and W. Lucy & Co., six disconnecting boxes, £26. 11s. The following firms also tendered: Universal Electrical Mfg. Co. (*a*) feeder boxes £107, (*b*) distributing boxes £151. 5s., and (*c*) disconnecting boxes £33; British Insulated and Helsby Cables, (*a*) £115, (*b*) £154, (*c*) £39; alternative (*a*) £98, (*b*) 148. 10s., (*c*) £30; W. T. Henley's Telegraph Works Co., (*a*) £138, (*b*) £236, (*c*) £39; T. Richmond (*a*) £144, (*b*) £247. 10s., (*c*) £42.

Glasgow Electricity committee have recommended the acceptance of the following tenders:—

Bruce Peebles & Co., for 1,000 kw. motor generator, £2,280; British Westinghouse Co., 500 kw. 500 volt rotary converter; British Thomson-Houston Co., 250 kw. 500 volt rotary converter, £1,568; and 250 k.w. 210 volt rotary converter £1,632; and Matthew & Yates, fans for cooling towers at St. Andrew's Cross station, £1,049.

Lowestoft Council have accepted the following tenders:—

T. H. Yelf, 300 meter battens at 1s. each; Crompton & Co., capstan and 5 H.P. electric motor, £105; Herbert Morris & Bastert, lifting gear, £39. 17s.

Worksop Council have accepted the tender of W. Lucy & Co. for 50 house service cut-outs, that of the Electric & Ordnance Accessories Co. for arc lamp globes, resistances, &c., and that of the British Insulated & Helsby Cables for disconnecting joint boxes.

Plymouth Council have accepted the tender of Watlington & Co. for copper wire for the tramways, bracket fittings, line hangers, section insulators, bronze, galvanised insulated bolts, &c., and that of R. W. Blackwell & Co. for trolley ears and frogs.

Siemens Bros. Dynamo Works have secured the contract for supply of generating plant, switchboard, wiring, fans, motors and about 1,500 Tantalum lamps for Messrs. Whiteaway & Laidlaws' new building in Calcutta.

Woolwich (London) Council have accepted the tender of W. T. Henley's Telegraph Works Co. for supply of 2,100 yds. three-core 0·025 c.h.t. cable at £384. 10s. There were six tenders, varying in amount from £383 to £396. 10s.

The L.C.C. Education committee received 16 tenders for an electric lighting and bell installation at the Putney secondary school, varying in amount from £655 to £876. 14s. 9d., and that of Pinching & Walton at £665. 3s. was accepted.

For the electric lighting of the extension to the Oliver Goldsmith School (Peckham) 14 tenders, varying from £135. 8s. to £277. 5s. 3d., were received, and that of Grant & Blake at £142 was accepted.

Barrow-in-Furness Corporation have accepted the tender of the Tudor Accumulator Co. for the maintenance of the storage battery at the electricity works for 10 years at £138. 12s.

Wandsworth (London) Council received seven tenders, ranging from £85 to £180, for wiring the Putney library, and have accepted the lowest, that of H. J. Whitehead.

Poplar (London) Guardians have received 34 tenders for the supply of two electric fans for the workhouse laundry, and that of Cooper, Penn & Thorp has been accepted.

Stoke-on-Trent Guardians have accepted the tender of the Wolverhampton District Electric Co. for wiring, &c., at the cottage houses at £334.

Stoke Newington (London) Council has accepted the tender of the British Thomson-Houston Co., of Rugby, for supply of mercury meters for two years.

Whitehaven Council have accepted the tender of the Phoenix Dynamo Mfg. Co. for a balancer.

Stretford Council have accepted the tender of the British Insulated & Helsby Cables for cables.

Bedford Education committee have accepted the tender of W. Appleby for electricians' work at the schools for six months.

Plymouth Council have accepted the tender of W. G. Heath & Co. for the wiring of the new Free Library, Museum and Art Galleries.

Ilford Council have accepted the tender of the Brush Co. for top covered double-deck tramcars, at £561 each.

Devonport Education committee have accepted the tender of W. J. Corse & Co. for wiring the Higher Elementary Schools at £238.

Gillingham Council have accepted the tender of the Electric Construction Co. for a 135–140 kw. Mirrlees-Diesel-E.C.C. set at £2,420.

Prahran and Malvern (Victoria) Tramways Trust have placed the following contracts:—

Noyes Bros. (Melbourne), 990 tons steel rails at £6. 18s. 6d. per ton, fastenings, and bonding materials (fish-bolts, dog-spikes and tie-bars, of Victorian manufacture), total £7,786, and Mannesman steel poles, £912. 10s.; Edgar Allen & Co., for special work, points and crossings (solid manganese steel castings), £1,010.

A report, prepared by the Mayor of Malvern, states that these tenders are 20 and 25 per cent. under estimated cost, representing a saving of over £2,000.

The Postmaster-General's Department, Melbourne, Victoria, have placed orders with the Eastern Extension Telegraph Co. for two bell buoys (£200); the Western Electric Co. for telegraph instruments (£153), and Zwicker, Todd & Co. for insulators (£138).

Sydney (N.S.W.) Council have placed orders with Siemens Bros. Dynamo Works for two 1,000 kw., and two 600 kw. generators at £8,740.

Octavius Steel & Co. (Calcutta), have supplied the North Western (India) State Railway administration with 1,000 complete Leclanché cells, required for inter-station telegraphs.

The South Indian Railway Co. have placed orders with Siemens Bros. Dynamo Works for cables and wires; with the Sun Electrical Co. for various electrical stores; with the Chloride Electrical Storage Co. for accumulators; and with J. Stone & Co. for dynamos.

Electric Plant Contracts.—Among recent contracts secured by Messrs. Johnson & Phillips, Charlton, Kent, and 14, Union-court, London, E.C., are the following:—

Gravesend Electricity committee, supply and erection of their long burning magazine flame arc lamps, posts, &c.

Ebbw Vale Steel, Iron & Coal Co., supply and erection of a 6,600 volt three-phase overhead transmission line.

Victoria Postmaster-General, supply of a submarine cable gear for the Australian Commonwealth.

Messrs. J. G. White & Co., supply of the main switchboard for the Manaos Electric Light & Power Co.

Lincoln Waterworks committee, supply and erection of telephone line, instruments, &c.

Lyme Regis Electric Light & Power Co., supply and erection of overhead transmission line and underground mains.

Abertillery Council, supply and erection of an overhead transmission line and underground mains.

Leith electricity department, supply of 40 arc lamps "Bell" contact gears and accessories.

Midland Coal, Coke & Iron Co., supply and erection of single and three-cored vulcanised bitumen cables for their Birley Pit.

Urban Electric Supply Co., supply of 16 long burning magazine flame arc lamps for Berwick.

The Bryndu Colliery Co. (Bridgend), supply and erection of vulcanised bitumen surface and shaft cables, distribution boards, &c., for the Bryndu Colliery.

BUSINESS NOTICES.

The address of Messrs. Kincaid, Waller, Manville & Dawson will be changed on 24th inst. to St. Stephen's House, Victoria Embankment, Westminster, S.W., the lease of their present premises having been acquired by H.M. Office of Works. The telegraphic address and the telephone numbers will remain the same—"Kincaid London" and 10 and 11 Westminster.

Owing to the rapid growth of their business, Engineering Instruments (Ltd.) are removing their works to Darlington, where they have fitted up extensive and modern shops. The Company's address after the end of June will be Skerne Works, Darlington, where all communications should be sent.

Hy. C. P. Jean & Edward Coxhead (trading as the Hanway Art Metal Works), 4, John-street, Hanway-street, London, W., have dissolved partnership. Debts by Mr. Coxhead, who continues the business.

Sidney J. Suter and Fredk. C. Wood (trading as S. J. Suter & Wood), electrical engineers, 2, Lower James-street, Golden-square, London, W., have dissolved partnership. Debts by Mr. Wood.

Sale by Auction.—By order of the Lords Commissioners of the Admiralty Messrs. Fuller, Horsey, Sons & Cassell will include in their sale by auction at H.M. Dockyard, Portsmouth, on Tuesday, July 13, and following days, quantities of old brass tubes, and scrap metal, old lead and zinc ashes and bottoms, zinc scrap and slabs, old lead, mild scrap steel, wrought and cast iron scrap, old wire rope, electrical gear and stores, steam engines, dynamos, motors, lamps and lanterns, vices and tools, &c. May be viewed three days prior to and on morning of sale. Catalogues (6d. each) may be had at the Dockyard or of Messrs. Fuller, Horsey, Sons & Cassell, 11, Billiter-square, E.C. See also an advertisement.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

Electrical Engineering Business.—Messrs. Josolyne, Miles & Co., 28, King-street, Cheapside, E.C., advertise for sale the business of a well-known firm of electrical engineers.

An electrical contractor's business with large stock of electroliers, &c., is advertised for sale.

Patent Development.—The proprietor of Letters Patent No. 12,210 of 1901 relating to "Electrostatic separators," wishes to dispose of the patent or to grant licences for the adequate working of same in this country. Applications to Messrs. Cruikshank & Fairweather, Ltd., 65 and 66, Chancery-lane, W.C.

The owners of British Patent No. 14,851/1906, for "Improved Apparatus for the Automatic Distribution of the Operating Service in Telephone Exchanges," also desire to sell their patent rights or to grant licences. Particulars from Messrs. Day, Davies & Hunt, 321, High Holborn, London. W.C.

CATALOGUES, &c.

HART STORAGE BATTERIES.—The Hart Accumulator Co., of Marshgate-lane, Stratford, London, E., have prepared a useful form of advertisement in the shape of a hanging card, giving illustrations and particulars of various types of the Company's cells. Perhaps we could not do better than present our trade readers with a reduced facsimile of the card, which measures 21 in. by 15 in. Applications for copies of this show card should be accompanied by the trade card of the applicant.

PRINTING INSTALLATIONS.—Messrs. J. H. Holmes & Co. are issuing a booklet describing the Holmes-Clatworthy system of driving newspaper printing machines.

SIEMENS CONTINUOUS-CURRENT MOTORS.—Siemens Bros. Dynamo Works have just issued motors of a new design, whose various details are illustrated and described in a catalogue we have received. This subject being of importance, we have referred to it at greater length on another page in this issue.

CURTIS TURBINES.—The British Thomson-Houston Co., whose activities in the turbine field are well known, have issued, for the benefit of their clients, a pamphlet giving full details of the Curtis exhaust and mixed pressure turbines. These turbines have been extremely successful wherever they have been installed, and owing to their compact design it is claimed they occupy considerably less floor space than any other turbines of a similar type. The machines are manufactured entirely at the company's Rugby works, and the demand for them shows that a flattering appreciation of their merits exists.

MEASURING INSTRUMENTS.—In a catalogue just issued Messrs. Siemens Bros. & Co. describe and illustrate the following new apparatus: Moving coil ammeter and voltmeter, which is used for very sensitive current and pressure measurements; no temperature correction is necessary with these instruments; a portable potentiometer which combines the properties of the above instrument with the advantage that it can be easily checked against a standard cell, special precautions being taken to prevent errors through outside disturbances. Other instruments include standards of mutual and self-induction, new glow lamp photometers and outfits for adjusting and testing arc lamps.

"Z" TIME SWITCH.—Messrs. Marsh, Son & Co. forward a circular dealing with their new type of time switch, to which we called attention in connection with a show card published by them some weeks ago. We have also received a pamphlet of the same firm's D.D. time switch.

WALL PATTERN RESISTANCE.—Messrs. E. F. Moy deal in their latest pamphlet with a wall pattern resistance, which consists of an aluminium frame carrying two plain slate slabs. Between these slabs the resistance coils are stretched, and a five-point switch allows more or less resistance to be cut out as required. Owing to the fact that these resistances get very hot during working, wood work and other combustible material has been avoided in their construction.

FEED WATER HEATING.—In a pamphlet recently issued by the Hudson Economiser Co. of London, the specialities of this firm are fully dealt with. These include a combined feed water heater and oil separator. The advantages of these apparatus are adequately put forward.

"TINOL."—Messrs. Neville, Williams & Co. have recently placed on the market a combined solder and flux, which rejoices in the name of "Tinol." It is claimed for this that it is specially suitable for electrical work. Samples of the paste and stick which have been sent us seem suitable for the work.

ARC LAMP LOWERING GEAR.—The London Electric Firm of Croydon have issued a catalogue which deals very fully, both as regards detail and finished equipment, with their well-known lowering gear for arc lamps. Numerous photographs of actual installations are illustrated and their peculiarities described.

ARC LAMP CARBONS.—Messrs. Wm. Geipel & Co. have ready a catalogue of arc lamp carbons.

BANKRUPTCIES, LIQUIDATIONS, &c.

A meeting of creditors of the Lumb Electrical Bleaching Co. (Ltd.) will take place on June 24 at the Thatched House Hotel, Newmarket-place, Manchester. Claims to be sent to Mr. W. B. Winnicott, Prudential-buildings, Queen-street, Nottingham.

At Edmonton Bankruptcy Court on Monday an application by the Assistant Official Receiver for the adjournment sine die of the public examination of Thos. Ward, formerly managing director of the Electrical Instrument Manufacturers (Ltd.) Waltham Cross, was acceded to, but an application for the adjudication of debtor was refused.

A dividend is to be paid to the creditors of Arnold Roberts (trading as Roberts Bros.), electrical engineer, 21, North-parade, Bradford. Claims by July 3 to Mr. J. H. Haley, 29, Tyrrel-street, Bradford, or Mr. R. A. Vinter, King's-arcade, Bradford.

A supplemental dividend of 6½d. is payable at 47, Full-street, Derby, to the creditors of Hy. J. Furniss, electrician, 5A, Queen-street, Derby.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE. *The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

March 13, 1909.

6,065 RUSSO. Regulating electric currents.
6,069 BRUCE PEEBLES & CO. (O. S. Bragstad & Jens Lassen la Cour, Germany.) Dynamo-electric machinery.*
6,076 HOSKING. Drums or reels for coiling and transporting electric cables, wire ropes.
6,088 AKTIEBOLAGET ELEKTROMETALL. Electric production of iron and steel and other metals and in furnaces for carrying out the same. (Date applied for, 1/8/08.)*†
6,093 JACOVIELLO. High-frequency oscillatory current generators and transformers.*
6,103 MOSER. Alternating electric current machines. (Date applied for, 14/3/08.)*†

March 15, 1909.

6,106 COOPER & SHARP. Electrical resistances.*
6,151 STRATTON & CLAREMONT. Electric cables.
6,161 RUTZKY. Electric insulators.
6,177 PARSONS, STONEY & LAW. Dynamo-electric machinery.
6,186 B.T.-H. CO. & PARK. Control of electrically-propelled vehicles.
6,187 VOLKERS. Rotary field magnet. (Date applied for, 23/4/08.)*†

March 16, 1909.

6,191 GOLDSTONE. Cut-out and current regulator.
6,248 ACCUMULATOREN-FABRIK AKT.-GES. Accumulator plates. (Date applied for, 31/12/08.)*†
6,267 STEINERT & STEIN. Electromagnetic separation. (Addition to No. 6,323/08.)*

6,281 Siemens Bros. & Co. (Siemens & Halske Act.-Ges., Germany.) Telephone exchanges.*
6,289 Price. Electric block-signal systems.*
6,312 Allgemeine Elektricitats-Ges. Dynamo-electric machines. (Date applied for, 17/3/08.)*†
6,313 Allgemeine Elektricitats-Ges. Electric transformers. (Addition to No. 92 09. Date applied for, 17 3 08.)*†

March 17, 1909.

6,317 Day & Wiesengrund. Production of electric power.
6,326 Richmond. Primary batteries.
6,328 Lincoln. Plot point and controlling mechanism of conduit system of electric traction.
6,351 Russell. Bridge pieces for electric fuse boxes.
6,398 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of refractory electric conductors.
6,405 Grote. Electric switches.
6,419 Grange. Magnetic clocks and timing mechanism.
6,424 Thompson. (Ges. für Drahtlose Telegraphie m.b.H., Germany.) Producing but very slightly damped electrical oscillations.*
6,429 Pauling. Electric arcs in series.*

March 18, 1909.

6,443 Tucker. High-potential primary battery.
6,447 Williams. Enumeration of telephone calls.
6,477 Lancashire Dynamo & Motor Co. & Stelling. Rotors of alternating-current dynamo-electric machines.
6,504 Wilson & Wilson. Metering and transforming electrical energy.
6,525 Clark. Receiving instruments for electric telegraphy.*
6,534 Ormston & Charlton. Overhead conductors for electric railways and tramways.
6,564 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control.
6,565 B.T.-H. Co. & D'Arcy. Electricity meters.
6,566 Allgemeine Elektricitats Ges. Control of electric motors. (Date applied for, 18/3/08.)*†
6,567 White. Systems of motor control. (Date applied for, 18/5/08.)*†

March 19, 1909.

6,574 Ireland. Electrical depth recorder.
6,599 Davies & Evans. Speed limit switch for internal combustion engine with high-tension magnets for motor cars.
6,646 Plato. Converting short contacts into contacts of longer duration.*
6,673 B.T.-H. Co. (G.E. Co., U.S.) Speed indicators for electric motors.
6,674 B.T.-H. Co. (G.E. Co., U.S.) Electric resistance units.
6,675 Allgemeine Elektricitats-Ges. Polyphase relays and the like. (Date applied for, 19/3/08.)*†

March 20, 1909.

6,691 Taylor. Motor-generators for use with electric accumulator batteries.
6,749 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.
6,752 Childs & Hill. Electrical generating sets driven by wind or like fluctuating power.
6,758 Durtnall. Electrical transmission of power and speed regulation.

March 22, 1909.

6,764 Varley. Making and breaking electric contacts.
6,773 Fennell & Perry. Storage batteries.
6,777 Parkinson. Heating ovens, radiators, cooking utensils, hot plates, irons, and the like, by means of electricity.
6,808 Cagliani. Fuse boxes.
6,809 Claremont & Stratton. Steel armouring of electric cables.
6,818 Fisher. Electric street-car indicator.*
6,820 Reid. Electric furnaces. (Date applied for, 22/8/08.)*
6,832 Lake. (Cutler-Hammer Mfg. Co., U.S.) Electric snap switches.*
6,836 Allom. Electric-light reflectors for concentrating light.
6,843 Auerbach. Incandescent electric lamps. (Date applied for, 23/1/09.)*†
6,849 Rizzo. Solenoid brakes for electrically-driven carriages.
6,850 Justice. (La Société Anonyme Electricité Electromécanique, Belgium.) Friction couplings.*
6,872 B.T.-H. Co. (G.E. Co., U.S.) Electrolytic cells.
6,877 Siemens Bros. & Co., Riber, & Ireland. Hand-operated magneto-electric machines.*
6,878 Siemens Bros. & Co. (Siemens & Halske A.-G., Germany.) Telephone installations.*
6,883 Cagliani. Long-distance control apparatus.

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6,888 Simmons. Signalling by electrical apparatus.
6,902 Foster. Arrangement and combination of electric with steam and internal-combustion engines for ship propulsion.
6,916 Walker. Generation, storage and use of electric power.
6,936 Westinghouse Metal Filament Lamp Co. (Anton Lederer, Austria.) Manufacturing metal filaments for incandescent electric lamps.
6,939 Lucas. Electro-magnetic relays and the like.
6,940 Lucas. Switching-apparatus for the control of direct-current motor-generators and the like.
6,945 Szek. Expanded metal for electric accumulators, electrodes and other purposes.
6,948 Siemens Bros. Dynamo Works Kloss & Schaeffer. Induction electric motors.
6,949 Siemens Bros. Dynamo Works & Kloss. Dynamo-electric machines for operating searchlights and the like.*
6,956 Siemens Bros. Dynamo Works & Kloss. Starting and regulating of electric induction alternate-current motors.
6,957 Kallmann. Starting devices for alternating and three-phase current motors. (Date applied for, 28/3/08.)*†
6,962 Sharman. Induction coils. (Date applied for, 4/6/08. Comprised in application No. 1,214, 4 6 08.)*
6,974 Webb. Short-distance telegraphic apparatus.
6,985 B.T.-H. Co. (G.E. Co., U.S.) Signalling systems.*
7,005 Bowden, Robinson & Jacks. Electric prepayment meter mechanism and the like.

SPECIFICATIONS PUBLISHED.

1908 Specifications.

6,961 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors of the commutator type
7,327 B.T.-H. Co. & Clough. Dynamo-electric machines.
7,565 Vernum. Current-conducting wire terminals.
7,811 Sir W. G. Armstrong, Whitworth & Co. & Harlow. Controlling of electric motors.
8,269 Lamkin, Crofts & Beazley. Testing the circuits of induction coils, magneto-machines, or batteries.
9,790 W. T. Henley's Telegraph Works Co. & Pfiffner. Electric cables.
9,917 Parsons & Ball. Contact making and breaking devices.
10,773 Rock. Holders for electric lamps.
11,035 New Ignition Synd. & Sandy. Electric batteries.
11,163 Petersen & Callender's Cable & Construction Co. Submarine signalling cable.
11,288 Baker & Gunstone. Mercury interrupters for alternating electric currents.
11,554 Jack & Robertson. High-tension distributors for electric ignition in internal combustion motors.
11,610 New Ignition Synd., Rouse & Sandy. Electric batteries.
12,390 Siemens Bros. Dynamo Works & Kloss. Obtaining a smooth E.M.F. curve in alternate-current dynamos.
12,650 Johnson & Phillips, Ltd., & Paterson. Electric motors.
12,684 B.T.-H. Co. (G.E. Co., U.S.) Electromagnetic relays. (Addition to No. 16,195 06.)
12,841 Marschall. Thermo-electric batteries.
13,078 Schattner & Amberton. Electric motor-controllers
13,580 Siemens Bros. Dynamo Works & Riber. Arc lamps.
13,854 Snook. X-ray system. (Date applied for, 20/7/07.)
14,161 B.T.-H. Co. (A.E.G.). Electrical-power transmission systems.

COMPANIES' MEETINGS AND REPORTS.

India Rubber, Gutta Percha & Telegraph Works Co. (Ltd.)

The half-yearly general meeting was held on Tuesday, Major Leonard Darwin presiding.

The SECRETARY (Mr. A. P. Crouch) read the notice calling the meeting.

The CHAIRMAN then said: Gentlemen, as usual, no accounts are submitted for your consideration on this occasion. Since I addressed you six months ago a considerable change has taken place in the market for raw material. In December last the price of fine Para rubber was 5s. 0½d. per lb., now the quotations are about 6s., and the medium grades have also advanced in sympathy. To protect ourselves we, in common with the principal manufacturers, have advanced the selling prices of our general goods, and will doubtless have to advance the price of our special goods, as contracts fall in for renewal. The Palmer cord tyre and the Persan tyre continue to give satisfaction to motor-car owners, their well-recognised merits outweighing, in the opinion of owners, an initial cost which is greater than that of any other motor tyre on the English and French market. Some 20 years ago we introduced, in conjunction with Messrs. Harland & Wolff, indiarubber tiling for the trans-Atlantic liners which that firm was constructing, and this flooring proved so successful that it was adopted for use in some of the large buildings in the city of New York. Some of the large buildings in London have also adopted it on account of its silent tread and cleanliness. We are now introducing a mosaic rubber tiling which has an excellent appearance and lends itself to surroundings.

At a former meeting I mentioned that we had completed the electric installation of the town of Dumfries under a provisional order granted by the Board of Trade. I have now further to state that the negotiations are all but completed for the transfer of this undertaking to a company, but some time must necessarily elapse before we can realise our investment in this work. I now move that the distribution of a dividend of 5s. 4d. per share, or at the rate of 5 per cent. per annum, payable 1st prox., on the preference shares be approved, and that the distribution of an interim dividend of 2½ per cent., or 5s. per share, tax free, on 17th inst., to ordinary shareholders be approved.

Mr. C. H. MOORE seconded the motion, which was agreed to unanimously.

The CHAIRMAN then announced that the board had appointed Mr. Matthew Hamilton Gray, Mr. Christian Hamilton Gray and Mr. William Ernest Gray extraordinary directors.

The proceedings then terminated.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend to June 30 in respect of the profits for the first half of 1909 at the rate of 3s. per share on the 6 per cent. cumulative first preference shares, being at the rate of 6 per cent. per annum (less tax); a dividend of 5s. per share on the cumulative second preference shares, being at the rate of 10 per cent. per annum (less tax): also 2s. 6d. per share on the cumulative third preference shares, being at the rate of 5 per cent. per annum (less tax), and at the rate of 1s. 2·63d. per share on the cumulative third preference shares, being at rate of 5 per cent. per annum from April 3 to June 30 (less tax).

ANGLO PORTUGUESE TELEPHONE CO. (LTD.)—On Monday the chairman (Mr. H. Allen) said that owing to the somewhat disturbed political, commercial and financial conditions in Portugal and to the prolonged droughts the increase in the company's business during 1908 was not so marked as in some previous years. They had had, however, a successful year on the whole. The gross income was £42,048, an increase of £2,353. The total expenses (including royalties) were £23,840, an increase of £1,230. The net profit was £18,208, against £17,085 in 1907. The most dangerous element in their business was the course of exchange between Lisbon and London, which at times was subject to considerable fluctuation. As in the case of earthquake risks, so in the case of exchange, they had taken steps—practically an insurance—that no matter how severe the fall in exchange during the next 12 to 18 months their remittances would be at a remunerative rate. Their reserve was £20,000, and in the future they proposed to charge direct to profit and loss account any sum which it was intended to carry to reserve. The capital expenditure last year was £13,636, and more than half was due to the further substitution of underground cables for overhead wires, and additions to the switchboard in their central exchange at Lisbon, as the outcome of which their effective working capacity was nearly doubled. Their relations with the authorities remained perfectly harmonious, and a slight difference of opinion which had arisen with the Post and Telegraph Department as to the precise nature of their concessionary rights promised to be settled satisfactorily with the Government.

BIRMINGHAM & MIDLAND TRAMWAYS (LTD.) The report for 1908 states that the total revenue was £97,004 compared with £83,837 for 1907; expenses were £45,639 against £38,652. After providing for all expenses placing £1,500 to renewals account and adding £83 brought forward there remains £49,948. The directors propose to apply to debenture redemption £3,550 to pay a dividend on the preferred ordinary shares of 2½ per cent. for the year, £82 is carried forward. The capital expenditure during the year on tramways was £1,054 and on lighting £11,002. Plant valued at £1,526 was transferred from the tramway to the lighting undertaking and electrical plant, cables, &c., in Oldbury (valued at £7,180) were sold to the Shropshire, Worcestershire & Stafford-

shire Electric Power Co. The company acquired a controlling interest in the Shropshire Power Co. at the beginning of last year, and subscribed for 57,312 £5 shares in that company to enable it to comply with the provisions of its acts of Parliament. With the consent of the debenture trustees, Smethwick power station has been withdrawn from the specifically mortgaged premises, and 25,152 shares of £5 each of the Shropshire Co. have been substituted, and the station will be sold to the Power Co as soon as the necessary legal preliminaries have been arranged. The total amount of debenture stock now outstanding is £344,357. An agreement has been entered into with the Dudley Corporation which provides for the payment of the purchase money by the Corporation (£10,631) on fixed alternative dates during the present year with interest from Jan. 1 last to the date of payment at the rate of 4½ per cent. per annum. The terms of the lease have been agreed, and a bill is being promoted by the Corporation to empower the Corporation to grant a lease to the company of the tramways for 30 years from Jan. 1 last.

CHADBURN'S SHIP TELEGRAPH CO. (LTD.)—After paying managing director's remuneration, directors' expenses, depreciation on plant, &c., the profit for the year ended March was £8,331. 5s. 3d., added £1,686. 14s. 9d. brought forward. After paying preference dividends and an interim ordinary dividend at the rate of 6 per cent., £4,618 remains to be dealt with. The directors propose to pay a final ordinary dividend at the rate of 10 per cent. (less tax) (making 8 per cent. for the year) carrying forward £1,618.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The net revenue for the year ended May 31, after deduction of expenses, is £207,347. 8s. 10d., making with £27,206. 5s. 5d. brought forward, £234,553. 14s. 3d. From this there has been distributed £131,769. 8s. 11d. in interim dividends, leaving available £102,784. 5s. 4d. The directors now recommeud payment of the following final dividends: 3s. per share (less tax) on the preference shares, making 6 per cent. for the year (less tax) and 5s. 6d. per share net on the ordinary shares, making 5⅝ per cent. net for the year. These dividends will absorb £75,479. 0s. 4d., and leave £27,305. 5s. to be carried forward.

UNITED ELECTRIC TRAMWAYS OF MONTE VIDEO (LTD.)—Mr. Geo. A. Touche stated at the meeting on Tuesday that the results of the past year's working were as satisfactory as could be reasonably expected. They had 80 miles of single track in operation under electric traction, and in due course that would be increased to about 84 miles by the extension to Colon. At the close of the year they had 77½ miles open, but the average during the year was slightly under 60 miles. The traffic receipts were $1,093,870 (£232,738), an increase of 17 per cent. over 1907 and 79 per cent. over 1906, when the lines were being operated entirely by animal power. The number of passengers carried was 25,901,439, an increase of 21 per cent. and of 87 per cent. over 1906. Last year, on a mixed service, the operating expenses were reduced from 66·24 to 64·09 per cent., but compared with 1906 (when the lines were operated by animal traction) the decrease was nearly 10 per cent. They were increasing the power-house plant and adding to the feeder system. After paying debenture stock interest, &c., they proposed to pay the final preference dividend (requiring £11,047) and a dividend at the rate of 5 per cent. on the ordinary shares for the year to March 31 (£15,960). The question of paying interim dividends on the ordinary shares was receiving the consideration of the board.

R. WAYGOOD & CO. (LTD.)—At the meeting on Wednesday Mr. Hy. C. Walker said they had been able to substantially maintain their margin of profit and to pay the same rate of dividend as a twelvemonth ago. The company had again been entrusted with extensive orders from various Government departments and others, among which he instanced a patent automatic electric lift for the use of the President of the Brazils and a Waygood passenger lift for use in the Turkish Houses of Parliament in Constantinople. They had also been called upon to provide at short notice one of their automatic electric lifts in Leeds Town Hall for his Majesty's use on the occasion of the King's visit to that town for the purpose of opening the new buildings of the university. They had acquired what they believed to be very valuable patents in connection with heavy crane work on specially advantageous terms.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

GRASSINGTON ELECTRIC SUPPLY CO. (LTD.) (103,382.)—Reg. June 9, capital £1,000 in £1 shares, to carry on at Grassington and elsewhere in Yorkshire the business of an electric supply company, and to adopt agreements with J. S. Fielden and with C. Pullan. Provisional directors, C. Pullan, J. Crowther, F. Hillman, J. H. Heyworth, J. S. Fielden, H. Moss and H. Briley. Reg. office, 51, King's Arcade, Bradford.

VAUGHAN ENGINEERING INSTALLATIONS (LTD.) (103,469.)—Reg. June 11, capital £5,000 in £1 shares, to acquire the business carried on as Vaughan & Cook Ltd., to adopt an agreement with W. Briggs, LL.D., and to carry on the business of electric light, gas, hot water and ventilating engineers, electricians, manufacturers of motors, batteries, &c. Private company. First directors, Dr. W. Briggs, W. R. Briggs and T. W. Vaughan. Reg. office, 298 and 300, Goswell-road, London, E.C.

WALKER HANNA PATENT BEARINGS CO. (LTD.) (103,401.)—Reg. June 8, capital £2,400 in £1 shares, to acquire the patents and rights granted to R. Walker Hanna relating to improvements in the manufacture of brasses or bushes for the bearings of shafts and axles applicable to railways, tramways, rolling stock, &c., and to develop and turn same to account. Private company. First directors, H. G. Hills, R. Walker Hanna and E. M. Knowles. Reg. office, 2, Booth-street, Manchester.

STATUTORY RETURNS.

LAURENCE, SCOTT & CO. (LTD.)—Return to April 13 gives capital as £50,000 in 50 shares of £1 each and 4,995 of £10 each, of which 45 £1 and 4,181 £10 shares have been taken up. £1 per share has been called up on 45 and £10 per share on 2,793, resulting in the receipt of £28,025. £13,830 is considered as paid on 1,383 shares. Mortgages and charges, £22,200.

MARSH, SON & CO. (LTD.)—Return to April 19 gives capital as £20,000 in £1 shares, of which 18,608 have been taken up. £6,608 has been paid and £12,000 is considered as paid. Mortgages and charges, £9,200.

SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)—In return to April 6 capital is £260,000 in £4 shares, all of which have been taken up and paid for in full. Mortgages and charges, £100,000.

WINDERMERE & DISTRICT ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to April 10 is £50,000 in 5,000 preference and 5,000 ordinary shares of £5 each, of which 5,000 preference and 3,000 ordinary have been taken up. £5 per share has been called up on 3,040 preference and 1,730 ordinary, resulting in the receipt of £23,850. £16,150 is considered as paid on 1,960 preference and 1,270 ordinary shares. Mortgages and charges, £16,800.

MORTGAGES AND CHARGES.

CALMONT, KING & CO. (LTD.)—Issue on June 7 of £500 debentures, part of series created Aug. 7, 1908, to secure £2,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees.

RAWORTH'S TRACTION PATENTS (LTD.)—Particulars of £1,500 debentures created April 7, and secured by trust deed dated May 19, 1909, filed pursuant to sec. 93 (3) of the Companies (Consolidation) Act, 1908, amount of present issue being £1,000. Property charged: Company's undertaking and property, present and future, including uncalled capital, and all inventions and improvements connected with regenerative control on electric cars. Trustees, C. Shirreff, B. Hilton and J. S. Raworth.

TYPEWRITING TELEGRAPH CORPN. (LTD.)—Particulars of £3,000 debentures created Nov. 4, 1904, has been filed, amount of present issue being £440. Property charged: Company's undertaking and property, present and future, including uncalled capital. No trustees

CITY NOTES.

MEMORANDA (June 17).—Bank rate 2½ per cent. (since April 1 1909). Price of silver, 24⅛d. per oz. Consols 84$\frac{3}{16}$—84$\frac{5}{16}$ for money and 84⅛—84¼ for account. Consols Pay Day, July 1; Stock and Shares Continuation Days, June 23 and July 12; Ticket Days, June 24 and July 13; Pay Days, June 25 and July 14; Mining Shares Carry Over Day, June 22.

PRICES OF METALS (London).—*Copper*, cash, 58$\frac{15}{16}$; three months 59$\frac{13}{16}$—63. *Lead*, English, 13⅝—13¾; foreign, cash, 13$\frac{1}{16}$—13⅛; three months, 13⅜. *Spelter*, cash, 22; three months, 22⅛—22¼. *Tin*, English, 132½—134½; foreign, cash, 133⅞ three months, 134⅜—135⅜. *Iron*, Cleveland, cash, 48/7½ and three months, 49/3. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

AMERICAN TELEPHONE & TELEGRAPH CO.—The directors have declared the regular dividend of $2 per share.

SHAWINIGAN WATER & POWER CO.—A dividend of 1 per cent. for the quarter ending June 30 has been declared.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed June 18 a special settling day in scrip, fully paid, for £300,000 4½ per cent. perpetual consolidated debenture stock of the *Winnipeg Electric Railway Co.*, and June 21 a special settling day in 169,406 £5 fully-paid cumulative third preference shares of the *Anglo-Argentine Tramways Co. (Ltd.)*, and have granted official quotations in both cases. A further issue of $4,823,200 common stock, in shares of $100, of the *Mexico Tramways Co.* is also ordered to be quoted. The committee have been asked to grant quotations to a further issue of £200,000 £100 5 per cent. 50 year mortgage bonds of the *Rio de Janeiro Tramway, Light & Power Co. (Ltd.)* and a further issue of 1,000 £10 fully-paid shares of the *South African Lighting Association (Ltd.)*.

WINNIPEG ELECTRIC RAILWAY CO.—The directors have declared a quarterly dividend of 2½d. per cent.

YORKSHIRE (WOOLLEN DISTRICT) ELECTRIC TRAMWAYS CO. (LTD.)—The directors have declared a dividend of 2 per cent. on the ordinary shares for the past year, £1,500 has been placed to renewals, £1,000 to capital redemption and £500 to depreciation and reserve funds, the balance (£608) being carried forward.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 9	1,770	– 28	§1	1,770	– 28
Airdrie	" 4	226	– 14	22	4,758	– 86
Anglo-Argentine	" 10	37,685	+ 80	23	905,484	+ 49,100
Ayr Corporation	" 12	293	+ 23	4	1,122	– 57
Baker St. & Waterloo Ry.	" 12	3,290	+ 210	23	76,890	+ 6,735
Barnsley	" 4	220	+ 37	22	3,690	– 60
Barrow	" 4	305	+ 45	22	4,666	– 253
Bath Electric Trams, Ltd.	" 9	748	– 395	23	15,970	+ 573
Birmingham Corporation	" 12	6,007	– 1,437	11	69,205	+ 193
Birmingham & Mid.	May 28	843	+ 23	21	16,872	+ 127
Blackburn Corporation	June 9	997	– 443	11	12,720	– 164
Blackpool and Fleetwood	...	...	...	...	...	...
Bolton Corporation	" 13	2,499	– 87	11	25,681	– 123
Bombay	May 13	R33,352	+ R1,125	19	R732,137	+ R43,534
Bournemouth Corporation	June 9	1,629	– 439	10	17,070	+ 252
Bradford Corporation	" 12	4,764	– 1,043	10	51,982	+ 869
Brighton Corporation	" 13	893	– 317	11	10,026	+ 725
Bristol Trams & Carriage	" 11	5,236	– 1,766	3	18,015	+ 705
Burnley Corporation	" 12	1,227	– 233	11	14,218	+ 233
Burton Corporation	" 13	244	– 74	11	2,820	– 63
Bury Corporation	" 13	1,338	– 37	†11	12,990	– 89
Calcutta Tramways Co.	" 12	R17,820	– R722	23	R1,140,034	+ R94,572
Camborne-Redruth	" 12	156	– 30	24	2,879	– 50
Cardiff Corporation	" 12	2,153	– 787	11	22,920	– 399
Cavehill	" 4	103	– 10	22	1,538	– 177
Central London Railway	" 12	5,861	– 1,362	23	127,501	– 13,970
Charing C., Euston & H'stead	" 12	3,795	– 125	23	89,340	+ 14,740
Chatham & Dist. Lt. Rys.	" 10	798	– 317	23	17,526	+ 1,227
City & South London Rly.	" 13	3,200	+ 83	23	74,886	+ 1,128
City of Birmingham	" 4	3,453	+ 516	22	60,159	+ 87
Colchester Corporation	" 9	176	– 254	...	...	...
Cork Electric Trams Co.	" 10	497	– 23	23	8,938	– 951
Croydon Corporation	" 11	1,316	– 636	‖10	15,752	+ 220
Devonport & Dist. Trams	" 4	427	– 68	22	8,114	– 1,438
Dover Corporation	" 12	188	– 64	11	2,106	– 126
Dublin & Lucan Railway	" 11	158	– 32	23	2,860	+ 237
Dublin United	" 11	5,408	– 83	23	117,268	+ 636
Dudley-Stourbridge	" 4	1,387	+ 552	22	16,920	+ 319
Dundee Corporation	" 9	1,215	– 2	†4	4,268	– 226
East Ham Council	" 12	926	– 152	§10	10,749	+ 1,692
Exeter Corporation	" 11	304	– 119	11	3,860	+ 685
Gateshead & Dist. Trams	" 4	1,118	+ 118	23	21,665	+ 89
Glasgow Corporation	" 12	17,717	+ 638	12	31,408	+ 1,312
Glossop Trams	" 5	130	– 7	23	2,714	– 104
Gravesend—Northfleet	" 4	312	+ 90	22	4,212	– 56
Great Northern & City Rly.	" 12	1,339	– 185	23	34,662	– 4,185
Gt. Northern, Piccadilly, &c.	" 12	5,940	+ 525	23	133,235	+ 8,655
Greenock & Port Glasgow	" 4	538	...	22	10,921	+ 63
Hartlepool Tramways	" 4	322	+ 73	22	4,661	– 30
Hastings Elec. Trams Co.	" 10	958	– 307	23	19,674	– 492
Hong Kong	...	...	...	...	...	...
Huddersfield Corpn.	" 12	1,622	– 450	10	17,761	+ 519
Hull Corporation	" 12	2,324	– 256	10	26,037	+ 114
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	" 10	114	– 74	10	1,325	– 140
Ipswich Corporation	" 12	376	– 167	11	4,018	+ 21
Isle of Thanet Co.	" 12	578	– 409	§28	12,253	+ 327
Jarrow	" 4	160	+ 51	22	2,439	+ 263
Keighley Corporation	" 10	157	– 47	10	1,747	+ 46
Kidderminster & District	" 4	238	+ 133	22	2,051	+ 63
Kilmarnock Corporation	" 12	143	– 1	4	597	– 55
Lanarkshire Trams Co.	" 10	1,278	– 35	23	27,765	– 1,750
Lancashire United	" 9	1,453	– 48	23	29,055	+ 114
Leamington	" 4	279	+ 87	22	3,436	+ 304
Leeds Corporation	" 13	6,698	– 1,183	11	71,267	+ 2,163
Leicester Corporation	" 12	2,000	– 769	...	...	...
Leith Corporation	...	...	...	...	...	...
Lincoln Corporation	" 12	129	– 12	11	1,381	+ 60
Liverpool Corporation	" 5	11,486	+ 158	‖22	231,055	– 1,458
Liverpool Overhead Rly.	" 13	1,345	– 262	24	31,418	– 2,259
Llandudno & Colwyn Bay Ry	" 4	569	+ 443	27	4,218	+ 1,839
*London County Council	May 29	36,603	+ 907	§8	303,209	+ 21,120
London United	June 12	5,659	– 5,318	‖26	131,357	– 10,867
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	" 12	166	– 111	10	1,930	– 149
Manchester Corporation	" 12	14,712	– 2,628	11	159,376	– 459
Mersey Railway	" 12	2,209	+ 112	23	45,455	+ 1,410
Merthyr	" 4	295	+ 77	22	4,534	+ 79
Metropolitan Dist. Railway	" 12	10,617	+ 1,503	23	226,340	+ 21,209
Metropolitan Elec. Trams	" 4	8,560	+ 2,014	22	128,277	+ 14,561
Middleton	" 4	468	+ 70	22	7,046	– 258
Nelson Corporation	" 12	140	– 16	†11	1,497	– 55
Newcastle-on-Tyne Corp.	" 12	3,653	– 276	10	40,811	+ 497
Newport (Mon.)	" 12	641	– 327	11	7,304	– 150
Northampton Corporation	" 11	444	– 335	§11	5,078	+ 130
Oldham, Ashton & Hyde	" 4	651	+ 33	22	12,060	– 742
Oldham Corporation	" 13	1,978	+ 32	11	22,269	– 1,043
Perth (N.B.) Corporation	" 9	173	+ 8	3	563	– 15
Perth (W.A.) Elec. Trams	" 11	1,388	+ 123	23	33,362	+ 11
Peterborough	" 4	181	+ 41	22	2,359	– 100
Portsmouth Corporation	...	...	...	...	...	...
Potteries	" 4	2,037	+ 181	22	38,839	– 823
Preston Corporation	" 9	673	– 359	10	7,317	+ 32
Rotherham Corporation	" 10	550	– 292	10	6,274	– 194
Rothesay	" 4	175	– 3	22	1,980	– 45
Salford Corporation	" 11	4,412	+ 1,829	‡11	50,152	– 1,111
Sheerness	" 4	73	+ 11	23	1,003	– 118
Sheffield Corporation	" 15	5,463	– 1,125	§11	64,636	– 1,171
Singapore Trams	" ‡12	$9,327	– $236	23	$320,578	+ $2,260
South Metropolitan	" 4	1,219	+ 187	23	16,315	+ 469
South Staffs	" 4	1,174	+ 288	22	18,230	– 661
Southend Corporation	" 9	451	– 148	10	4,637	+ 787
Southport Tramways	" 4	488	+ 180	22	5,606	+ 153
Stalyb'dge, Hyde, &c., Jt. Bd.	" 12	764	– 201	§10	8,287	– 161
Sunderland Corporation	" 13	1,178	– 292	11	12,117	– 365
Sunderland District	" 9	432	– 235	33	14,315	– 466
Swansea Trams	" 4	1,402	+ 450	22	20,072	+ 891
Swindon Corporation	...	...	...	...	...	...
Taunton	" 4	51	+ 12	22	789	– 57
Tynemouth and District	" 4	447	+ 222	22	3,632	+ 164
Tyneside Trams Co.	" 3	422	– 67	23	9,374	+ 719
Wallasey District Council	" 12	903	– 217	§10	9,826	+ 445
Walsall Corpn.	" 12	460	– 258	23	11,618	– 975
Warrington Corpn.	" 3	401	+ 19	9	3,424	– 36
West Ham Corporation	" 3	2,983	+ 637	9	22,175	+ 2,251
Weston-super-Mare	" 4	381	+ 272	22	1,534	+ 142
Wolverhampton Co.	" 4	730	+ 281	23	9,038	– 633
Wolverhampton Corpn.	" 9	707	– 627	23	16,844	– 1,163
*Worcester	" 4	120	+ 115	22	5,605	+ 112
Wrexham	" 4	125	+ 24	22	2,076	– 42
Yorkshire W.R. Trams	" 13	1,191	– 822	24	27,825	...
‡Yorkshire Woollen District	" 4	1,212	+ 269	22	19,314	– 203

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus [illegible] days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed. June 16	Rate % Yielded	Dividend Due.	Business Week to June 16: Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½–10	6 0 0	Mar, Sep	..	–
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞–10⅛	4 9 0	Feb, Aug	10	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼–10¾	5 11 6	Feb, Aug	10	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101–105	4 5 6	Jan, July	102½	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4¼–4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93–96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½–9	5 11 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	8–8½	4 2 0	Mar, Sept	..	–
St.	4%	Cent l Elec. Sup. Co. 4% Guar. Db. Stock	97–100	4 0 0	June, Dec	..	–
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅞–4⅛	5 11 0	Feb, Aug	4	..
5	2/3	Do. 4½ per Cent. Pref.	4½–4¾	4 12 0	Feb, Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	96–99	4 1 0	Jan, July	..	–
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100–102	4 8 0	..	101½	101½
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾–4¼	5 5 6	Jan, July	4	3⅞
5	2/6	Chelsea Electric Supply Ord.	3¾–4½	4 9 3	March	4	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102–105	4 7 6	June, Dec	..	–
10	7/0	City of London Electric Lighting Ord.	10½–11	5 10 0	Feb, Aug	[illegible]	10½
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼–11¾	4 13 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121–123	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101–104	4 6 6	Jan, July	102	–
5	..	County of Durham Elec. P.D. Ord.	1¾–2¼	–	April, Oct	–	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3¼–3¾	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8½–8¾	5 15 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞–11⅛	5 8 0	Mar, Sept	11	[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	106–109	4 2 9	Jan, July	–	..
St.	4½%	Do. Second Deb. Stock	100–103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½–5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	98–101	4 9 0	Feb, Aug	.	..
5	4/6	Hove Electric Lighting Ord.	7½–7⅞	5 11 6	April, Oct	.	..
5	4/0	Kensington & Knightsbridge Ord.	6¾–7⅛	6 2 0	Feb, Aug	..	–
5	6%	Do. 6 per Cent. 1st Pref.	6⅝–6⅞	4 14 6	Jan, July	..	–
t.	4%	Do. 4 per Cent. Deb. Stock (red.)	97–100	4 0 0	..	–	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98–101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85–89	5 1 0	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞–2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛–5¼	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	89–94	4 5 0	Jan, July	–	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅝–4¾	5 13 0	April, Oct	4½	4
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼–5⅛	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107–110	4 2 0	June, Dec	–	–
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85–88	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95–98	4 12 0	June, Dec	..	–
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4⅞–5	4 2 1	Feb, Aug	..	–
100	4½%	Do. 4½ per Cent. Deb.	81–86	5 5 11	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅝–4⅞	2 13 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅝–5⅜	5 0 0	Feb, Aug	–	–
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99–101	4 0 0	Jan, July	–	–
100	50/	North Metro. Elec. Power Sup. 5 Morts	99–101	4 19 0	..	99¾	99½
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	–
100	4½%	Do. 4½ per Cent. Deb.	91–93	4 17 10	Jan, July	–	..
10	8/0	Notting Hill Electric Ord.	11½–12½	5 12 0	March	–	..
5	4/6	Oxford Electric Ord.	6–6½	5 8 0	March	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94–97	4 2 6	Jan, July	..	–
5	5/0	St. James' & Pall Mall Elec. Ord.	9–9½	5 5 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7–7½	4 13 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85–90	3 18 0	Jan, July	..	–
5	..	Smithfield Markets Electric Sup. Ord.	[illegible]	..	Feb	[illegible]	..
5	4/0	South London Electric Supply Ord.	2¼–3¼	6 8 0	April	–	..
St.	..	Do. 5% 1st Mort. Stk. Red.	[illegible]	..	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	–	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	[illegible]	5 7 0	Feb, Aug	1	–
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100–103	4 7 6	April, Oct	..	–
5	2/6	Urban Electric Supply Ord.	⅝–1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1⅛–2⅜	11 15 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80–84	5 7 3	April, Oct	83	..
5	5/0	Westminster Elec. Sup. Ord.	8⅝–9⅜	5 7 0	Mar, Sept	8⅞	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛–5½	4 11 0	Jan, July	5¼	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	93–100	4 0 0	Jan, July	99	98½
1	..	Bath Elec. Trams Pref. Ord.	¼–⅜	..	April	..	.
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝–¾	6 13 0	Jan, July	..	–
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87–91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89–92	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	7¾–8¼	7 9 8	Feb, Aug	..	–
10	4%	Do. Cum. Pref. (fully paid)	8½–8¾	4 11 5	..	..	–
St.	4%	Do. 4 per Cent. Debs.	100–101	3 19 2	Feb, Aug	..	–
10	..	British Electric Traction Ord.	1½–1⅝	..	June, Dec	1	[illegible]
10	8/0	Do. 6 per Cent. Cum. Pref.	2⅞–3⅜	8 13 0	Feb, Aug	3	2⅞
St.	5%	Do. 5 per Cent. Perpetual Debs.	92–95	5 5 0	April, Oct	91½	91½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	65–72	6 5 0	May, Nov	71	[illegible]
St.	3½%	Central London Ordinary Stock	65–67	5 4 9	Feb, Aug	65	91½
St.	4%	Do. 4 per Cent. Pref. Stock	85–87	5 12 0	Feb, Aug	.	..
St.	2½%	Do. Deferred Stock	41–51	4 18 0	Feb	41½	..
100	4%	Do. 4 per Cent. Debs.	102–104	3 16 6	Jan, July	[illegible]	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92–94	4 5 0	Jan, July	–	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾–5¼	4 15 0	April, Oct	..	.
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97–101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	32–33	4 9 0	Feb, Aug	3	32
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110–112	4 9 0	Feb, Aug	..	..
St.	5%	Do. (1895)	103–109	4 11 0	Feb, Aug	–	..
St.	5%	Do. (1901)	103–115	4 15 3	Feb, Aug	..	–
St.	5%	Do. (1903)	93–96	5 4 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99–101	3 19 0	May, Nov	.	–
10	6/0	Dublin United Trams. Ord.	—	4 15 0	Feb, Aug	..	–
10	6/0	Do. 6 per Cent. Pref.	13–14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	[illegible]	..	Feb, Aug	..	–
10	..	G. Northern, Picc. & Brompton 4% G.P.	8½–[illegible]	—	Feb, Aug	[illegible]	[illegible]
St.	4%	Do. 4 per Cent. Deb. Stock	94–9[illegible]	4 3 0	Jan, July	[illegible]	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2–2½	..	Mar, Sept	[illegible]	–
St.	4½%	Do. 4½ Db. St.	82–87	5 3 6	April, Oct	.	..
10	6%	Imperial Tramways Ord.	5½–6	8 0 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6¾–7½	7 15 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	87–89	5 1 11	Jan, July	..	–
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅛	..	Mar, Sept	..	–
St.	4%	Do. 4 per Cent. Deb. Stock	57–62	6 9 0	Jan, July	..	–
10	6/0	Lanarkshire Tramways	[illegible]	5 15 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91–93	5 7 6	Jan, July	..	.
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	–	–
10	5%	Do. 5 per Cent. Pref.	[illegible]	5 [illegible]	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	8[illegible]–1	4 1[illegible] 3	Jan, July	–	..
10	2/0	London United Trams. 5% Cum. Pref.	1–[illegible]	..	Jan, July	.	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	7[illegible]	5 [illegible]	Jan, July	..	–
St.	—	Mersey Con. Ord. Stock	1–2	—	Feb, Aug	–	..
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April	.	..
1	0/6	Do. 5 per Cent. Cum. Pref.	—	5 15 0	Feb, Aug	[illegible]	[illegible]
St.	4½%	Do. 4½ per Cent. Deb. Stock	9[illegible]–101	4 9 0	Jan, July	99½	..
St.	[illegible]	Metropolitan Railway Consolidated	[illegible]	1 5 6	Feb, Aug	[illegible]	[illegible]
St.	3%	Do. Surplus Lands Stocks	[illegible]–71	4 4 6	Feb, Aug	70	69
St.	3½%	Do. 3½ per Cent. Preference	89–91	3 17 0	Feb, Aug	90	89
St.	3½%	Do. 3½ per Cent. "A" Preference	82–84	4 3 6	Feb, Aug	83	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82–84	4 3 6	Feb, Aug	8[illegible]	82
St.	3½%	Do. 3½ per Cent. Debenture Stock	93–95	3 13 3	Jan, July	94	9[illegible]

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., June 16.	Rate % Yielded (£ s. d.)	Dividend Due	Business Week to June 16 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS— *Continued.*					
St.	3½	Met Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	94	93½
St.	..	Metropolitan District Railway Ord.	17 —17½	..	Feb, Aug	17½	16⅞
St	..	Do. Extension Pref. (5 per Cent.)	40 —42	..	Feb, Aug	41½	39½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	68 —70	5 0 0	Feb, Aug	–	–
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	78 —80	3 15 0	Jan, July	–	–
St.	4%	Do. 4 per Cent. Midland Rent-charge	103 —106	3 15 6	Jan, July	105½	..
St	6%	Do Guar Stock 4 per Cent.	89 —92	4 7 0	Mar, Sept	90	89
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	141 —143	4 3 9	Jan, July	141½	..
St.	4%	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	...	...
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	–	May	..	–
1	..	Potteries Electric Traction Ord.	[illegible]		April, Oct	..	–
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 0 0	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb Stock	86 —89	5 1 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	[illegible]	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db.	84 —88	5 14 0	Jan, July	84	..
..	...	UndergdE.Rys.Lon.6 In.bds.with coup.9	38 —40	..	June, Dec	..	..
..	..	Do. 5% Prior Lien Bonds	101 —102	4 18 0	..	102¼	102
–	4½	Do. 4½% Bonds with coup 8	89 —91	4 19 0	..	90½	89⅞
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	–	March ..	..	–
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	–	–	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	86 —90	5 0 0	Jan, July	–	–
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	[illegible]	..			..
1	[illegible]	Do. 6% Cum. Pf.	[illegible]	7 3 2	April, Oct	[illegible]	..
1	[illegible]	Babcock & Wilcox Ord.	4½—4¾	4 14 0	April, Oct	4½	..
1	0/7½	Do. Pref.	1⅛—1⅜	4 6 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅞—7¾	6 9 6	July, Feb	..	...
5	3 0	Do 6 per Cent. Pref.	6¼—6⅝	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	107	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	[illegible]		Feb, Aug	¾	–
100	..	Do 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0		98	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	40 —44	9 2 0	Jan, July	43	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	43 —48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	..	..
5	10 0	Callender's Cable Con. Ord.	9¾—10½	7 2 9	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	–	–
1	1/0	Castner-Kellner Alkali Co.	[illegible]	6 17 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —106	4 4 0	Feb. Aug	103½	..
	0 7½	Chadburn's (Ship) Telegraph Ord.	1 —1¼	6 4 0	March ..	..	..
	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	5 14 0	April, Oct	..	..
1	[illegible]	Consolidated Electrical Co.	[illegible]	5 4 0	August ...	–	..
1	1/0	Consolidated Signal Co.	1¼—1½	7 5 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	1	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	1 —1½	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	94 —97	5 2 6	Jan, July	..	–
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	–
5	2/0	Dick, Kerr & Co. Ord.	[illegible]	8 0 0	Sept	–	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	4 16 9	Sept ...	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	½—¾	–	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	–	–
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	70 —75	5 6 8	June, Dec	..	–
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
..		Edmundson's Elec. Corp. Ord.	[illegible]	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 8 0	Jan, July	–	–
2	..	Electric Construction Co.	[illegible]	..	Jan, July	½	[illegible]
2	[illegible]	Do. 7 per Cent. Cum. Pref.	1½—1¾	9 6 8	July	[illegible]	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59 —63	6 7 0	Jan, July	[illegible]	..
10	5/0	General Electric (1900) 5% Cum. Pref....	7⅝—7⅞	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	10/8	Henley's Telegraph Works Ord.	11⅞—12⅜	6 2 6	Feb, Aug	..	..
5	2/3	Do 4½ per Cent. Pref.	[illegible]	4 3 6	Feb, Aug	5	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	104 —106	4 5 0	Mar, Sept	..	..
10	15/6	India Rubber, Gut. Per., &c., Wrks.	14½—15½	6 10 0	Feb, Aug	15½	14½
10	..	Do 5 per Cent. Cum. Pref.	10½—11		..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	99½	–
1	..	National Elec. Construction Co.	½—⅝	..	April.....	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	[illegible]	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock	83 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	–		..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	–	–	..	–
12	24/0	Telegraph Construction & Maintenance	32½—34	5 6 0	Mar, July	33½	33¼
100	4%	Do. 4 per Cent Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1 0	Vickers, Sons & Maxim, Ltd., Ord.	[illegible]	4 10 6	–	[illegible]	[illegible]
1	0/6	Do. 5 per Cent. non-Cum. Preference	[illegible]	4 8 0	–	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	108½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	101 —103	3 17 6	June, Dec	102½	101½
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	102½ —104½	4 6 0	June, Dec	104	..
10	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	104½ —106½	4 14 0	..	105½	105⅝
10	..	J. G. White & Co. 5% Cm. Pref.	9 —10	6 0 0		..	..
1	1/0	Willans & Robinson Ord.	[illegible]	3 15 0	Apr, Oct	..	..
5	3/0	Do 6 per Cent. Cum. Pref.	[illegible]	9 4 0	Apr, Oct	3	2½
St.	4%	Do 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3½	–	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	94 —96	5 3 6	June, Dec	..	..
St.	15 0	Anglo-American	57 —59	5 12 0	F,My,Ag,N	57	56½
St.	30 0	Do. Preferred	99 —100	6 0 0	F,My,Ag,N	100	99
St.	3 0	Do. Deferred	15 —15¼	2 12 6	F,My,Ag,N	16⅛	15 1/16
St	4%	Commercial Cable 4 per Cent. Deb. Stk.	90½—92½	4 6 6	Jn,Ap,Jy,O	91¼	90
10	6 0	Cuba Submarine Ord	[illegible]	6 1[illegible] 0	Feb, Aug	..	–
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	–
5	2 0	Direct Spanish Ord	2⅞—3⅜	5 18 0	April, Oct	–	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9	5 9 0	April, Oct	–	..
50	4½%	Do. 4½ per Cent. Deb	100% —102%	4 8 0	Jan, July	..	..
20	4/0	Direct United States Cable	12⅞—13⅛	6 5 9	Ja,Ap,Jy,O	12⅞	12⅞
100	4½%	Direct West India Cable 4½% Bg. Db. (rd.)	101 —103	4 7 0	June, Dec	101½	..
St	15/0	Eastern Ordinary	132 —135	5 4 6	Ja,My,JyO	133½	132
St	17/6	Do. 3½ per Cent. Pref. Stock	85 —86½	4 1 0	Ja,My,JyO	86½	85½
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 16 0	May, Nov	..	..
St	6,6	Eastern Extension	11⅞—12⅛	6 13 0	Ja,Ap,Jy,O	12 1/16	12
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	102¼	..
25	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	3 18 0	May, Nov	..	..
10	16 0	G N. (of Copenhagen), with Coupon 76...	27 —28	6 8 0	Jan, July	28	27⅞
100	4½	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	101 —103	4 7 6	June, Dec	..	..
..	32 6	Indo-European ex all	61½—62½	5 16 9	May, Nov	...	–
100	$1	†Mackay Companies Common	80 —84	4 16 0	Ja,Ap,Jy,O	–	..
100	$1	†Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April....	[illegible]	[illegible]
1	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	100 —102	3 18 0	June, Dec	..	–
2½	1/3	West Coast of America	1⅛ —1⅜	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
10	..	West India & Panama	[illegible]	..	May, Nov	[illegible]	[illegible]
10	6/0	Do. 6 per Cent. 1st Pref	[illegible]	6 17 0	May, Nov	[illegible]	–
10	[illegible]	Do. [illegible] 2nd Pref.	8 —9	6 13 6	May, Nov	[illegible]	–
100	5%	Do. 5 per Cent. Debs.	102 —104	4 16 6	Jan, July	–	..
10	3 0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	13⅞	[illegible]
..	4%	Do 4 per Cent. Deb Stock (red.)	101½—103½	3 16	June, Dec	102½	101½
...	4%	Western Union Telegh. $1 000 4% Bonds	93 —95	4 6 0	..	..	..
		TELEPHONES.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	145 —146	5 12 6	..	145¼	[illegible]
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98½—100½	3 19 6	Jan, July	..	[illegible]
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100—102	4 18 0	Mar, Sept	..	–
5	3.0	Chili Telephone	8 —8⅜	4 16 0	August ..	..	–
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..	–
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	–
St.	6%	National Co. Pref. Stock	107 —108½	5 10 6	Feb, Aug	107⅞	[illegible]
St.	6%	Do. Def. Stock	120 —122	4 18 6	Feb, Aug	122¾	[illegible]
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11	5 9 0	Feb, Aug	..	–
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —10¾	5 11 6	Feb, Aug	..	–
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5⅞	4 7 0	Feb, Aug	5⅜	[illegible]
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	98½	[illegible]
St.	4%	Do 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	102	[illegible]
1	1/0	Oriental	[illegible]	5 7 6	April, Oct	[illegible]	[illegible]
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	4 17 6	April, Oct	[illegible]	[illegible]
St.	4%	Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	89½	[illegible]
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	[illegible]
5	3/0	United River Plate	[illegible]	5 13 3	July	7	[illegible]
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	June, Dec	..	[illegible]
St.	4½%	Do. 4½ Deb. St. Red.	104 —105½	4 5 0	Jan, July	–	[illegible]
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅛—3⅝	8 5 0	Jan, July	..	
10	2 0	Globe Telegraph & Trust	10¾—11½	5 2 0	SpDeMrJu	11⅛	
10	8/0	Do. 6 per Cent. Pref.	12¾—13¼	4 10 6	SpDeMrJu	13⅛	
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	128[illegible]	
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅛—6⅜	4 14 0	April, Oct	[illegible]	
5	5/0	Do. 10% Non-cum. 2nd Pref.	9½—9¾	5 2 6	Jan, July	9⅝	
St.	4%	Do. 4% Deb. Stock	94 — 96	4 3 6	June, Dec	94½	
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102½ —104½	4 15 6	Jan, July	..	
5	3/6	Brisbane Electric Trams. Invest. Ord.	5¾—6⅛	4 19 0	May	6 1/16	
5	2,6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	5 1/16	
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	103 —107	4 4 0	Jan, July	105½	1½
St.	8%	British Columbia El.Ry.Df. Ord.	143 —147	5 6 9	Mar, Sept	..	
St.	6%	Do. Pref. Ord. Stock	122 —123	4 17 6	May, Nov	123½	1½
St.	5%	Do. 5% Cum. Perp. Pref. Stock	109 —112	4 9 0	Jan, July	..	
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	103	
St.	4½%	Do. 4½% Perp Con. Deb. St.	98½ - 100½	4 4 6	–	100½	
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98½—100½	4 19 6	Mar, Sept	99½	
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96 —100	6 0 0	Feb, Aug	..	
5	2/0	Calcutta Tramways (1 to 137,610)	4⅜—4¾	4 14 9	Mar, Sept	4⅝	
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 18 0	Jan, July	..	
1	4½%	Do. 4½% 1st Deb. Stock (red.)	100 —103	4 7 0	Jan, July	100	
St.	..	Cape Electric Tram Shares	⅛—⅜	..	..	..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅜—5⅞	4 5 6	F,My,A,N	5 1/16	
St.	4%	Do 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..	
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	..	
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	95 —98	5 2 0	Feb, Aug	..	
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..	
100	5%	†Do. 5 per Cent. "A" Deb. Stock	87 —90	5 11 0	Jan, July	..	
5	6%	†Do. 6 per Cent. "B" Ditto	63 - 67	9 0 0	Jan, July	..	
5	1/0	Lisbon Elec. Trams. Ord.	15/16 —1 1/16	4 14 0	July	..	
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Jan, July	–	
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	90 —91	5 7 0	Jan, July	–	
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —96	5 4 0	Jan, July	..	
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	94 —97	5 2 6	Feb, Aug	..	
100	$1½	Mexico Trams Co Com. St.	143 —145	3 9 0	..	143	[illegible]
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92 —94	5 6 3	..	93½	92
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..		–
1	0/6	†Perth Elec. Trams Ord.	[illegible]	7 5 0	May	..	–
St.	5%	Do. 1st Mt. Db. Stock	103 —106	4 15 0	Jan, July	–	
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5⅞	5 2 0	..	5½	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	109 —102	4 8 0	..	..	
100	..	Rio Janeiro Tram, Lt. & P. Co.	97 —99	..	..	10[illegible]	9[illegible]
..	5%	Do. 30 yr. Gold Bnds.	95½— 96½	5 2 6	..	96½	96
100	5%	Do. 50 yr. Mt. Bnds	84½ — 86½	..	..	85¼	84½
–	$1½	Sao Paulo Tramway, Light & Power Co. $100 Stock	154½ -156½	6 8 0	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	96½—98½	5 1 6	June, Dec	97½	..
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½ —10	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95½—97½	4 12 6	Jan, July	96[illegible]	95½
5	4,9	†Calcutta Elec. Supply Ord.	5¾—6¼	6 8 0	April, Oct	[illegible]	[illegible]
100	$1½	Canadian Gen. Elec. Co. Com. St.	120 —123	5 11 0	..	[illegible]	121½
100	$3½	Do. 7% Cm. Pf. Stock	120 —122	..	..	121½	[illegible]
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —101	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	88 — 90	5 11 0	–	88½	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	1¾ —2	..	Feb, Aug	..	–
St.	5%	Do. 5 per Cent. Deb Stock	89 —92	5 8 0	Jan, July	–	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	83 —91	5 10 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅝—2	–	..	..	..
10s	4%	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	[illegible]	–
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	6 17 0	April, Oct	[illegible]	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83 —85%	5 17 0	..	85	84½
St.	$1	Mexican Lt. & Power Co. Com. St.	70 —73	6 3 0	–	73	72½
500	5%	Do. 5% 1st Mort. Gold Bnds.	87 —89	5 12 0	..	88¼	87
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	123 —127	4 14 6	F,My,A,N	126½	123½
1	1/7½	River Plate Electricity Co. Ord.	1⅜—1½	5 6 8	April	[illegible]	..
1	1 2⅜	Do. 6 per Cent. non-Cum. Pref	[illegible]	5 4 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	103 —107	4 13 6	Jan, July	106½	..
5	8/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅝—5⅞	5 6 6	April, Oct	[illegible]	–
100	$1	Shawinigan Water & Power Co. Ca	94 —96	4 3 3	–	96½	96
..	5%	Do. 5 per Cent. Bds.	107 —109	4 11 6	Jan, July	105	107
St.	4½%	Do 4½ Per. Con. Mt. Db St.	96 — 98	4 12 0	–	98	97
..	6d.	Victoria Falls Power Co. Pref.	[illegible]	5 18 0	Jan, July	[illegible]	[illegible]

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. *Ex* dividend. † The London Stock Exchange Committee have declined to quote these

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NOTES.

The Municipal Electrical Association.

THERE can be no doubt that such an engineering meeting as that held in Manchester during the present week is potential of a great deal of good. Those who listen to the Papers, and even those who read them, learn much; those who discuss them still more, and those who ponder them over and put the suggestions into practice in their own stations, perhaps learn most of all. There is plenty to think about this year. By immemorial custom the presidential address is immune from discussion, but had it been open to debate then in all probability the remainder of the week's meeting would have been devoted to it, unless the closure had been applied with a rigour more familiar in another assembly.

MR. PEARCE's address is given on another page of this issue, so that details as to its contents are unnecessary here, but we may be permitted to congratulate him on the breadth of view shown and range of subjects dealt with. It certainly provides food for reflection, as well as discussion, though the experience obtained at Manchester may not always be directly applicable to a smaller undertaking. The view MR. PEARCE takes as regards contributions from the profits of a municipal trading undertaking to the relief of rates is the same as that so often expressed by ourselves; and in spite of the fact that Ald. HOLT advanced very plausible arguments on the other side, we agree that increased contributions in relief of rates "should be resisted as detrimental to the best interests of trading concerns." Again, if municipalities are to be traders they should be treated as such, and should not be made to disclose preferential terms granted to large users. If the ratepayers are dissatisfied with the state of things, they have their remedy—every year or every three years. It may be conceded that, in general, municipal officials have the welfare of the public at heart, and any undue inquiry into ways and means is to be discouraged.

THE Paper by Councillor SINCLAIR on "Cheap Units" had one attribute of a good Paper; it provoked a hearty, though sometimes rather long-winded, discussion. Some speakers agreed with the Author, some did not, and we leave our readers to determine for themselves in our next issue the relative merits of each argument advanced. It was, however, disappointing to notice that many engineers who really deal in cheap units, like MR. DAY, of Bolton, MR. SEABROOK, of West Ham, and even MR. PEARCE himself did not take part in the discussion. Perhaps their methods do not include, or need, such complications as "chopping off peaks" and "come-on discounts." The net result, as far as can be seen, left everybody where they were at the start, each being convinced that his methods were right—perhaps they are for the particular problem to be solved.

AT the Liverpool meeting on Wednesday, MR. HOADLEY's Paper on the "Influence of Metallic Filament Lamps" gave rise to an interesting discussion, if discussion it could be called. It consisted mainly of various councillors and engineers bringing forward details of the results obtained with metal lamps as regards life, reduction of load, &c., in their districts, or of the results that they hoped would be obtained in the future. MR. FEDDEN was decidedly pessimistic, and thought that the worst was yet to come, though Councillor DYKES considered the "rot" might be stopped if dealt with in the proper way. From such a variety of facts it is difficult to draw anything like a general conclusion on the whole question. Local conditions are practically the greatest determining factors, and what applies in Sheffield need not, and in fact will not, apply in Beckenham. The same remark as to a detailing of local conditions applies to the discussion on MR. HOLLINGSWORTH's Paper.

WE take this opportunity of congratulating Mr. S. L. PEARCE on his admirable conduct of the arduous duties of chairman. His task has been no easy one, owing to the large number of speakers in waiting and the short time available, but he has come through the ordeal with great and even enhanced credit. Would that all chairmen displayed the same discrimination as he has done.

Small Power Stations.

FROM time to time we have drawn attention to the desirability of small towns obtaining a supply of electrical energy, as far as possible, from existing power companies or large municipal undertakings in the neighbourhood, and we are pleased to see that the idea of co-operation is also endorsed by Mr. S. L. PEARCE in his presidential address to the Incorporated Municipal Electrical Association. If desired, the smaller undertakings can, of course, purchase the electrical energy "in bulk" and act as distributors, whilst obtaining the benefit of the economical generation of current by the larger undertakings. Although there is a growing tendency to proceed on these lines, and for co-operation between neighbouring undertakings, there are many cases where small towns are far removed from the field of operation of a power company or of a large electric supply authority. Chichester may be cited as a case in point. In the past many such towns similarly situated, after obtaining provisional orders, have hesitated to proceed with an electric supply scheme. In other countries, often well provided with water power, and always permitting less onerous conditions, the financial difficulties in giving a supply of electricity are not so great, with the result that a large number of small power supply stations have been constructed. The Diesel oil engine, however, appears to prove a convenient prime mover for isolated situations in this country, and, if we may judge by the results achieved at Leatherhead, there is no doubt that it is also a very economical source of power. This point—the diminution of works costs—is extremely important in small undertakings, and too much attention cannot be paid to the use of oil and gas plant under such conditions. The most recent station to be equipped with plant of this type is that at Chichester, a short account of which will be found elsewhere in this issue, and if the results expected are obtained in actual practice, there is little doubt that greater developments may be looked for in the equipment of small stations in this country.

The "G.B." System.

IN view of the great interest which has of late been taken in the "G.B." system of electric traction, the accounts of the Lincoln Corporation tramways undertaking and the annual report of Mr. S. CLEGG, city electrical and tramways engineer, for the year ended March 31st last, are of importance at the present time. It appears that the working expenses for the year amounted to 5·60d. per car-mile, a considerable reduction on the figure of 6·10d. recorded a year ago; but perhaps the most interesting feature is the reduction in repairs and maintenance from 1·25d. to 1·12d. per car-mile. Of the sum of £731 appearing under this heading, £522 is allocated to cars—*i.e.*, a saving of nearly £60, compared with the previous year, notwithstanding an increase of 7 per cent. in the number of car-miles run. Most interest, however, will be taken in the cost of repairs to the electrical equipment of the line, and at first sight the increase from £75 last year to £148 in the present accounts appears unfavourable, when it is remembered that the "G.B." Company guaranteed the annual cost of upkeep not to exceed £90. The engineer explains in his report, however, that the latter figure has really not been exceeded, since the amount stated in the accounts contains the cost of alterations at a railway crossing, also a sum of £15 for improvements, which will give the parts affected longer life, and of £16 for maintaining feeder cables, cleaning feeder access boxes, conduits, &c. The net result is that only £82 is chargeable to the direct upkeep of the "G.B." system; but this seems to leave little margin over the guaranteed figure, considering that the guarantee applied to the first 10 years' operation of the system. On the other hand, it is explained that several special repairs have been carried out which are not likely to occur again in the near future, whilst the stud heads throughout the track have been packed up, so that it is expected the estimated five years' life will be realised. In view of the number of unforseen repairs necessitated in the past, the future operation of the system will be watched with interest, but it must be admitted that the present repairs and maintenance expenses are considerably higher than those of the majority of tramway undertakings, although the total working costs are considerably below the average.

Electrical Signalling.—It is stated that the two existing signal cabins at London-road station, Manchester, are to be replaced by one large electrical cabin. The alteration will be made in connection with an important extension scheme being carried out by the London & North-Western Railway Co.

Personal.—Mr. James Graves, who has been for 43 years superintendent of the Valentia station of the Anglo-American Telegraph Co., has, to the great regret of his directors, retired upon pension. Mr. Graves has been led to take this step owing to ill-health since February last, and on the urgent advice of his son, Dr. Walter J. Graves, of Boston, Mass., who came to Valentia to attend him. Mr. Graves has so far recovered as to be able to take an occasional drive. His many friends will wish him a speedy return to good health and long years of well-earned rest.

Mr. H. D. Wilkinson.—Our readers will sympathise with Mr. H. D. Wilkinson in the great bereavement which has overtaken him by the death of his sister, Miss Florence Wilkinson, and his cousin, Miss Emily Wilkinson, in the boating disaster which occurred on the Lake of Killarney on Wednesday afternoon, by which nine lives were lost. Miss Florence Wilkinson had broken down in health, and was seeking restitution from a visit to this charming resort. Mr. Wilkinson, who was greatly distressed at the sad news, has proceeded to Killarney.

Royal Society.—Among the Papers read at the meeting held yesterday afternoon were the following: "The Effect of a Magnetic Field on the Electrical Conductivity of Flame," by Prof. H. A. Wilson, F.R.S.; "The Electrical Reactions of certain Bacteria, and an Application in the Detection of Tubercle Bacilli in Urine by means of an Electric Current," by Mr. C. Russ; "Sensitive Micro-Balances, and a New Method of weighing Minute Quantities," by Messrs. B. D. Steele and Kerr Grant; and "The Polarisation of Secondary γ-Rays," by Dr. R. D. Kleeman.

Cable Interruptions.	Date of Interruption.
Dakar—Conakry	May 13, 1909
Tangier—Cadiz	May 19, 1909
Cayenne—Salinas	June 7, 1909
Paramaribo—Cayenne	June 8, 1909
Tourane—Amoy	June 17, 1909
Trinidad—Demerara	June 21, 1909

Tramways and Light Railways Association.—The "Official Circular" for June announces the formation of a special committee to examine suitable speed indicators and to report thereon, and a translation is given of the Paper on rail corrugation read by the chief engineer of the Great Berlin Tramways before the International Tramway Congress, held at Munich last September, together with other matters bearing on the same subject. A list is also given of the applications for light railways made during May, 1909.

The Value of Radium.—It is stated that the British Metalliferous Mines (Ltd.) have agreed to supply 7½ grammes of pure radium bromide to Lord Iveagh and Sir Ernest Cassel for presentation to the Radium Institute. The radium is to be obtained from Cornish pitchblende, and the value is given as £4 per milligramme—*i.e.*, £114,000 per ounce. Additional interest is attached to the gift on account of the large amount of radium to be obtained, which is many times greater than any previous order.

Royal Society of Arts.—The Albert Medal of the society has been awarded for the current year to Sir Andrew Noble, F.R.S., for his researches in connection with explosives.

The Council have awarded the Society's silver medal to the following readers, among others, of Papers during the session, 1908-9: Mr. G. Albert Smith, "Kinematography in Natural Colours"; Mr. Walter Rosenhain, "The Application of the Microscope to the Study of Metals"; and Herr Sam Eyde, "The Manufacture of Nitrates from the Atmosphere by the Electric Arc."

Large Canadian Water-power Scheme.—A company has been formed for utilising the falls of the St. John River, at Grand Falls, New Brunswick, in the generation of electrical energy for power. It is proposed to erect a power station at Grand Falls of 60,000 kw. capacity, whence the power will be transmitted to St. John, Fredericton, and other points in New Brunswick and the State of Maine. It is probable that part of the power may be used for the electric operation of the Grand Trunk Pacific Railway, now in course of construction between Quebec and Moncton. Mr. H. F. Parshall, who has been retained to report on the project, is now on his way to New Brunswick, and Mr. E. Parry, who has been associated with Mr. Parshall for many years, is accompanying him.

Merchant Venturers' College.—Under the terms of the charter, the faculty of engineering of the University of Bristol will be provided and maintained by the Society of Merchant Venturers in their technical college. The principal of that college (Prof. J. Wertheimer, B.Sc., B.A.) will be ex-officio dean of the faculty and will also hold the post of professor of applied chemistry in the University, while the following professors in the college will hold corresponding posts in the University; viz., Prof. J. Munro, A.R.C.S., professor of mechanical engineering; Prof. E. S. Boulton, M.A., B.Sc., professor of applied mathematics; Prof. D. Robertson, B.Sc., professor of electrical engineering; and Prof. W. Morgan, B.Sc., professor of motor car engineering. Mr. F. R. B. Watson, B.Sc., will hold the post of lecturer in mechanical engineering, and Mr. H. A. M. Borland, A.R.C.S., that of lecturer on applied chemistry.

Institution of Electrical Engineers.—Full particulars of the forthcoming students' tour to Germany have now been issued. The party will leave London by the 8:30 p.m. service from Liverpool-street on Friday, July 9th, and travel to Berlin, arriving on Saturday evening, July 10th. Sunday is to be spent in Berlin. On Monday, July 12th, the various works of the Allgemeine Elektricitäts Gesellschaft will be visited, and Tuesday morning is also to be devoted to the turbine shops of that firm, whilst in the afternoon a visit will be paid to the electrical engineering department of the Königliche Technische Hochschule, Charlottenburg. On Wednesday the works of Messrs. Siemens-Schuckert and of Messrs. Dr. Cassirer & Co. will be inspected, whilst the programme for Thursday includes visits to the Reichsanstalt and to the works of Messrs. Bergmann & Co. The party will leave Berlin on Friday morning for Cologne (the arrangements for Saturday in that city are not yet completed) and will start the return journey on Saturday evening, arriving in London about 8 a.m. on Sunday, July 18th, but the tickets will allow members to prolong their visit, if desired. A circular will be issued a few days before the visit giving the final arrangements.

Obituary.—With deep regret we learn of the unexpected death of Mr. Alfred Charles Monkhouse Weaver, a member of the electrical staff of the Eastern Extension Telegraph Co. at Singapore, who was home on leave, and appeared to be in the best of health only a few days ago. Mr. Weaver early last week was attacked with acute appendicitis, underwent an operation at St. Thomas's Home, Westminster, and was apparently making satisfactory progress. A relapse, however, occurred on Monday, and Mr. Weaver passed away on that day, to the great regret of a very large circle of friends in the telegraph world both at home and abroad. Mr. Weaver received his early training at Messrs. Siemens Brothers' works at Woolwich, and joined the Eastern Extension Company's service at Singapore in 1880, on the electrical staff at the cable depot. At the time of his death he was assistant manager of the company's cable depot at Singapore. He was an able electrician, and had carried out many important cable-laying operations during his long service with the company. By his death submarine telegraphy loses a keen and competent electrician, the Eastern Extension Company a valuable officer, and the staff of the company a kind and genial comrade. Mr. Weaver was in his forty-eighth year. The funeral will take place to-day (Friday) at Brompton Cemetery, London, S.W., at 12:30 a.m.

The death occurred a few days ago of one of the few remaining veterans of the early telegraph service, Mr. George Frederick Deacon, of 16, Great George-street, Westminster, and Coombe Wood, Addington. Mr. Deacon was born in 1843 at Bridgwater, was educated at Heversham and Glasgow University, and in 1865 accompanied the Atlantic Telegraph Expedition on the "Great Eastern" as assistant to Lord Kelvin. In 1897 he was president of the mechanical science section of the British Association meeting at Toronto. He held the Telford, the Watt, and the George Stephenson medals of the Institution of Civil Engineers, and was a writer on many scientific and engineering subjects.

ARRANGEMENTS FOR THE WEEK.

20 30/60

FRIDAY, June 25th (to-day).

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

10:30 a.m. Annual General Meeting at the Municipal School of Technology, Whitworth-street, Manchester.

1 p.m. Luncheon at the Midland Hotel, Manchester.

2:30 p.m. Visit to the Salford Electricity Works at Frederick road, Pendleton.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: (1) "A Transition Point in Zinc Amalgam," by Prof. Carhart; (2) "A Method of producing an intense Cadmium Spectrum, with a proposal for the use of Mercury and Cadmium as Standards in Refractometry," by Dr. T. M. Lowry, F.C.S.; (3) "On the Measurement of Wave-length for High Frequency Electrical Oscillations," by Mr. A. Campbell, B.A.; (4) "An Electromagnetic Method of studying the Theory of and solving Algebraical Equations of any Degree," by Dr. A. Russell and Mr. J. N. Alty; (5) "The Sine Condition in relation to the Coma of Optical Systems," by Mr. S. D. Chalmers; (6) "Exhibition of a New Féry Thermo-electric Calorimeter," by Dr. C. V. Drysdale; (7) "An Instrument for measuring the Strength of an Intense Horizontal Magnetic Field," by Mr. F. W. Jordan, B.Sc.; (8) "On a Method of determining the Sensibility of a Balance," by Prof. Poynting, F.R.S., and Mr. G. W. Todd, M.Sc.; and (9) "The Balance as a Sensitive Barometer," by Mr. G. W. Todd, M.Sc.

SATURDAY, June 26th.

INSTITUTION OF MINING ELECTRICAL ENGINEERS.

7 p.m. Meeting in the Lecture Theatre, North of England Institute of Mining and Mechanical Engineers, Newcastle-on-Tyne, to nominate officers for representation on the General committee. A report of the progress of the institution will also be presented.

TUESDAY, June 29th.

FARADAY SOCIETY.

7:45 p.m. Annual General Meeting at the Institution of Electrical Engineers, 92, Victoria-street, S.W. To be followed at *8:15 p.m.* by an Ordinary Meeting, when the following Papers will be read: "Researches on the Relative Rates of Migration of Ions in Aqueous Solution," by Mr. R. B. Denison, D.Sc., Ph.D.; "Apparatus for the Rapid Electro-analytical Separation of Metals," by Mr. H. J. S. Sand, Ph.D., D.Sc.; and "The Conditions which determine the Composition of Electro-deposited Alloys," by Mr. S. Field, A.R.C.S.

THE INFLUENCE OF METALLIC FILAMENT LAMPS ON THE ELECTRICAL INDUSTRY AND ON STREET LIGHTING.*

BY E. E. HOADLEY.

(Chief Electrical Engineer, Maidstone.)

¶ *Summary.*—The author regards the advent of the metal lamp as a blessing, though possibly in disguise for a time, even to the average alternating-current station, and is of opinion that electric heating and cooking, rather than the raising of prices, should be looked to as a remedy for any drop in revenue. In order to benefit by the new lamps to the utmost, however, undertakings should have the power to raise money for wiring and for letting apparatus on hire. Interesting figures are given showing the excellent results achieved by metal lamps in street lighting.

This Paper may be divided into two main divisions, the first being the effect of the metal lamp on the manufacturing and selling branches of the industry, and the second its effect on the supply station branch; the first part of the subject being treated very briefly. From the point of view of most manufacturers of generating plant the metal lamp is anything but a blessing, since it will keep the peak load in a generating station from rising at anything like its normal rate for a year or two to come, and in many cases will actually reduce it; and it is the peak load which determines whether extension plant is wanted or not. Cable makers, however, may not be so unfortunate. On the manufacturing side, the reapers of the harvest brought about by metal lamps will be first and foremost the lamp makers themselves; and next, the accessory makers. Although not directly affected by the lamp *per se*, the author has very little doubt but that the makers of motors and of cooking and heating apparatus will be beneficially affected by its introduction. The wiring contractor should, and the author think does, reap a decided benefit from its introduction.

Now as to the point of view of the supply station engineer; here, again, there is a multiplicity of standpoints. It is practically impossible to take a single example, and, after exhaustively studying the facts presented, to lay down general rules or to make general deductions. The result of the introduction of the metal lamp varies according to whether the station supplies alternating or continuous current, whether the output is solely for lighting, or is made up of power, lighting and traction; and if the supply is practically a lighting supply whether that supply has a large proportion of shop lighting, or is to a great extent residential. Taking the case of the alternating-current stations first, these may be roughly divided into two classes—those stations in manufacturing districts supplying two or three-phase current and having a large proportion of their output used for power; and the single-phase stations, most of them of somewhat ancient date and generally supplying an area in which the demand is chiefly for the lighting of residential property.

Considering the latter case first, as it is undoubtedly these stations which will feel the pinch first and will feel it hardest. Generally the property they supply is of the better class; houses whose owners will face the outlay demanded by a transformer and metal lamps with equanimity. In most cases the houses supplied are sufficiently well lighted already, and the same amount of light for a greatly reduced amount of money will be obtained. In most of the towns in question gas is not particularly cheap, so that a large proportion of the available houses already take a supply; thus, purely for the lighting supply, it is doubtful if new consumers will come along fast enough to take all the units that existing consumers will save. Even if they do, it means that the capital charges per unit sold will be increased, as although the generating plant will not need addition, yet new mains and services must be provided, and in such residential towns these are generally an expensive item per consumer, and with the poor load factor generally prevalent, capital outlay should be kept as low as possible. To stations of this class it must be confessed that the outlook is not particularly rosy for the next few years, and it can hardly be wondered at that several are considering the raising of prices. In some special cases this may be the right policy, but the author is of opinion that what may be called the domestic uses of electrical energy should be pushed as widely and as hard as possible—heating and cooking in the better class houses are not exploited nearly as much as they should be.

Where an alternating-current station has the benefit of a good shop lighting load and at the same time supplies a fair amount of power the metal lamp should be looked on as a blessing in disguise, for a short period if you will, but still as a blessing, for the amount of harm done to the revenue account now will be amply repaid later on.

Most engineers of continuous-current stations, particularly of those where the pressure is 200 volts or over, look with distinct favour on the lamp, but even they must look further than some of them have done up to the present, namely, to the time when a lamp of 16 c.p., or even smaller, can be obtained for all pressures commonly in use, and at a price which will be but little in advance of the selling price of the ordinary carbon filament lamp. It is all a question of supply and demand—a parallel case can be cited in the case of the gas mantle.

To get the utmost good from the metal lamps it is practically certain that most central stations owned by municipalities must have legal rights and privileges which they do not at present possess. In the opinion of the author the first and foremost necessity is that municipal bodies generally should have the power to raise money for the purposes of wiring houses and other premises, and for letting out cooking and heating apparatus as well as motors on hire and hire purchase. This raises points of a controversial nature as to the rights of private traders and municipal interference, but surely if this matter is looked at in the right light it is the contractor as well as the supply authority who is going to reap the benefit. Most municipal bodies would be quite satisfied if the powers were granted with the proviso that the wiring work should be done by contractors; with regard to cooking and heating apparatus how many contractors could truthfully say that an appreciable source of income will be taken from them if the supply authority is allowed to hire heating stoves, ovens, and things of like nature, it being understood that the wiring for these is done by a contractor. In this connection, if it be good law for some 44 towns to possess these powers, then how stupid and how typical of British legislation it is for the rest to be denied them unless they go to the expense of a special act; further, if it be fair and just for the gas companies themselves to do all these things and many others besides, is it more unfair to the electrical contractors than to gas fitters, that electricity supply authorities should possess equal or similar powers. In the author's opinion, the gas companies are to be congratulated for doing everything themselves, for who is more interested in seeing that the consumer is satisfied than the supplier of the commodity—electrical engineers have too long been content to sell the consumer electricity whereas it is light or heat that he buys, and it is vital to the interest of the supply authority to see that he is satisfied with the amount of heat or light that he gets for the money he pays. But how can this be done when the supply authority is bound down by silly restrictions and is spied upon at every step by the officials of the local gas company to see that these restrictions are not broken. A determined effort should be made to get these necessary powers—necessary at least to all supply authorities except those in our large manufacturing towns where the connecting up of consumers of a quarter or half a million units annually excites no comment.

Next to the above comes the necessity for cheaper wiring. A large number of systems of cheap wiring are now in course of evolution and the success already obtained with some of them has provoked the ire and the pens of interested parties. The author can state from his own experience that the Continental system of flexibles on special insulators requires a lot of beating—among other places, he has tried it in the damp warm atmosphere of a conservatory for 18 months without the slightest trouble. With cheap wiring, the necessary powers to hire out cooking and heating apparatus, wiring and fittings, and the improvements in cooking and heating apparatus which are bound to come with extended experience, most central stations should be able to look on the metal lamp as an ally and not as an enemy. To the above advantages should be added the very important fact of a large reduction in the selling price of the lamp.

Provided it can be arranged that central stations can obtain the advantages set out above, viz., extended powers, cheaper wiring and cheaper lamps, it is the author's opinion that a new era of prosperity for the greater part of the electrical industry will begin, and in the meantime supply engineers should do their utmost to counteract any disadvantage there may be in a falling revenue from purely lighting consumers, by pushing into prominence the many other uses of electrical energy, some of which have up to the present been seriously neglected.

In the field of public street lighting the importance of the new invention cannot be over-estimated; up to the present its full effect has not been considered, and the author feels sure that when engineers and committees responsible for the lighting of streets have fully realised the possibilities of a lamp with an efficiency of approximately 1 watt per candle-power, that can be obtained in single units giving candle-powers ranging from 50 to 1,000, there will be many schemes of street lighting by arc lamps and by incandescent gas that will be altered and modernised. Up to the present most streets lighted by incandescent gas at ordinary pressures, in towns where electric light mains are laid, are so lighted chiefly on the score of

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* Abstract of a Paper read before the Incorporated Municipal Electrical Association on Wednesday.

cheapness, the supporters of gas lighting claiming that electric light was beaten in the competition, as the light given by carbon or other lamps available up till recently was not equal to the light of an ordinary gas mantle; while for many streets the cost of arc lighting, even with the lamps spaced as far apart as possible, was prohibitive. Whatever truth there was in these statements then has considerably altered now, for an ordinary 60-watt metal lamp without any reflector will, from the point of view of the ordinary public, produce the same results as a good gas mantle in the heyday of its youth, while with reflectors the effect can be considerably increased. The other advantages, from an electrical point of view, are that no special mains are necessary, with the same fitting different candle-power lamps graded according to the importance of the streets can be employed, lamps that fail can be renewed at any time without trouble, the candle-power of the lamp does not appreciably diminish with age, and last, but not least, the average life of the lamps is a revelation. In the author's own experience, some 18 months has given an average life of very nearly 1,100 hours, individual lamps lasting 6,750, 5,450 and 5,044 hours on a circuit at 230 volts where a large and fluctuating power demand does not make for a particularly steady volt chart.

In conclusion, the author would urge all station engineers to unite in trying to obtain what he considers the necessary powers to enable them to utilise to the full the immense power put into their hands by this epoch-marking invention, and by themselves getting into personal contact with their consumers, putting before them the great advantages of more light for the same money instead of the same light for less money.

(An abstract of the discussion appears on p. 433)

MODERN CABLE SYSTEMS.*

BY E. M. HOLLINGSWORTH.

(Chief Electrical Engineer, St. Helens.)

Summary.—Aluminium cables are first discussed; the author then proceeds to consider the properties of various insulating materials for underground cables. He finally describes the methods of laying cables, giving his experience and opinion of the different systems.

Aluminium.—For overhead transmission lines aluminium has been used for many years with satisfactory results; it is also being used for 'bus bars, lightning arresters, fuse strips, &c., but until quite recently it had not been tried for the conductors of insulated cables. Compared with copper conductors of equal conductivity, aluminium conductors are 50 per cent. lighter in weight, and 28 per cent. greater in diameter. Beyond a probable saving in carriage the reduced weight does not affect the question of insulated cables, that is, with copper and aluminium at present prices. In the matter of increased diameter the advantage of a greater cooling surface is obtained, but against this there is the extra insulating and sheathing materials required, and the necessity of using troughs or conduits of larger size. From the experience obtained with overhead conductors, the behaviour of the metal is such that it should be quite as reliable as copper for the conductors of insulated cables, provided, of course, that the insulating materials are free from any matter that might cause deleterious action.

There is some little difficulty in the matter of jointing and making connections to the conductors. So far a satisfactory solder has not been produced, and, therefore, the joints have to be made by means other than those usually employed for copper conductors. For cables of large section liable to be subjected to considerable strain the mechanical joint is the most satisfactory, and for this purpose clamps of aluminium should be used in preference to those of brass or copper in order to prevent oxidisation. For cables of small section the joints can be made on the moulded principle, molten aluminium heated to a dull red being poured into an iron mould, in which the cable ends have been clamped. In any case it is very probable that the joints will require more skill and will take longer to make than in the case of copper, and will, therefore, be somewhat more expensive.

With copper at the price of £60 per ton and aluminium at £65 per ton, there is an advantage in favour of the latter for single-core cables above the equivalent of 0·05 sq. in. of copper. Taking cables having the equivalent of 0·1 sq. in., 0·2 sq. in. and 1 sq. in. copper conductors, there is a saving of 15, 20, and 30 per cent. respectively. With triple concentric and three-core cables the difference is less.

Rubber Insulation.—For underground work, rubber-insulated cables have almost entirely dropped out of use, chiefly owing to the fact that they are considerably more costly than vulcanised bitumen or paper-insulated cables, and that they have not proved permanently satisfactory. Mr. Highfield informs the author, however, that the Metropolitan Electric Supply Co. has some rubber cables working at 3,000 volts which have been in use for over 18 years, but this is a very exceptional case.

Vulcanised Bitumen Insulation.—For medium pressure systems vulcanised bitumen cables are used instead of rubber cables for the reason that they are considerably less costly and have more lasting qualities. Compared with paper insulation, vulcanised bitumen claims the advantage of being absolutely non-hygroscopic, thereby obviating the necessity for lead sheathing, but too much reliability must not be put on this material to exclude moisture permanently, for although moisture that is neutral, or acid, has little or no action, moisture that is at all alkaline will attack this cable, and under certain conditions rapid deterioration takes place, the material becoming a spongy mass and, of course, no longer waterproof. It is certainly the best plan to lay vulcanised bitumen cables underground on the solid system to prevent as far as possible contact with deleterious matter.

These cables are very extensively used in collieries where the conditions generally are damp and where in the case of the pit shaft the question of weight is an important factor, for a single-core vulcanised bitumen cable of 0·1 sq. in. section is only half the weight of the equivalent paper-insulated lead-covered cable. Such cables should be handled very carefully, more especially in cold weather, otherwise the insulation is liable to crack. When laid on the solid system they should be supported at distances short enough to distribute the pressure and prevent possible decentralisation. Unfortunately, this class of cable has to be bought more or less on faith, for it is a difficult matter to distinguish between a good and inferior cable, and the only test is that of constant use and time. Cables suitable for a working pressure of 600 volts should be tested at the makers' works to at least 2,500 volts alternating current for half an hour. The insulation resistance for a 0·1 sq. in. and 1 sq. in. cable should not be less than 100, and 50 megohms per mile, respectively. The use of a paper separator will increase these figures. At 60°F. it should be possible to bend an all-bitumen cable round its own diameter several times without fracturing the insulation, but if a separator is used the test will be limited by the material of which the separator is made.

Paper Insulation.—For all systems and pressures paper insulation is used, as it possesses the advantages of high dielectric strength, greater durability and low electrostatic capacity. For the last reason it is the most suitable insulation for telephone, telegraph and high-tension cables. It is strong, does not soften under heat, and is not liable to crack, and cables so insulated can be safely worked at a greater current density. The chief drawback to this class of insulation is its susceptibility to moisture, which necessitates lead or other sheathing to render it waterproof, and, of course, the reliability of the cable is dependent upon the sheathing remaining intact. Precautions must also be taken when jointing. The use of the proper quality of paper, its treatment and application are of great importance, for upon these largely depend the life of the cable.

When lead-covered cables were first introduced there were many prophecies as to the troubles that were likely to result from the action of electrolysis, but practical experience has not sustained these early views. In the matter of bonding, the leads cannot be connected too frequently, and the bonds should err on the substantial side to ensure as low a resistance as possible. Whatever arrangements are to be made at the joint and disconnecting boxes, it is also advisable to bond across them as an additional precaution. Good sturdy bonds of lead strip are far superior to copper wire. They have the advantage of being of the same metal as the sheathing, and, therefore, less skill is required to make a connection to ensure permanent contact without injuring the cable.

Considerable discretion is necessary in the placing of earth plates, otherwise the dangerous conditions may be intensified rather than reduced. Likely places are those where the cables cross under a tramway track or are laid in the vicinity of negative feeders, for in the majority of such cases the lead sheaths will be found to be positive to the track. It is advisable to keep a record of all the earth plates, and they should be tested as frequently as possible to see that the conditions remain unchanged.

Systems of Laying Cables.—The "direct" system finds favour where the initial outlay is a consideration; and for cables placed where there is little danger of mechanical injury, and where the soil is of a sandy nature and free from acids and organic matter, this system is very suitable. In one or two towns plain lead-covered cables are laid in the ground and protected with creosoted timber or tiles, but with these exceptions all the cables laid direct are armoured with steel tape or galvanised iron wires. Where space is limited,

* Abstract of a Paper read before the Incorporated Municipal Electrical Association on Wednesday.

or where many underground structures such as cellars, drains, &c., are encountered, armoured cables laid direct have obviously an advantage over any other system. Their flexibility can also be taken advantage of in laying cables in localities where the ground is likely to settle. Although comparatively little of this cable is in use at St. Helens, it has given more trouble than all the rest of the network. For one reason the soil, being impregnated with acids, quickly rotted away the jute covering, and in places the armouring entirely disappeared. In nearly every case the faults occurred in single-core cables, the triple concentric cables giving little or no trouble. It must be admitted that 10 or 11 years ago the manufacturer did not pay that attention to the armouring of the cable that it is receiving at the present day, and probably the importance of bonding and earthing the lead sheathing and the armouring was not then realised.

The "solid" system is very little more expensive and is almost as flexible as regards laying as the direct system, and cables laid in this way are better protected from external influences than when laid in any other way. Stoneware troughs appear to have superseded to a great extent those of wood or iron; for one reason they are as cheap as wood, considerably cheaper than iron, more durable, and if properly glazed inside and outside, proof against chemical action. They have, however, the disadvantage of being only about 2 ft. long, which of course means an increase in the number of joints in a given length. Butt-jointed troughs should not be used. For bitumen cables bitumen filling is used, but, comparatively speaking, very little bitumen is now used with lead-covered cables, good pitch reduced by a suitable oil being found satisfactory and very much cheaper. Pitch has also the advantage of a lower melting point than bitumen and does not require the same care in filling, and in the case of a fracture there is a better chance of it healing again. To reduce the cost still further, some engineers use a mixture of sand and tar, but as this requires to be kept in a constant state of agitation, and even then does not flow as freely as pitch, there is some risk attached to its use. The minimum thickness of filling should not be less than ½ in., and to ensure an even thickness the bridge pieces should be placed at suitable intervals, usually 18 in. apart, but never exceeding 2 ft., depending upon the size and weight of the cable. It is absolutely necessary that bridge pieces should not be porous. There is very little to choose between the properly compounded wood pieces and those made of glazed stoneware. Asphalt pieces are probably the best, but are considerably more costly. Another support which is being used very extensively is the "Ruthven Murray" iron strap, the use of which ensures the filling getting all round the cable, but it is of importance that the iron strap and lead sheathing should be in clean contact, otherwise local electrolytic action may be set up.

When cables are laid through a busy thoroughfare, or where a great many of them are banked together, the system in which they are drawn into conduits or pipes is the only one suitable. This system is the most costly in the first instance, but it provides for future extensions, and it admits of the cables being got at in case of breakdown without disturbing the street and interfering with the traffic. Unfortunately, in practice it is not possible to lay conduits through a street for any great distance and maintain a straight course, and, therefore, on this account many manholes are required which considerably adds to the cost. There is also the question of keeping the conduit dry and free from gas, a very difficult matter, but one that is met to some extent by sloping the conduit, and draining and ventilating the manholes. Some engineers, where possible, construct conduits of greater height than width, thus having the fewer ways, which will be the wet ways, at the bottom.

Of the various materials employed in the construction of conduits, cast iron, fibre, and glazed stoneware are in most common use, and many engineers have decided in favour of the latter in one form or another. A conduit constructed of cast-iron pipes gives good mechanical protection, and compared with stoneware has the advantage of fewer joints, but it is more expensive and does not give that secondary insulation, which is a great advantage in some cases. On several occasions the author has found it impossible to draw out of a cast-iron pipe a length of cable that had failed. Apparently the lead of the cable had soldered itself to the pipe. The author understands that fibre ducts treated with bituminous compound are satisfactory when laid in concrete, and cheaper than iron pipes. It is claimed that they are proof against acids and alkalis, and that they do not absorb moisture to any extent. Where a great many ways are required one good method is to build up in concrete with single ducts the number of ways required, care being taken to prevent the cement at the joints from entering the ducts. This type, provided not less than nine ways are installed, represents the cheapest form of conduit. It is the practice of some engineers to cover the cables from side to side of the manholes with asbestos braid and then to coat them over with a special paint. The large-sized covered cables that are drawn into conduits should not be jute covered, as there is a tendency for the covering to be torn off and to jamb the cable, but in the case of small service cables where the lead is comparatively very thin a jute covering is necessary for mechanical protection.

Subways.—Extensions are likely to be a very difficult problem in connection with some streets where the underground structures are already very much congested. For this reason the author thinks that subways are likely to be more generally adopted in the future, and he gives a short description of the one in use in St. Helens. This is down the two principal thoroughfares and is 6 ft. 6 in. high, and 5 ft. 6 in. wide, nearly half a mile in length, with an entrance at each end and one midway, and with lateral ways at the intersections of the other streets. With the exception of a 4½ in. ring of blue bricks forming the inner arch, it is constructed entirely of concrete. The cost, including the lateral ways, was £7 per linear yard, and the electricity department's share of the capital and maintenance charges is £90 per annum. The cables are supported on strong racks, and the average cost, including the racks and the placing of the cables is about 1½d. per yard of cable. The feeders and distributors are connected to distribution boards placed in a chamber at the centre entrance to the subway.

Overhead Conductors.—A brief description is given of the system that has been in use in connection with the St. Helens Corporation scheme since 1902. By means of overhead conductors a supply of energy at 500 volts direct current, with one side earthed, is given to several glass works and collieries situated within a radius of two miles from the power station, but separated by rough ground impregnated in places with chemical waste. For this reason it was quite out of the question to lay cables underground, and the Board of Trade being convinced of this consented to the conductors being placed overhead. Details of the construction are given in the Paper. The cost of the work, exclusive of the conductors, was £220 per mile, and for each pair of conductors erected must be added £170 per mile. If copper conductors were replaced by aluminium at present prices the cost would be for each pair of conductors £120 per mile. For comparison the cost of equivalent underground mains, *i.e.*, two 0·15 sq. in. cables, laid solid in earthenware troughs, would be £800 per mile.

In an appendix to the Paper the author gives comparative costs of various types of cables and methods of laying them.

(An abstract of the discussion appears on p. 433).

STEAM TURBINES.*

FROM THE USERS' POINT OF VIEW.

BY A. S. BLACKMAN.

(Borough Electrical Engineer and Manager, Sunderland.)

Summary.—The author first gives his experience of the relative advantages of the impulse and reaction types of steam turbines, and discusses the most efficient combination of power and speed. After discussing turbines *v.* reciprocating engines, he passes on to condensing equipment and exhaust steam turbines. Valuable information as to the reliability and cost of maintenance of turbines, based on experience at Sunderland, is also given in the Paper.

The present situation of the steam turbine industry is a battle for supremacy between the impulse and reaction types, and while the partisans of each type claim all sorts of wonderful advantages, yet the following statements are put forward as representing the point of view of a user who has studied the problem from all sides. (1) All turbines must fulfil a certain law of combination of blade speed and number of running rows. (2) Steam expanding between boiler pressure and condenser must generate a certain velocity, and this velocity must be imparted to the revolving mass in small increments as in the Parsons machine, entailing many rows of blades, or in larger increments as in the Zoelly or Curtis machines, or in one increment as in the Laval. (3) The fewer the rows of running blades, the higher must be the speed at which the blades run, and consequently the higher the speed of the steam impinging on the blades. (4) The impulse type turbine runs at a much higher speed at blading than the reaction type, and necessitates particular attention being given to the design of the wheels and blades, owing to the greater stresses that prevail. (5) The impulse type turbine lends itself to a more mechanical-looking construction than the reaction type. (6) The reaction type, as illustrated by the best Parsons type, is more economical than the impulse type. (7) For speeds of 3,000 revs. per min. and below 1,000 kw. the impulse type is better than the reaction. (8) For speeds of 1,500 revs. per min. and up to 3,000 kw. the reaction type has, up to the present, proved most satisfactory. (9) For speeds of 1,000 and 750 revs. per min., and up to the largest

*Abstract of a Paper read before the Incorporated Municipal Electrical Association on Thursday.

sizes likely to be used, there is absolutely no evidence that the impulse type can compete in reliability or economy with the Parsons type.

Output and Speed.—Too little attention is given nowadays to selecting an efficient combination of power and speed. Take two instances: (1) 750 kw. on 50 cycle, and (2) 1,500 kw. on 40 cycle. Firstly, the frequency being 50, only two speeds can be considered, viz., 3,000 revs. per min., with a two-pole machine, or 1,500 revs. per min., with a four-pole machine. Many engineers have selected the slower speed in putting down their installations, but there is no argument in reason which can be given against the higher speed, as the high set speed will: (1) be more economical by about 10 per cent., (2) take up less floor space, (3) be about 15 per cent. cheaper in first cost. The same remarks apply also to the 40 cycle plant. A very good rule to follow, and one which should be insisted on, is: Choose the size of your unit to suit the highest speed that the frequency will allow, and here the assistance to be obtained from external fan cooling of the generator should not be overlooked, because the higher the speed at which the set is run, the greater the benefits which will be obtained from a turbine installation. At Sunderland we have a 1,500 revs. per min. Willans-Dick, Kerr combination, installed to carry a load of 2,000 kw. continuously, and 2,500 kw. for two hours, and the economies effected by this plant have been most pronounced.

For direct-current turbo sets the merits of the tandem machine must not be lost sight of. For a given size unit the advantages accruing from tandem machines are many, for instance: (1) By putting in tandem generators, the speed of the set can be increased by about 75 per cent. with all the attendant advantages, as already pointed out. (2) The electrical portion being divided into two, there is only 50 per cent. of the machine out of commission should troubles of any sort arise. The writer recently heard the remark of a well-known dynamo designer, that if direct current was wanted the best way of providing it was to put down turbo alternators, and use motor generators for conversion to direct current, but it is to be hoped that the serious commutation difficulties of a few years ago are being surmounted, and in this respect the radial brush gear of the Westinghouse Co. looks promising on paper.

Turbines v. Reciprocating Engines.—It is impossible to draw any definite line of demarcation as to at what size of unit it becomes advisable to adopt turbines in preference to reciprocating engines. For instance, the temperature and quantity of circulating water affects the situation very seriously. Every case calls for a detailed investigation. There is, however, not the slightest doubt that with the higher speeds at which it is now possible to run turbo-generators, the proposition of turbines versus engines will soon disappear, and it will be a case of turbines only; in fact, it is even now difficult to prove a case for the reciprocating engine under any ordinary conditions. The Brush Company, who have made a speciality of small turbo-generator sets, give the following typical figures for a 300 kw. plant: With dry steam at 160 lb. per square inch the reciprocating engine with 26 in. vacuum takes 24 lb. of steam per kilowatt-hour, whilst the turbine at 28 in. vacuum requires only 22 lb. With steam superheated 100 deg., these figures become $20\frac{1}{2}$ lb. and $19\frac{3}{4}$ lb. respectively. The capital cost of the two plants complete with condensers is practically the same.

The conditions for a turbine installation can be summed up as follows: (1) 150 lb. per square inch steam pressure (because at higher pressures the volume becomes small and leakage percentages are increased, with only a small gain in B.Th.U.'s available). (2) 150 deg. superheat (because there is no appreciable gain in plant over-all economy above 150 deg. superheat). (3) Highest possible speed. (4) Best vacuum possible (because it is the strongest feature in turbine working, and it will pay to maintain as high a vacuum as possible).

Condensing Equipment—A vacuum should be selected with an equivalent temperature about 25 deg. above the available temperature of circulating water, and should be always maintained. An inch drop in vacuum will mean a 5 per cent. rise in the coal bill. The writer has found a vacuum recorder kept under lock and key, worth considerably more than its weight in gold, and is of opinion that the field for improvement in condensing plant is even greater than in turbines.

There are three main types of condensing plant: Surface, low-level jet and barometric. Parsons augmentor plant is, in the writer's opinion, undoubtedly the best form of condensing plant. As a rule, the capital cost of surface condensing plant will be rather higher than either jet or barometric condensers. Jet condensers require rather more power than surface plants. On account of air entrained with the circulating water, very complete air extracting apparatus is necessary. Barometric condensers are very satisfactory, provided every precaution is taken to prevent air leakage and ample passage way is given to steam and water. The power taken for pumping is, however, slightly in excess of other types, but from the writer's experience it makes a very satisfactory installation. A great point is the uniformity of the vacuum which can be maintained owing to the absence of cooling surfaces which become dirty and therefore inefficient. It is probable that this type of condensing plant has been kept back owing to the fact that when used with reciprocating engines the presence of oil in the exhaust steam puts difficulties in the way of using the hotwell water for boiler feed purposes. With turbines this difficulty has, of course, disappeared, and it is possible that barometric condensing plants will be more heard of in future; they are certainly more easy to maintain at their best than surface condensers.

Reliability.—Sunderland experience has shown the Willans-Parsons turbine to be absolutely trustworthy. For over 16 months the bulk of the work has been done by the 2,000 kw. turbine plant of this make, running at 1,500 revs. per min., and during the year ended March 31 last no less than 87 per cent. of the whole output was generated by this one turbine plant. Such dependence upon a single unit calls for the utmost reliability, and after fairly lengthy experience of both high-speed, piston valve and slow-speed, Corliss valve reciprocating engines, the writer trusts the turbine with equal confidence to either of these alternatives.

Maintenance.—The writer is of opinion that maintenance costs on steam turbine plant (consisting of turbine, alternator and condensing plant) complete should not exceed, say, £100 per annum per 10,000,000 units generated. As a matter of fact, the maintenance of the Sunderland 2,000 kw. plant for the year ended March 31st last, including opening the turbine twice to measure clearances, came to less than £35. The Sunderland turbine exhausts into a barometric condenser, and it is probable that the maintenance costs would be greater upon a surface condensing plant. As regards wear upon the turbine itself, it appears to be negligible, and most careful examination has failed to reveal any signs of blade erosion.

Exhaust Steam Turbines.—The advantages of the exhaust steam turbine do not appear to be fully appreciated, even at the present time. As compared with a high-pressure turbine, an exhaust steam set requires about double the steam, and the gain due to high vacua is more than twice as great. The machine can be of robust construction owing to there being no necessity for fine clearances, and, moreover, the temperature distortions are small. The impulse type can be of very simple construction for exhaust steam working, but does not, upon the other hand, lend itself so well to economical working as the reaction type. Many present day condensing engine plants, with a good supply of cold water for circulating, could be increased in output by 25 per cent. without any appreciable extra expense, save the capital cost of the exhaust turbine installation; it is, however, the exception to find such plants in electricity works.

Costs.—Sunderland experience shows the cost of working with turbine plant to be much lower than with reciprocating engines. The 2,000 kw. set was tested on setting to work, and again on the expiration of one year and two months' work, during which time the plant ran over 9,000 hours, and generated over 9,000,000 units. The steam consumption on a $27\frac{1}{2}$ in. vacuum was 17·07 lb. of steam per unit on one test, and 17·1 lb. on the other. As regards oil, which was logged separately from the other plant, the total cost for the year ended March last was for the turbine £13. 8s., and for the turbine auxiliaries £18. 8s. 6d., a total of £31. 16s. 6d., equivalent to 0·000953d. per unit generated.

(An abstract of the discussion appears on p. 434).

HEATING OF UNDERGROUND CABLES.*

BY J. R. DICK, B.SC.

In every cable used for electrical distribution some of the energy transmitted is converted into heat, the rate of conversion being proportional to C^2R, where C is the current (supposed uniform) and R is the resistance. This transmission loss is to some extent unavoidable, but it must be kept within definite limits for several reasons.

In the first place, the resistance of the cable increases with the rise in temperature—0·4 per cent. for 1°C., or 10 per cent. for a total rise of 25°C. The drop in pressure is affected in the same proportion, and in the case of a 25 deg. rise, with a cable closely calculated for the current it had to carry, the current density might possibly have to be diminished merely to obviate this additional drop, apart from any other consideration.

 From a forthcoming book by Messrs. J. R. Dick and F. Fernie.

For a cable working at a high load factor the extra loss of energy due to the enhanced resistance from heating can scarcely be neglected. With ordinary types of underground mains the effect of heating on the regulation or the economy is of less importance than the physical results it may produce on the insulating covering. Most of the impregnating liquids for fibre or paper cables will begin to vaporise in air at 100°C. At lower temperatures the tendency to vaporisation would be much smaller, but it is highly probable that any re-actions taking place at the higher temperature would tend to be produced, although in a corresponding less degree. Where vulcanised bitumen is used as the dielectric the temperature must be limited with special reference to the tendency of the conductor to decentralise when hot, and for this reason the permissible current-densities for this class of cable are less than the usual values.

The great engineering desideratum with buried cables is that they should require a minimum of maintenance, and that they should never be run under conditions that would cause any shortening of their useful life of 30 or 40 years. The greatest current density that can be permitted in a buried cable depends entirely on the maximum temperature which the insulation can safely stand. The rise of temperature, in its turn, is dependent on several factors in addition to the quantity of heat produced per unit length, chief among which are the following :—

1. The character of the load, whether of long or short duration and of constant or variable value.

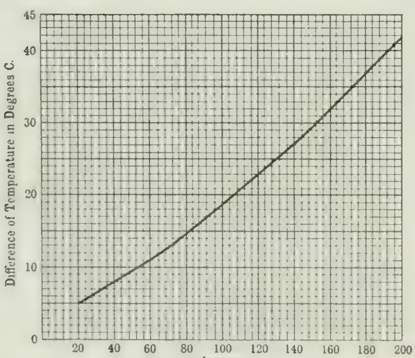


Fig. 1.

2. The depth of trench in which the cable is laid and the character of the soil, whether wet or dry.

3. The size of the conductors carrying the current.

4. The method of laying, whether in ducts or direct in the ground, singly or several cables bunched in the same trench.

In a cable carrying a steady current the final temperature is only attained after several hours, the exact period depending on the conductivity for heat of the soil, its specific heat and the temperature at the surface of the ground. The relation between the rise in temperature and the current is indicated in Fig. 1. When the values of the temperature with respect to time are plotted in a curve its form resembles that of the successive readings at short intervals of a Wright demand indicator under a constant current, until they become asymptotic to the final value.

The physical reason is the same in both cases. In Fig. 2 the "time lag" is illustrated graphically (curve A) for a single armoured cable laid direct in the ground, and also the effect produced by bunching the cables. Curve B refers to a group of nine cables of the same cross-section as the single one, and each carrying the same constant current. The temperature in the latter case rises more quickly and ultimately attains a higher value. From these curves it is apparent how important it is to know how the cable is laid.

The character of the soil, except for the amount of moisture it contains, does not affect materially the curve of temperatures. In perfectly dry earth the final temperature of a cable is found to be about 10 per cent. higher than that of another tested under the same conditions but with 20 per cent. of moisture in the soil. As it is but rarely that cables are laid in ground devoid of moisture, the effect produced by its varying amount can be safely neglected.

The physical law of the flow of heat from the cable into the ground is analogous to that of the potential gradient in the insulation of a cable, and can be expressed by a similar logarithmic formula. If the temperature at the surface is considered as zero, the flow of heat at any point upwards from the cable will obey the heat analogue of Ohm's law—C=V/R.

The corresponding quantities to C, V and R are : C=quantity of heat flowing at any point, and, therefore, $=C^2R$ for unit length of the cable at its surface$=\frac{C^2}{KS}$, V=temperature, t and R=reciprocal of heat conductivity or heat resistance. This quantity diminishes as the distance from the cable increases.

If x is the depth measured from the zero surface the formula becomes

$$\frac{C^2}{KS}=\frac{1}{A}\cdot\frac{t}{\log x},$$

where A is a constant.

This formula is of great use in co-ordinating the experiments on which all the tables of permissible current-densities are based, and also in the interpolation of intermediate values not given in the tables.

If it should for any reason appear desirable to work at a different temperature to that of the table the formula readily

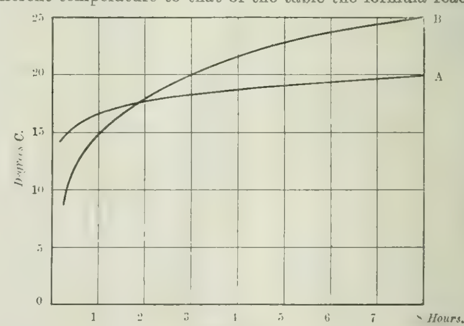


Fig. 2.

enables the result of the change to be calculated. When the concentric "zero" surface is assumed to pass through that of the ground

$$\log x = \log\frac{2l}{d},$$

where l is the depth of the trench and d is the diameter of the cable. It is found, however, that this assumption does not harmonise with the experimental results so closely as that expressed by the equation $\log x=\frac{4l}{d}$. The reason of this is not far to seek, for the heat produced in the cable cannot remain in the ground, but must ultimately be radiated into space. Consequently, the earth's surface is not the true surface of zero potential, and, although at different seasons of the year the amount of radiation will vary greatly, the zero surface is indicated accurately enough by the relation $\log x=\frac{4l}{d}$. The graphical agreement between this expression and the experimental facts is indicated in Fig. 3, which represents for a number of cables of different sizes.

$$\frac{SK}{C^2}\cdot t = y = A\log x=A\log\frac{4l}{d}.$$

The straight line graph of this function, allowing for errors of

observation, coincides very fairly with the actual results of experiments.

To facilitate the interpolation of current-densities not given in the usual tables the formula is conveniently written

$$C = M\sqrt{\frac{St}{\log\frac{4l}{d}}}$$

where S is in square inches, t is temperature in degrees C., and l and d are in inches. With these units the value of the constant M is approximately 0·46.

In using a table of current-densities the facts it embodies should be carefully borne in mind. A rise of temperature of 25°C. is taken as the standard, as it has been found to be quite safe

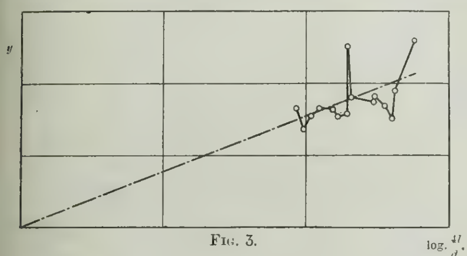


FIG. 3.

for ordinary conditions of working with a pair of single cables laid direct in the ground. If they are drawn into stoneware ducts the same current applied for the same period will cause the temperature to rise about 10 deg. higher. For cables laid in this manner, therefore, only about 75 per cent. of the values given in the tables should be employed. Where several cables lie in the same trench a corresponding diminution should also be made.

In view of the time-lag in the attainment of the final temperature, a higher current-density can be permitted where the load is only of short duration, as in the case of certain feeders at times of peak. Some latitude can also be given with cables supplying rapidly fluctuating loads, such as lifts, cranes, rolling mills, &c. The extent to which this is allowable can be ascertained by taking the square root of the mean of C^2 just as

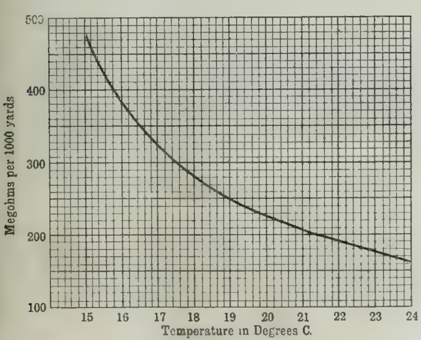


FIG. 4.

in the exact application of Kelvin's law. The only other variable in the expression is l, the depth at which the cable is laid. In the tables this is taken as 28 in., which agrees with general practice, leaving special cases to be dealt with by the help of the formula.

In dealing with three-core cables it is found to be sufficiently accurate to take the sum of the cross-sections of the conductors, and, after selecting the maximum current corresponding to a single cable of equivalent area to this sum, to divide it among the three conductors proportionately to their respective cross-sections.

A similar method is applicable to triple concentric cables, except that the maximum current should be about 10 per cent. less than given by the calculation, on account of the inferiority of the heat conduction of the insulation between the conductors. Concentric instead of single cables would appear to be disadvantageous for feeders on account of the higher temperature produced in them with the same current density. For example, a 0·25 concentric will only carry 300 amperes, as compared with 390 amperes if the conductors were laid separately. Thus, the section of a concentric feeder, especially if laid in a stoneware duct, could seldom be calculated in accordance with Kelvin's law of Economy, for the current-density satisfying the latter condition might cause too high a rise of temperature. Consequently, concentric cables will be heavier, and, inclusive of laying, will probably prove more costly.

It has frequently been stated that there is a great likelihood of the insulation breaking down under dielectric stress when the cable is running hot. Careful experiments have failed to verify this, although they have proved that the insulation resistance in megohms diminishes very considerably at high temperatures, a phenomenon shown graphically in Fig. 4. An increase of 20°C. will cause the insulation resistance of a paper cable to drop to 3 per cent. of its value at ordinary temperatures, but this has no observable effect on the dielectric strength (*see* Paper by E. Jona, St. Louis International Congress, 1904). The crucial factor in fixing the safe limit of current-density would, therefore, appear to be the temperature below which the chemical stability of the dielectric remains unaffected.

Mention may be made of another consequence of the heating of cables.

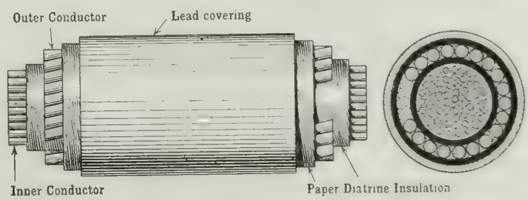


FIG. 5.—EXPANSION CABLE. TWO-CORE CONCENTRIC, 0·5 SQUARE INCH.
(Scale: Half full size.)

This is the possibility of the fittings in joint and disconnecting boxes being so strained by alternate expansion and contraction that the electrical connections are ultimately broken, or great difficulty may be found in replacing the links after they have been removed for testing.

With lead-covered cabes, particularly when drawn into ducts so that there is plenty of freedom for movement, the plumbed joints are liable to be broken.

Mr. H. Gray, of Accrington, who has given considerable attention to this phenomenon, has devised and patented a special construction of cables for taking up the expansion at every point along their length. Cables of this kind are now being made by Messrs. Glover.

A sufficient amount of play is allowed between wire and wire on the same lay, and all motion due to contraction or expansion is taken up locally, so that no bodily displacement of the ends can occur. The illustration of a concentric cable built to this specification (Fig. 5) will render the principle clear.

With a "solid" or "armoured direct" system the effects of temperature changes are naturally less serious than with drawn-in cables, but even with them trouble will be experienced if they are laid too taut in cold weather.

Society of Engineers.—We would remind our readers that Wednesday next, June 30th, is the last date on which Papers will be received in connection with the "Status Prize" of this society. Particulars of the competition were given in our issue of March 19 last, p. 870.

SOME NOTES ON POWER SUPPLY IN BOLTON.

To the man in the street, in that or any other town, Bolton does not appear very different from the ordinary Lancashire town. There is the same air of dampness over all, the same cobbles on the roads and the same clogs on the feet of the inhabitants ; but to the electrical engineer, just lately, the town of Bolton has become of greater interest, owing to the way in which its Electricity Department, and especially its Borough Electrical Engineer, have taken up the question of electric power supply, and have almost obtained the ideal of being able to make the power, rather than the lighting, their staple load. For this reason it will probably be of interest to give some details of the plant by which these excellent results are obtained, and, as far as possible, to describe some of the installations which are supplied from the mains of the Bolton Corporation. This latter desideratum, however, will be practically impossible, owing to the fact that the various manufactureres are averse to giving away details and to having photographs of their plant taken—a state of mind which is inexplicable to the ordinary journalist.

To deal first with the matter historically, the Bolton electricity works were started 14 years ago on the site which they at present occupy, but, of course, on a much smaller scale. Single-phase alternating current at a pressure of 2,000 volts and a frequency of 83 was generated, and this supply was transformed in sub-stations in the centre of the town to a secondary pressure of 200 volts. This arrangement was, naturally, not at all suitable for power supply, and, as an interesting sidelight on the way electricity supply was looked upon in those days, it may be mentioned that the undertaking was under the control of the Gas committee.

This (in these enlightened days) antiquated method of distributing electrical energy was continued until 1900, when tramways were laid down and continuous-current plant had to be installed for supplying them. The central area of supply was then provided with current for lighting and power by means of low-tension feeders, the sub-stations mentioned above, one of which is shown in Fig. 1, being used as distributing centres. The single-phase alternating-current network was, and still is, used for the supply of outlying districts for lighting, but the central area is now all supplied by means of continuous current.

The next development came in 1906, when a three-phase system of supply was also installed. The plant for this consists of two large three-phase slow-speed sets generating current at 6,500 volts and a frequency of 50. These sets are fitted with barometric condensers, which are placed outside the engine room, and with Edwards air pumps in the engine room.

As is by this time well known to our readers, a very pushing policy in regard to power supply has recently been adopted by the Bolton Corporation ; while for these purposes three-phase current has been mainly used. The bid which has been made for a large day load, by lowering the price for current supplied during daylight hours and for power purposes, has been very successful, as will be seen when it is stated that the horse-power of motors installed at the present time is considerably over 9,000, and is still increasing at a rapid rate, a result which it will be agreed is highly satisfactory when comparison is made with other towns of population equal to that of Bolton, and when the well-known inertia of the British manufacturer is taken into account.

The three-phase supply is, however, not entirely used for power purposes, a certain portion of the energy thus generated being converted by means of rotary converters into continuous current, the network then being fed at its most distant points, or where an exceptionally heavy demand occurs, by these machines. In fact the future policy will be to transform the high-pressure three-phase current in sub-stations and then either convert it to continuous current if required, or to supply it direct to the consumers as three-phase current. Figs. 2 and 3 illustrate the Duncan-street sub-station of the Bolton Corporation. This station now contains three 600 kw. rotary converters, which are equipped with the necessary static transformers, while low-pressure and high-pressure switchboards are also installed. In connection with the operation of this sub-station it is interesting to note, having regard to the fact that heated discussions on the subject have recently taken place, that the rotaries there installed work on a frequency of 50. Considerable difference of opinion as to the desirability of using such high frequencies was expressed at the time the sub-station was laid down, and, in fact, this difference of opinion still exists amongst many electrical engineers. Supporters of rotary converters will, therefore, be pleased to hear that there has been no trouble in connection with these machines, and that the borough electrical engineer is of opinion that they are a pronounced success.

The central station at Spa-road is also a sub-station, and in it rotary converters and motor-generators of about 900 kw. capacity are installed, as shown in Fig. 4. These machines are used not only for taking the light load on the three-phase network at night, but also as a means of converting a certain amount of energy from one system to the other, say from continuous current to three-phase current or vice versa. This

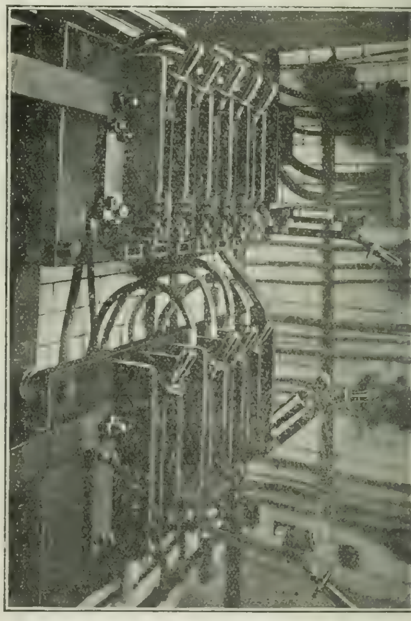


Fig. 1.—D.C. Low-tension Distribution Board (Balmoral Sub-station).

enables the machines of either class to be fully loaded, or, in the event of a breakdown of one type of steam generator, to enable a steam generator of another type to act as a stand-by. It will thus be seen that advantage has been taken to the fullest extent of the assorted plant laid down at Bolton, and that the continuity of supply which is so necessary to the success of a public supply station is quite ensured.

The present station at Spa-road, however, suffers from many considerable disadvantages, among them being the lack of adequate water for condensing purposes, and the limited space for cooling towers and reservoirs, points which made it practically impossible to adopt turbines when the last extensions were made. Further, the facilities for taking in coal are very defective, the whole of the fuel having to be carted from the railway siding, which is a considerable distance away. Under these circumstances it would not, perhaps, be surprising to find that the generating costs at Bolton compared unfavourably with those of undertakings possessing better situated stations. This is not the case, however, and the way in which economies

are obtained under such unfavourable circumstances is a credit to all concerned.

The present generating station cannot, however, be further extended, and when the time arrives that extensions become necessary, which at the rate motors are being added to the mains should not be far distant, they will have to be carried out on another site, for which negotiations are in progress, and where much better facilities exist. We may then hope to see something rather startling in the way of generating costs.

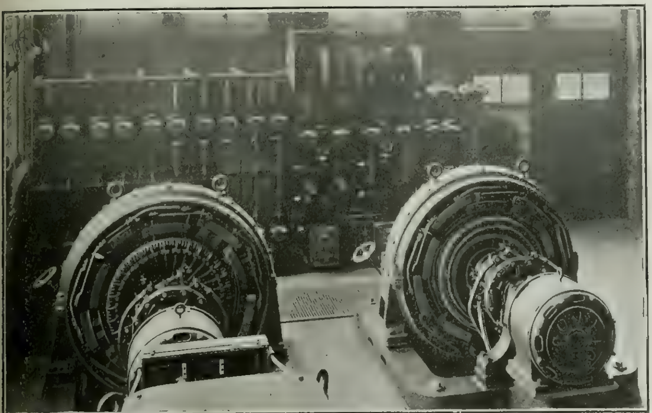


Fig. 2.—Rotaries in Duncan street Sub station, showing D.C. Board.

The main part of the three-phase current, other than that which is converted as stated, is used direct for cotton-spinning work, there being at the present time something like 300,000 spindles driven off the Corporation's mains, but in no case is a complete mill driven electrically, a state of things which we hope will soon be altered. In nearly all cases, in fact, the supply to these mills is for one, two or three floors only, as the case may be, and the electric drive is generally employed for the purpose of working the mules, which are, of course, the most awkward part of the cotton-spinning equipment to drive, as the power is very great for a short time and then drops to nothing for an interval, thus imposing a very arduous task on the motor. The transformers and necessary switchboard for transforming the supply for mule-driving purposes have, up to the present, always been installed in a special substation on the mill premises. This station is, however, kept under the entire control of the Corporation electricity department. The voltage is in all cases stepped-down from 6,500 to 400 volts for use on the mill motors. In some cases, however, the mill lighting is also carried out by means of a fourth wire at 230 volts. The experience obtained in Bolton in connection with this type of motor drive shows that the results are satisfactory in every way, although it is very difficult to get absolute evidence of this. The one point about which any trouble occurs is generally the matter of price, as would, perhaps, be expected in such a business neighbourhood as that around Bolton; but there is no doubt, in the opinion of the electrical engineer, that current can be supplied from a public station for mill driving purposes at such a price that its adoption will pay both Corporation and mill owners. The usual course adopted by the Bolton Corporation in installing the electric drive in mills has been to fix a three-phase motor with slip-rings direct to the line shafting driving the mule operating room. The speed of the shafting has generally been increased over that which was used under the old steam-driving machines. The speed of the machine has also been somewhat increased, and, no doubt, a further increase could be very well managed; but this is a question which depends on the size of the yarn being spun on the machine at the time, rather than on the actual methods which are used for driving the shafting.

In Bolton fine counts are usually spun, an operation which requires that the mill should run fairly slowly, the finer the count the slower the speed being the rule. Although the speed has been increased somewhat, a further step forward in this direction might well be made, and on this question for a definite quality and size of yarn depends the price at which electric driving will compete with steam driving, any small advantage in the output being of the utmost importance. From time to time it is found that statements are made in respect to the electric driving of cotton-spining machinery which show rather a pessimistic tendency. There appears to be no need for these outpourings. For although to compete with a brand new mill equipped with the latest improvements in every department only a very small margin of saving would be shown by changing over to the electric drive, there are a very large number of mills which do not belong to this class, and which are quite capable of giving the local supply department all the load they require for some little time to come, given trade prosperity and an up-to-date policy on the part of the supply authorities.

Although cotton spinning is, perhaps, the industry on which the town of Bolton most relies, it must not be thought that this is the only iron the electricity supply department have in the fire for developing their power load. There are several engineering works, including one very well-known firm of engine builders and at least one steel works, which have but recently laid down motors amounting in all to over 1,200 H.P. for driving cranes, rolls and conveyors, generally in connection with some new extensions which they have just made.

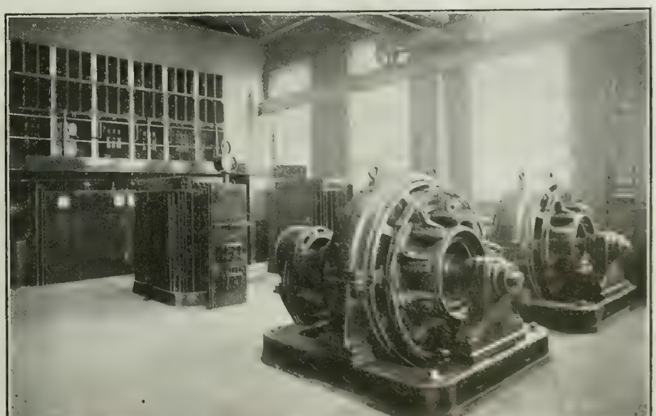


Fig. 3. Rotaries in Duncan street Sub-station, showing Transformers and A.C. Board.

Turning to the statistical side of the question, it is interesting to note that three of the continuous-current consumers take

an aggregate amount of energy from the Corporation's mains of over 3,000,000 units per annum, and have installed 3,000 H.P. of motors. In addition, these consumers are, or will be shortly, entirely lighted from the Corporation's mains. Two of these concerns are engineering workshops, and have a load factor of over 30 per cent.

The recently-issued accounts for the year show that the total output from the Bolton station was 10,677,761 units, of which no less than 46 per cent. was for power purposes pure and simple, while 15 per cent. only was for lighting. It is, of course, essential in a place like Bolton that the energy supplied for power purposes should be at a low rate, for the load which is obtained is of such a steady character and in such large-sized units that consumers will use their own plant unless the price offered is very low. It appears from the accounts that the average price obtained per unit from all classes of supply is 1·23d., and for power purposes is only 0·84d. per unit. It may be noted as a matter of interest that when the electricity works first started 5·4d. per unit was charged, and that the price remained well above 3d. until the present forward policy was instituted in 1900. Since that date it has steadily fallen. Although this price may be considered fairly low for a municipal station of the size of that at Bolton, a handsome gross profit of 9 per cent. on the capital has been obtained, and this result could be very well improved if the position of the station as regards the supply of water and cooling facilities were better. The whole of the water used for condensing purposes has to be cooled by means of cooling towers, and it is considered that this places Bolton at a disadvantage over a station where such plant need not be employed, a disadvantage which may be placed at at least 10 per cent. of the coal costs, or, say, £1,000 a year. Further, until quite recently, the undertaking suffered from the fact that town water at 6d. per thousand gallons had to be used for evaporating purposes. This, however, has now been remedied, as a well has been sunk specially for the purpose and electrically-driven pumping plant installed, with the result that a considerable saving has been obtained, though the new equipment has not been under way long enough to show any substantial results.

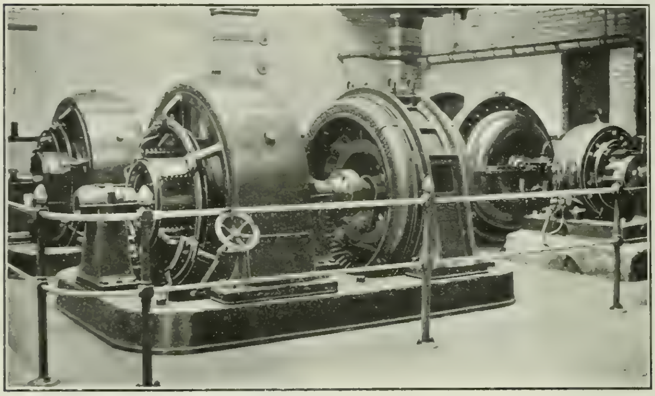


FIG. 4.—SINGLE-PHASE TO D.C. MOTOR GENERATORS, AND THREE-PHASE TO D.C. MOTOR GENERATORS (SPA-ROAD GENERATING STATION).

We mentioned above that, in spite of the low price charged per unit, a gross profit of 9 per cent. was obtained on the capital. Such a result, of course, predicates very low costs, and it is very interesting to know that the works costs come out at 0·472d. per unit and the total costs at 0·583d. per unit. The inclusive cost, including capital charges, is practically 1·2d., while in 1895, the first year of complete working of the station, the corresponding figure was 11·84d., so that a very substantial reduction has been made. Those interested in statistics will note that on March 31, 1901, the number of motors on the mains was 27, with an aggregate horse-power of 148. On the same date in 1909—or eight years afterwards—the number of motors was 816, with an aggregate horse-power of 9,219, an average yearly increase of 100 per cent. This increase has, however, been extraordinarily rapid during the latter part of this period.

Such a result, as regards price, is, no doubt, very satisfactory, but the borough electrical engineer considers that, although these prices are low, they are not yet low enough for a town such as Bolton. He considers, in fact, that unless the prices are brought down the present increase in the number of motors connected to the power mains cannot be maintained. The effect of this will be bad for the undertaking, as the costs have dropped considerably during the last few years, and comparison of these costs with the motors installed shows how important a power load is if low costs are to be maintained.

We have to thank Mr. A. A. Day, the borough electrical engineer and tramways manager of Bolton, for allowing us to inspect many of the interesting installations which are supplied with power from his mains, and to Mr. B. S. Hornby, his chief assistant, for taking a good deal of trouble in explaining the main points to our representative. We are not able to describe these installations in this article, as explained above, owing to the reticence of the owners on the subject. We have also to thank Mr. Day for supplying us with much of the information here given with regard to the development of power supply in Bolton.

TWO LARGE BOOSTERS.

The recent more extended employment of large powers at comparatively low voltages, for instance, in railway work or for power supply, requires for its success machinery which shall be capable of dealing with large currents under a number of varying conditions. Such work further requires that special attention be paid to the design of these machines, in order that the equipment may operate sparklessly and without heating, even when the load is about as troublesome as it can be.

In this connection we may draw attention to the large boosters, illustrated herewith (Figs. 1 and 2), five of which have been supplied by the Lancashire Dynamo & Motor Co. to the Lancashire & Yorkshire Railway Co., for use on that company's "electrified" main line, and also three to the Manchester Corporation. We can perhaps best describe the essential points of these machines by outlining the general features of the "Lancashire" automatic reversible booster.

This machine consists of two essential parts, the motor and booster; the former of which is supplied from the 'bus bars, its starter being arranged on the "live" side, an arrangement which both simplifies the wiring and ensures the motor being "dead" when the starter is "off." The motor breaker, as will be seen from the diagram (Fig. 3) is connected in a special manner with the battery breaker. The effect of this arrangement is that the motor can never be cut off when current is passing through the booster, an accident which would cause the booster to run up to a dangerously high speed. As will be seen, when the battery breaker comes out it leaves the motor running on the battery, although cut off from the 'bus bars; while, if the motor breaker comes out, the motor is left running on the 'bus bars. This method is the only one that has been found satisfactory in practice. The booster has four coils, A, B, C and D, their functions being as follows:—The A coil is peculiar to the Lancashire booster. It is connected across the booster brushes, and is therefore energised by the difference of voltage between the battery and the 'bus bars. Supposing the battery to have a pressure 10 volts higher than the 'bus bars, the A coil will then cause the booster to oppose the battery voltage

by this amount. On the other hand, if the battery volts are lower than the 'bus bar volts, the A coil will cause the booster to act in favour of the battery to the same required amount. Hence, in every case, the result will be that the algebraic sum of the battery and booster pressures will be equal to the 'bus bar pressure. The D coil consists of a few turns on the booster fields in series with the booster armature. These turns balance the armature reaction, and cause the booster to act as if there were no voltage drop in it.

The action of the A and D coils then causes the booster to balance all variations of the battery volts. If these coils were only in action,

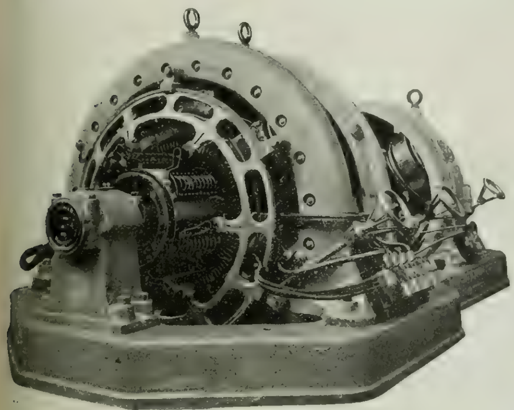


FIG. 1.—END VIEW OF "LANCASHIRE" PATENT AUTOMATIC REVERSIBLE BOOSTER FOR THE LANCASHIRE & YORKSHIRE RAILWAY ELECTRIFIED SECTION.

the effect would be to make the booster unstable. It would, in fact, rush off with a charge or discharge at its own sweet will. A controlling force, therefore, is required, and this is supplied by the action of the B and C coils. The B coil is constant in its action, being energised by the 'bus bar volts. It is controlled by a "potentiometer" resistance instead of by an ordinary resistance, as will be explained later. When the booster is working in the ordinary way with the generators running, the excitation of this coil is in such a direction as to cause the current from it to charge the battery. It is conveniently connected across the motor brushes, as it then

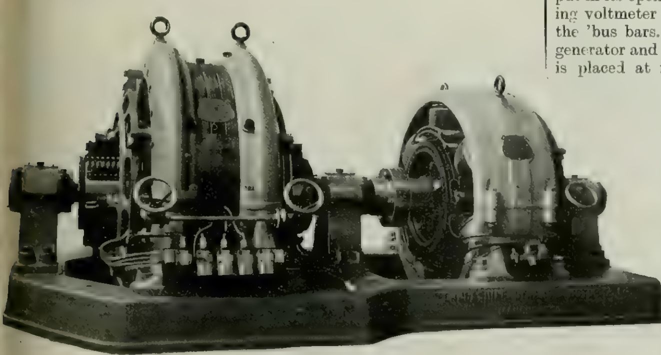


FIG. 2.—VIEW SHOWING MOTOR AND BOOSTER.

becomes quite dead when the motor is cut off. The C coil is arranged to take the main dynamo current or a certain proportion of it, and its adjustment can be arranged by the diverter shown in the diagram. The current passing through C coil energises the booster in such a manner as to take current out of the battery. Hence it is opposed to the B coil. The action of B and C coils is as follows:—Supposing that the booster be in operation and running with the generator. If the B and C coils be adjusted for, say, 100 amperes generator current, then at this load they will neutralise each other, and the booster will neither charge nor discharge the battery. If an excess load, however, comes on to the feeders, the generator will give out a little more current, which, passing through C coil, will strengthen the latter's action. This will cause the C coil to overpower the B coil's action, and so draw the excess current needed on the feeders from the battery. Supposing that the feeder current is reduced below 100 amperes, the result will be that a little less current will be supplied by the generator, and so there will be a little less through the C coil, and its action will become weaker than that of the B coil. The superior strength of the B coil will cause the excess current to charge the battery, so that the load on the generator will still remain at the standard 100 amperes. The load on the generator can always be adjusted by varying the strength of the B coil regulator, and also by adjusting the diverter.

It is advisable to adjust the coils at varying periods of the load to get the best possible results from both booster and battery. For instance, when the load on the feeders is such that the generators are always at their full capacity the action of C coil must be increased by

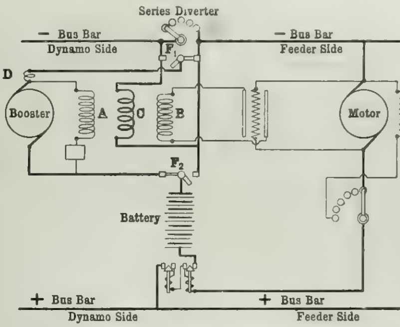


FIG. 3.—DIAGRAM OF CONNECTIONS.

reducing the current diverted through the resistance, thus increasing the amount passing through the C coil. The strength of the B coil must also be increased. The A coil should also be run with the resistance largely cut out.

The diagram (Fig. 3) shows the arrangement adopted for starting the set with the main generator running. The switches F_1 and F_2 are closed on their right and left hand sides respectively, while the series diverter is right over on the left. The battery breaker is closed, thus putting the motor on the 'bus bars, and the latter is then started in the usual way by means of the motor starter. The A rheostat is put in its open position and the B rheostat adjusted until the paralleling voltmeter shows that the battery volts are equal to those on the 'bus bars. The motor breaker is then closed and load on the generator and battery adjusted with the B rheostat. The A rheostat is placed at its most sensitive position, a position which can be adjusted by the series diverter. When this latter arrangement is in the extreme left position the booster will act strongly and will keep the load on the main generator steady. On the other hand, when it is on the right hand side, the battery will do less work and the generator load will vary with the feeder load. The battery and booster can be run on the bars without the main generator or the battery without the booster, if desired, by a suitable modification of the above arrangements.

Coming now from the general to the particular, the boosters supplied by the Lancashire Dynamo & Motor Co. to the Lancashire & Yorkshire Railway are of the above type and have a capacity of 2,000 amperes. They are, as will be seen (Fig. 2), exceedingly sturdy machines, and should be capable of doing the work for which they have been designed.

Three machines similar to that shown in Fig. 2 have recently been ordered from the Lancashire Dynamo & Motor Co. for the Manchester Corporation. The output of each booster is 2,000 amperes at 80 volts for four hours; 2,800 amperes at 60 volts for one hour; 2,800 at 100 volts for 15 minutes; 3,700 amperes at 80 volts for half an hour; and 5,600 amperes for three to five minutes. Each booster will be fitted with a shunt winding, the regulation of which will be effected by an auxiliary motor-driven exciter. This exciter automatically varies the booster fields according to the load, the exciter being wound in an exactly similar manner to the standard machines

described above. The motors for the main sets are also of a standard type, and the booster field systems will be laminated throughout thus allowing quick field variations to be obtained. The booster will be fitted with copper brushes, each brush having a special interpole coil connected in series with it.

This machine should, therefore, be capable of doing all the work likely to be imposed upon it, for its range is certainly very wide. In this and in other directions it marks a distinct step forward in booster practice.

CHICHESTER ELECTRICITY WORKS.

A feature of the electric supply industry both on the Continent and in America, is the large number of small power stations. In fact, most towns whatever their size are provided with a supply of electrical energy. In this country, on the other hand, we are far from realising this state of affairs, and at the present time additions to the number of electric supply stations are few and far between. It follows, therefore that new installations are of more than passing interest and in the case of the undertaking which was inaugurated at Chichester on the 3rd inst., the interest is increased by the fact that the installation is of unusual character, all current being obtained from a couple of generators driven by Diesel oil engines.

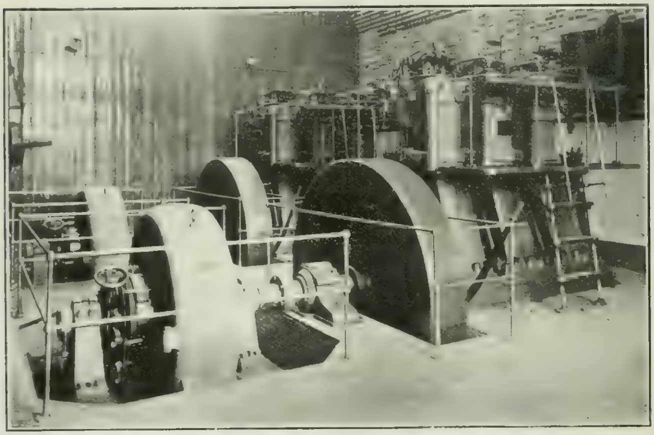


Fig. 1.—Diesel Oil Engines in the Electricity Works at Chichester.

Excellent results are already being obtained at Leatherhead, Hindhead, and other places with this type of plant, which operates to the best advantage in small sizes, and it is to be hoped that other towns without a supply of electricity will consider carefully an installation on the lines of that at Chichester. As is so frequently the case in other towns, the question of a supply of electricity was in the air for many years; in fact it was first mooted at Chichester some 15 years ago, but a Provisional Order was not obtained until 1898. The Corporation, however, never exercised the powers they then obtained, and the Order was eventually transferred to the Chichester Electric Light and Power Co., who are responsible for the present installation.

Owing to the adoption of Diesel oil engines, the buildings are of a very simple nature, comprising merely an engine house. This is of red brick, lined inside with white glazed bricks. The floor is black and white terrazzo with a black border, whilst the building is spanned by a 5 ton crane, supplied by Messrs. Morris & Bastert.

The plant, which is illustrated in Fig. 1, consists of two Diesel oil engines designed and constructed by Messrs. Mirrlees, Bickerton & Day, direct coupled to two 100 kw. 500 volt continuous-current generators of the General Electric Co.'s manufacture. Provision has been made on the generators for the fitting of compound winding, should this be required for traction purposes. It is interesting to note that the engines, which run at 250 revs. per min., were some of the first to be manufactured by Messrs. Mirrlees, Bickerton & Day at their new works at Stockport since the transference of the works from Glasgow.

Starting up is effected by compressed air stored in suitable receivers, and it is stated that an engine can be run up and fully loaded in the space of two to three minutes. This is an important feature of oil engine plants, from the central station point of view, particularly where, as in the present instance, batteries are not installed, for it is well known that internal combustion engines are not particularly adapted for taking overloads.

Water for keeping the cylinder jackets cool is obtained from a canal adjacent to the works, a circulating pump being driven by spur gear from the engine shaft. About 600 gallons of water per hour are passed through the cylinder jackets when the engines are developing full load, and a visible outlet is provided, so as to cause any interruption of the water supply to be quickly observed.

In regard to fuel supply, a circular tank 6 ft. 9 in. by 12 ft. 1 in., situated near the engine house, provides sufficient oil storage to allow both engines to be run continuously for a week. It is worth noting that when the oil has been delivered to the storage tank no further handling is necessary, so that the labour required is reduced to a minimum.

As a three-wire system of distribution is being employed, with 440 volts across the outers, a balancer has been installed, consisting of two 25 kw. shunt-wound machines coupled together on the same bedplate.

The switchboard which is illustrated in Fig. 2, has been

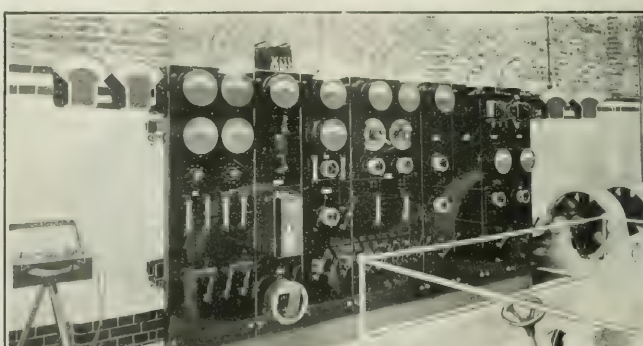


Fig. 2.—Main Switchboard, Chichester Electricity Works.

supplied by Messrs. Johnson & Phillips, and is of standard design for a three-wire system. It will be noticed from Fig. 2 that the board is arranged to control three generators (one panel being provided for extensions), the panels reading from

left to right being feeders, middle wire, balancer, battery, motor, dynamo (extension), and two dynamo panels. It will be noticed that provision is made for the installation of a battery, although one has not yet been installed; in fact one of the features claimed for the installation is that the oil engines are entirely relied upon for maintaining the supply of electrical energy.

The cables have all been supplied by Messrs. Johnson & Phillips, and in the case of feeders are triple concentric, lead covered, drawn into Sykes conduits, whilst three-core cables are used for the distributing network. These latter are armoured with steel tape and laid direct in the ground, a board being placed over them to indicate their position when future excavations are made. At present a 0·2 sq in. feeder cable has been installed and runs to a feeder pillar near the cross, the distributors being fed through switch fuses. For house services concentric armoured cables are used, the service boxes and fuse boxes being of Messrs. Johnson & Phillips' standard type.

The prospects of success of the undertaking are distinctly bright, since when the supply was commenced over 1,200 lamps had been connected. In addition to private lighting, it is hoped that before long a considerable motor load will have developed, as several consumers are preparing to instal motors.

In conclusion we may mention that we are indebted to Mr. H. Boot, who has been responsible for the whole scheme, to Mr. R. V. Weare, who has been appointed resident engineer by the Company, and who represented Mr. Boot at Chichester during the construction of the works, and to Messrs. Johnson & Phillips, the contractors for the whole of the work, for supplying us with the photographs and particular of this interesting installation.

THE NEW BATTERY CHARGING STATION AT THE MONTAGUE-STREET GARAGE OF THE BRIGHTON, HOVE & PRESTON UNITED OMNIBUS CO.

The problem of electric omnibus traction by means of secondary batteries has from time to time exercised the minds, not only of the travelling public, but of the directors and operating engineers of the omnibus companies. Systems, varying in detail, have been advocated, and in many cases put to the test. The long-promised Edison battery has been the subject of many discussions, technical and otherwise, but still the number of purely electric omnibuses is very limited. It is an admitted fact, that for public service vehicles the electric omnibus is ideal, and that if the cost of battery charging and battery maintenance can be brought to a reasonable figure, the inexorable law of the survival of the fittest will leave the electric vehicle in possession of the field in all cases where the streets have no excessive gradients and a sufficient number of vehicles can be employed.

For municipalities with their own electric supply the electric omnibus offers many attractions, some of which are obvious—the vehicles could be used as feeders to tramways and will run in streets too narrow for tramcars. No overhead equipment or rails are required. The batteries can be charged in the night or at times of light load, thus improving the load factor of the station. The transmission, being electrical, will be thoroughly understood by the tramways operating staff.

To omnibus companies, however, these advantages do not appeal so strongly, but signs are not wanting that the purely electric vehicle is receiving their careful consideration. This attention will naturally increase as the price of petrol rises. The whole problem of the financial success of the electric omnibus hinges on battery first cost and maintenance, and the cost of the electrical energy required for charging the batteries. It has been amply demonstrated that the upkeep of an electric chassis, including the electrical equipment is very small as compared with that of a petrol-driven vehicle.

Fig. 2.—One of the Brighton Electric Omnibuses.

Within the last two years the first cost and cost of maintenance of traction batteries has been greatly reduced and manufacturers are seriously attacking the weight question with gratifying results. The battery usually supplied to electric omnibuses has a capacity of 500 ampere hours at the 100 ampere discharge rate, the number of cells being 47. This number being very suitable to pack in the main battery boxes, with five lines of eight and one line of seven cells, a vacant space being left at the end of the last row, for convenience of removing the cells from the box. The charging voltage of the batteries varies from 100 at the beginning of the charge to 130 when fully charged. Where a main generator is employed and several batteries are charged in parallel without the use of boosters the voltage of the generator must be kept at 130 and variable resistances used in circuit with each battery. It is obvious that this arrangement is very wasteful, the average voltage absorbed by the resistance being 15, the loss of energy through resistances alone being 12 per cent. of the total output of the dynamo.

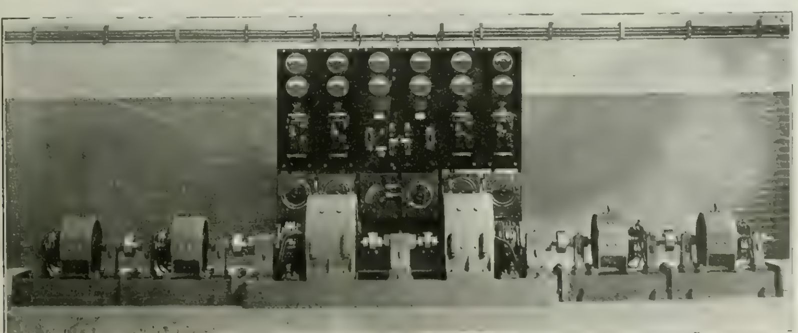


Fig. 1.—Stevens' Charging Set at Brighton.

A more economical method is to run the main generator at 115 volts, inserting in circuit with each battery the armature of a motor-driven booster of the interpolar regenerative type. By means of a potentiometer rheostat in the booster fields, the booster can be made

to absorb electrical energy in the earlier stages of the charge, running as a motor and causing the erstwhile motor to which it is direct-coupled to act as a generator to return current to the line. As the voltage required by the battery rises, the resistance of the booster fields is progressively short-circuited by means of the potentiometer rheostat, until the average voltage of 115 is reached. At this point the shunt-field windings of the booster are short-circuited and the armature of the booster is inert, only serving as a conductor in series with the battery. By a further movement of the potentiometer resistance switch, the current in the shunt fields of the booster is reversed, and the voltage is gradually raised until the maximum of 130 is reached, when the battery is fully charged—during the latter stage the booster armature is generating electrical energy and is driven by the machine to which it is direct-coupled.

With the supply from the public mains the voltage is generally either 220 or 230 on either side of the middle wire. In this case, two batteries are charged in series, with a motor-driven booster in series with each pair of batteries. This, until quite lately, has been the practice of the Brighton, Hove & Preston United Omnibus Co., who are adopting electric traction for their new omnibuses. With an increase in the number of electric vehicles, however, it became necessary to build new premises at Montague-street for their exclusive accommodation, and the directors of the omnibus company, after consulting Mr. Christie, borough electrical engineer at Brighton, decided to adopt the Stevens regenerative battery charging system for the new garage, the electrical energy being supplied from the Brighton Corporation mains. As a middle wire of sufficient capacity to deal with an out of balance current of 100 amperes was not available in the neighbourhood of Montague-street, the outers only, at a pressure of 460 volts, were brought to the building, the section being 0·3 sq. in., with provision for bringing in additional mains of 0·2 sq. in. section for future requirements. As a voltage of 230 for charging two batteries in series was required it was necessary to include a pair of balancers to bring in the middle wire. A diagram of connections in the "Stevens system" is shown in Fig. 3, and it will be seen that the main supply is connected across the outer terminals of the balancers, which are direct-coupled by means of flexible couplings to a line of reversible booster armatures, four on each side so that the system will consist of ten machines running on the same axis. At the present time only two boosters are connected on each side of the balancers, but provision in the foundations is made to add additional boosters as required. It will be seen that the circuit from each booster is through a fuse, reverse current circuit-breaker and ammeter to the terminals of a battery, the circuit being completed through the middle wire as shown. A four-way double-pole voltmeter switch on each panel enables indications of (*a*) line volts, (*b*) battery volts, (*c*) booster volts and (*d*) by connecting across the circuit-breaker when the circuit can be closed *i.e.*, when the potential difference is shown on the voltmeter (which is graduated to 40 volts on one side of zero and 300 on the other) to be zero. Under service conditions the batteries to be charged arrive at the garage at regular intervals, being brought in by the omnibuses and replaced by fully-charged batteries, the operation of changing the batteries taking about 10 minutes. It follows that the plant is dealing with batteries at all stages of charge. In the earlier conditions the boosters are running as motors, but when the charging of the batteries is more fully advanced they run as dynamos—the motoring boosters pulling round the generating boosters so that the actual energy required to control the system is extremely small—in some cases the resultant effort is to drive the balancers as generators, in others the balancers act as motors. The plant when completed will have a charging capacity of 16 batteries at one time, and the total losses in conversion from 460 volts to the voltage required for individual batteries will not exceed 5 per cent.

The whole of the electrical plant, including balancers, boosters and switchboard was manufactured and put down by Messrs. W. A. Stevens, of Maidstone, and Fig. 1 shows it as at present running. A "Hallford-Stevens" electric omnibus, one of three in public service in Brighton, jointly manufactured by Messrs. J. & E. Hall and the above company, is shown in Fig. 2.

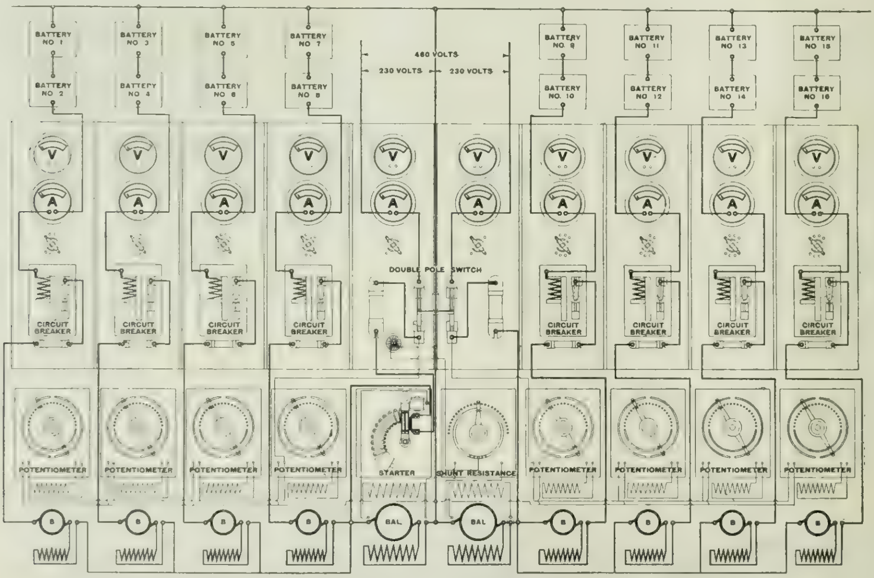


FIG. 3. DIAGRAM OF CONNECTIONS AT ELECTRIC OMNIBUS CHARGING STATION.

A somewhat similar arrangement to that described above is the Stevens system of regenerative boosters for automatically maintaining a constant voltage at the ends of three-wire feeders of varying lengths. The main feature of the system is the application of two or more boosters, with their armatures directly coupled on the same shaft or series of shafts flexibly connected together by means of couplings so that they must all rotate at the same speed. A line of boosters can be conveniently coupled to each of the outer ends of the balancer shafts as shown in Fig. 4, so that each feeder, or set of feeders, has a booster armature in series with its positive and negative terminals. Feeders of average length, taking the main load of the station, are not included in the system, as the drop in voltage at peak can be dealt with by raising the main 'bus-bar voltage, balance being obtained by interconnecting the neutral wire and outers of the distributors respectively, and by the aid of the balancer already mentioned.

The boosters are connected up as shown, those controlling long feeders having their fields series wound, so that the current through the fields raises the voltage across the booster armatures proportionately to the current passing through them; and the volts across

the booster armature can be made equal to the drop in volts in the feeder by adjusting the shunt which is provided with each machine. With this object the fields of the boosters work at a low magnetic density. The voltage across the armature of the booster at no load is zero, and the machine will work automatically throughout all its range, after the shunt is adjusted to the load. As the voltage of the booster is proportional to the current passing through it, it is obvious that the boosters will also act as balancers, as any increase of current demanded on one side of a feeder will be accompanied by an increase of voltage on that side, making up for the increased drop of voltage on the main, and in addition providing for the drop in the middle wire for the return current. Long feeders may, it is claimed, be left to take care of themselves with a certainty of the voltage and balance being satisfactory at all loads.

Boosters which control very short feeders, such as supply the station and immediate surroundings, are provided with a shunt field winding controlled by a shunt regulator. The direction of this field is such that the machine runs as a motor and opposes the line pressure, keeping the voltage of supply normal when the station voltage is raised to deal with the drop in the feeders of medium length at peak load. A few turns of series winding acting differentially to the shunt winding will reduce the volts of the negative boost when the load on the short feeders increases and the series coils will also tend to balance the load on the short feeders. As an illustration of the action of the system in practice, feeders of varying length are shown in Fig. 4. Feeder 1 is taken as 3,000 yards, 2 as 2,000 yards, 4 as 1,000 yards, 3 as 200 yards, and the current density at peak is taken

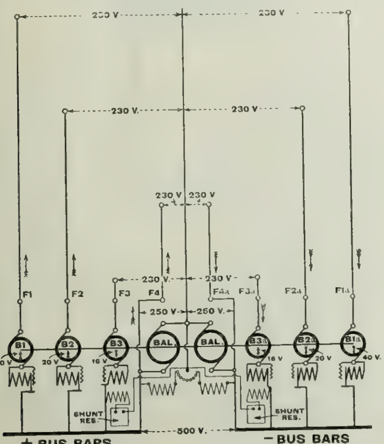


Fig. 4.—Diagram of Connections for Arrangement of Selective Feeder Boosting.

for all feeders at 800 amperes per square inch; with this density the fall of potential will be approximately two volts for each 100 yards (single) of feeder. On feeder 4, length 1,000 yards, representing the average length of main feeders for main supply, the voltage of main 'bus bars, raised at peak load 20 volts on each side of middle wire, will bring the voltage at feeding point to 230. Feeder 3, length 200 yards, will then be boosted down to 16 volts so that the voltage at feeding point will be 230. Feeder 2, length 2,000 yards, will require a boost of 20 volts on each side in addition to the 'bus bar voltage of 250 to supply at 230 volts at feeding point. Feeder 1, length 3,000 yards, will require a boost of 40 volts on each side in addition to 'bus bar voltage of 250 to supply at 230 volts at feeding point. All boosting with exception of that on feeder 3 is done automatically.

The advantages claimed for the system are:—Great economy in running owing to the load on the series of boosters being only the average of the total boosts some of which are negative or motoring. Convenience, owing to the majority of the operation including balancing, being automatic. Economy in first cost. The size of the feeders can be calculated from Kelvin's law without the necessity of keeping a large cross sectional area to avoid excessive drop as in the present system. The figures given are only intended as an illustration, as probably the total length and drop on feeders will be less than in the example cited. The same principles will, however, apply.

NEW WESTON INSTRUMENTS.

Since the very earliest days of the electrical industry the question of the proper measurement of currents and pressures has been a problem that has exercised the minds of both theoretical and practical engineers. And it is certainly a matter in which theoretical and practical knowledge can be very well combined. On the one hand it is necessary to design instruments that shall measure, accurately and within required limits, pressures or currents over a certain scale, but, on the other hand, such an instrument must not be of so flimsy a nature that it will deteriorate rapidly in the atmosphere, or under the working conditions present in generating stations or machine shops.

Fig. 1.—Weston A.C. Voltmeter.

A combination fulfilling these conditions has, as is well known, been long effected by many electrical firms, so that it is at the present time possible to obtain an instrument that will work satisfactorily under very arduous circumstances. A firm which has by no means slightly contributed to this state of affairs is the Weston Electrical Instrument Co., of Newark, U.S.A., and of London. They have long been noted for their "Weston" moving-coil instruments, and they have now launched out in a new direction by placing on the market a set of instruments suitable for working on alternating-current circuits. These instruments, it is claimed, contain so many revolutionary characteristics—a statement which, we think, will not be disputed when the results obtainable with them are considered—that they cannot be adequately described at the present time. As, however, they are now being placed on the market, we take this opportunity of enumerating some of their features, reserving a more technical description for a more convenient season.

Fig. 2.—Weston A.C. Ammeter.

The work of designing the "Weston" alternating-current instrument has been extended over a period of many years, and though the company claim that at any time during that period they could have produced better results than those then obtainable, their policy has been to refrain from so doing until the problems had been completely solved, and results obtained that would not detract from, but rather enhance, their reputation.

Examples of the new Weston alternating-current switchboard voltmeters and ammeters are shown in Figs. 1 and 2. It is claimed for them that they have no inductance error, and can, therefore, be used on all commercial frequencies, while the working error may be

practically neglected. Temperature affects them very slightly, as will be gathered from the statement that a change of 100° F. will cause an error of less than one-half of 1 per cent. on a voltmeter with a range of 150 volts. Perhaps the most interesting feature of these instruments is their remarkable "deadbeatness." Even when watching the scale closely it is almost impossible to detect any swing at all, and in this respect, it is claimed, they are at least equal to the Weston moving-coil instruments. Another feature of interest is the uniform scale; in fact, on the upper or working portion, the divisions seem exactly equal when inspected, and that they are not can only be proved by means of dividers. Two sizes of this class of instrument, both voltmeters and ammeters, are made. The larger size (Fig. 1) is $9\frac{1}{2}$ in. in diameter, with a scale arc $6\frac{1}{2}$ in. long, while in

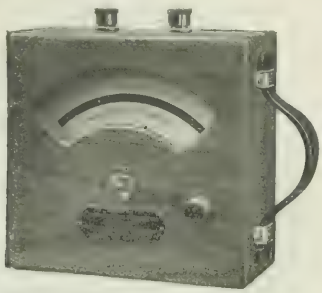


Fig. 3. Portable A.C. Voltmeter.

the smaller size (Fig. 2) the corresponding dimensions are $7\frac{1}{4}$ in. and $5\frac{1}{4}$ in. respectively. Seven sets of ranges are provided in both classes of voltmeter and 16 in both classes of ammeter, the maximum being 750 volts and 500 amperes respectively. In the latter case larger currents can also be dealt with by employing current transformers. A secondary current of 5 amperes is recommended, and the instruments are directly calibrated. Voltmeters with ranges above 300 volts and 150 volts are provided with an external resistance in the case of the larger and smaller sizes of instrument respectively. The fact that these new instruments are made by the Weston Electrical Instrument Co. should secure their ready adoption, and there is no doubt that many points in their manufacture mark a distinct step along the road of progress.

The activities of the company as regards alternating-current work are not confined to switchboard instruments, for in Figs. 3 and 4 we illustrate types of portable voltmeter and ammeter which have re-

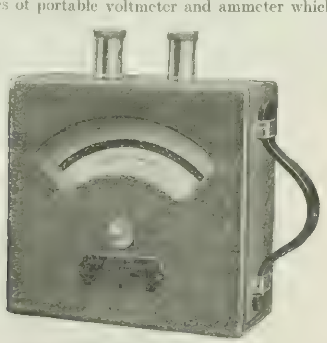


Fig. 4. Portable A.C. Ammeter.

cently been put on the market. These instruments are, it is claimed, the result of much arduous scientific work. They comprise 16 different ranges of alternating-current ammeters, five different ranges of alternating-current mil-ammeters, and seven different ranges of alternating-current voltmeters; in all a goodly show. In designing these "portables" care has been taken to produce instruments of the highest accuracy and perfectly suited for the work they will be called upon to do. They are practically "dead-beat," and may be used on circuits of any frequency between 15 and 140 without sensible error in their indications. As regards the other ordinary errors to which alternating-current instruments are liable, they are as free from them as is the switchboard type described above.

In these "portables" the moving system is light, though strong, the pivots being of hardened steel, which is accurately ground and highly polished. The bearings are sapphires, and the whole movement is contained in neat dust-proof wood cases. The voltmeters of this class are self-contained, and include instruments for those with a maximum scale reading of 75 volts to those with a scale reading of 10 times that amount. The ammeters have maximum scale readings from 1 to 500 amperes, and can be used on all circuits whose voltage does not exceed 2,300 volts. Higher voltages or currents can be dealt with by using suitable transformers. The standard sizes of the portable instrument case, as shown, are $7\frac{1}{2}$ in. $\times$ $7\frac{1}{4}$ in. $\times$ $3\frac{1}{4}$ in. for voltages up to 300, and $7\frac{7}{8}$ in. $\times$ $8\frac{3}{4}$ in. $\times$ $3\frac{1}{4}$ in. for voltages between 300 and 750 volts. The dimensions of the ammeters are 7 in. $\times$ $7\frac{1}{8}$ in. $\times$ $3\frac{1}{4}$ in. The lightness of these instruments is quite extraordinary, in comparison with the moving-coil continuous-current type, and this property at least should benefit those who have to use them.

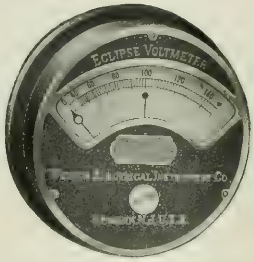


Fig. 5.—"Eclipse" Moving Iron Continuous Current Voltmeter.

Of the past achievements of the Weston Electrical Instrument Co. in solving the problem of continuous-current measurement it is needless to speak, but attention must certainly be drawn to a new type of instrument intended for use on continuous-current switchboards. A voltmeter and an ammeter of this type we illustrate in Figs. 5 and 6. They are known as the Weston "Eclipse," and are of the electromagnetic type. They are, it is claimed, far in advance of all preceding forms of soft-iron instruments, and are, in fact, more accurate than many imitations of the Weston permanent magnet type of instrument. The "Eclipse" instruments have neither working or chamber error; and, more remarkable still for soft-iron instruments, are practically free from magnetic lag or troubles due to hysteresis. These points, as regards the voltmeter especially, mark a distinct

Fig. 6.—"Eclipse" Moving Iron Continuous-Current Ammeter.

step forward. In external dimensions and length of scale are these instruments are practically the same as those described above, while the scale itself is very evenly divided for the electromagnetic type. The ranges are also practically the same as those given above for the Weston alternating-current instruments, and they are, in fact, very similar to these instruments in every respect.

Enough has been said to show that the Weston Electrical Instrument Co. have succeeded in solving two further problems connected with measuring instruments. They have obtained an alternating-current instrument from which many of the faults often present in this class of apparatus have been eliminated, while they have also made possible an accurate continuous-current instrument of the moving-iron type. We shall await with interest the details of how these results are achieved

ELECTRIC POWER SUPPLY AND TARIFFS.

The demand for electricity for power purposes of all descriptions, such as factories, mines, engineering shops, railways, tramways, &c., has increased very rapidly during the past few years, and the question of the price to be charged is undoubtedly a most important one. One of the fairest methods, and one which is often advantageous, is that which is based on a fixed charge per annum per kilowatt demanded, combined with a flat rate per unit registered on the meter. This gives the consumer a benefit from longer hour use, and at the same time insures that the supply authority obtains a sufficient return to cover standing charges. The curves illustrated in Fig. 1 show how the equivalent price per unit varies in this system at different load factors. It is essential, if this system of charging is to be correctly carried out in practice, that an instrument

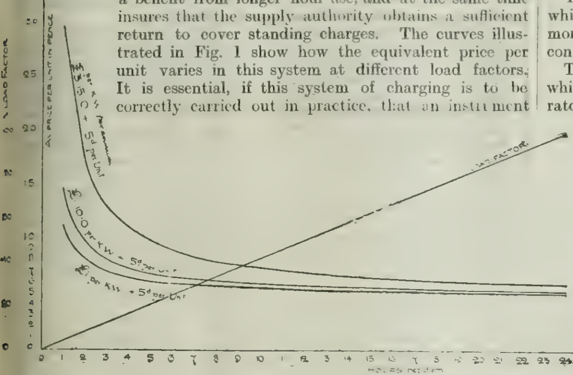


Fig. 1.

be used which measures the maximum number of kilowatts taken under ordinary circumstances, while taking no account of momentary excess or short-circuits. Moreover, it is absolutely essential to use an accurate instrument, for an error of a few per cent. on a large power installation may mean a considerable loss of revenue.

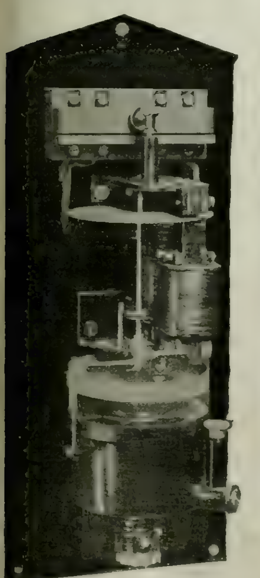


Fig. 2.

Fig. 3.

Hitherto the instruments used for this purpose have only registered the maximum current taken, which in the case of alternating-current circuits in particular gives no indication of the actual power demanded.

An instrument which Messrs. Elliott Bros. are now placing on the market indicates the maximum power in kilowatts, and is claimed to be accurate at all loads and at any power factor within large variations of pressure and frequency. The instruments, of which one is shown in Figs. 2 and 3, can be made for single and multi-phase and also continuous-current circuits, and it will be seen from the above illustrations, which are of a single-phase instrument, that it consists of a disc rotating between magnets against a spring, the amount of torque measuring the kilowatts. The spindle with its disc is fixed on a float which moves in a vessel containing oil, which not only provides the retarding medium but also reduces the friction to a minimum by allowing the spindle to be pivoted on a top jewelled bearing.

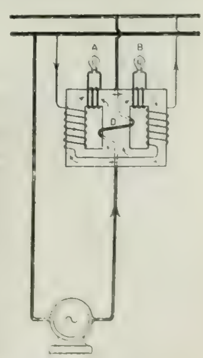
The time lag can be varied, according to the density of the oil which is supplied by the makers, from one minute to one hour or more. It may be mentioned that the float very nearly fills up the containing vessel, so that a very small quantity of oil is required.

The registering is effected by a ratchet fixed to the spindle wheel, which also serves to carry the scale. A very light pawl prevents the ratchet wheel from moving backwards, and at the same time allows the scale to revolve to its correct reading. The resetting is accomplished without removing the cover or seals, by lowering the oil vessel by means of a bottom thumbscrew until the pawl is released and just allows the disc to return to zero. On further screwing down the oil vessel the same is sealed for transit.

It will be seen that, compared with existing indicators, the instrument has several advantages, including simplicity, long uniform scale and direct kilowatt readings, so that the apparatus should be welcomed by those desirous of charging for electric energy on the maximum demand system.

ENERGY DIRECTION INDICATOR.

In the discussion following Mr. J. H. Rider's recent Paper, read before the Institution of Electrical Engineers, reference was made to the uncertainty of the working of reverse current relays on alternating-current circuits. In some cases, perhaps, failure in working is due to want of adjustment of the apparatus to meet the conditions, since most modern instruments provide for adjustment for phase displacement, surging, drop of pressure, &c. Although the conditions may not always admit of the use of relays, yet to couple generators direct to the 'bus bars must be regarded as a practice involving a serious risk—a vital part of a system, which otherwise is protected throughout, being left without any protection of any kind. Even if the inductance of the machine prevents a disastrous rise of current this partial protection does not apply to the cables between the machine and the 'bus bars.



Though a prompt indication at the beginning of the trouble is not so effective as automatic action, it is clearly better than nothing, and an instrument for indicating when an alternator is supplying energy to, or receiving energy from, the 'bus bars has been in use for some time in America. It depends for its operation on a relay, which closes a switch and thereby causes a red lamp to light up when the generator is receiving motoring current. This apparatus, however, has the disadvantage of depending upon a switch, so that the energy direction indicator (Andrews' patent) recently placed on the market by Messrs. Cowans (Ltd.) will doubtless be welcomed by many engineers.

Its action is purely inductive, as will be seen from the diagram herewith. It is arranged to indicate by means of a green lamp when a generator is generating and by means of a red lamp when a generator is motoring. There is nothing to get out of order, and, as its only function is to indicate, no switches are tripped when it would be desirable that they should remain closed. The indication of an ammeter is misleading and not sufficiently noticeable, but the lighting up of a red lamp is seen at a glance and its indication is unmistakable. A and B (*see* diagram) respectively are red and green lamps connected across independent secondary windings. The combined effect of the series and shunt windings is to light the green lamp B when the series is in phase with the shunt—*i.e.*, when the generator is feeding energy into the 'bus bars—and to extinguish the green lamp and light the red lamp on a reversal of the series current relatively to the E.M.F.

Among the uses of this energy direction indicator may be mentioned: (1) To indicate a faulty generator when several machines are connected in parallel; (2) to indicate when the load on a machine has fallen to zero in switching out a machine; (3) to indicate the direction of energy in a distributing network, an ammeter merely giving the amount. These indicators are designed for use on circuits up to 10,000 volts, and made for either high-tension or low-tension current. The high-tension apparatus is designed for connecting directly in series with the high-tension circuit, while the low-tension apparatus is arranged for connecting in series with the secondary circuit of current transformers. In either case the potential windings must be supplied with low-pressure current, and not directly from the high-tension 'bus bars, as shown on the diagram herewith, in order to simplify the connections.

UNIVERSITY COLLEGES OF GREAT BRITAIN.

A report of the Advisory Committee on University Colleges and a Treasury minute relating thereto were issued last week. It will be remembered that the Committee consists of Dr. H. G. Woods, Sir Francis Mowatt, Sir W. J. Collins, M.P., Mr. F. G. Ogilvie, Prof. H. Jackson and Mr. W. S. McCormick. In a previous report, dated June 6, 1907, the Committee recommended a distribution of the Treasury grants to university colleges for a period of only two years, instead of the usual five, so as to afford an opportunity for early reconsideration when the principles governing future allocations should have been placed on a more permanent footing. The present report (which is dated July 24, 1908) gives the conclusions at which they have arrived. Those of chief interest are as follows:

If State aid to universities and university colleges is to be fully effective a degree of freedom must be allowed in the working of these institutions which is not possible, and, indeed, is not desirable, in the case of schools. While it is necessary that there should be sufficient guarantee of educational results to justify the expenditure of public money, the methods usually adopted in this country in the administration of Parliamentary grants for educational purposes are not wholly applicable to the institutions with which we have to deal.

We attach much importance to the standard of preliminary education to be demanded of a student as a condition of admission to a degree course. No education should be regarded as of university standard which is antecedent to matriculation. One condition of any college receiving a grant from the Treasury should be an adequate standard for such matriculation or other preliminary examination; it is not intended that this should imply uniformity of test. In our judgment, the question is of sufficient national importance to demand the immediate attention of all concerned, and to warrant such financial adjustments as may be required to facilitate a settlement.

We attach great importance to the fact that an increasing number of students in each year are reading for degrees. But we recognise that the student who cannot enter for a degree course may be a true representative of the class for which the Treasury grants were originally designed, a class which the nation does well to encourage.

We have considered the question whether it is desirable to amalgamate the grants to universities as examining bodies with those to the same universities as teaching bodies; but while we think that it would be convenient if expenditure under the two classes of grants were brought under the cognisance of the same advisory committee, we are not at present in a position to formulate definite recommendations.

We have considered the question to what extent the Treasury grants to colleges should be made to depend on a minimum sum of money being obtained from fees and other local contributions. A rigid qualifying condition of minimum local income and fees undeniably has certain disadvantages. It is apt to induce colleges which fall near the border line in this matter to adjust their financial policy with a view to this test, irrespectively of other considerations. It also encourages the view that if the financial conditions are satisfied (provided there is no actual inefficiency) a college not at present on the list has a positive claim to recognition. Finally, this rule, though reasonable enough when judiciously interpreted as a condition of admittance to the privileges of the grant, might create grave hardship if rigidly enforced as a condition of retaining a share in it.

On the other hand, in testing the claims of a new college to be admitted, or of an existing college to remain on the list, it is necessary to insist on some minimum standard of development. While we would recommend assistance, so far as the amount of the grant allows, to struggling institutions which show promise of development, no money ought, in our opinion, to be allocated to any institution unless it is clearly capable of effectively carrying on a number of departments of study, and has a local income which justifies it in occupying the ground. We recommend that the mechanical minimum qualifications hitherto required should be replaced by the following conditions in the case of any institution seeking to obtain or retain a grant:—

(1) The institution, or the local teaching organisation of which it forms part, must be prepared to afford satisfactory instruction of university standard, which should normally include the following branches of arts and science: English, classics, French, German, history, philosophy, mathematics, physics, chemistry and biology. (2) The courses of instruction so established must be attended by a reasonable number of students capable of profiting by the education which these courses afford. (3) Since the main object of the Treasury grants is maintenance rather than initial or capital expenditure, the buildings and initial equipment of the college must be adequate for the courses established. (4) Its local income, when supplemented by Government grants, including such a grant as the Committee could recommend the Treasury to give, must be sufficient to maintain all its departments of university teaching in a state of efficiency, and to establish a superannuation scheme.

While we recommend your Lordships to prescribe these conditions, we think it should be made quite clear that while they are *necessary*, they are not in themselves *sufficient* to justify recognition, and that there may be colleges which conform to them but which cannot be recommended for grants. The grants have, from the beginning, been limited to colleges situated in great centres of population, and in our opinion this condition should be maintained. We are also of opinion that no new institution should be admitted unless it serves a district not already adequately served by a college giving instruction of a university character. Due account must be taken, not only of the efficiency and university standard of the teaching in each department, but also of the spirit animating the institution and of its influences as an intellectual centre. Finally, we may observe that while the Treasury grant in aid continues at the same fixed sum, it will be difficult to admit new institutions to participation in the grant, since the money can only be found by reducing the sums allocated to institutions which are already on the list and have duly maintained their standard.

In accordance with a Treasury Minute of July 18, 1905, special grants have been devoted to (1) books and apparatus, (2) post-graduate work, (3) the establishment of superannuation schemes. We recognise the importance of each of these objects, but we have come to the conclusion that it is unnecessary to continue the system of separate special grants, as the quinquennial re-assessment of the grants for general purposes will afford the Committee ample opportunity for securing the development of the colleges in these directions.

Universities and university colleges are at present doing much work referable to categories (technical or other—*e.g.*, technological, agricultural, professional) for which grants are authorised by Parliament otherwise than from the university colleges grant in aid. It is, therefore, possible (*a*) that both such other grants and the university colleges grant in aid might be paid to these institutions in respect of the same work, and (*b*) that there might be undue competition between these institutions and others supported by State aid in the same area. We have examined carefully in these respects the actual position, and we are satisfied that there has not yet arisen any serious overlapping of grants or wasteful competition. At the same time we believe that the sound and harmonious development of the universities and university colleges, and of their separate departments, will be promoted by the consolidation of the assistance they receive from the State, and by bringing the record of their varied activities under review by a single authority.

The University Colleges Advisory Committee, in considering the grants which ought to be made to the colleges, should have before them a reasoned statement of all work done by each college, which represents grant-value under Parliamentary sanction other than the university colleges grant. Such a statement might be prepared by the Board of Education, who administer most of these grants, and to whom the universities and university colleges in receipt of the grant in aid are required to furnish particulars of their work, organisation and finance.

Subject to limitations and conditions of aid set out, we recommend that, in the distribution of the amount of £100,000 (excluding for the present £1,000 for University College, Dundee), the methods hitherto in force should be replaced by an allocation turning upon the recognition of the essential college establishment charges on the one hand, and of the number and nature of the effective departments on the other. The total award of grant to each college should be a single aggregate sum, however the amount was calculated; and this aggregate grant for each college should hold good for a quinquennium, subject to any readjustment necessary in respect of possible transference of sections of work between the colleges and other institutions.

We trust that it may be found possible to regard such a scheme as being merely transitional, and to replace it in the near future by one on more simple lines—a scheme that would comprise in a single vote the whole aid granted by Parliament to universities and university colleges for education of university character and standard. We recognise that the present is a period of adjustment in many matters that have an effective bearing on university education, and we would urge that the methods adopted with a view to meeting the needs of the moment should have a relation as direct as possible to a broad conception of the place of university work in the national scheme of education.

The Treasury concur with the Committee in the recommendations made as to the conditions to be required, and agree that State aid to general education of a university standard should, as far as possible, be distinguished from State aid to professional and technical education; and they recognise the great difficulty of allocating the grants in such a manner as to secure this end. They are satisfied, however, that it would not be practicable under present circumstances to consolidate

the grants or to place their distribution in the hands of any one Department of the State. The Treasury propose to invite the Board of Education and the Board of Agriculture to furnish the Committee from time to time, as far as practicable, with a statement showing, in the case of each college, the extent and character of the work in respect of which grants are made by those Departments, so that the Committee will be able so to frame their recommendations as to ensure that the same work is not paid for twice over. They are further of opinion that the Committee should aim at excluding from the purview of the university colleges grant all work for which the colleges could obtain grants either from the Board of Education or the Board of Agriculture. As, however, this change may at first affect the arrangements and practice of some of the colleges it should be introduced gradually and with due consideration for existing conditions.

As to the annual grants of £2,000 now made to universities as distinct from colleges in respect of their examining or degree-granting, rather than of their teaching, functions, the Treasury doubt whether assistance from public funds should continue to be given for these purposes, and think that the grants might, with advantage, be merged in the aggregate sum to be allocated by the Committee; but before finally deciding the question they will await a further expression of the views of the Committee.

THE INTERNATIONAL CANDLE.

In our issue of May 21st last we published a communication on the International Candle from the National Physical Laboratory. We have received from the Bureau of Standards a somewhat similar communication, published in the United States at the same time as the one in this country. After giving the report *in extenso*, some interesting comments on it are made to show how the new standard will affect the present state of affairs in the United States. These comments are as follows :—

The above announcement* marks an important step forward in the history of photometric measurements. For many years the British parliamentary candle was the unit recognised in this country, but the lack of precision in practical photometry did not permit its value to be very accurately expressed or reproduced. In recent years the gas industry has employed the 1 c.p. sperm candle, the 10 c.p. Harcourt pentane lamp, the Hefner lamp, and various secondary standards, while the electrical industry has employed incandescent electric lamps, either certified by the Bureau of Standards or rated in terms of standards that are consistent with those of the Bureau. The unit of the Bureau has been maintained very constant, as shown by frequent comparisons with the standards of France, Germany, and Great Britain, but differed appreciably from the British unit and hence from the unit employed by most of the gas companies in America.

The Bureau of Standards took the initiative several years ago in bringing about international uniformity in the unit of light, by sending its representatives abroad with copies of its standards to determine more accurately the relative values of the units of the several European countries, and to urge the adoption of an international unit. In this country the American Institute of Electrical Engineers, the American Gas Institute, and the Illuminating Engineering Society have acted together in support of the movement, and have voted in advance to recognise the new unit of candle-power.

In England the National Physical Laboratory has secured the endorsement of the London Gas Referees and the Institution of Gas Engineers.

The union of the three national standardising institutions of America, France, and Great Britain in maintaining a common unit of candle-power, and the co-operation of the German Reichsanstalt in redetermining, from time to time, the ratio of the Hefner unit to the common international candle, assures the highest attainable constancy for the new unit of light.

Unfortunately there is no primary photometric standard that is sufficiently constant and reproducible to be generally accepted as an international standard. France, Germany, and Great Britain each has its own primary flame standard, and a great deal of effort has been expended in attempting to determine accurately the relations between them. Until the flame standards themselves are better understood, however, and the atmospheric and other conditions more perfectly controlled, the unit of light can not be preserved as accurately by primary flame standards as by incandescent electric secondary standards. The latter, when well made, properly seasoned, and carefully measured, permit comparisons to be made (using the means of many settings on several lamps) with excellent precision, the lamps themselves being constant enough, and the precision of measurement high enough to fix the final values to about one or two tenths of 1 per cent. There is good reason to believe that in this way the international unit of light can be preserved so nearly constant that any inevitable drift occurring one way or the other would be too small to detect with certainty by any of our present flame standards in many years. The Bureau of Standards will continue to standardise flame standards by the electric standards, and will also carefully investigate the more important flame standards. Similar tests and investigations will also be made in Europe, and if any appreciable drift does occur it will sooner or later be detected.

Careful distinction should be made in this connection between a unit and a standard. An international unit maintained by the co-operative effort of several national standardising institutions, and checked from time to time by means of all the best primary standards in use, is more likely to be maintained constant than if it were defined to be represented by any single primary standard, unless such a primary standard were reproducible to a very high degree of precision. Such a unit can be continued permanent even though all present primary standards are ultimately superseded by better ones. The Hefner lamp as a convenient flame standard will not be displaced in America or any other country which adopts the international candle as its unit of light. Uniformity among different countries and continuity of value are prime necessities with respect to the unit. But the particular standard by which the unit is realised in practice is largely a matter of convenience and circumstance. In the photometry of electric lamps, electric standards are most suitable. In gas photometry one form of flame standard or another will be employed according to circumstances. It is not expected that all countries of the world will at once adopt the proposed international candle as their unit of light. Those countries which already have the Hefner unit in general use may prefer to continue it. But if all countries which have a unit differing appreciably from the Hefner shall adopt the international candle as their unit, there will then be only two units in use throughout the world, and they will have the simple ratio 9 : 10. This would result in a distinct gain both in the practice of photometry and in definitions and nomenclature.

The effect of this change of 1·6 per cent. in the unit of the Bureau, which is in general use for electric lighting throughout the country, is to raise the candle-power rating and decrease slightly the watts-per-candle of electric lamps. A 16 c.p. lamp will give 16·26 candles in the new unit, or a 16 c.p. carbon-filament lamp burning at 110 volts will give 16 candles on the new basis at 109·69 volts. The change, though small, is important in the photometry and rating of lamps.

The new unit of candle-power being in agreement with the present English unit, as represented by a 10 c.p. standard pentane lamp, there will be no change in the unit of light now employed by those gas companies which use pentane lamps, provided they are in agreement with the English standard. But as pentane lamps may differ slightly from one another, even when burned under the same conditions, it is desirable for the sake of greater uniformity to have them standardised in terms of the standard candle of the Bureau. These variations, amounting to from 1 to 5 per cent, are generally in the same direction; that is, the lamps if not correct usually give less than 10 international candles under standard conditions when burning in a pure atmosphere, at a normal barometric pressure of 76 cm. of mercury, and an atmospheric humidity of 8 litres of water vapour per cubic metre. In anticipation of this change some of the largest gas companies in the United States have already had their pentane and Hefner standard lamps standardised by the Bureau in terms of the new unit.

Gas standards will hereafter be certified in terms of the international candle. Electric standards will be certified in terms of the old unit until July 1, 1909, unless otherwise requested. On July 1 the new unit will be adopted by the Bureau of Standards in the certification of electric standards, and it is hoped that manufacturers of electric lamps will adopt the new unit as soon thereafter as possible.

The Bureau recommends that all gas and electric companies, all photometric laboratories, and all the manufacturers of electric lamps in the United States adopt the new unit of candlepower, if possible, not later than January 1, 1910.

Further information with regard to change of photometric unit or to the testing of gas and electric standards will be given on request.

* The report already published in The Electrician.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The thirty-seveth issue of the Supplement is published (Gratis) with the current number of "THE ELECTRICIAN."

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THE METAL LAMP PROBLEM.

We are glad to see that Mr. E. E. HOADLEY, in a Paper read before the Incorporated Municipal Electrical Association this week, takes a broad and common-sense view of the influence of the metal lamp on the electrical industry. As will be seen elsewhere, the author suggests that even in the case of an alternating-current station, provided it has the benefit of a good shop lighting load and a fair power load, the new high-efficiency lamps should be looked upon as a blessing, very possibly in disguise for a time, but nevertheless a blessing, for the amount of harm done to the revenue account at the present time will be amply repaid later on; in fact, a new era of prosperity is likely to be opened up, not merely in the lighter branches of electrical engineering, but also in the manufacture of heavy plant when the present temporary check has been overcome. In many cases, of course, there will be a fall of revenue more rapid than can be compensated by any increased demand for the moment, and in some few cases the raising of prices may seem to be the only workable hypothesis. The latter applies to the alternating current station dependent on house lighting and very little else. Generally, however, the remedy lies in pushing, as far as possible, the other domestic uses of electrical energy, such as heating and cooking, which have not been exploited nearly as much as they should have been.

As the author points out, it is well to remember that we are only at the beginning of the metal lamp era. At present the smallest high-voltage lamp has a somewhat high candle-power and costs, say, 3s. 6d., but this state of things is not likely to continue indefinitely. A parallel case is that of the gas mantle. This is fragile and must have been regarded as intricate by the public when first adopted, yet it sells for a few pence now, whereas the price originally was several shillings. The carbon lamp, also, at one time was sold at 5s., whereas now the price is only about 9d. At present consumers sometimes hesitate at the price of metal lamps unless they are certain that a considerable advantage will result. As prices fall the consumer will be more and more influenced by the high-efficiency point of view, and a great impetus to electric lighting will be the result.

In order, however, to meet the present situation successfully it is necessary, as the author points out, that supply authorities should have powers which in many cases are still wanting. It is essential that they should be able to hire out apparatus, or to let apparatus out on hire-purchase terms. This question raises some points of a controversial nature, as it is undesirable to trench upon the sphere of private traders. The author suggests that no appreciable income would be taken from the wiring contractor if it were understood that the wiring of hired apparatus would be done by a contractor. We think in the long run the contractor would benefit considerably, though it would probably be difficult for the supply authority to avoid wiring altogether. Although a gas company does not undertake to put in gas piping throughout a house, gas connections to stoves and cooking apparatus are fitted as a matter of course, and the gas consumer would probably think it rather a hardship if he had to get a plumber into the house after having arranged matters with the gas company. Simplicity in negotiation is essential. Unfortunately, electrical connections are not made quite so easily as those for gas, and, perhaps, therefore, the simplest solution of the difficulty would be for the electrical undertaking to arrange with two or three responsible wiring contractors to carry out the necessary alterations whenever apparatus is let out on hire. At all events, the present position is somewhat absurd. Gas companies are free from such restrictions, and even the electrical undertakings in some 44 towns have these privilages. There is, therefore, nothing to be said in favour of such want of uniformity.

With regard to the vexed question of interior wiring, it is interesting to note that Mr. Hoadley is in favour of the Continental system of wiring with flexible, which he has tried in the damp warm atmosphere of a conservatory for 18 months without the slightest trouble. It appears to us that the critics of this system are generally those who have had no experience of it, and that consequently the criticisms are rather theoretical than practical.

It is not, however, to private lighting alone that the influence of the metal lamp is restricted. In street lighting it opens up a very large field. Whatever difficulties there may be in obtaining lamp units sufficiently small for popular use in house illumination, these do not apply to street lighting, in which lamps of, say, 50 to 100 c.p. are extremely suitable. Such lamps produce as good a light as any gas mantle on the market, and they have the great advantage that the light does not fall off with the life of the lamp to any great extent; no special mains are necessary, the gas street lamps can be easily converted, and the glow lamps can be renewed with the greatest ease. Moreover, the life obtained is extremely good. According to Mr. Hoadley's experience the average life has been something like 1,100 hours, individual lamps lasting 6,750 hours, 5,450 hours, and 5,041 hours on a circuit of 230 volts. Considering that the conditions in this case were not altogether ideal, these results must be considered most satisfactory, and they should encourage other engineers to look into the matter and to bring the subject before their committees, with a view to the extension of electric street lighting to side streets, where gas has hitherto been at a very great advantage.

REVIEWS.

Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Heavy Electrical Engineering. By H. M. Hobart. (London: A. Constable & Co.) Pp. xxiv.—338. 16s. net.

This book contains a great deal of useful information conveniently tabulated and arranged for use, but is, unfortunately, somewhat marred by three irrelevant chapters, in one of which the author vents his spleen against contractors as a body because they do not always adhere to his specifications, and in the others attacks the Thury continuous-current system and the single-phase railway system. These chapters are written in the style of controversial letters to the technical Press, and tend to depreciate the value of the book as a whole.

The useful part, contained in Chapters I., II., III., IV., V., VII. and VIII., is arranged on the plan of explaining in detail how to calculate the sizes and costs of all the parts of power stations and transmission lines. Each chapter contains extensive data relating to existing installations, classified and tabulated so as to be easily available for use in calculations. Some of the curves, of which there are an enormous number, appear to be based on rather insufficient data, and it would add to their usefulness if more information were given as to their reliability. The author himself has some doubts about the accuracy of the 34 sets of curves relating to steam turbines, and they should not be accepted as more than an indication of the sort of results to be expected. Mr. Hobart is a great believer in working out formulæ or curves for everything. The principle is good, but it is important to remember how entirely the results depend on the assumptions made to begin with. This fact, we think, he rather overlooks.

In actual practice the conditions are, as a rule, not all fixed. Alternative schemes cannot, therefore, be compared by simply comparing the costs for a given set of conditions. We must rather try to make the best of each scheme and compare costs and results conjointly, though there may be no mathematical way in which this comparison can be made. Each scheme will have its good and its bad points, and it is a matter of judgment or experience to balance these. Mr. Hobart's cut-and-dried methods are very useful up to a certain point—beyond that they become misleading.

One interesting feature in the book is that all the quantities are given in metric measure and all energy is measured in kilowatt-hours and all power in kilowatts. Weights are all given in terms of the "ton" of 1,000 kg. It is a little bewildering at first to find the heating value of coal and the heat required to evaporate the water in the boilers both given in kilowatt-hours per ton, but the advantages are obvious. All steam data have been worked out in these units. There seems, however, to be no gain in giving boiler pressures in kilogrammes per square centimetre and grate areas in square decimetres. The

ordinary mixed system of units has many advantages. Even Mr. Hobart has not altered the scales (feet) on the drawings of his power stations, and in a few cases has even given quantities of water in gallons as a concession to his weaker brethren.

We shall only briefly refer to Chapters VI., IX. and XI. In Chapter VI. Mr. Hobart slangs contractors. "The technical policy of large electrical manufacturers is notoriously short-sighted." "The indifference to insulation is deplorable." "To trust to Providence that a docile inspector shall be allotted to them is to harbour the dishonest intention not to live up to the specification," and so on.

Chapter IX. deals with the Thury direct-current system. It is mainly a lengthy and controversial reply to Mr. Highfield's Paper ("Journal" I.E.E., Vol. XXXVIII., p. 471).

Chapter X. is a short discussion of electric traction calculations. The reader is referred to "Electric Railway Engineering," by Hobart and Parshall, for full particulars.

Chapter XI. is a violent attack on what Mr. Hobart calls "this single-phase monstrosity." The following is an example of the arguments used: "The advocates of the single-phase system . . . generally draw attention to such weaknesses of the continuous-current system as the rotary converter, but they omit to point out the disadvantages that must be suffered in order to avoid this undesirable adjunct. Each system must be considered as a whole, and it is not an advantage to transfer a weakness from terra firma to what is always the weakest portion of the system—the train equipment." But Mr. Hobart does not describe any single-phase equipment in which a rotary converter has been transferred to the car.

Whether single-phase or direct-current or three-phase will ultimately supersede all other systems, or whether each will have its sphere of usefulness can only be determined by experience. Prejudiced attacks will not forward "the progress of electrical engineering along sound lines," which Mr. Hobart desires. In the meantime all engineers will welcome the Paper which we believe is shortly to be read describing the first single-phase line in England—the Lancaster–Morecambe–Heysham line on the Midland Railway.

Apart from these few chapters, the book is excellent and likely to be of great use to engineers. C. F. JENKIN.

La Télégraphie Sans Fil et la Télémécanique. By E. MONIER. 4th edition. (Paris: H. Dunod & E. Pinat.) Pp. vii.—174 Fr.2.

A popular, bookstall sort of book, such as this, possesses, naturally, no interest for the technical person conversant with, or anxious to become conversant with, the details of wireless telegraph methods. But sometimes a book of this kind is just the thing to give to a busy engineer *not* interested in wireless telegraphy a notion of what is going on in the wireless world. We feel that this particular book is rather too popular, and assumes rather too complete an ignorance of the rudiments of electrical fact and theory, to be recommended to even the heaviest electrical engineer. It might, however, be suitable for, say, gas engineers or other anti-electricians.

The journalistic touch abounds throughout the book. For instance, the chapter on telemechanism is headed "What can be done in an abandoned fortress." Throughout, M. Branly is held up as the one individual without whom wireless telegraphy could not have existed. This view is surely not quite correct; it was somewhat of a chance that the coherer was used rather than, say, the magnetic detector, in the infancy of practical wireless telegraphy.

FOURTEENTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

It is, perhaps, a statement bordering on the trite to say that no better place than Manchester could be found for the 14th annual convention of the Incorporated Municipal Electrical Association. Not only have the members been able to see—in fact, scarcely able to avoid seeing—an excellent system of electric tramways, which seem to go to and come from everywhere, but they have had an opportunity of inspecting the arrangements made for supplying the biggest power load in the kingdom, and of visiting works where this power is utilised. Apart from this, a number of electrical manufacturers in the district have thrown open their works to members, so that they have been able to refresh their memories by inspecting the hundred-and-one operations which are necessary for the production of a piece of electrical machinery.

Among the numerous engineers, municipal and otherwise, who are attending the convention may be mentioned: Messrs. R. L. Acland, L. Andrews, F. Ayton, T. W. Bloxham, H. Boot, J. Christie, W. A. Chamen, S. Clegg, A. Clough, E. W. Cowan, A. C. Cramb, F. W. Crawter, A. A. Day, S. E. Fedden, S. Z. de Ferranti, M. B. Field, E. J. Fox, E. E. Hoadley, E. M. Hollingsworth, J. Huddlestone, W. W. Lackie, V. A. H. McCowen, J. M. McElroy, F. A. Newington, G. H. Nisbett, S. L. Pearce, J. S. Peck, P. J. Pringle, H. Faraday Proctor, J. H. Rider, W. M. Rogerson, T. Roles, C. E. C. Shawfield, J. F. C. Snell, H. F. Street, C. D. Taite, H. Talbot, S. J. Watson, G. Wilkinson, T. P. Wilmshurst, A. P. Wood and W. B. Woodhouse.

Monday, June 21st.

The proceedings of the convention opened this evening with a reception at the Town Hall by the Lord Mayor and Lady Mayoress of Manchester (Ald. and Mrs. Edward Holt). About a thousand guests were present in all, but this number included, besides members of the association, many Manchester citizens representative of municipal work, as well as of art, science, literature and diplomacy. The hall was beautifully decorated, and entertainment was provided by Messrs. Forsyth's band and by Mr. Henry Houston, who exhibited a number of magical problems.

Tuesday, June 22nd.

To-day members were greeted by the Clerk of the Weather, a regular Manchester variety of atmospheric conditions being provided for their entertainment; in fact, matters were so bad that the arc lamps in the beautifully decorated hall of the Municipal School of Technology in Whitworth-street, where the meetings were held, had to be lighted. Here it may be remarked that the hall is acoustically bad, and that the adjustment of the above-mentioned arc lamps is, as remarked by the Lord Mayor, a matter which requires further development.

The meeting was called to order very punctually by the president (Mr. S. L. Pearce, city electrical engineer, Manchester), who briefly introduced the Lord Mayor of Manchester. His lordship then addressed the meeting as follows: —

He said that he believed in reasonable profit for a municipal trading scheme, and did not consider that ratepayers should find the capital without any remuneration. His own electricity committee did not, however, agree with him. Another serious question was that of competition, which was nowadays taking the form of competition with other departments of the same Corporation. There were departments in connection with gas, hydraulics, steam and electricity, and it was foolish for these to cut each others' throats by competing for business. They must not forget that all municipal undertakings were subject to the same depressions as other businesses, and they should be extremely careful to allow sufficient depreciation and reserve fund in times of prosperity, so as to be ready for times of depression. These were matters they would have to consider. Whether there was more to be got out of electricity for the benefit of the general public, or out of gas, or out of steam, was another question the members present would probably help to solve. They were all aware that there was not so much being obtained from these items as there might be. He was gratified that Mr. Pearce had been

selected for the office of President for the year. In him Manchester was represented by a most able man; a man who was greatly improving the department, and he (the Lord Mayor) was glad to say Mr. Pearce was supported by the committee in every improvement he had found to be in the interests of the consumers. He hoped their stay in Manchester would be beneficial not only to themselves but also to the public generally throughout the country.

Mr. S. L. Pearce proposed a vote of thanks to his lordship for attending. This was carried with acclamation, and the Lord Mayor then withdrew.

The president, Mr. S. L. Pearce, then delivered his address, of which the following is an abstract :—

For the second time in its history the Association is meeting in Manchester, and it is interesting to look back over the past records and mark the progress which has been made in the development of the Association since its second convention in this city in 1897. To-day its representations on any matters affecting the industry, and particularly the municipal aspect, are listened to with respect and attention. Judged also in the light of past achievements, the Association has gained considerably in prestige and status.

The growth of the Association has been coincident with the development of municipal undertakings. In 1897 the total capital sunk in electric supply works, including traction, by local authorities was £3,509,000. To-day this figure stands at no less a sum than £83,860,000. The success which has attended our branch of municipal enterprise, judged not merely from the points of view of sales and costs of production, but also from the sounder financial position of the majority of undertakings, has done much to silence the criticisms of those who would contend that municipal undertakings are neither progressive nor business-like.

The name of Manchester is always associated with that of its first consulting electrical engineer, the late Dr. John Hopkinson, to whose genius the electrical world generally owes so much. It is interesting to mention, as a striking commentary on the advance of electrical science, that practically none of the electrical plant installed by Dr. Hopkinson in the early days of the undertaking, from 1893 to 1897, now remains.

Too much stress cannot be laid on the point that the financial stability is, or should be, the most important aspect of a committee's policy. The provision of adequate reserves for renewals of plant, in so far as these cannot be met by further borrowings, should be the first necessary step in this direction. It is now generally accepted that in so far as the statutory sinking fund instalments unaided will not provide for the redemption of the loans for short-lived assets by the end of the term fixed by the sanctioning authority, some additional charge against revenue is necessary. It is desirable that this supplementary charge on revenue should be annually apportioned. The fund thus accumulated then also serves to equalise the charge against the yearly revenue accounts, and relieves the latter from the fluctuations that would otherwise normally occur. Too often, it is feared, moneys are taken in relief of the rates which should have been applied in provision for renewals or depreciation. The question of a reserve to meet any general contingencies that may arise, or to provide for an "antiquation" fund, is more difficult to determine, but should, if at all possible, be provided for.

Having given due consideration to this aspect of financial policy, it is at least arguable as to whether the object of all municipal undertakings should not be to supply current at, or near, cost price, and not to relieve the rates out of profits to benefit non-consumers. Unfortunately, the tendency at the present time, in view of ever-increasing rates, is to look to the trading departments for more and yet more relief in the shape of increased contributions. So far as lies in our power, this tendency should be resisted, as being detrimental to the best interests of trading concerns. The recent decision of the House of Lords Committee on the gas clauses in the Salford Corporation bill is noteworthy by reason of its bearing on this question of rate aid from trading departments. The Corporation were in future to be allowed to use in relief of rates 1 per cent. upon their capital, equivalent to some £6,000 per annum, instead of about £28,000, the amount previously contributed.

Next as to matters that have come more particularly beneath our notice during the past year, I venture to put first and foremost the rapid adoption of the new metallic filament lamp, and the many questions which arise as practical issues from its adoption. There are probably few undertakings during the past year which have not experienced serious reductions in output and diminished revenue in consequence of the adoption of the new lamps. But we all admit that it is only a temporary check to the progress of supply undertakings, and eventually, as the advantages become more widely known and appreciated, and as consumers recognise that a substantial increase in candle-power can be obtained with a corresponding decrease in energy consumption, there will be an inevitable reaction to the present "slump" in output. Those authorities who have a lighting supply business only, particularly with alternating current, have been most badly hit, and it is only natural that various proposals should have been made to devise a tariff which shall meet the altered conditions of supply. A raising of prices is to be deprecated at all times, but at the present time, now that the industry has something with which to compete with the gas mantle on more level terms, it would appear to be a very questionable policy.

We are undoubtedly passing through a transitional period, the growth of the lighting portion of our undertakings having been temporarily checked. I incline to the view that the worst of the check has been experienced. Still higher efficiency lamps for low voltages may be put on the market, but, against this, the high-voltage lamp of moderate candle-power is likely to be more widely used, which must have a tendency to keep the consumption steady whilst giving increased illumination. Further, I think there will be a demand for a lamp in which some of the efficiency is sacrificed for stability. On the whole, therefore, it would be well for the present to mark time in the matter of reduction of price, even though revenues should suffer for the time, in the belief that the prospects of the electric lighting business have been altogether improved by the advent of the metal filament lamp, and that nothing should be done to arrest an increase in new connections just when they are most urgently wanted. In the case of those authorities supplying a mixed load, it may be pointed out that the small percentage of the plant liberated is available for power demands, so that the resultant effect on the station must be some increase in the load factor, and on the system as a whole a probable increase in the diversity factor.

The advent of the metal filament lamp emphasises one thing, and that is the utmost importance of having the public educated up to the advantages offered by the high efficiency lamps. Particularly does this apply to those householders on the line of route of existing distributing mains, so that at a trifling capital expenditure a substantial addition to the revenues may be obtained.

As to the amendment of the existing wiring rules of "The Institution" in connection with cheapened methods of wiring, probably the "Continental" system, involving the use of flexibles, has been most discussed. It is to be hoped that the cable manufacturers will give their serious attention towards producing a class of flexible that will meet the conditions of service required in this country. On one point all are agreed—that cheapened methods of wiring must not involve in any shape or form a lowering of the standard of safety. In my opinion, a system involving the use of "flexibles" above a given height from the ground, excepting where wires pass through walls, floors or ceilings, is not inconsistent with the above axiom.

Some economies can be further made in the following directions: (1) Increasing the limit for the number of lamps to be wired on a two-wire service. (2) The use of two-wire circuits wherever possible in houses instead of three-wire circuits. (3) Increasing the allowable number of lamps per circuit.

The writer thinks that it is to large power supplies that supply undertakings will have chiefly to look in the future for increased sales and substantial growth. Most engineers are agreed that the power supply business must, on account of the improved load factor, and the increase in the diversity factor, bring about a general reduction in the costs of production, and for these reasons is a load to be steadily cultivated. It is estimated that in the area of supply of this city something approaching 1,000,000 H.P. is utilised, and the growth in the development of the department's power sales has been very striking, so that it is a matter of supreme importance to consider the question carefully in all its bearings, and be certain that the financial aspect is sound, and not likely to lead the undertaking into a critical condition.

The argument of the critics is that many of the power tariffs are unremunerative, the present deficit on power sales being masked by a big surplus on lighting sales on account of the greatly preponderating output for the latter. The writer believes that the majority of power tariffs framed are remunerative, although in certain cases they may have involved some remission in the fixed charges to large power users. Take the case of a system in which plant is now being put down to deal chiefly with power supplies, the installation of this more modern plant, and utilising larger units, will, on present-day prices, only cost one-half to one-third of the price per kilowatt of the plant forming the existing installation, erected, say, seven years ago. I think in this hypothetical case it would most certainly be equitable to remit a proportion of the fixed charges on capital in the case of those consumers, whilst debiting them with their full share of the remaining standing costs.

I believe the above basis is fundamentally sound, and that it must lead to three results: (a) That power business will be secured at profitable rates. (b) As the power load grows there will be a broad-

ening of the basis over which all fixed costs are spread. (c) There will be a general decrease in the costs of production. From the latter two results lighting consumers must inevitably benefit in a lowering of the lighting tariff, and this is an answer to the criticisms that the lighting consumer is subsidised for the benefit of the doubtfully valuable power consumer. It has been stated that the correct basis of all tariffs is "the equal allocation of all charges on a load factor basis." Everything turns on the interpretation of the word "equal." "Equitable" would be a better word, and then we get rid of the idea of "averaging," which means little or nothing, but is so dear to the hearts of our gas friends.

As to the criticism by authorities controlling tramway undertakings, that the electricity departments are obtaining big prices from traction supplies, whilst very much lower prices are being given to large power consumers, it will be found that in each case the load factor on the power supply is substantially greater than it is for traction supplies. Thus, on the Manchester system, the traction load factor is 32 per cent., and the average power load factor 51 per cent. As regards diversity factor, in the ordinarily accepted meaning of the term, it does not apply in the same degree to the tramway supplies as to power supplies. It will be found in the majority of cases, especially in large systems, that if all costs are equitably allocated to the traction supplies, current is being provided with little margin of profit, and, in not a few cases, at bare cost.

There has lately been a disposition in certain quarters, to force local authorities to disclose the nature and terms of special supplies on the ground of preferential treatment. Whilst believing that publicity is good, and that supply authorities cannot be too ready to give information in regard to their undertakings, which will lead to mutual confidence between the ratepayers and themselves, it is greatly to be regretted that such an unbusinesslike method of proceeding as the above should be forced upon them. Municipal trading or non-municipal trading may be arguable, but once the principle has been decided upon, the same business principles as apply to private company undertakings should apply to municipalities, and they should be left free to develop their undertaking on strictly business lines.

Reference is next made to the Electric Lighting Acts Amendment Bill, the North British Electric Power Synd. (which is working under no Act), to the work of the I.M.E.A. hon. secretary on behalf of the Association during the past year, especially in connection with Parliamentary matters, and also to the success of the Manchester Electrical Exhibition.

Attention is also drawn to the necessity for co-operation in the electrical supply business. It is well known that arrangements have been made in certain parts of the country whereby the supply company purchases energy in the form of waste heat, or waste steam, from manufacturers; but it is not to this aspect of co-operation that the writer wishes to draw attention so much as to the question of mutual assistance between existing supply authorities, as in the bills that were before Parliament last session in connection with London's electricity supply. The problem of supply from the stations of small local authorities has been materially altered during the past few years, and if economical and sound progress is to be made it will in many cases prove to be along the lines of purchasing bulk supplies at low rates from neighbouring municipalities, or, failing them, from power companies. The Legislature should, therefore, speedily provide for combination amongst municipal authorities along the lines suggested in the Amendment Bill to the Electric Lighting Acts now before Parliament. The time will come when the question of closer co-operation between the larger municipalities will be carefully considered, and no one can doubt that there are elements of substantial advantages and economies to be realised for mutual benefit.

As to the status of the municipal electrical engineer, there are not wanting signs to-day that there was never a time when it was more necessary for him to uphold his position. There seems to be a disposition abroad to depose him from the position of the controlling force, that whilst his technical abilities are not called into question, he is supposed to be lacking in sufficient commercial knowledge, or business acumen, to enable him successfully to pilot the concern for which he is responsible. Pushfulness he may lack, but it cannot be said that an engineer worthy of the name lacks commercial knowledge and aptitude; and as in the administration of electricity departments science and technical knowledge enter in at every point and largely determine all questions of high policy, the engineer must be referred to in the end as the controlling officer acting under, and subject to, the municipal committee.

The status of the engineering profession is difficult to define. Our institutions do not take any responsibility in regard to the acts of their individual members, whether of recognised etiquette, or other unwritten laws, that should be observed between members of the same profession. It is warmly discussed even whether engineers do belong to a profession in the sense that barristers and medical men belong to their respective professions. At any rate, it is the duty of this, as well as other scientific associations, to do whatever may be possible to raise the status of the profession to which we all belong.

In conclusion, reference is made to the visits in connection with the Convention and to the assistance of Mr. Bromley Holmes in arranging the visit to Liverpool.

A vote of thanks to the president for his address was proposed by Bailie Willock (Glasgow), to which Mr. Pearce briefly responded.

Councillor Alex. Sinclair (Swansea) then read his Paper on "Cheap Units" in abstract. This will be given in our next issue. During the reading of this Paper the mediocre acoustic properties of the hall were very evident, and the attention of those present, which had been very close during the president's address, showed a tendency to wander. An interesting discussion took place, to which we shall refer at a later date.

This concluded the morning's business, and the members and guests then adjourned to the Town Hall for luncheon at the invitation of members of the Manchester Electricity Committee. The hall in which the luncheon was held is all that can be desired from an architectural point of view, but it is certainly not a place where speeches can be made, or heard, with any degree of comfort. The pressman is on such occasions in the position of a guest, and may not, therefore, look a gift horse in the mouth; but when no special accommodation is provided for him, and all that he can hear of the speeches is a confused murmur, there is some just cause for complaint.

The Lord Mayor of Manchester presided at this luncheon, being supported by the Dean (Dr. Welldon), by numerous members of the City Council and by the officers and council of the Association. After the usual loyal toasts, the health of the "Incorporated Municipal Electrical Association" was proposed by Councillor S. W. Royse and responded to by Mr. S. L. Pearce. The toast of "The Manchester Corporation Electricity Department" was proposed by Ald. G. Pearson, of Bristol, and responded to by Councillor Howarth, chairman of the Manchester Electricity Committee.

At the conclusion of luncheon members were conveyed by special cars to the Stuart-street station of the Manchester Corporation. The details of this station are so well known to readers of THE ELECTRICIAN that there is no need to deal with them at any great length. It may, however, be mentioned that the total capacity is 29,000 kw., 17,000 kw. of which is provided by reciprocating engines and the remainder by two 6,000 kw. turbines. From this station high-tension current is delivered to various sub-stations, both public and private, where it is stepped down to 500, 410 and 205 volts for tramway, power and lighting purposes respectively. The station was originally designed for the installation of reciprocating engines only, but Mr. S. L. Pearce has erected turbines, and it will now be possible to instal some further 20,000 kw. of plant, instead of some 5,000 kw. which would have been the limit had reciprocating engines been used.

At the Bloom-street and Dickinson-street stations, which the members of the Association visited later in the afternoon, low-tension continuous current is generated for supplying the lighting and tramways within the city area. Both turbines and reciprocating engines are at work in these stations. Dickinson-street also contains 7,400 kw. of sub-station plant, seven Peebles-La Cour converters of varying capacity being installed. A 3,000 kw. battery has also recently been erected; in connection with which there is an interesting booster plant, described on p. 418 of this issue. The high-tension current from Stuart-street is converted and stepped down in 20 public sub-stations, while no less than 15 private consumers have similar stations on their own premises. Power supply is, of course, a leading feature of electrical work in Manchester, and as regards the main details of this, though there has since, of course, been a numerical increase, we must refer our readers to THE ELECTRICIAN, Vol. LIX., p. 746.

The visits to these stations concluded the business for Monday, and the members then separated, no doubt to take part in those informal discussions which are often of more benefit to the individual than those laid down in the programme.

Wednesday, June 23rd.

To-day the members of the Association were astir early and assembled at the Central Station, Manchester, for the journey to Liverpool. The Cheshire Lines Committee provided a special train, and a comfortable and speedy journey was made to the Central Station, Liverpool, which was reached at 9:40. The members then proceeded to the small Concert Hall of St. George's Hall, where they were welcomed, in the name of the Corporation of Liverpool, by Ald. Sir Chas. Petrie, chairman of the Tramways and Electric Power and Lighting Committee. A vote of thanks to Sir Chas. Petrie for his hearty welcome of the Association to Liverpool was moved by Mr. S. L. Pearce, and carried with acclamation.

A Paper on "The Influence of Metallic Filament Lamps on the Electrical Industry and on Street Lighting" which will be found in abstract elsewhere in this issue, was then read by Mr. E. E. Hoadley, chief electrical engineer, Maidstone. An interesting discussion on this Paper followed, and this we give in abstract below.

Mr. S. E. FEDDEN (Sheffield) said he appreciated the fact that the manufacturers of dynamos and other plant had had a considerable set back through the advent of the metal lamp, as plant for extensions would not be wanted for a year or two. Cable makers would be affected to some extent, and the price of copper would be lower, owing to less being required. A maker had told him that the total cost of the metal lamp was about 7d. Makers present might explain why he could not obtain them under 1s. 8d. The lighting load revenue at Sheffield had diminished by £4,000 since the advent of the lamp, although only 5,000 200-volt, 10,000 100-volt, 420 50 volt and 144 25-volt were installed, a very small percentage of the total. To make up for one consumer changing his lamps, three new consumers of a similar demand were necessary, two to make up the revenue and a third to cover the charges. In regard to heating and cooking, in Sheffield they had the problem of cheap gas, and although a canvasser went round with all kinds of accessories, it was very uphill work. He admitted, however, that the lamp might be a blessing in disguise. It had saved a number of his consumers from going back to gas through the blackening of carbon lamps. In the course of his remarks Mr. Fedden said that of the 8,000 orders dealt with by the wiring and fittings department, 4,000 were small orders occurring after working hours, mostly during the night. They had one or two men to look after these, but, of course, contractors could not keep a staff for this purpose.

Councillor DYKES (Beckenham) said in regard to a station like Beckenham, supplying almost entirely a lighting load and generating alternating current, they should try to get a fixed price, dependent upon the number of lamps used at one time, with a small charge per unit. Otherwise small consumers did not pay for the cost of putting in and reading the meter. Before the advent of the metal lamp, the average consumption per lamp installed, mostly 8 c.p., was 15·6 units per annum, and they got a total revenue of 8s. per lamp. Last year they allowed such consumers to have transformers, taking the precaution of making them use 16 c.p. lamps. Receipts from the sale of current dropped from 6s. 6d. to 4s., and the units from 15·6 to 9·8. The rental was raised, and brought the figure up to 6s. 4d., against 8s. previously obtained. A consumer using, 30 watt. 25 c.p. lamps, with current at 5d. per unit, and using 45 units per annum, with wiring and meter rental, paid 21s. 6d. Were they justified in charging 21s. 6d. to a consumer burning for 1,500 hours, when they were prepared to supply a consumer burning 500 hours for 6s. 4d.? The extra 1 000 hours cost only about another 1s. 3d. bringing the figure to 7s. 7d., and, allowing for the consumer turning on all his lamps at once, they could supply profitably at 10s. per lamp per annum.

Mr. HAYDN HARRISON drew attention to the high cost of services, both for street and private lighting, and suggested that means should be sought for reducing this. He thought that large unit metallic filament lamps were an advantage for small consumers, as an improved load factor could thereby be obtained and subdivision was impossible. For street lighting there was no doubt that the new lamps were of the greatest use, especially where the electricity works were owned by the local authority and the price of gas was high.

Mr. H. C. BISHOP (Newport), gave some results of street lighting with metallic filament lamps. Their average life was 2,800 hours, and the life was longer with alternating current; also the high voltage lamp had an advantage in this respect over the low voltage. There had been a large reduction in old consumers' bills, and the new consumers had not brought any increase in revenue, so that the net result was a decrease.

Councillor D. STUART (Wimbledon) gave some figures relating to the life of the lamps, showing the improvement in this respect over the older lamps.

Mr. F. SELLS said that the manufacturers were not dealing entirely in profits. The lamp could not be produced as cheaply as stated by Mr. Fedden, as the expenses were very great. Engineers did not always know quite what they wanted.

Mr. A. J. CRIDGE (Sheffield) said gas was 1s. 4d. per 1,000 at Sheffield. It had been suggested that prices should be raised to users of metal lamps, but he thought this would be a disastrous policy.

Ald. SMITH (Liverpool) and Councillor CROWTHER (Sheffield) also briefly contributed to the discussion. Several others present had intimated a desire to speak on the Paper but owing to lack of time they were requested to postpone their remarks for publication in the "Proceedings."

Mr. HOADLEY (in reply) said, in regard to Mr. Fedden's remarks, he thought the initial wiring should be done by contractors, but everything else should be done by the department. He would postpone further reply for the "Proceedings."

A Paper on "Modern Cable Systems" was then read by Mr. E. M. Hollingsworth, chief electrical engineer, St. Helens. An abstract of this Paper is given on page 411, and below we give an account of the discussion.

Mr. W. W. LACKIE (Glasgow) said they were not all agreed on the subject of earthing. He was rather in favour of earthing at a limited number of points, so that the earth plates could be disconnected for testing or other purposes. He preferred lead to armoured cable.

Mr. S. J. WATSON (Bury) regretted there was no standard practice in regard to mains. With reference to laying solid versus drawing in, it was always difficult for him to see why cables should be laid solid underground where it was difficult to get at them. He endorsed Mr. Lackie's opinion that V.B. cable was better than any system of lead-covered cable. Overhead mains had not, in his opinion, had the attention they deserved and should have, as they were very cheap.

Mr. F. A. NEWINGTON (Edinburgh) said he had found lead-covered paper cables to suit his system best. He favoured the drawing in of cables, the paving in Edinburgh consisting almost entirely of cement. They laid some of the ways a year or so before laying the mains. Bitumen they found unreliable.

Mr. JAMES CALLENDER (Callender's Cable Co.), being asked by the President if he would like to contribute to the discussion, said that, while thanking the President for the opportunity, he was there to learn the views of the members of the association.

Mr. W. A. VIGNOLES (Grimsby) said he had found that nearly all the trouble was due to the boxes. He had designed a cast-iron box, with the lead cable wiped on, which answered very well.

Mr. F. AYTON (Ipswich) said he had consulted several makers as to the best kind of cable for small services in Ipswich, and the consensus of opinion was in favour of rubber insulation. They must expect more trouble with small street services than with ordinary services. In regard to overhead mains, he had never had any trouble with these. He had one over the river Orwell, with a 350 ft. span, which had been up for three years without giving any trouble. In this case the alternative was to go a long way round and take the cable over a bridge.

Mr. J. E. EDGCOME (Kingston-upon-Thames) spoke very highly of his experience in laying cables direct in the ground. In regard to danger from picks, he had only had about half a dozen cases in 16 years. He believed in laying direct in the ground on the score of cheapness and flexibility. The Local Government Board had evidently some idea that these cables had not so long a life, as only 15 years were allowed in loans, compared with 20 years on cables laid on the solid system. He pointed out his experience, however, and was able to get a loan at 20 years.

Mr. C. C. ATCHISON (Rochdale) said in most cases the faults they had on the cables were in the boxes. In regard to overhead mains, it was difficult to carry these in some of the larger districts. The author had spoken of using aluminium instead of copper for overhead cables. They would have to take notice of extra size of conductor in connection with wind pressure. For outlying districts he used the overhead tramway feeders for small consumers.

Mr. S. E. FEDDEN (Sheffield) said bitumen cables were absolutely reliable if laid properly on the solid system. His cables had been laid for 16 years without any fault or the expenditure of a penny on them. Draw-in systems should not be laid with cable that caused gas to form when a fault occurred. It should be an iron system, with lead-covered paper insulation, so that any fault occurring would blow out the cutouts without causing a lot of gas to form. If they bought cable with pure Manila paper, made by a good English firm, he thought they would have no cable faults. He had 230 miles of lead-covered cable without a fault in eight years. In regard to the author's reference to getting the conduit dry, why trouble about this? The best thing to do was to get a decent covering on the cable He had known jute to get stuck in the pipes, but he had an easy method for dealing with that. He disagreed with the table at the end of the Paper, as he thought the figures were misleading.

Owing to the time having expired, Mr. Hollingsworth was asked to hold over his reply for the "Proceedings."

After the meeting the members of the Association were entertained to luncheon at the Exchange Hotel by the chairman and members of the Electricity Committee.

At luncheon the members were split up into a number of small parties. The room in which our representative found himself was presided over by Ald. Lloyd, vice-chairman of the Liverpool Tramways Committee, and if the other chairmen carried out their duties as he did his, the members must have thoroughly enjoyed themselves.

At the conclusion of luncheon the members proceeded to the Lister Drive station of the Liverpool Corporation. This station really consists of two distinct parts, in one of which are installed 12 Willans-Siemens reciprocating sets generating

current at 550 volts (the Pumpfields station of the Corporation is similarly equipped). In the second part of the station will be erected eventually four 2,000 kw. horizontal Curtis turbine sets to supply three-phase current at 6,000 volts to sub-stations equipped with motor-generators, whence continuous current is delivered at 460 to 500 volts. Electricity is also generated at Liverpool by means of heat from dust destructors. High-speed continuous-current generators are employed, and the stations where these sets are in operation are also used as sub-stations in connection with Lister Drive.

After the various features at the Lister Drive station had been inspected, the members were conveyed by special cars to the Huskisson Dock, where, by kind permission of the Cunard Steamship Co., they were allowed to inspect the "Mauretania." Tea was served in the first-class saloon, and the living portions of the ship were then visited. The time allowed was very short, as the vessel was just about to move into graving dock, so that a detailed survey of the electrical and engineering features was not possible. This ship, of course, teems with electrical appliances, and for a full description of these we refer our readers to THE ELECTRICIAN, Vol. LIX., p. 939, and to the INDUSTRIAL SUPPLEMENT published with this issue. This visit concluded Wednesday's official business.

Thursday, June 24th.

The meeting this morning was again in the Municipal School of Technology, Manchester, and Papers were read by Mr. A. S. Blackman, on "Steam Turbines from the Users' Point of View," and by Mr. E. Lunn on "Notes on Condensing and Water-cooling Plants." An abstract of the former of these Papers appears elsewhere in this issue, whilst an account of the discussion, received by telegraph, is given below. These papers were jointly discussed. After the meeting the members adjourned to the Midland Hotel, where luncheon was served. This afternoon the works of the British Westinghouse Co., at Trafford Park, of the Lancashire Dynamo & Motor Co. (see the INDUSTRIAL SUPPLEMENT with this issue), and of Messrs. Connolly Bros., were visited, and in the evening the annual dinner of the Association was held at the Midland Hotel.

DISCUSSION.

Mr. J. H. BOLAM (Weymouth), who opened the discussion, gave some details of a 160 kw. direct-current turbo-generator set recently laid down at Weymouth, and showed that reciprocating engines of the same size could equal or better the results obtained. Good economy as regards maintenance and repairs had, however, been obtained, and there was great economy in steam consumption. When capital cost was considered, a very strong case for the small direct-current turbo-generator could be made out.

Mr. D. B. MORISON (Richardsons, Westgarth & Co.) said that Mr. Blackman had given very fair criticism of the general position of the turbine. Reliability might be accepted without question, notwithstanding the unfortunate occurrence at Sunderland referred to by Mr. Blackman. They had under construction at the present time a 7,500 kw. machine for Newcastle, which would have as its companion a machine of the same power by the Allgemeine Co., so that an interesting comparison with regard to consumption and running expenses would be possible, and next year he hoped to be able to give some particulars. He mentioned that Messrs. Brown, Boveri contemplated the construction of a 15,000 kw. machine, which, he supposed, would be the largest in the world. The popular size on the Continent was 10,000 kw., a very respectable power. In regard to air, it was not until Prof. Weighton's invention that they could tell definitely how much air actually went into the system. The behaviour of air in a condenser was only just being understood. If there was much difference of temperature between the top and bottom of any condenser, there was a superabundance of air, and efficient service was seriously prejudiced. Reference had been made to Mr. Parsons' invention of the augmentor. This was a very good air withdrawer. It had no connection with the condenser, but was an auxiliary to an air pump—in fact, it was an air pump. Mr. Parsons had combined the steam jet with the air pump, which enabled it to withdraw a greater weight of air than was possible with the same pump without the augmentor. He thought that the best pump for withdrawing hot water from a condenser would be a steam-driven single-cylinder reciprocating pump. The value of exhaust steam turbines was just dawning on engineers. They had an installation in which three condensing blowing machines indicated between them 3,300 H.P., and they could absolutely guarantee another 1,200 H.P. by means of exhaust turbines, without any expense or alteration to the present installation. Two new White Star steamers of 50,000 H.P. were to be fitted with exhaust steam turbines and this would be the largest installation there was of that particular type.

Mr. T. P. WILMSHURST (Derby) had heard that the steam consumption of impulse turbines increased in time owing to the attrition of the blades. He would like to know whether this was so. Was it possible to build a 2,000 kw. direct-current set? He had had no commutation troubles due to flashing round with his direct current sets, and it might be said that there were no commutation troubles in sets up to the 1,000 kw. size. Excessive superheat might cause stripping. He thought that the figures for maintenance given in the Paper could not be taken as an average. If there was an accident the maintenance might be very serious.

Mr. GREGORY (B.T.-H. Co.), disagreed with some of the author's conclusions. He thought that the impulse type could be made mechanically sound. In his experience he had never heard of a blade stripping. He also considered that the impulse type had made great headway, and he gave figures for Curtis turbines made at Rugby, illustrating this point and showing the economies obtained with this class of engine. One of these had a steam consumption of 11·9 lb. of steam per kilowatt-hour.

Mr. E. E. HOADLEY (Maidstone) asked some questions on exhaust steam turbines. How was the steam pressure on these arranged when the main sets were running on varying load? Were the last few inches of vacuum of so much importance? Would not lower speeds be best, and what speeds should be used?

Mr. SEATON (Willans & Robinson) thought that this was the first time any credit for turbine performance had been given to the makers or contractors. He made some caustic comments on various points raised in the discussion, and thought Mr. Hoadley could get all the information he wanted by dropping a postcard to the turbine makers.

Mr. W. B. WOODHOUSE (Yorkshire Power Co.) said he used both the types of machines referred to in the Paper. The oil bill for each machine was less than £5 a year. As to the rows of blades, he had opened his Curtis machine after five years' running, and the whole machine was found to be as good as when put in. He thought exhaust steam turbines would soon disappear.

Mr. F. A. NEWINGTON (Edinburgh) had had slight commutation troubles, but he thought this was due to flexible couplings. He thought a 15 per cent. better coal consumption could be obtained with turbines. There was apt to be a vibration of the atmospheric valve, and some improvement in this direction was needed.

BY TELEGRAPH FROM OUR OWN CORRESPONDENTS.

MANCHESTER, *Thursday Evening.*

Mr. CRAWFORD (Bellis & Morcom) thought that a combined system should be adopted, the turbines being adjuncts to the reciprocating plant.

Mr. A. G. COOPER (Colne) remarked that two objections to evaporative condensers had been missed. Humidity as high as 95 per cent. resulted, and there was a large number of pipe joints. He also questioned the figures for vacuum in testing condensers. Corrections for sea level and barometer caused trouble. The speaker described a method for overcoming the latter difficulty by installing multi-jet injector condensers, each consisting of eight jets. He thereby obtained 2 in. better vacuum for the same amount of water. Much depended upon the pump. Water packed glands were best. The vacuum was measured by taking the temperature of mercury in a pocket in the exhaust pipe.

Mr. H. FARADAY PROCTOR (Bristol) did not think the conditions at Sunderland exacting, but most favourable, as there was a greater risk when starting turbines than during running. The eight turbines at Bristol provided a good example of reliability. Blades became loose owing to unequal expansion and through caulking strips being of different material. Nevertheless, the turbines ran continuously for two months. He asked whether a turbine shaft could be used safely when bent and straightened several times, or was annealing necessary. Mr. Blackman might have trouble due to the stripping of blades if the shaft whipped. Whipping had been overcome in the latest form of Parsons turbine by strengthening the rotor spindle.

Mr. F. W. PURSE (Watford) did not agree with the statements made: the reaction type of turbine was not reliable, and banked boilers were necessary. Small stations should not follow big ones like lambs, and should not instal turbines for economy. It was necessary to have more than one set of at least 1,000 kw. capacity; 750 kw. was too small. He gave the coal and works costs for several stations, the average being 0·23d. for coal costs and 0·45d. for works costs in the case of stations where reciprocating engines were used, whereas the coal costs were 0·5d. and the works costs 1·1d. for turbines. The latter had a high efficiency at full load, but a bad efficiency at low loads.

Mr. I. V. ROBINSON (Richardsons, Westgarth & Co.) was of the opinion that impulse turbines were not so good as reaction turbines at speeds of 1,500 revs. per min., although possibly they might be at 3,000 revs. per min. The higher speed machine was cheaper and more economical, besides taking up less floor space. He was working with a steam temperature of from 570 deg. to 600 deg. The thermal efficiency was increased by working at the maximum steam temperature possible. Mr. Blackman's figures for maintenance worked out at about 13s. per week, assuming 10,000,000 units per annum. This was double the figure given by Mr. Fox. Mr. Blackman's coal costs also were 0·42d. per unit. The figures for the turbines at Glasgow were 14·3 lb. of steam per kilowatt-hour on a 25 per cent. overload, 14·66 lb. at full load and 15·47 lb. at three-quarter load, the temperature of the steam being 572 deg. and the vacuum 93·3 per cent.

Mr. H. RICHARDSON (Dundee) thought it would be interesting to have definite information from users in regard to steam pressure and superheat.

Mr. S. J. WATSON (Bury) thought the question of steam v. electric motors for auxiliary plant had not been carefully enough considered. The latter type were the cheaper in first cost, but the former more economical, if properly coupled and with units of fair size. The 25,000 lb. condensers at Bury were steam driven combined sets, and required 350 lb. of steam per hour, the horse-power being 20—*i.e.*, about 17 lb.,

per horse-power-hour. This result was better than with the generator, but as the power from the generator could be used for auxiliary motors this ought to be taken into account. The result was that it was more economical to use steam for steam pumps than to use motors.

Mr. S. E. FEDDEN (Sheffield) had not heard of any case of blade distortion through excessive superheat, nor had they had any stripping of blades at Sheffield, although they used steam at 200 lb. pressure. The maintenance costs were £109 per annum for 9½ million units. This worked out very near the figure given by Mr. Blackman. He also gave figures showing that the efficiency of the impulse type was not nearly so good as the reaction type.

Mr. T. W. BLOXAM (Belfast) said the question of whether reciprocating engines or turbines should be installed had been considered at Belfast. Turbines were decided upon of the same capacity as the existing 1,000 kw. reciprocating sets. After running the turbines for 12 months he found there was nothing to choose between the two types of machines as regards steam consumption. The repairs for the reciprocating engines, however, were heavy, but as yet no repairs had been found necessary on the turbines. This cost, however, would probably rise very suddenly with the latter type of plant. He compared the reliability of the two machines by describing the effect of water in both. With a reciprocating set the low pressure cylinder had been destroyed. but the turbine was unaffected.

Mr. S. L. PEARCE (Manchester) was astonished that nobody had compared the prices of the two types of steam turbines. This was very important. The lower first cost of the reaction type might be the deciding factor, but the Parsons-Willans type would prevail if there were no difference in steam consumption. The impulse type would have been erected at Stuart-street station if the British makers could have supplied a 5,000 kw. size. As a result of visits to the Continent, he found the Parsons type there losing ground. The Manchester station offered a good opportunity for making comparisons, and the results to be published later would show which of the two types gave the best results. The figures for Curtis turbines given by Mr. Gregory were not guaranteed by the makers, and the guaranteed figures were not so high for the conditions at Manchester, as the Parsons, Willans and Zoelley types.

Mr. BLACKMAN, in reply, said, in regard to blade erosion, the manufacturers of the impulse type turbines could give no information. This question was raised by him some years ago, and he was assured by the makers that erosion did not occur. They were not so sure now. The Curtis turbine tests were really made at the works. Full particulars of the conditions were not available, and were different here to those in America. He asked did Mr. Gregory's figures include auxiliary plant. The figures given by Mr. Woodhouse for oil consumption were interesting, as showing the improvement that could be made. In answer to Mr. Purse, the banking of fires was necessary owing to the inefficiency of reciprocating sets compared with turbines. The boilers had to be banked in case the turbine sets broke down and the reciprocating sets had to be used. Mr. Purse had picked out stations with low speed variable expansion engines in making his comparison. These engines were economical, but high in first cost. The turbine figures included several small stations, which increased the average figures. Nine-tenths of the troubles experienced with turbines were due to using steam exceeding 150 lb. pressure, and 150 deg. superheat. This pressure and superheat were quite sufficient.

BOOKS RECEIVED.

Copies of the undermentioned works can be had from *The Electrician* office, post free, n receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Science Abstracts," May, 1909. Vol. XII. Part V. Section A, Physics; Section B, Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

"Proceedings of the Royal Society." Vol. LXXXII. No. A554. Series A, Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s.

THE PROPOSED ELECTRICAL ASSOCIATION.

In the last issue of THE ELECTRICIAN (p. 391) we gave some particulars as to the present stage of the negotiations which have been proceeding for some time in regard to the formation of an association comprehending the strictly commercial and financial sides of the electrical industry. The letter of Sir William Preece was given in full. This letter has now been circulated among the subscribers to the fund which a provisional committee have in hand for the purposes of the proposed association. Sir William Preece's letter was accompanied by the following letter from the provisional committee:—

At the beginning of the year a pamphlet was issued by a provisional committee suggesting the formation of an Electrical League to promote and protect the commercial and general interests of the electrical industries, and, as you were good enough to give the movement your support, we desire to inform you as to the present position.

Sir William Preece, K.C.B., F.R.S., while not endorsing all the statements made in the pamphlet, expressed his willingness to interest himself in any movement that was calculated to improve the present position of the electrical industry. The undersigned members of the provisional committee were thereupon appointed to confer with Sir William Preece, as it was felt by securing his adhesion very material strength would be given to the movement. As a result of the conferences which have taken place, Sir William Preece has written the letter to the undersigned, which is printed herewith. (*See* THE ELECTRICIAN, June 18, p. 391.)

The undersigned recommend that the suggestions made by Sir William Preece in regard to the title of the association and otherwise should be cordially accepted, and that an united effort should be made to secure for the association general and influential support, with a view to Sir William Preece being invited to accept the presidency of the association.—B. M. DRAKE, E. GARCKE, H. HIRST, MARK ROBINSON, A. A. CAMPBELL SWINTON.

CORRESPONDENCE.

DIFFERENTIAL METHODS OF MEASURING HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have studied with very great interest the two novel methods of carrying out hysteresis tests expounded by Dr. Beattie and Prof. Kapp respectively.

With reference to Dr. Beattie's tests, I am rather disturbed at the difference in the losses found on straight bundles and rings. I find it hard to believe that there should be this difference, and I cannot help thinking that there must be some error made in estimating H in the specific loss method. I am not at all clear how H is measured. It seems to me, in any case, it should not be taken as proportional to the current. Perhaps Dr. Beattie would kindly clear this matter up, as probably I am not the only one to misunderstand this point. The same difficulty crops up in the magnetic square. How is one to allow for the magnetic reluctance of the joints and the increased section of the corners?

The differential method of making a ballistic test is undoubtedly a great advance upon the step-by step method, if viscosity is small and due precaution is taken to limit the time constant. I venture to think, however, that this method, improved as it is, can never be so quick as a wattmeter method and must require greater care in the carrying out. My own practice is to employ a magnetic square with butt joints interleaved as commonly employed in transformers. This is wound evenly with a magnetising coil right up to the corners, a second coil for the wattmeter shunt, and finally a set of fine wire coils for an electrostatic voltmeter. The tests are made on a sine wave (mean ordinate factor 0·900, amplitude factor 1·413) and the drop in magnetising coil, wattmeter and transformer is only about 1 per cent. normally, thus securing that the transformer voltage has also a sine wave and likewise the induction. If tests are made at 100 and 25 periods the eddies can be separated from the hysteresis with great accuracy. By taking a large number of tests at intermediate periodicities I have established the accuracy of the law that hysteresis varies as periodicity and eddies as the square of periodicity, even for alloyed iron.

The assumption that hysteresis varies as $B^{1 \cdot 6}$ is not safe. I find that the exponent increases considerably for both very high and very low inductions and varies also with every brand of iron. The wattmeter method gets over the difficulty of the reluctance of the joints, but still, I am sorry to say, leaves the effect of the increased section at corners uncertain.

With regard to Prof. Kapp's most ingenious method of comparing inductances, I hardly think that the saving to be effected by leaving out a second coil is of great moment where a second coil can be put on. It occurs to me, however, that the method would be extremely useful for measuring the inductance of a wattmeter pressure coil, without its attendant non-inductive resistance. This would, perhaps, lead to greater accuracy than the method of doubling the non-inductive resistance and noting the alteration of the reading.—I am, &c.,

LANCELOT W. WILD.

Westminster Electrical Testing Laboratory, June 19.

MEASURING SMALL HIGH-FREQUENCY CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As it might otherwise be thought that the galvanometer for high-frequency currents, referred to this week in your abstract of Prof. Arnò's communication to the Société Internationale des Électriciens, is a new form of instrument, I should like to point out that, so far from this being the case

it is simply an apparatus according to and fully described in a British Patent of 1902, granted to myself and Prof. Ewing, though Prof. Arnò carefully refrains from any reference to my work.

At the same time it is interesting to note that Prof. Arnò's persistent efforts have enabled him to succeed in measuring telephonic currents as small as 20 microamperes.

Although the method first proposed by me is thus useful for currents of both medium and very high frequency, it is a remarkable thing that, whereas in France the advantages of such an apparatus were readily recognised and the manufacture taken up, no British firm has as yet been enterprising enough to do this.—I am, &c.,

Westminster, June 21. L. H. WALTER.

THE GROUPING OF CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: From the new edition of his "Telephony," it seems that Mr. T. E. Herbert (engineer, Post Office Telegraphs) has independently and empirically discovered that the usual rule for the regular grouping of cells for maximum current is inaccurate, but that it becomes accurate if we insert the words "logarithm of the" immediately before the word "resistance," thus making the rule read as follows: "The greatest current is obtained when the logarithm of the resistance of the group is as nearly as possible equal to the logarithm of the resistance of the external circuit." I think he must have arrived at this independently and empirically because, in the first place, he does not tell his readers that a mathematical proof of the rule (or, rather, of the law from which the rule is easily deducible) is to be found in my pamphlet on the Grouping of Electric Cells, which was published in 1906, and discussed in your columns in November of that year; and, in the second place, he immediately afterwards gives another rule, which he apparently considers an improvement on the first, but which is, as a matter of fact, inaccurate and directly contradicted by the law just referred to. This second rule states that the current will be greatest when the number of cells in series is as near as possible to $\sqrt{NR/r}$, where N is the number of cells to be grouped, R is the external resistance, and r the resistance of each cell. Applying this rule to the case of 12 1-volt and 1-ohm cells and an external resistance of 6·7 ohms, we find that the number of cells in series should be, as near as possible, to $\sqrt{12 \times 6{\cdot}7}$, or $\sqrt{80{\cdot}4}$—that is to say, it should be 6, since this square root is smaller than 9, and, therefore, nearer to 6 than to 12. But with six cells in series the current is only $6/(3+6{\cdot}7)=0{\cdot}618$ ampere; whereas by putting the 12 cells all in series, in accordance with my rule, or Mr. Herbert's first rule, or any other rule that is deducible from the law that was first stated in my pamphlet, we could get a current of $12/(12+6{\cdot}7) = 0{\cdot}642$ ampere.—I am, &c.,

London, June 17. W. F. DUNTON.

PARLIAMENTARY INTELLIGENCE.

Greenock Corporation Bill.—In the course of the adjustment of the clauses of this bill on the 8th inst. by the section of the Local Legislative Committee of the House of Commons (presided over by Mr. C. Nicholson), Mr. Kennedy, Parliamentary agent for the promoters, stated that it was proposed to delete from the bill the proviso that the Greenock & Port Glasgow Tramways Co. should be supplied by the Corporation with all the electrical energy they require for use both inside and outside the burgh. Mr. Sydney Morse, for the company, opposed the deletion of the provision, which deletion had been proposed to meet the wishes of Gourock and Port Glasgow Corporations. Mr. Morse stated that the Corporation had always supplied the electricity for the company, and when the company obtained their powers in 1902 they had a lease in the schedule to the act providing that their whole supply should be given by Greenock Corporation, the minimum being fixed at 500,000 units per annum. The Corporation had given an undertaking to insert a clause providing that the consent of Gourock and Port Glasgow should not be required.

At a previous sitting the clause authorising the erection of a destructor in connection with the electricity undertaking had been authorised, the period for the repayment of the capital being 25 years.

The bill was ordered to be reported to the House, the Chairman remarking that if the parties were dissatisfied in regard to the tramway co.'s supply of current, they must fight it out in the other House.

LEGAL INTELLIGENCE.

The King (Dublin United Tramways Co.) v. Divisional Justices and Dublin Corporation v. Dublin United Tramways Co.

Last week in the King's Bench Division, Dublin (before the Lord Chief Justice, Mr. Justice Johnson and Mr. Justice Wright) arguments were concluded in this application of the company for an order of prohibition making absolute a conditional order of prohibition of March 1 last, directed to Mr Swifte, one of the Metropolitan Magistrates, to restrain him from hearing 18 summonses brought by the Corporation against the company for non-repair of track, &c.

Mr. Justice JOHNSON, in delivering judgment, said that sec. 33 of the Tramways Act, 1870, relied on as to arbitration, in no wise interfered with the summary jurisdiction conferred by other parts of the act. His lordship referred to the cases cited, and considered that the company ought to keep the tramways so as not to be an annoyance or danger to the ordinary traffic. Sec. 37 gave a concurrent remedy. Therefore, he considered that the point had been already settled by the judgment heretofore pronounced by the Court, and therefore the application of the tramways company must be refused, the conditional order to be discharged.

The other judges concurred, and the order was discharged, with costs

British Westinghouse Electric & Mfg. Co. (Ltd.) v. Braulik.

On Tuesday Mr. Justice Joyce commenced the hearing of this action.

In opening the case for plaintiffs, Mr. WALTER, K.C., said that the action was brought to restrain an alleged infringement of letters patent (No. 18,786 of 1902) which related to an invention for improvements in arc lamps. Counsel proceeded to explain the principles upon which arc lamps are constructed, and pointed out that in all arc lighting an important feature was the regulation of the length of the arc, and this was an invention relating to the regulation of the arc.

Mr. Justice JOYCE: And it is mechanical regulation?

Mr. WALTER said it was purely mechanical. It was governed by the electric current itself. Carbons burnt out, and therefore it was necessary to provide a "feed" so as to bring the carbons together and so that the length of the arc might not get too great for the pressure of the current. If the carbons were got at a fixed distance after they had touched they would go on burning. The time would, however, arrive when they wore away, and when the resistance of the arc to the resistance of the current became so great that the current would not go across and the light would go out. That was one thing that had to be considered. If the carbons were kept in a fixed piece the arc would go out when once they were burnt away sufficiently to prevent the current from crossing. With ordinary carbons this was bad enough, because they were not of an even consistency all through, but recently there had been a greater variation in the carbons owing to the flame arc lamps that were now very largely used. For those lamps which gave a very intense yellow light metallic salts were introduced into the carbon, and the introduction of those salts caused a still further variation in the character of the carbon points, and consequently still further fluctuations in the relative distance of the carbons. That, of course, caused still further difficulty in the regulation of an arc lamp. In some of the old lamps the carbons were put vertically one above the other, but this caused a difficulty because the mechanism under the bottom part interfered with the light, and therefore quite early in the day carbons were introduced that both pointed downwards but were inclined to one another. He was not going into that and a great deal which had been raked up in the course of this case because he thought it belonged to the rubbish heap of the past, though he did not like using the words "rubbish heap."

Mr. BOUSFIELD: They were not rubbish before the last invention. First of all there was an arrangement by which the carbon slid down against a fixed stop, being held in tubes so as to allow it to be fed down against the fixed stop. Then devices were made by which the carbons were fed down equally, a matter of great importance in a lamp. The invention in question related to an arc lamp having downwardly pointed inclined carbons, and it further related to downwardly pointed inclined carbons which did not slip, but which were clipped at the top firmly. It also had this further limitation—that it related to that class of lamp in which the carbons were simultaneously lowered. Practically three-quarters of the flame arc lamps that were in use at the present day used this invention. Oxford-street, London, one of the most brilliantly lighted streets in the country, was lighted with these lamps. The difficulty had been to lower the carbons as they were consumed and yet keep the points at the proper relative distance.

Mr. Justice JOYCE: Is that your invention?

COUNSEL: Yes. With this invention, as the carbons were allowed to come down they simultaneously came together.

Mr. Justice JOYCE: The mere lowering would not bring them together?

COUNSEL: Yes, it would, because they were inclined towards each other. They were allowed to come downwards in the same direction, but having brought them together they had to strike the arc. For that purpose they had a bar or lever acting on an electric magnet. That brought the carbons apart from one another. You could move both, but it was more convenient to move one, and that was generally done. Now, if that only related to the downward movement—namely, the feed—they

could not regulate the lamp properly. The invention in question related to that—on to those downwardly inclined carbons that were simultaneously fed they introduced a regulating movement that moved the carbons forward and backward. The arc was consistently varied in accordance with the electrical conditions with which the carbons were held at the two top points. So as to move properly the carbons were governed by the electricity—they were governed by the actual physical conditions that existed at the time. It allowed one of the carbons to move on one side, and so make the arc that fitted the conditions that existed at the time. It was important in order to get the proper burning of the lamp that the downward movement should not continue while the distance between the ends of the carbons was being regulated. With this invention they had got mechanism for giving the downward or feeding movement connected with mechanism for giving the internal direction of the arc, so that it prevented the carbons coming down while the sideways movement was in operation.

Mr. Justice JOYCE: When the movement to regulate the arc is in operation the downward movement is prevented, but when the sideways movement is not felt the descending mechanism again comes into operation?

Mr. WALTER said that was so. The swinging movement took the place of the downward movement, and vice versa. That was the invention, and it turned out to be a very important one as applied in the modern system of flame arc lamps. Counsel proceeded to deal in detail with the specification, and went on to the bench to explain the working of the invention to the judge with the aid of a model. The whole thing, he said, was worked by the same current which supplied the flame. The current passed through the electromagnet, the force of which was increased or diminished as required by the difference in the size of the arc. It was, therefore, automatic, and the balance was kept adjusted by the working of the magnet on the lever. That was the whole thing in principle. The essence of it was that it gave a sideway movement that gave a complete adjustment of the arc without setting into operation the downward movement; they thus had a little sideways movement before the feed took place, and had the movement of the magnet always at a fixed point by the current governing the whole.

Mr. Justice JOYCE: But is your invention an invention of principle or what?

Mr. WALTER said their claim was not for principle, but for a combination of parts. The defendant had adopted a new departure, he supposed, because he did not like to face this action. He had taken proceedings under the Patent Act of 1907, asking to have the letters patent revoked, because the invention was not worked sufficiently in this country, but in that, counsel was happy to say, he had failed. His claim was for a combination, but it was confined to lamps with downwardly pointed electrodes inclined to each other. It was confined also to lamps that had a power feed mechanism, by which the electrodes were lowered simultaneously through the same distance and where the carbons had a swing movement in accordance with the resistance of the current. That was brought about by the lever. It was still further confined to lamps where the horizontal movement took place before the downward feed mechanism was allowed to operate. Until the horizontal movement had entirely stopped the downward mechanism was retarded, and it was only when the swing of the horizontal movement had ceased that the downward took place. The defendant had taken every part of the invention—every single part.

Mr. BOUSFIELD said that the question of infringement did come into the case, but the more serious questions would be anticipation and subject matter.

Mr. WALTER said at that stage he was not going into validity.

Mr. JAS. SWINBURNE said he had read plaintiffs' specification, No. 18,786 of 1902. It was a question of importance in the regulation of electric lamps that the governing of the internal conditions of the arc should be independent of the downward feed mechanism. He had tested Fig. 1 as regarded its capacity for work, and found that it worked. He thought there was no difficulty in making a lamp from the description. Witness said that the invention was obviously useful and was commercially of great value. He did not find that there was any nonconformity between the provisional and complete specifications. He had read the list of documents that were set out by the defendants, alleging that the invention was not novel, but he did not find the invention therein described. He did find, however, the invention which had been described in the plaintiffs' specification in defendants. There was nothing to mark the distance apart of the lower carbons until you got them to a certain point, and it then released the downward feed. The mechanism did nothing but move the lower carbons apart and together.

Do you find all the parts in that that you find in plaintiffs'?

WITNESS: Yes. It was essentially the same mechanism, though, of course, the details were different. For instance, instead of working with a wheel with teeth, so that the pin could work in and out of the teeth, the alleged infringement had a part which was not moved until the mechanism got a certain distance, but there was no vital distinction in that. They were known as alternative forms of escapement, in which the carbons were connected by chains.

Mr. Justice JOYCE: It is the same thing that acts when the clock strikes?

Yes. The carbons in both cases descended by gravity. In both cases the escapement was regulated by a shunt magnet, which only allowed escapement after a certain amount of movement of the carbons had taken place horizontally. The defendants had both shunt and series. That was in form shown in Figs. 1 and 2 of plaintiffs. It depended on what circuit you were running your lamps on.

The hearing had not concluded when we went to press.

John Musgrave & Sons v. Bradford Corporation.

This action was heard by Mr. Justice Darling last week, and was brought by plaintiffs to recover from Bradford Corporation £1,200 0s. 10d., being the balance due on an engine supplied by plaintiffs for the Corporation electricity works. The defence was that the engine did not fulfil the terms of the contract, and that payment was only to be made on the certificate of the engineer of the Corporation, which had not been given. There was also a counterclaim for the cost of making certain alterations to the engine.

Mr. WALTER, K.C., for plaintiffs, said the engine was a large slow-speed machine, a type largely used for driving electric generating plant. Plaintiffs, who had supplied many of those engines, had been asked to tender for the engine, in consequence of their having supplied a similar engine to defendants previously. There was a condition in the contract that the engine, after erection, should be run for four weeks by the contractors, during which time they were to make good at their own expense any fault due to inferior material or workmanship, or any defect that might arise from heated bearings, &c., within 12 months. That trial run took place satisfactorily, but later on the Corporation sought to extend the 12 months' liability of plaintiffs beyond what was originally contemplated.

Sir ALFRED CRIPPS, K.C. (for the Corporation) said that when the engine was discovered to be unsatisfactory his clients asked plaintiffs to remove it, but as they did not do so, the Corporation had the defects remedied at their own expense, and for that they now counterclaimed. As regarded the trial run, he said, there would be no complaint made, but it was found that the shaft of the engine was defective in nature and quality of material, and was of insufficient strength to withstand without failure the strain and stress caused by the working of the engine.

Mr. WALTER contended that the engine had been submitted to undue strain, and that plaintiffs should not be held liable for the cost of a new shaft, more particularly as the shaft supplied by plaintiffs was found to be in perfect condition when taken down.

Mr. FRANK MUSGRAVE, director of the plaintiff company, stated that the shaft of the engine, which defendants declared to be inadequate to the stress brought to bear upon it by the working of the engine, was like the shaft of the other engine supplied by the firm, which was still working, and that the parts of the two engines supplied by his firm to defendants were alike.

In cross-examination he said that the chairman of the Bradford Electricity committee told him if he would not put in a shaft of larger diameter and extend the time of the guarantee he would not get paid. He admitted that Mr. Blackman, the engineer, had not given his certificate of the efficiency of the engine, but Mr. Blackman had made no personal complaint to him on the subject at their interview. Mr. Blackman had, however, made complaints in letters.

Ald. G. H. ROBINSON, chairman of Bradford Electricity committee, denied that he had ever at any time made any suggestion to Mr. Blackman as to giving or withholding his certificate for the engine, and so far as he knew, none of his committee had made any such suggestion. In cross-examination witness said he remembered the shaft of one of their Morley engines breaking in 1904 and the Corporation having to pay for the new one, but it was not that that induced them to make a demand upon plaintiffs for a larger shaft. That was only brought forward when the engineer in 1906 declined to give the certificate because of the breaking of the bolts on the engine, which he ascribed to the weakness of the shaft.

Mr. H. F. PARSHALL said that he had examined the history of this engine and he had come to the conclusion that the breaking of the bolts was due to improper assembling of the machine.

Mr. WALTER: What would be the effect of a short-circuit upon the shaft to which the armature was fixed?

Sir ALFRED CRIPPS objected to this question.

His LORDSHIP pointed out that if he did not have any evidence upon that point he should come to the conclusion that a short-circuit did throw a heavy strain on the shaft and different parts of the engine, and he should apply that theory when coming to his conclusion on the case.

WITNESS replied that a heavy short-circuit would have the effect of stopping the rotation of the engine. Short-circuits in the case of some machines had been known to twist the shaft free. Machines of the class in question, however, if they were correctly assembled, would not be greatly affected by short-circuit, but, if not accurately put together, one of the effects of short-circuiting would be to break the bolts.

His LORDSHIP: Whose business was it to put the machine together?

Mr. WALTER: The business of the British Westinghouse Co.

Sir ALFRED CRIPPS: No, no, it is absolutely Messrs. Musgrave's duty.

His LORDSHIP: Who forced the armature on to the shaft?

Sir A. CRIPPS: Messrs. Musgrave bolted it to the flywheel.

His LORDSHIP: I should have thought that they were responsible for its running upon trial.

WITNESS, continuing, stated that had the bolts been fitted quite true nothing would have happened to them if a "short" occurred. There had been no breakage with the other engine, and the two machines were identical, so there must have been a difference in assembly. It was not an unusual thing for the bolts to break, and the best remedy was to leave them off altogether. It was always done in modern practice because it was admitted that they could not bring the surface of the flanges together with such accuracy as to obtain any benefit from that form of construction. These parts of the machine were fitted together under enormous hydraulic pressure, and could be run perfectly safely without bolts. As an instance, six similar machines were laid down in the Dublin tramway station, and as far as was humanly possible they were identical. Five of them assembled accurately, but the six did not, and the bolts smashed. They simply took the bolts out and the machine was still running quite safely.

His Lordship: Why not make the shaft square?

Witness admitted they might do so: it would be a matter of expense.

For the defence Mr. A. Blackman, formerly borough electrical engineer (and now at Sunderland), was called. He had heard what had been said about a "short" but there was a circuit-breaker on the machine in question, which acted at approximately a load and a half, or 1,500 kw. That circuit-breaker was for protecting the engine when a short-circuit occurred. Short-circuiting was unavoidable. It was one of the conditions of work, and that was the reason why circuit-breakers were put on these engines. He always acted on his own initiative and absolutely denied that he was in any way influenced by the Corporation or the Electricity committee in using his own discretion over that contract.

His Lordship gave judgment on the point raised as to the refusal of the certificate and the alleged collusion between the engineer and the Corporation. He said he came to the conclusion that the engineer was not well satisfied with the engine. He might have been right or wrong in taking that view; personally his Lordship thought he ought to have been satisfied. The fact that the bolts broke ought not to have been sufficient to convince him that the engine required a new shaft. Therefore, although he came to the conclusion that Mr. Blackman was not satisfied, and thought the engine ought to have another shaft, he held that that gentleman was unreasonable in forming such an opinion, because they had had it proved that it was not unusual for the bolts to break in those machines, and that even if they did the engines were quite as safe and efficient without them. There was a further statement by the plaintiffs "that at the instigation of, and in collusion with the defendants and for obtaining the plaintiffs' consent and undertaking to certain obligations, the engineer wrongfully failed to certify in writing that he was satisfied with the engine." He was of opinion that Mr. Blackman did refuse the certificate to obtain an obligation from plaintiffs to which he was not entitled under the agreement; but he thought he tried to do so because he was not satisfied with the engine—although he ought to have been. Therefore, with regard to the allegation of collusion he found that the engineer did not act at the instigation of defendants, and that there was no collusion. Although it was a wrong one, the engineer formed his own honest conclusion on the matter. He did not, as alleged by plaintiffs, wrongfully fail to certify upon those findings, and therefore plaintiffs were dispossessed of their claims, and he would give judgment for defendants.

The case for defendants on the counter-claim was then heard, and after taking evidence, judgment was given for defendants for £10, with the general costs of the case.

County of Durham Electrical Power Distribution Co. (Ltd.) v. Commissioners of Inland Revenue.

The Court of Appeal (the Master of the Rolls and Lords Justices Farwell and Kennedy) on Tuesday heard this appeal of the company from a decision of Mr. Justice Channell upon a case stated by the Commissioners of Inland Revenue. It appeared that on Aug. 3, 1907, an instrument dated Aug. 1, 1907, was presented on behalf of the company by their solicitor to the Commissioners for their opinion as to the duty with which the instrument was chargeable. The instrument set out that Snowball, Son & Co. were to take for seven years from the date of the instrument all electric current used for motive power, heating and lighting on the consumers' premises, for which the consumers were to pay a fixed charge of £57. 10s. per quarter, and in addition 1d. per Board of Trade unit for all current supplied and consumed, as indicated by the company's meters, and 10s. per quarter as a rental for the meters. By clause 5 of the agreement the consumers were to be entitled to a supply of electric current up to the capacity of the existing installation, which was to be deemed equal to 46 kw., and clauses 6 and 7 provided for the increase of the quarterly payments on decrease of capacity of existing installation, with a proviso that in no case should the said fixed charge of £57. 10s. be reduced below £50 per quarter. The Commissioners held that the instrument was an agreement or memorandum relating to the sale of goods, wares or merchandise within exemption 3 of the words in the head in the schedule to the Stamp Act—"agreement or any memorandum of agreement"; but, in the circumstances, they held that duty was payable at the rate of 2s. 6d. per £100 of the aggregate amount of the minimum annual payments for seven years. The company's contention was that no ad valorem or other duty was payable, and the question for the court was whether the assessment was correct. Mr. Justice Channell held that the assessment of the Commissioners was correct, and gave judgment for the Crown. Hence the present appeal of the company.

Mr. Danckwerts, K.C., and Mr. Tomlin appeared for appellants, and the Solicitor-General and Mr. Finlay for the Crown.

At the conclusion of the arguments, their lordships affirmed the decision of Mr. Justice Channell and dismissed the appeal, with costs.

Blair v. Maidstone Palace of Varieties (Ltd.)

Last week in the High Court, London, Mr. Justice Neville heard a summons in this matter. Mr A. P. Van Neck said the receiver was desirous of passing his final account and of distributing the money realised. There was a claim by the Electric Light, Power & Hiring Co., and the summons was issued to obtain an order that this Electric Company (the third party) should bring in its claim in the debenture holders' action, or otherwise be barred. The property had now been sold, and they were in a position to deal with that claim, but the Electric Company contended that it had six years in which to bring its claim, and that it could bring it as and when it liked.

Mr. David, for the Electric Company said the fittings remained the property of the company by the terms of the agreement.

His Lordship: If you recovered judgment for the whole of the remaining term of five years you cannot claim delivery up as well

Mr. David said that was in accordance with the terms of the agreement.

Mr. Van Neck said he wanted an order that the Electric Company hould bring before the Court within seven days any claim it might have, so that the assets might be distributed, and that, should such claim not be made within that time, the distribution should take place without regard to such claim. Counsel also asked for an injunction restraining the Electric Company from taking proceedings against the receiver in the event of his proceeding with the distribution.

His Lordship directed that the claim should be brought in within 14 days. Costs of the applicant would be costs in the proceedings and costs of defendants would be reserved.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An electrical engineer, familiar with the electrical and mechanical design of d.c. motors, is required. See an advertisement.

An assistant master for the science section is required at the Borough of Aston Manor Technical School, who must be qualified to teach electrical engineering (including laboratory instruction), mechanical engineering and mathematics. Commencing salary £150. Applications to the secretary (Mr. H. Norwood), Education Offices, Aston Manor, near Birmingham, by Monday July 5.

An instructor in electrical engineering (practical and theoretical) and electric wiring, and an instructor for electricity and magnetism, are wanted at the Borough of Kingston-on-Thames Technical Institute for the winter session, for one evening a week each. Salary 21s. and 15s., respectively per evening of three hours. Applications to Mr. H. T. Roberts by June 26.

A science master and principal is wanted for the Loughborough Technical Institute. Particulars from Mr. W. A. Brockington, Leicestershire Education Committee, 33, Bowling Green-street, Leicester. Applications by July 14.

West Hartlepool Electricity committee require a consumers' engineer. Salary £90 per annum. Applications to Town Clerk by June 26.

Rochdale Guardians require an engineer (with electrical knowledge) for the workhouse. Salary £2. 10s. per week. Particulars from the Clerk.

On Tuesday West Ham Town Council appointed Mr. H. H. Couzens A.M.I.E.E., borough electrical engineer. Mr. Couzens is at present deputy electrical engineer at Bristol. The salary attached to his new appointment is £500 per annum, rising to £700 by annual increments of £50. There were 36 applicants out of whom the following short list was selected:—Messrs. H. H. Couzens, W. J. Bache (Cheltenham) and G. L. Jones (resident engineer, West Ham).

Islington (London) Council have appointed Mr. A. E. Faver constructional and repairs engineer to the lighting department at £3 per week, vice Mr. M. H. Adams resigned. Mr. Alfred Jarratt (testing assistant), and who has been in the service of the Council for three years, has been promoted to fill the vacancy caused by the resignation of Mr. J. J. Hargreaves, mains engineer.

EDUCATIONAL NOTICES.

University of Liverpool.—We have received a copy of the syllabus of the faculty of engineering for the session which starts on Oct. 5. The main alterations that have been made are:—

(1) The inclusion of Naval Architecture as a recognised course of study, and advantage has been taken of the necessary change in the ordinance to slightly rearrange the course leading to the final examination for the degree of B.Eng. Strength of Materials and Theory of Machines has been taken from the more professional sections and placed with Engineering Design and Drawing as compulsory subjects. (2) Honours schools for mechanical, civil and electrical engineering and naval architecture have been established, in place of the more general course leading to the degree of B.Eng. with honours. This means that the first three years leading to the final degree of B.Eng. is general in character, while in the fourth (or honours year) the men are allowed to specialise to a considerable extent, but not too closely. It is rightly provided that an honours student should have a good knowledge of mathematics, but frequently there are men who promise to make excellent engineers and yet are not very good at mathematics, and for these there is an avenue to stop a fourth year and take what is termed a "qualifying examination for the degree of Master of Engineering."

The Dean of the Faculty of Engineering of the University will be pleased to see intending students any time up to July 30.

Acton.—Subject to the Clerk receiving an intimation from the Metropolitan Electric Supply Co. that it will regard its offer of

November 3 last, and the Council's acceptance of it as a binding agreement, the electrical engineer (Mr. J. M. Blair) has been instructed to prepare the arc lamps in certain thoroughfares and again light such roads with electric light on and from July 1.

Aldershot.—The Council have obtained sanction to a loan of £1,000 for extensions of mains, &c.

Australasian Cable Rates.—We have previously called attention to a series of articles which have appeared in the "Manchester Guardian" and have dealt with the question of submarine cable rates to Australia. In one of these series Mr. T. Temperley, editor of the "Richmond River Times," Ballina, N.S.W., made certain statements and expressed certain views on the subject of the service rendered by the Eastern Extension Telegraph Co. which called for and received a reply from Mr. T. E. Townend, London manager of the Australian Press Association in another issue of the "Manchester Guardian." Mr. Temperley again referred to this matter in the columns of our contemporary on June 16, and in the course of what he described as "Five Grievances" he made the following statement:—

I know also that when Sir J. Ward, Premier of New Zealand, was in England at the Prime Ministers' Conference (which naturally dealt with matters of great moment relating to New Zealand) he went to the cable office with a lengthy account of some such matter, requesting its transmission to Australia and New Zealand. There he was told, "We can't send this; it's too long. We'll send a portion of it if you will cut it down." He replied, "I want the lot sent, and I'll pay for it at full rates, three shillings a word." The cable company's representative replied, "Well, we can't send it, and they wouldn't publish it if we did. The papers which receive the cablegrams from the Eastern Extension Company are under a penalty bond included in their contracts (which the Metropolitan combine make with those who participate in the service) not to publish anything except what goes through the London office of the 'Argus.'" "This," added Mr. Temperley, "may account for Sir Joseph Ward's special efforts in New Zealand to break away from this monopoly."

To this there was a complete reply, so far as the Eastern Extension Co. was concerned, and Sir J. Denison-Pender forwarded on June 18 the following letter to the "Manchester Guardian":—

SIR: The attention of this company has been called to a statement in your issue of the 16th instant that a long message tendered by Sir Joseph Ward to one of the offices of this company was refused as being too long.

I beg to inform you that under the licence of the British Government, under which this company accepts messages in Great Britain, it has no power to refuse any fully-paid message handed in for transmission by its system to any part of the world.

As regards press messages, it is necessary that the sender should be authorised by the newspaper to which the telegram is addressed, and if anyone should hand in a message to be sent at press rates it would be refused unless the sender was a duly authorised correspondent.

You will, therefore, see that the statement made in your paper that a message tendered to my company, to be charged at full rates, was refused cannot be accurate.

Mr. Temperley has since written at great length to the "Manchester Guardian," but has vouchsafed no answer to Sir J. Denison Pender's letter.

Bath.—An inquiry was held on Wednesday into the application of the Council for permission to borrow £11,700 for the electricity undertaking. There was no opposition.

The Town Clerk explained that the application was somewhat belated, the reason being that for the last $2\frac{1}{2}$ years they had been engaged in negotiating for the sale of the undertaking to Mr. Ernest Schenk, acting for a syndicate. Those negotiations had now fallen through. The loan was required for excess expenditure on loans sanctioned between February, 1905, and January, 1909, £1,957. 11s. 2d.; expenditure on capital account on works in respect of which no sanction has been applied for, £3,242. 0s. 6d.; extensions of mains and services during the next three years £6,000 and for the provision of a new automatic stoker, £500. The inquiry was adjourned until July 2.

Experiments were recently made by the Corporation electricity department to ascertain the relative efficiency for street lighting of the present 60 c.p. incandescent gas lamps, and 100 c.p. Leuconium metallic filament lamps, made by the Stearn Electric Lamp Co. It was found that the electric light was incomparably more brilliant and that the area of diffusion was much wider. It is probable that before the end of next winter metallic filament lamps will be used for lighting many side streets where mains are already laid.

Bexhill.—Mr. R. H. Bicknell held an inquiry on Tuesday into the application of the Council for sanction to a loan of £2,120 for the electricity department.

The town clerk (Mr. T. E. Rodgers) said £1,900 was required for a condenser and cooling tower and £220 for a chain grate stoker.

Mr. W. T. LE FEUVRE, borough electrical engineer, said the use of chain grate stokers had saved £470 in the coal bill. The present cooling tower would have to be scrapped.

Darlington.—At a recent meeting of the Corporation the accounts of the Electricity department for the past year were approved.

The borough electrical engineer (Mr. J. R. P. Lunn) protested against so large a sum as £2,000 being handed over from the profits in aid of the rates, and suggested that the Electricity committee should make a rule to hand over each year 10 per cent. of their profit-earning revenue and place the remainder, if any, to reserve.

A discussion took place, but ultimately the committee decided not to bind itself by any rule, but each year when profits were reported to consider the proportion that should be handed over in aid of the rates.

Electricity in Mining.—At the meeting of the Village Main Reef Gold Mining Co., the chairman, Mr. L. Phillips, stated that a large company had been formed for supplying electrical power to the mines on the Rand, in which they were interested as consumers. The estimated reduction in working costs was particularly marked in their case, as the consolidation of scattered sources of power was calculated to save them about £14,000 per annum. The outlay for the use of electricity was estimated at £16,270.

Epsom.—The new fire brigade station is to be wired for the electric light at a cost of about £600.

Fire Insurance.—The Northern Assurance Co. issue the following notice, dated June, 1909, concerning shop lighting, which is of interest:—

FURNITURE DEALERS, HABERDASHERS, DRAPERS (other than Woollen only), MAKERS OF AND / OR DEALERS IN MANTLES, AND UPHOLSTERERS.

A discount of 5 per cent. is now allowed off the premium on shops used for the purpose of any of the above trades which are rated at over 5s. per cent. and which are lighted, with the exception of living rooms, wholly by the electric light.

The use of gas is temporarily allowed during the breakdown of the electric light without prejudice to this allowance, but only during the continuance of such breakdown.

A discount is also allowed off the premium for any of the aforesaid shops rated at over 5s. per cent. in which fire-extinguishing appliances of an adequate nature are provided, particulars of which will be given on application.

Hackney (London).—Mains are to be laid in additional thoroughfares at a cost of £1,156.

Hospital Lighting.—Aberdeen Public Health Committee will receive a report on the proposal to adopt electric lighting at the City Hospital.

Italy.—The "Bolletino Finanze" (Rome) states that the company operating the Spezia electric tramways have applied to the Ministry of Public Works for authority to duplicate portions of their track.

The Terni Electric Tramways Co. have applied for powers to construct and work an electric tramway from the Terni-Collestatte line to the Penna Rossa shipbuilding yards.

The "Bulletin Mensuel" de la Chambre de Commerce Française, Milan, states that plans are being prepared for an electric tramway, 17 miles in length, from Masnago to Angera, and that the Soc. Anon. Elettro Industriale della Valle del Rosario is to be formed in Spezia with a capital of £92,000 for constructing and working an electric tramway from Spezia to Fivizzano.

Leeds.—The Horsforth-Guisely section of the tramways was completed on Thursday last.

Littleborough.—Rochdale Council will supply current in bulk to Littleborough at 10 per cent. above the cost of generation.

Llandaff.—Mr. H. Ross Hooper, M.Inst.C.E., held an inquiry on Tuesday into the application of the Council for permission to borrow £2,960 for electric lighting in Whitchurch.

The clerk (Mr. M. WARREN) explained that it was proposed to take current in bulk under an agreement with the South Wales Electrical Power Distribution Co. and the Treforest Electrical Consumers Co., the maximum price being $1\frac{1}{4}$d. and the minimum $\frac{3}{4}$d. per unit, subject to a minimum payment of £150 per annum.

Llandudno.—Sanction has been obtained to a loan of £2,450 for additional plant at the generating station.

London County Council.—On Tuesday it was agreed to increase the rate of pay for motor demonstrators from £2. 10s. to £3 per week.

Testing of Electric Meters.—The Highways committee reported that the London Electric Supply Corporation proposed to submit for testing and sealing a large proportion, and later the whole of the meters used on its circuits. The Company will in the first place submit 1,250 to 1,500 meters a year in batches of not less than 100, and these meters will be practically of one make, and of two capacities—viz., 5 and 10 amperes. The Committee are of opinion that the step proposed by the Company is a commendable one, in that it offers greater security to the consumer, and suggest that for periods of 12 months the ordinary fee for testing meters be reduced from 5s. 3d. to 2s. 6d., providing the meters are sent in batches of not less than 100.

Market Harborough.—The Council's Electric Lighting Order has been extended for a further 12 months.

Marylebone (London).—Mr. A. Hugh Seabrook has now taken up his duties as engineer and manager of the electricity undertaking and the Electric Supply committee has approved a scheme submitted by him for the future management of the undertaking.

Nelson.—The tramway manager has been instructed to arrange with the Colne & Trawden Light Railway Co. for a through service of cars over both systems.

Newton-in-Makerfield.—The Board of Trade refuse to further extend the Council's electric lighting order.

Norway.—A report of H.M. Legation at Christiania, states that the Storthing last year decided that during the next 12 years £275,000 a year will be spent on the construction of State railways, the total length to be laid during that period being 600 km. (372 miles). The report further states that the enormous amount of water power that is available in most parts of the country would appear to make the electrification of the railways a comparatively easy and cheap matter, and H.M. Minister understands that foreign firms have submitted tenders for works of this description, and the Government have secured waterfalls with a view to their utilisation for the production of electric power for railways.

Plymouth.—Regent-street Schools are to be wired for the electric light.

Poland.—The report of the British Consul (Mr. Clive Bailey) states that the telephone subscribers in Warsaw increased from 2,372 in 1901 to 14,817 in 1908. The annual charge, for unlimited service, day and night, is £7. 5s. 4d. for business, and £6. 6s. 8d. for private premises. There is a trunk line to Kalisz, on the German frontier, via Lodz, Lask and other towns. The line from Warsaw to Lodz is Government property, but the Lodz to Kalisz line (68 miles) was constructed by private enterprise and cost £45,000. A line from Warsaw to Lublin is practically completed. The Director of Posts and Telegraphs at Lemburg has proposed the construction of a line from Warsaw to Cracow, which would place Warsaw in direct communication with Vienna. The charge would probably be 2s. 10d. for three minutes' conversation.

Warsaw electric tramways were opened last year. The overhead system is used, and the rolling stock consists of 200 corridor cars, each seating 24 persons, and having standing space for 16 persons on the platforms. It is stated that the receipts are £2 per car per day above the estimate.

The "first and second class" streets of Warsaw are now lighted electrically, and the suburb of Mokotow has its own station, and is about to put in additional plant in consequence of the growing demand for current. Lodz, Zgierz, and Ozorkow are also establishing electricity works.

Railway Amalgamation and Railway Rates.—At the annual general meeting of the Mansion House Association on Railway and Canal Traffic on 15th inst., dissatisfaction was expressed at the constitution of the Departmental Committee on Railway Amalgamation appointed by the President of the Board of Trade, as giving wholly inadequate representation to the trading community, and it was decided to urge Mr. Churchill to add further representatives.

Royal Agricultural Show at Gloucester.—The 70th annual exhibition of the Royal Agricultural Society is being held at Gloucester this week, and closes to-morrow (Saturday). Among the exhibitors are Messrs. Ransomes, Sims & Jefferies, Ipswich; Merryweather & Sons, London; W. H. Willcox & Co., London (who have a large variety of exhibits on show at stand No. 230); Ruston, Proctor & Co., Lincoln (besides a varied assortment of engines, chiefly for agricultural purposes, this firm show dynamos suitable for farm and farming operations); Davey, Paxman & Co., Colchester (engines, suction gas plant, &c.); Robey & Co., Lincoln (exhibit includes several steam engines specially suited for electric lighting installations); Crossley Bros., Openshaw (gas, oil and petrol engines combined with dynamos for various classes of work); Tangyes (Ltd.), Birmingham (gas and oil engines, suction gas producer plant, &c.); Sisson & Co., Barnwood (engine and dynamo for agricultural uses); National Gas Engine Co., Ashton-under-Lyne (gas, oil and petrol engines with direct-coupled dynamos designed for small country house lighting, suction gas plant, &c.)

At Stand No. 395, Messrs. J. G. Childs & Co., of Hawthorn-road, Willesden Green, London, have the most important electrical exhibit at the show. This includes their wind turbine electrical plant which has been described recently in The Electrician, and which has, during the week, attracted considerable attention at Gloucester. There is, in addition, a collection of electrical domestic and cooking apparatus, operated by wind-turbine plant, which has made the stand a popular rendezvous. Churns, cream separators, circular saw, &c., all in operation, gives added interest to the stand. An item of considerable interest was the manipulation of the storage

battery on this company's stand. A portion of the battery was employed for working the cooking apparatus and dairy machinery and the remaining portion for lighting the stand by means of metallic filament lamps. An economical electric oven was also shown. The plant exhibited by Messrs. Childs is likely to have considerable interest for agriculturists.

The Royal Agricultural Society's annual show is recognised as the most important event of the year agriculturally, and a very large attendance is always certain. In connection with the popular side of electricity supply this would seem to be a favourable opportunity for the display of electrically-operated appliances. So far as our representatives were able to discover Messrs. Childs & Co. had the only working electrical plant and appliances on the show grounds, and were responsible for the lighting of the show cottage of the Country Gentlemen's Association, where an electric grill was also in use.

Southwark (London).—The total amount expended on wiring consumers premises up to March 31 last was £1,371, being a small sum of £21 in excess of the amount sanctioned by the Council.

Tinsley.—Sheffield Corporation have decided to apply for a Provisional Electric Lighting Order for this district.

Middlesex Tramways.—The Metropolitan Electric Tramways (Ltd.) have applied to the Board of Trade for an extension of two years for completing the works authorised by the Tottenham, and Walthamstow Light Railways Order, 1906.

West Ham.—Mr. A. H. Seabrook, the retiring engineer and manager, points out that since he took over the electricity undertaking in 1905 the output has quadrupled, the load at the generating station nearly trebled, while the number of motors has been increased six times, and their horse-power 12 times.

It is also stated that by seeking the class of load which costs the least to supply the load factor has been brought up from 17·7 per cent. to 29 per cent., and the percentage of capital repaid to the capital expended has been increased from 8 per cent. to 21 per cent. In view of this high percentage considering the undertaking is only ten years old, only a nominal reserve fund is in his opinion necessary. There was a loss of £717 in 1905 against a surplus of £3,853 in 1909, while at the same time the average charge to consumers is considerably less than half, being 1d. against nearly 2½d. The charge for power is now only one-third of what it was in 1905. The total cost of production has been reduced from nearly 1¼d. to ½d., the cost of management by two thirds, the cost of wages and repairs by half, and the cost of coal by half. For the year ending March 31 last, the working expenses had decreased by £202, while the total income had risen to £72,114 from £63,069, and the gross profit had increased from £23,743 to £32,990. There was a surplus after payment of interest and sinking fund of £3,853, which is to be transferred to reserve.

The balance of the tramway undertaking (£3,767) is to be transferred to reserve.

Mr. H. E. Blain, tramways manager, has been voted an increase of salary of £100, to be followed by two subsequent annual increments of £50 each.

Willesden.—The Metropolitan Electric Tramways (Ltd.) have been informed by the Council that in their plans in connection with the proposed joining up of the Middlesex light railways with the L.C.C. tramways system in Scrubbs-lane, arrangements must be made with the L. & N.-W. Rly. Co. for widening the roadway on each side of the permanent way to at least 9 ft. 6 in., and a pathway of a minimum width of 9 ft.

Representatives have been appointed to attend a conference of the London County Council with reference to the proposed construction of an electric tramway from the Marble Arch to Cricklewood.

Wireless Telegraph Notes.—It is stated that the Pacific Islands Radio-Telegraphy Co., recently incorporated in London with a capital of £60,000, will soon commence operations in the Pacific, and that a French company has been formed for the establishment of a station at Tahiti.

A commission is sitting at the Meteorological Office in Victoria-street, Westminster, London, to consider the steps necessary to be taken to develop the existing system of conveying weather information by wireless telegraphy. The members of this commission include Dr. W. N. Shaw, director of the Meteorological Office, Prof. W. Moore, chief of the U.S. Weather Bureau at Washington, and Prof. Grossman of the Deutsche Seewarte, of Hamburg. The main

suggestion before the commission is that all ships of every nationality above a given tonnage shall compulsorily be equipped with wireless telegraph apparatus in order that a systematic international service of weather reports may be organised. One of the principal proposals before the commission has originated, with Father Froc, of the Zi-Ka-Wei Observatory, China, who recommends the general adoption of the code of maritime weather signals now in use in the China Sea, while Prof. Moore favours an international system of weather signals, and the adoption of a uniform storm signal. The provisions of the International Radio-Telegraph Convention relating to ship and shore station intercommunication are likely to prove of service in the discussion now proceeding.

A sad fatality occurred this week at the Humberstone wireless telegraph station, belonging to the Admiralty. The chief electrician (Mr. Michael Cooney) in entering the operating room at the station received a severe shock, and all attempts at resuscitation were unavailing. The accident was attributed to Mr. Cooney's being overworked and his extreme anxiety that the station should be completed in time for the manœuvres now taking place. "Death from misadventure" was the verdict returned at the inquest.

Workhouse Lighting.—Barnstaple Guardians have decided to have the workhouse wired and fitted up for electric lighting.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bradford.—The accounts of the tramways department for the year ended March show a net profit of about £15,000, a decrease of £2,000 compared with the preceding year.

Coventry.—On Monday the Electric Light committee considered the accounts of the electricity undertaking for the past year. The net profit is £3,765, of which £1,000 is to be paid to the district fund in aid of rates, £2,598 is placed to reserve and the balance (£167) carried forward.

Croydon.—The accounts of the electricity department for the year ended March have been approved by the Corporation, and show total capital expenditure £345,186 (increase £3,775).

Current supplied by meter produced £32,151, for traction £24,036, public lighting £7,513, meter, &c., rentals, £1,097, total receipts £64,650 (against £66,938 in the previous year). Expenditure on revenue account was £34,975 (£31,133), gross profit was £29,650, added to £25 brought forward. After meeting capital charges and income tax on profits and transferring £146 to capital account in respect of works superseded, the net profit was £6,953. There was a balance in hand at March, 1908, of £14,490, and £12,000 has been transferred to reserve fund, leaving the balance in hand £9,443. 7,291,643 (7,005,141) units were generated, and the units supplied were, for public lamps 634,326 (655,762), traction 3,150,929 (3,044,362), private consumers 2,255,296 (2,174,879). The total maximum demand was 3,295 kw. (3,255 kw.).

The report of the borough electrical engineer (Mr. A. C. Cramb) states that the reductions that have been made in the charges for current have affected the revenue to the extent of £3,584, and the use of metal filament lamps is estimated to have caused a loss of about £2,000 on revenue. There was a drop in efficiency of distribution from 84·93 to 82·59 per cent., due to the adoption of metal filament lamps with auto-transformers and a large number of older type meters failing to record when small amounts are passed through them. 223 motors (943 H.P.) are connected to the mains. Mr. Cramb says that certain expenditure is being incurred to comply with the new Home Office regulations, and next year the h.t. switchboard ought to be replaced. The coal conveyors and bunkers have been completed and are in operation, and two mechanical stokers were completed during the autumn. The Council have agreed to the reduction of the private lighting flat rate from 4½d. to 4d. and the arc lighting rate from £16 to £15 as from midsummer.

Glasgow.—An abstract of the accounts of the Tramways Department for the year ended May 31 has been submitted to the Tramways committee and shows total revenue £892,751.

The traffic expenses were £258,219; general expenses, £106,886; repairs, £102,646; power, £37,867, making a total of £505,618, and leaving a balance of £387,133, which, with interest, &c. £29,791) made £416,924. Deducting Govan tramway rental (£5,075), Paisley tramway rental (£4,659), interest (£63,349), sinking fund (£71,323), income tax (£10,445), Common Good (£50,000), depreciation (£195,798), the net balance was £16,275, against £38,930. Last year only £35,000 was set apart for the Common Good, but this was subsequently increased out of the reserve fund to £50,000.

Great Yarmouth.—The accounts of the electricity supply department for the year ended March show capital expenditure £104,842 (increase £7,579).

Income was £20,386 (against £19,523). Total costs were £12,788 (£12,443). Gross profit was £7,597 (£7,080), net profit £194 (£14 less than previous year). Maximum demand was 39,767 kw. (37,100). 1,928,420 units were generated and 1,574,153 sold. The public lamps include 181 arcs and 283 Osrams.

Islington (London).—For the year ended March 31 the surplus on the electricity department was £4,263.

Receipts amounted to £52,244, of which £15,734 was for public lighting. The cost of generation was £16,692, and distribution cost £2,934, general expenses absorbed £6,084, while rents, rates and taxes accounted for £1,830. The gross profit was £25,752. The reserve fund on March 31 was £18,758, while the outstanding loans were £415,554.

Stalybridge.—The accounts of the Stalybridge, Hyde, Mossley and Dukinfield Tramways and Electricity Board, for the year ended March, show capital expenditure £278,866 (increase £1,898) on the tramway department.

The revenue of the department was £37,917 (against £39,976 in previous year), working expenses £31,676 (£33,742), and the net result, after meeting capital charges, is a deficit of £9,518 (£10,381). 10,241,544 (10,285,973) passengers were carried and 1,248,835 (1,404,434) car-miles run. The total units used per car-mile were 1·674 (1·669) and the average fare per passenger was 0·889d. (0·928d.).

The accounts of the electricity department show capital expenditure £227,557 (increase £18,863).

Revenue was £27,293 (against £26,674), working expenses £14,909 (£14,494), gross profit £12,386 (£12,181) and deficit, after providing for capital charges, £538 (£463). Works costs per unit were 0·293d. (0·364d.) and total costs, exclusive of capital charges, 0·372d. (0·453d.). Interest and sinking fund charges were this year 0·322d. 11,718,186 (8,897,769) units were generated, 7,532,090 (5,396,862) supplied to private consumers and 2,100,022 (2,341,120) for tramways.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited for supply of 18 transformers to the MELBOURNE (Australia) Municipal Council. Tender forms, conditions, &c., may be obtained from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co., Proprietory, (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by Wednesday, July 7. See also an advertisement.

The City of MELBOURNE Municipal Council invite tenders for the supply of 80 alternating-current flame arc lamps. Specifications, tender form, conditions of tender, &c., from the agents of the City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by Wednesday, July 7. See also an advertisement.

Tenders are invited for the supply of a 15 ton overhead travelling hand crane to the city of MELBOURNE, Victoria. Tender forms, conditions, &c., from the agents of the City Council, Messrs. McIlwraith, McEacharn & Co., Proprietary (Ltd.), Billiter-square Buildings, London, E.C. Tenders to the Chairman of the Electrical Supply committee, Town Hall, Melbourne, by 2 p.m. of August 4.

LONDON County Council want tenders by 11 a.m. July 6, for supply of 2,350 steel tyres for driving wheels and 1,500 for pony wheels of tramcars. Particulars from the chief officer, L.C.C. Tramways, 62, Finsbury-pavement, E.C.

BURSLEM Corporation require tenders by noon June 29 for a 660 kw. steam generator, or (alternatively) a 660 kw. turbo-generator (450 volts), condensing plant, water tube boiler and switchgear. Specifications from the Electrical Engineer.

HASLINGDEN Corporation want tenders by noon July 3 for the sub-station equipment, with battery and reversible booster, in connection with their electric tramways. Specification, &c., from the Town Clerk.

LEWISHAM (London) Guardians want tenders by 2 p.m. June 29 for the supply and fitting up of telephone instruments and fittings at the workhouse and infirmary. Particulars from the Union Offices, 394, High-street, Lewisham, S.E.

GREENWICH (London) Guardians want tenders by noon July 8 for the erection, &c., of two electric lifts at the Infirmary. Specification, &c., from the Clerk, Woolwich-road, S.E.

WORKSOP Council want tenders by June 29 for underground cables. Specification from Mr. J. P. Crowther, electricity works, Worksop.

ACTON Council want tenders by 3 p.m. July 12 for 12 months' supply of lead-covered paper-insulated cables. Form of tender, &c., from Mr. M. J. Martin Blair, 130 Churchfield-road, Acton, W.

ROTHERHAM Corporation want tenders by July 13 for 12 months' supply of electricity meters. Particulars from the Borough Electrical Engineer.

ROTHERHAM Corporation also want tenders (by noon, June 28) for 12 months' supply of single vulcanised bitumen (covered) cable.

SALFORD Electricity committee want tenders by noon July 5 for alterations of and additions to their electricity works buildings. Specification, &c., from the Borough Electrical Engineer.

The NORWEGIAN State Railways Department require tenders by 3 p.m. July 2 for supply of 288,000 pairs of carbon points. Specifications may be seen at 73, Basinghall-street, London, E.C. A preference of from 10 to 15 per cent. (apart from customs duties) is given to Norwegian manufacturers, and local representation is necessary.

Chinese Contracts.—In our Contracts Open pages there will be found an invitation from the Chinese, Government through its representatives, for sealed proposals for the erection and completion of a group of buildings to be used as a Bureau of Engraving and Printing in Peking, China. It will be noted that the plans and specifications are on file at, amongst other places, the Chinese Consulate-General, 88, Fenchurch-street, London, E.C. Tenders from European contractors must be filed with the Chinese Legation at Washington, D.C., not later than July 15 next. The conditions of the contract are instructive.

TENDERS RECEIVED AND ACCEPTED.

London County Council have received the following tenders for car bodies, trucks, &c., for the tramways department :—

200 CAR BODIES

Hurst, Nelson & Co (*accepted*)	**£78,000.**	£77,350
United Electric Car Co	80,000,	80,000
Brush Co	82,400,	82,500
Metropolitan Amalg. Rly. Carriage & Wagon Co	82,400,	82,700
Gloucester Railway Carriage & Wagon Co	*20,950,	*21,280

The first figure represents tenders for car bodies fitted with side life guards and lifting steps, as at present fitted on the L.C.C. cars, and both tenders include a provisional sum of £15 per car for extra work. The second figure is for car bodies fitted with lifeguards and lifting steps of the Simplex type.

* For supply of 50 car bodies.

200 CAR TRUCKS.

Hurst, Nelson & Co. (*accepted*)	**£23,900**
Mountain & Gibson	26,550
Heenan & Froude	26,950
W. R. Renshaw & Co.	27,500
United Electric Car Co.	28,000
Metropolitan Amalgamated Rly. Carriage & Wagon Co.	30,000
Brush Co.	31,000
Peckham Development Co.	33,000

ELECTRICAL EQUIPMENT AND ASSEMBLY OF 200 TRAMCARS.

British Westinghouse Elec. & Mfg. Co. (*accepted*)	**£63,630**
Dick, Kerr & Co.	65,000
British Thomson-Houston Co.	66,750

The Highways committee, reporting on the above tenders states that as regards the supply of the magnetic brakes for the 200 cars they had been in negotiation with the British Westinghouse Co., and that company had offered to supply the brakes required at £57 a set. The committee were advised that that offer was reasonable and they thought that it should be accepted. The cost of the brakes would be £11,400.

Hurst, Nelson & Co., had also offered to supply the trucks with steel castings of foreign manufacture instead of British made castings. If that offer were accepted the total cost of the 200 cars would amount to £175,950, against £176,950. Having regard, however, to the small difference between the two amounts and to the additional cost which would be involved in the supervision of the manufacture of the castings abroad, they had thought it right to recommend the acceptance of the tender as submitted, which provides for castings of British make. The cost of each car under the contracts proposed to be entered into would be £884. 15s., compared with £897, the cost of each car under the contracts obtained in 1908.

As regards the 50 special cars, the committee propose, in the first instance, to ascertain the exact type of car which the Board of Trade would be prepared to approve. With that object they thought that a specimen car should be built before any steps were taken to obtain the further 49 cars required. We are advised that the best course to adopt for the construction of that car would be to build the body of the car by direct labour at the Leytonstone car works, and to obtain the car-truck, steel underframe, electrical equipment and other necessary fittings under existing contracts or by inviting tenders from selected firms. The total cost of the 200 cars of standard pattern and of the 50 special cars is estimated at £237,500, and the successful tenderers have been allowed to sub-let certain portions of their contracts.

The following tenders have also been accepted by the London County Council :—

R. W. Blackwell & Co., bent poles for Streatham-Norbury tramways, £300; Appleby (Ltd.), conversion of overhead crane into three motor type crane, £374 : B. & S. Massey, electrically-driven power hammer for central car repair depot, £273 (with power to sublet part of work to The Electric Construction Co.); J. Holroyd (Ltd.), milling cutters for central car repair depot, £108; Hadfields Steel Foundry Co., manganese points for permanent way work, £960.

The Asylums committee of Essex County Council received the following tenders for electrical work for the new second county asylum, Colchester. The figures for contracts 3 and 5 refer to both main and detached buildings, the detached building being at the committee's option. The figures for contracts 1 and 4 include a number of alternatives. The amounts in heavy type and preceded by an asterisk are those of the tenders recommended for acceptance. The consulting engineers for the work are Messrs. Hawtayne & Zeden, 9, Queen-street-place, London, E.C. :—

CONTRACT NO. 1. *Two Steam Dynamos (100 kw.). Steam Balancers (two 50 kw.). Motor Balancer (14 kw.). Switchboard and Travelling Crane.*

British Thomson-Houston Co.	£3,068	3,000	2,990	Chas. Pullan	£3,335		
	2,930	***2,920**	2,911	H. J. Cash & Co.	3,314		
	2,901	2,871	2,861	Union Electric Co.	3,287,	3,090	2,996
	2,841	2,831			2,966		
Newtons (Ltd.)	4,218			Bruce Peebles & Co.	3,206	3,092	3,009
Tilley Bros.	3,960	3,254	3,139	General Electric Co.	3,176	3,114	3,046
T. Scott Anderson	3,863			Cox-Walkers	3,170	3,157	3,050
Higgins & Griffiths	3,727				3,037		
India Rubber, Gutta Percha & Telegraph Works Co.	3,675	3,639	3,470	Mann, Egerton & Co.	3,167	3,043	
	3,360	3,330		Morley Elec. Eng. Co.	3,129		
				Lanc. Dynamo & Motor Co.	3,128	3,044	2,930
J. H. Holmes & Co.	3,629	3,549	3,459				
Jas. Howden & Co.	3,565	3,495	3,437	Crompton & Co.	3,105	3,087	3,094
	3,368	3,251	3,181		3,066	3,064	3,062
Dargue, Griffiths & Co.	3,554				3,044	2,975	2,966
Tredegar & Co.	3,491	3,461			2,954	2,947	2,945
Brit. Elec. Plant Co.	3,489	3,402	3,372		2,932	2,926	2,923
Morris-Hawkins	3,413				2,887	2,874	2,866
W. J. Fryer & Co.	3,456				2,844	2,825	2,804
Elec. Construction Co.	3,396	3,239	3,173		2,752		
Johnson & Phillips	3,381	3,151		Phœnix Dyn. Mfg Co.	3,081	3,061	2,884
W. H. Allen, Son & Co.	3,378	3,197			2,864	2,810	2,760
A. W. Penrose & Co.	3,368			Mawdsleys (Ltd.)	3,040	3,036	2,952
Blackburn, Starling & Co.	3,360	3,330			2,922	2,790	2,780
				J. P. Hall & Co.	3,030	2,993	2,903
British Westinghouse Co.	3,346	3,256	3,029		2,871		
	2,939	2,909		Brush Co.	2,907	2,877	

CONTRACT NO. 2 —*Steam, Exhaust and Drain Pipes and Valves.*

Aiton & Co. ***£348**

W. J. Fryer & Co.	£489	J.E. & S. Spencer	£397
T. Scott Anderson	476	Dargue, Griffiths & Co.	395
Tilley Bros.	451	John Wilson & Co.	393
H. J. Cash & Co.	449	Johnson & Phillips	388
Tredegar & Co.	436	Crompton & Co.	383
Higgins & Griffiths	435	Blackburn, Starling & Co.	379
Brightside Foundry Co.	431	Cox-Walkers (Ltd.)	369
Brush Co.	409	Babcock & Wilcox	362, 356
Mann, Egerton & Co.	400		

CONTRACT NO. 3.—*Main Cables, Distribution Boards, Wiring and Lamps. For Main Buildings and Detached Blocks.*

H. J. Cash & Co ***£7,913. 18 1**

Wells, Rayner & Co.	£12,696	Mann, Egerton & Co.	£8,258
Felgate & Storey	10,915	A. V. Cifkins & Co.	8,160
Western Electric Co.	9,521	Dargue, Griffiths & Co.	8,130
Tredegar & Co.	9,490	G. E. Taylor & Co.	8,051
Tamplin & Makovski	8,894	Cox-Walkers (Ltd.)	7,958
Foote & Milne	8,624	Brush Co.	7,918
John Hunter & Co.	8,615	Lund Bros. & Co.	7,817
T. Scott Anderson	8,588	Pinching & Walton	7,801
Higgins & Griffiths	8,524	W. J. Furse & Co.	7,653
Charles Pullan	8,511	Tilley Bros.	7,606
W. J. Fryer & Co.	8,440	Johnson & Phillips	7,338
Blackburn, Starling & Co.	8,321	J. T. Mayfield & Co	6,707

CONTRACT NO. 4.—*Motors and Switchgear.*

Mawdsleys Limited £293, ***£306. 10 0**

Newmans	£1,024	India Rubber, Gutta Percha & Telegraph Works Co.	£399
T. Scott Anderson	785	Cox-Walkers (Ltd.)	398, 368
J. B. Saunders & Co.	675	Brush Co.	397, 389
Siemens Bros. Dynamo Works	600	C. C. Pudney	394
Electric Construction Co.	504, 448	Electromotors (Ltd.)	388
Pinching & Walton	498	Newtons Limited	381
W. J. Furse & Co.	480	H. J. Cash & Co.	380
Blackburn, Starling & Co.	471	W. J. Fryer & Co.	369
Higgins & Griffiths	455	J. H. Holmes & Co.	357, 327
Morris Hawkins (Ltd.)	439	Charles Pullan	356
British Electric Plant Co.	438	Tredegar & Co.	342
Electric & Ordnance Accessories Co.	437	C. E. Taylor & Co.	342, 327
Dargue, Griffiths & Co.	436, 373	Phœnix Dynamo Mfg. Co.	321, 293
Veritys (Ltd.)	435	Morley Electrical Engineering Co.	307, 292
Lund Bros. & Co.	426	Mann, Egerton & Co.	298
British Westinghouse Co.	421	Union Electric Co.	281, 266
Johnson & Phillips	407	Wells, Rayner & Co.	277
General Electric Co.	403, 381, 346		

CONTRACT NO. 5.—*Telephones, Bells, Time Recorders, Fire Alarms and Electrical Clocks. For Main Buildings and Detached Blocks.*

H. J. Cash & Co. ***£1,850. 14 6**

W. J. Fryer & Co. (main bldgs only)	£1,936	Johnson & Phillips	£2,451
Wells, Rayner & Co. (main buildings only)	1,590	Cox-Walkers (Ltd.)	2,357
S. Hammond & Co.	4,238	Higgins & Griffiths	2,311
Blackburn, Starling & Co.	3,005	Private Telephone Co.	2,116
Lund Bros. & Co.	2,996	Bell Telephone Co.	2,089
Charles Pullan	2,859	W. J. Furse & Co.	1,864
Brush Co.	2,632	J. T. Mayfield & Co.	1,840
Mann, Egerton & Co.	2,550	C. C. Pudney & Co.	1,828
		Marples, Leach & Co.	1,511

Hammersmith (London) Council has accepted the tender of W. Geipel & Co. for carbons at £284. 12s. 5d. ; that of Aiton & Co., for exhaust steam and water pipes at £95 ; and that of Gwynne's Ltd. for "Invincible" centrifugal pressure pump with motor (250,000 gallons per hour) at £470.

Merthyr Tydfil Council have accepted the tender of the local electric traction and light company for lighting the lower end of the borough at £240 per annum, or £4. 4s. less than the gas company's tender.

Partick Council have placed an order with the Lancashire Dynamo & Motor Co., Trafford Park, Manchester, for one 1,000 kw. Belliss-L.D.M. set, complete with condenser, cooling tower and the necessary pipe work.

Southend Council have accepted the tender of T. Bolton & Sons for 740 yds. of copper wire for tramway overhead equipment at £35. 4s. 2d.

Great Grimsby Corporation have accepted the tender of McPhail & Simpson for the supply and erection of two superheaters, and that of Hebb & Co. for the renewal of dripping bars in the cooling tower.

Westminster City Council have accepted the tender of Belshaw & Co. for the supply and erection of two arc lamps at Buckingham Palace-road swimming bath at £42. 15s.

J. Higgins & Co. have obtained the contract for wiring the Rawtenstall tramcar shed.

Swinton and Pendlebury Council have accepted the tender of Callender's Co. for cables, service boxes, &c., at £122.

Dorking Council have placed an order with Heenan & Froude at £3,225 for a refuse destructor.

Hornsey Council have accepted the tender of the British Thomson-Houston Co., Rugby, for supply of mercury meters for 12 months.

Rushworth & Dreaper have secured the contract for installing electrical organ blowing apparatus at Huyton Parish Church.

Rawtenstall Council have accepted the tender of Higgin & Co. for wiring the tramcar depot.

Bedford Town Council have placed an order with W. H. Allen, Son & Co. for an exciter at £98. 10s.

Kensington (London) Council have accepted the tender of Crompton & Co. at £256 for lowering contact gear for 50 arc lamps.

BUSINESS NOTICES.

The International Electric Co. announce that with the view of facilitating the general management they are removing from their city offices, and are transferring their stock to newly built premises adjoining their factory at Kilburn, and after 24th inst their only address will be Telephone Works, 111-115, Salusbury-road, Kilburn, N.W. The telegraphic address remains "Genest, London," the new telephone numbers being 477 P.O. Willesden, and 488 Paddington.

Owing to the operatives' annual holiday, the works of Messrs. Ed. Bennis & Co. (Ltd.), Little Hulton, Bolton, will be closed to-day (Friday) and will re-open on Monday, July 5,

Ship Carbons (Ltd.) announce that their secretary (Mr. Paul Weiss) and their manager (Mr. Franz Taussig) have ceased to be members of their staff. Mr. A. Pavlovits has been provisionally appointed as secretary and manager, and is at present sole recognised representative.

Messrs. H. G. Mayer & Co., 67, Aldersgate-street, London, E.C., have obtained the agency of the Maerkische Drahtwerke for the finer sizes of copper, bronze and brass wire from Nos. 17 to 50 S.W.G. The company are also agents for Plania arc lamp carbons.

Plant for Sale.—Messrs. G. Elliott & Co., 186–188, Long-lane Bermondsey, London, S.E., have for sale two compound Marshall steam engines coupled to two Crompton dynamos, and also three dynamos. Further particulars are given in an advertisement.

Electrical Engineering Business.—Messrs. Josolyne, Miles & Co., 28, King-street, Cheapside, E.C., advertise for sale the business of a well-known firm of electrical engineers.

Patents Development.—The proprietors of the following patents are desirous of entering into arrangements by way of licence or otherwise for exploiting same and ensuring their full development in this country :—

No. 10,495/1904, for "Improved Method of finding the Direction of Sound"; No. 10,477/1904, for "Improvements in Apparatus for Receiving Submarine Signals"; No. 10,463/1904, for "Improved Means for producing Sound Vibrations in Water applicable to Marine Signalling"; No. 3,266/1903, for "Improvements in Apparatus for producing Sound Vibrations in Water"; No. 13,288/1902 for "Improvements relating to the Transmission of Sound for Submarine purposes and to Apparatus therefor"; No. 13,287/1902, for "Improvements relating to Apparatus for the Transmission of Sound for Submarine purposes"; No. 18,570/1906, for "Improvements in Devices for producing Sound Signals in Water"; and No. 18,999/1905, for "Improved Method of Electric Welding Sheet Metal." Applications to Messrs. Hascitine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

No. 12,210/1901, relating to "Electrostatic Separators." Applications to Messrs. Cruikshank & Fairweather, Ltd., 65 and 66 Chancery-lane, W.C.

No. 14,851/1906, for "Improved Apparatus for the Automatic Distribution of the Operating Service in Telephone Exchanges." Particulars from Messrs. Day, Davies & Hunt, 321, High Holborn, London, W.C.

W. T. Glover's Specialities.—Messrs. W. T. Glover & Co., Trafford Park, Manchester, have more than one reputation to sustain. Their cables are known all over the world, and we think as much can be said for their advertising novelties. One is never surprised at receiving something quite out of the common from this firm, especially in the way of hanging calendars, and now we have to acknowledge receipt of the eighth almanac issued by the firm. This covers the period from July 1, 1909, to June 30, 1910. A good deal of interesting and useful matter is contained in this large aggregation of lift-off sheets, and in addition Messrs. W. T. Glover & Co. have the advantage of a well-earned advertisement.

Wind-Driven Generators.—Among the exhibits at the Royal Agricultural Show at Gloucester this week is that of Messrs. J. G. Childs & Co., of Willesden Green, N.W., who show a wind-driven variable speed generator, coupled to a battery of 450 ampere hours capacity. This plant follows Messrs. Childs' usual practice in most particulars. The storage battery is divided into two parts and by means of a special arrangement a pressure of 50 volts is obtained for working the cooking apparatus shown in the exhibit and 25 volts for lighting the "Show Cottage." The generator of this plant can also be used as a variable speed motor by means of a special switch for driving the machinery when there is no wind, the current being taken from the battery.

CATALOGUES, &c.

Portable Electric Tools.—The Consolidated Pneumatic Tool Co., (Ltd.), of 9, Bridge-street, S.W., send us their new list of portable electric tools of various kinds. The different types are amply illustrated, and a speciality is made of electric drills for special purposes. Those interested will be certain to find what they require.

Motor Car Accessories.—A new catalogue of motor car accessories has just come to hand from Messrs. Siemens Bros. & Co. In this list special features are made of the Siemens Obach dry cells for use on a car, and also of measuring instruments and charging and testing apparatus. An electric speed indicator is shown that can easily be adapted to any car, as the indicator is connected to an alternator by electric conductors. Details of a variety of handlamps, plugs and ignition coils make this list a very handy one for reference for car users.

"Direkton" Starters.—Engineering Instruments (Ltd.), are sending out a list of "Direkton" motor starters, with illustrations of the various types of apparatus made by the company, who are prepared to cater for any class of work and will be pleased to attend to enquiries at their new address, Skerne Works, Darlington.

Maschinenfabrik Oerlikon Specialities.—Mr. G. Wüthrich sends us an interesting pamphlet on a new electro-hydraulic portable rivetter. In this the advantages of electrical transmission together with hydraulic power are obtained. The rivetter is compactly built, and is made in several sizes, both portable and fixed. In the portable type the method of suspension seems to make them very adaptable for all kinds of rivetting work.

Osram Lamps, &c.—The General Electric Co., 71, Queen Victoria-street, London, E.C., have ready a reduced price list of Osram Lamps. In this list appreciable reductions are shown in the various types of lamp made.

We have also received from this firm several handy cards giving particulars and prices of switches, distribution boxes and electric cooking apparatus, which will be found handy for reference for those interested in these particular specialities.

A pamphlet on the application of electric power in shipyards shows the adaptation of the electric drive, in the form of G.E.C. motors, to the various types of machinery used in ship building work. Motor car accessories are also listed in booklet form.

Oak Panelling.—Messrs. Holler (Ltd.), 26, Soho-square, London, W., send a handsome brochure illustrating some elaborate carving work in oak carried out by them. They will be pleased to furnish particulars on receipt of enquiries.

Indestructible Cables.—The Indestructible Cable Co. have ready a booklet dealing with the merits of indestructible insulated wires and cables. A variety of classes of this cable are made and they are suitable for all kinds of work.

Electro-Therapeutics.—We have received from the Sanitas Co a descriptive list of their various electro-medical apparatus entitled "The Book of the Multostat." It is claimed that by using the earth-free Multostat all currents used in electro-therapeutics can be applied without the slightest possibility of earth shocks, which up to the present have always been a source of danger. The Sanitas Co. will be pleased to send copies of any of their lists to those interested.

Storage Batteries.—The Hart Accumulator Co., of Stratford, send us a neat pocket edition of their catalogue. In it are to be found full particulars of the various types of cells made by the company, together with detailed instructions as to how to use the same.

B.T.-H. Tungsten Lamps.—The British Thomson-Houston Co., Rugby, call particular attention to the fact that their tungsten lamps are rated according to the British standard in their new list just issued. Details of the sizes, shapes, and candle powers of the lamps are given, together with the current consumption in each case, and users of incandescent lamps are further reminded that these lamps are British made at Rugby.

Electrical Accessories.—The Sun Electrical Co., 118-120, Charing Cross-road, W.C., have sent us a pamphlet giving particulars and prices of their ornamental cigar lighters suitable for use in the smoking room. Particulars of a self-adjustable nipple made by this company for use with metallic filament lamps are also given.

"London Electric" Wires.—The London Electric Wire Co. & Smiths (Ltd.), Playhouse-yard, Golden-lane, E.C., have just issued a revised catalogue of insulated high conductivity copper and aluminium wires. This list not only gives the actual thickness of covering for every size of wire, but also contains wire tables for both copper and aluminium which should be very useful for comparing the utility of these metals for any purpose.

Carbon Brushes.—Messrs. Wm. Geipel & Co., send us a pamphlet which gives details of the various sizes and shapes together with prices of the Henrion Graphitic carbon brushes.

Condensing Plants.—The "Zylba" patent condensing and cooling plants are illustrated and described in a list just issued by the Midland Engineering Co., Birmingham. It is claimed that by improvements made in cooling towers this firm is able to cool on a given ground space 50 per cent. more water than most natural draft towers. That these plants have passed the experimental stage is shown by the illustrations of several of the installations at present working satisfactorily in Great Britain.

BANKRUPTCIES, LIQUIDATIONS, &c.

Claims against Wm. Terrell Garnett (trading as W. T. Garnett's Cable Co.), Barkerend Mills, Bradford, by July 16 to Mr. E. Musgrave, 1, Bank-street, Bradford. Debtor's discharge is suspended until May 18, 1911.

Claims against Generators Limited are to be sent by Aug. 5 to Mr. G. B. Murgatroyd, Duchy-chambers, Clarence-street, Manchester.

The trustee (Mr. A. S. Cully, 191, Corporation-street, Birmingham) in the bankruptcy of W. S., G. E. and H. T. Wright (trading as Wright's Patent Heater Condenser Co.) has been released.

The Electric Taxicab Co. (Ltd.) is being wound up voluntarily, and Mr. Wm. Milne, 9, New Broad-street, London, E.C., has been appointed liquidator. A meeting of creditors will be held at 9, New Broad-street, E.C., on July 5.

The United Kingdom Tramway, Light Railway & Electrical Synd. (Ltd.) is being wound up voluntarily.

An order to wind up Auto-Controllers (Ltd.) was made at Poole County Court on June 14. Meetings of creditors and contributories will be held at Arcade-chambers, Bournemouth, on July 1.

Winding-up Petition.—A petition for the winding-up of the Uxbridge & District Electric Supply Co. (Ltd.), presented by Callender's Cable & Construction Co., will be heard on June 29 by Mr. Justice Neville in the High Court, London.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*Note.—The undermentioned Applications, [illegible] marked † are [illegible] public [illegible] Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

March 29, 1909.

7,450 Taylor. Electric accumulator substations.
7,471 [illegible] (Date applied for, 29/3/08.)*†
7,508 Wittgensteiner. Regulating the feed of carbons in arc lamps.*
7,531 Owen. Covering wire or other electric conductors with insulating material.*

March 30, 1909.

7,5?3 and 7,7?3 Ha[illegible] Dyke & Ra[illegible]. [illegible] of electrical conductors and to means therefor.
7,595 Muller. Producing electric current by means of combustion engines. (Date applied for, 6/4/08.)*†
7,600 Denny. Electric motor starters, electromagnetic circuit-breakers and automatic switches.
7,610 Gould. Electric wire supports.*
7,616 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric distributing systems.
7,630 Conrad. Transformers for operating vapour electric apparatus. (Date applied for, 10/4/08.)*†
[illegible] (Date applied for, [illegible])*†

March 31, 1909.

7,706 Schmahl & A. Mfg. Co. Armoured conductors for portable electric appliances.
7,741 Ytterberg. Operating devices for electric switches.
7,754 Kallmann. Equalising current by means of automatically-regulated load resistances. (Date applied for, 18/7/08.)*†

April 1, 1909.

7,791 Gray. Electric conductors.
7,795 Venning. Trolley frogs and crossings. (Date applied for, 15/4/08.)*†
7,805 Burton. Combined electric switch and plug.
7,843 Sefton-Jones. (Julius Pintsch A.-G., Germany.) Electric lamps.*

April 2, 1909.

7,906 Burstyn. Diaphragm condensers. (Date applied for, 3/4/08.)*†
7,913 Farber. Electric glow lamps.*

April 3, 1909.

7,993 A. P. Lundberg, G. C. Lundberg & P. A. Lundberg. Electrical switches. (Addition to No. 6,899/07.)*
7,995 Simplex Conduits & Waterhouse. Wiring buildings and the like for the distribution of electricity.
8,014 Halfpenny. Electric incandescent lamp.
8,024 Baker. Switch for opening or closing electric circuits.
8,025 Baker. Mechanical movement and special application thereof to electric switches.*

April 5, 1909.

8,077 Sedgwick. Electric lamp-holders.
8,105 Hansen. Circuit-breaker.
8,106 Siemens Bros. & Co. (Siemens & Halske A.-G., Germany.) Heating coil protecting devices for weak current electrical circuits.*
8,111 Sharman. Discharge gaps for the production of electric oscillations.
8,112 Buckley. Electrically igniting miners' safety lamps in mines.
8,123 Schneider. Electric clock and movement.*
8,146 Hoppelt. Electric incandescent lamps.*
8,150 and 8,151 Senftner. Electrodes for arc lamps. (Date applied for, 14/4 and 17/12/08.)*†
8,168 Societe Ch. Legrand et Cie. Locking levers operating railway and other switches, signals, and the like from a distance. (Date applied for, 9/1/08.)*†
8,191 Felten & Guilleaume Lahmeyerwerke Act.-Ges. Indicators operated by alternating current. (Date applied for, 11/7/08.)*†
8,194 Grondal Kjellin Co., & Harden. Electric induction furnaces.*
8,195 Nya Ackumulator-Aktiebolaget Jungner & Estelle. Positive electrodes for primary or secondary electrical elements with alkaline electrolyte.*

SPECIFICATIONS PUBLISHED.

1908 Specifications.

177 Hindle. Controlling electric motors.
4,799 Crompton & Co. & Crompton. Controllers for electric motors.
6,972 Fennell & Perry. Electric wiring.
7,593 Byng & Gunner. Watertight holders for incandescent electric lamps.
7,621 Ateliers Thomson-Houston (Anciens Etablissements Postel-Vinay). Alternating-current electric motors of the compensated repulsion type. (Date applied for, 6/4/07.)
7,646 Fennell & Perry. Electric meters.
7,721 Brush Electrical Engineering Co., Chilton & Newton. Turbines.
7,800 Carver. Electric reciprocating tools.
7,886 Nalder Bros. & Thompson, Handcock & Dykes. Electric meter systems.
7,941 Turner. Electric braking.
7,943 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
8,277 Scheller. Production of high-frequency electrical oscillations. (Date applied for, 13/8/07.)
8,298 Langworthy. Choking-coils for use with arc lamps.
9,033 Fynn. Commutating dynamo-electric machines.
9,360 Millard. Trolley head for electric tramcars.
12,689 Charles. Construction of tumbler switch.
13,502 Knowles. Electric furnaces.
13,766 Harrison. Combination electric switches and fuses.
14,328 Angle. Electric railways on the conduit system.
14,518 Rhodes Motors, Ltd. & Fielden. Control of induction motors. (Addition to No. 18,956/07.)
14,868 B.T.-H. Co. (G.E. Co., U.S.) Signal systems for railways and the like.
15,753 Railless Electric Traction Co. (Schiemann.) Current collectors or contact arms for electric traction.
17,350 Siemens & Halske Akt.-Ges. Process for increasing the ductility of tungsten. (Date applied for, 14/9/07.)
20,969 Lang. Control of electric motors.
21,576 Aron. Electricity meters.
27,906 Justice. (American Automatic Switch Co.) Operating electric railway track points and switches.

COMPANIES' MEETINGS AND REPORTS.

Marconi's Wireless Telegraph Co. (Ltd.)

The directors' report to Dec. 31, 1908, states that of the increased capital (250,000 7 per cent. preference shares of £1 each) created at the last meeting, 125,080 preference shares have been subscribed for. Although this amount was short of the sum necessary to carry out the entire programme outlined in the prospectus, it was sufficient to meet the company's current engagements, and to provide for the expenditure required to complete the trans-Atlantic stations at Clifden and Glace Bay, and in addition allowed the carrying out of a scheme of re-organisation of the works, which have now been placed on a thoroughly profitable working basis. The close attention of the directors has been given to the completion of the trans-Atlantic stations at Clifden (Ireland) and Glace Bay (Canada), which has occupied a large portion of Mr. Marconi's time, and although there have been serious delays in the delivery of important sections of the electrical plant, the directors are able to state that the Clifden station is actually complete and fully able to carry out the transmission and reception of trans-Atlantic messages to the extent stated in the prospectus issued on May 29, 1908. The machinery required for the completion and duplication of the station at Glace Bay is also ready, and nearly all delivered and erected, but it will be necessary for Mr. Marconi to visit Glace Bay before the company can undertake the extension of the trans-Atlantic service, which may be anticipated so soon as the Post Office gives effect to the agreement relative to the acceptance and delivery of Marconi trans-Atlantic messages at all the Government telegraph offices throughout the United Kingdom, which will be probably about the end of August.

The accounts now issued cover a period of 15 months, as the directors thought it advisable to make the annual report and accounts synchronise with the calendar year. The directors regret that at present they are not able to declare a dividend. They feel, however, that the prospects and

position of the company are now highly satisfactory and promising, and they confidently anticipate that the dividend-paying period will speedily be entered upon. Remunerative business is extending in every direction. Economies have been effected wherever such have been found possible. Expenses have been cut down in all directions and the field of profitable operation is steadily and persistently extending throughout the world. The directors feel that the difficulties always attending the development of so great and novel an enterprise as this are at last yielding to the results of knowledge and experience, and profitable returns are now well within sight.

The following particulars are given of the various ramifications of the parent company :—

International Company.—The fears which they at one time entertained that the ratification of the Berlin Convention would be detrimental to the maritime business of the associated Marconi Companies have so far not been realised, and indeed a considerable addition has been made to the number of ships fitted and working the Marconi system (a list of which is given in an Appendix to the report now issued). The maritime business of the International Company continues to expand in a most satisfactory manner. Marconi apparatus is already installed on 185 mercantile ships for the purpose of a public telegraph service, and 38 ships are being equipped on many of the principal lines.

Canada.—Relations with the Canadian Government continue to be most satisfactory, and orders for the equipment of new Marconi stations at Montreal and Three Rivers are in course of execution by the Canadian Company. The duplication and enlargement of the trans-Atlantic station at Glace Bay will, it is expected, enable a speedy and thoroughly efficient direct wireless service between Europe and America to be provided in August.

United States.—The long-distance station at Cape Cod, which is at present employed in supplying a daily news service to ships fitted with Marconi long-distance receiving apparatus will, as soon as possible, be brought up to the same degree of efficiency as at the station at Clifden. With the completion of this station and the trans-Atlantic station at Poldhu, Cornwall, there will be two pairs of high-power stations available for trans-Atlantic service. Negotiations are proceeding for the establishment in New York City of a station to receive and distribute messages from Glace Bay and Cape Cod.

Argentina and Uruguay.—Mr. Marconi will visit Buenos Ayres in the autumn to arrange for the erection of a high-power station in the Argentine Republic, primarily to communicate with the high-power station in course of erection at Coltano in Italy. The operations of the Argentine Marconi Company are being steadily extended. Apparatus has been purchased by the Argentine Government for navy purposes and Marconi stations have been opened at Bernal and San Martin and at Punta del Este in the Republic of Uruguay.

France.—The Cie. Française Maritime et Coloniale de Telegraphie sans Fil is making satisfactory progress, and an arrangement is in prospect with the French Government for the erection of long-distance stations and for other developments of the greatest importance to France and her colonies and to this company.

Brazil.—The company has secured the contract, on satisfactory terms, for the equipment with the Marconi system of 10 torpedo boat destroyers two battleships and two scouts which are being built in this country to the order of the Brazilian Government. The work is now proceeding, four of the destroyers having already been completed and payment received in respect of them. The company has also secured the contract from the Hydrographical Department of Brazil for the equipment of the lighthouses at Ilha Raza, Ponta Negra and Guaratiba, and for the erection of a station at Rio de Janeiro to communicate with them. The apparatus for these stations has been delivered in Brazil, and the work of erection is proceeding, and is expected to be completed very shortly. Part payment has already been received under this contract. The Brazilian Madeira-Mamore Railway is intended to connect Porto Velho at the head of the navigable waters of the Madeira River with Guajara-Mirim, above which it is reckoned that there are some 4,000 miles of navigable rivers flowing through countries rich in the best quality of india rubber. Neither of these places being in telegraphic communication with the outside world, the Madeira-Mamore Railway obtained a concession for the erection and operation of wireless stations at Porto Velho and Manaos, the latter place being a cable station on the Amazon Telegraph Co.'s system. The contract for these stations has been awarded to the company, the price for the work, which it is expected will be completed in December next, being £35,800.

Belgium.—The Cie. de Telegraphie sans Fil of Brussels has considerably increased the number of ships carrying the Marconi system, and continues to conduct a remunerative business.

Bulgaria.—The Bulgarian Government has awarded to the company the contract for supply and erection of a station at Varna with a 300 mile working range for ship-to-shore communication.

Italy.—The whole of the Italian Navy has been fitted with the Marconi apparatus and the system is also in daily use on 37 ships of the Italian Mercantile Marine ; 18 land stations are likewise available for communication with ships fitted with Marconi apparatus. The completion of the long-distance station at Coltano was for some time delayed, as it was felt desirable to take advantage of the experience gained in the completion of the Irish-Canadian stations, but the work has now been resumed, and the station should this year be available for communication with England and America. A long-distance Marconi station is in course of erection in Italian Somaliland, which will presently form an important link between Europe and the Far East.

Patents, &c.—Over 600 patents are now owned by the Marconi Companies. Several of the patents recently taken out cover important improvements, thus further improving the patent position of the company. The directors determined that it was desirable to close their Dalston (London) factory and return to their former factory at Chelmsford. The necessary machinery and stores were transferred to Chelmsford in August last, and since the removal the works have been fully occupied with the execution of orders from the British Admiralty, foreign Governments and the associated companies for wireless telegraph apparatus and accessories. The value of the orders in hand amounts to over £87,000.

The directors again call attention to the utility of wireless telegraphy in the case of ships in distress, which was strikingly demonstrated in the accidents which resulted in the loss of the White Star liner "Republic" on January 23 and of the "Slavonia" on June 10, both this year. The directors state that these accidents illustrate the excellent working of the Marconi ship-to-ship and ship-to-shore telegraph organisation. The list (forming the Appendix) of large vessels of the principal lines of steamships which are fitted with Marconi apparatus number over 200 of all nationalities, and include two cable-repairing steamers, the "Mackay-Bennett" (Commercial Cable Co.) and the "Colonia" (Telegraph Construction & Maintenance Co.).

BIRMINGHAM & MIDLAND TRAMWAYS (LTD.)—At the meeting on Tuesday Mr. J. A. Lycett, managing director, said that in their lighting section there was a net increase to transfer to profit and loss account of £2,600—a result upon which they might fairly congratulate themselves. In the traction section the account showed that traffics had increased £960, but expenses, owing to the additional service and increases in rates, &c., had increased by £2,713. The net result was that about £400 less was transferred to profit and loss. Investments had increased by nearly £7,000, due to the dividends received for the first time from the Shropshire Power Co. Capital account during the past year showed £1,054 increase on the tramway side and £11,002 for lighting, and the accounts showed that the expenditure had been more than justified. During the current year developments in the lighting business would demand further capital expenditure.

BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—The total revenue for 1908 from all sources was £177,855. 11s. 9d., an increase of £49,935. 10s. compared with 1907. The total expenditure was £110,788. 15s. 6d., an increase of £23,749. 3s. 10d. The net receipts were £67,066. 16s. 3d., compared with £40,880. 10s. 1d. Deducting proportion of interest (£24,592. 13s. 7d.) chargeable to revenue, there remained £42.474. 2s. 8d., to which is added £2,889. 0s. 11d. brought forward, making £45,363. 3s. 7d. After deducting preference dividend (£35,977. 14s. 6d.), the balance is £9,385. 9s. 1d., which the directors recommend be carried forward. The entire system is now working by electric traction, and represents 20·38 miles of route, compared with 18·27 miles the previous year. Traffic receipts from working the horse and electric traction systems amounted to £126,698. 5s. 2d., compared with £105,503. 3s. 7d. Working expenses in Bombay were £67,966.14s.4d. compared with £64,536. 13s. 5d. The balance of receipts over expenses was £59,919. 14s. 11d., compared with £41,421. 6s. 9d.

From the electric supply department the gross receipts were £47,714. 2s. 10d. compared with £21,566. 3s. 1d. for the previous year, including £25,683. 3s. 7d. for current to the tramways, compared with £17,706. 17s. 11d. Working expenses were £39,737. 3s. 9d., against £19,544. 16s. 9d., and the balance was £7,976. 19s. 1d., against £2,021. 6s. 4d. There are 803 consumers (against 588), and the total equivalent 8 c.p. lamps connected is 124,856, against 84,648. The removal of the generating station will result in an important reduction in generating costs, and future developments of the power house, for which there is abundant space, can be provided far more economically than would have been possible at Wari Bunder.

The company have entered into a contract with the Brush Co. for the erection of a new generating station and have placed an order with that firm for the supply of 4,000 kw. of additional steam plant. Capital expenditure during the year in connection with the tramways, lighting, power and other expenses amounted to £232,482. 6s. 11d. The total capital expenditure to Dec. 31 last stands at £1,749,979. 14s.

INDIAN ELECTRIC SUPPLY & TRACTION CO. (LTD.)—The report for 1908 states that the year's working in Cawnpore resulted in a loss of £9, and after adding interest on construction debentures (£7,500), London expenditure (£2,127) and interest on loans (£912) the total deficiency was £10,549. With £6,681 brought forward, the total deficit is £17,231. Mr. Scott Moncrieff, who was for some years chief engineer of the Calcutta Electric Supply Corpn., and also has a personal knowledge of Cawnpore, has consented to join the board.

SOUTH METROPOLITAN ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.—The capital expended during 1908 amounted to £5,104. 7s. 4d., bringing the total to £490,407. 12s. 9d. The year's revenue was £52,240. 3s. 2d., and after deducting expenses, amounting to £44,462. 17s. 2d., the surplus is £7,777. 6s., added to £430. 10s. brought forward, total £8,207. 16s. Preference dividend for the half-year ended June 30 last absorbed £4,903. 19s. 5d., and the directors now recommend that £3,000 be placed to depreciation and reserve fund, leaving £303. 16s. 7d. to be carried forward. The directors regret the profits do not admit of the payment of the full preference dividend. The traffic receipts derived from the working of the tramways and light railways amounted to £41,884. 4s. 1d., an increase of £470. 15s. 1d. over the amount for 1907. The Board of Trade have approved the transfer to the company of the undertakings authorised under the Croydon and District Electric Tramways Acts, 1902 and 1903, and the Mitcham Light Railway Order, 1901.

The gross receipts from the electric supply section of the undertaking

(including energy supplied to the tramways) was £9,271. 7s. 1d., compared with £7,371. 17s. 7d. The introduction of metallic filament lamps has affected the sale of current, but even so the receipts show an increase of £969. 12s. 6d. The installations connected to the mains at the end of the year represent the equivalent of 48,397 30 watt lamps, an increase of 10 per cent., and the number of consumers connected was 809, compared with 603. Since the close of the year the Southern Hospital (Carshalton), with an installation equivalent to 4,503 30 watt lamps, has been connected, making the total to date 53,996 30 watt equivalent lamps.

SYLVERLYTE ELECTRIC LAMP CO. (LTD.) At an extraordinary meeting on Monday it was resolved to sell the undertaking to a new company to be called Sylverlyte (1909), Ltd., with a nominal capital of £20,000 in £1 shares. It was stated that the company started in April, 1908, with only £1,500 working capital, and additional capital was wanted for extensions.

WESTERN UNION TELEGRAPH CO.—The report for the June quarter states that the surplus, Jan. 1, 1909, was \$16,077,905 00, the net revenues in March quarter were \$1,684,893 50, and after appropriating for dividend of ¾ per cent (paid April 15 \$747,198 75, and for interest on bonded debt \$433,062 50, there was a surplus at March 31 of \$16,582,537 25 The net revenues of the quarter ending June 30, based upon nearly completed returns for April, partial returns for May, and estimating the business for June will be about \$1,700,000 00, and deducting interest on bonded debt \$433,062 50, leaves estimated net earnings for the quarter \$1,266,937 50. It requires for a dividend of ¾ per cent. about \$747,400 00, deducting which, leaves a surplus of \$17,102,074 75. The committee recommend the board to declare a dividend of ¾ per cent., payable on and after July 15.

J. G. WHITE & CO. (LTD.)—The directors' report for the year to Feb. 28 states that the results of the business have again been satisfactory, with a net profit on the year's trading of £39,977. 8s. 10d., an increase on the preceding period. As usual, profit has only been taken on work actually completed at date of balance-sheet. The depression of trade in the last two years has reduced the amount of construction business obtainable, but the company is carrying out important works in Brazil, Argentina and other points abroad. Negotiations now in progress should lead to additional business within the next few months. The directors feel that, in view of the generally adverse business conditions, the results shown are satisfactory, and they believe that the prospects for the current and future years are encouraging. The return of interest and dividends on investments during the year was equal to 5·9 per cent. on the amount of valuation. The balance to credit of profit and loss, after bringing in £16,249. 2s. 10d. from previous account, deducting interim preference dividend and making provision for percentages due to directors and staff, is £46,960. 6s. It is recommended that there be paid the balance preference dividend (tax free) (£4,500); a dividend (tax free) of 6 per cent. on the ordinary shares for the year to Feb. 28 (£3,000); an additional 2 per cent. on the preferred and ordinary shares (making 8 per cent. for the year on all shares) (£4,000), placing £20,000 to reserve (making the total £100,000), leaving £15,460. 6s. to be carried forward.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

BEAM CO. (BRITISH ELECTRICAL & MECHANICAL CO.) (LTD.) (103,386.) Reg. June 8, capital £1,000 in £1 shares, to take over the business of an electrical, telegraph and general engineer and contractor, carried on by Mr. A. Lawes as the Beam Co. Private company. First directors are A. Lawes and W. J. G. FitzGibbon. Reg. office, 35, Devonshire-chambers, London, E.C.

BRITISH VITRITE WORKS (SWAN'S PATENTS) (LTD.) (103,549.)—Reg. June 17, capital of £30,000 in £1 shares, to adopt an agreement with Swan's Patent (Ltd.) and to carry on the business of manufacturers of and dealers in nitrite and other caps or bases for incandescent electric lamps, electric lamps and fittings, apparatus and accessories, &c. First directors, B. M. Drake and W. A. Turquand. Swan's Patents (Ltd.) have the right to nominate two directors. Reg. office, Broad-street House, New Broad-street, London, E.C.

CHARLESTOWN ELECTRIC LIGHT & POWER CO. (LTD.) (3,440.)—Reg. in Dublin, June 16, capital £1,500 in £1 shares, with objects as indicated by the title. Private company. The Rev. M. Keveney is sole director until the election by shareholders. Reg. office, Charlestown, Co. Mayo.

FAIRBANKS, MORSE & CO. (LTD.) (103,493.)—Reg. June 14, capital £5,000 in £1 shares, to carry on the business of selling agents and salesmen of oil engines, motors, steam pumps, pumping, electrical and other plant and machinery, &c. Private company.

MAXWELL'S (DUNDEE) (LTD.) (7,161.)—Reg. in Edinburgh June 14, capital £25,000 in £1 shares, to purchase the property, electrical plant and goodwill of the business of Maxwell, Son & Co., electrical and mechanical engineers, &c., of Dundee. Private company. First directors, D. Maxwell, J. Lockhart and J. Forrester. Reg. office, 26, St. Andrew-street, Dundee.

POWER TRANSMISSION SYND. (LTD.) (103,581).—Reg. June 18, capital £40,000 in 39,500 cumulative preferred participating ordinary shares of £1 each and 10,000 deferred shares of 1s. each, to adopt an agreement with E. Hess-Remanda, and to carry on the business of electricians, generators, accumulators, distributors and suppliers of electricity, engineers, proprietors of tramways and railways, omnibuses, &c. First directors, W. Scott-Scott and E. Hess-Remanda.

STATUTORY RETURNS.

BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to April 1 is £500,000 in 25,000 ordinary, 7,500 4½ per cent. cumulative preference and 17,500 6 per cent. second preference shares of £10 each, of which 15,000 ordinary, 7,500 4½ per cent. preference and 15,000 6 per cent. second preference have been taken up. £375,000 has been received. Mortgages and charges, £187,500.

MATHER & PLATT (LTD.)—Return to March 10 (filed March 30) gives capital as £1,000,000 in 50,000 preference and 50,000 ordinary shares of £10 each, of which 40,000 preference and 40,000 ordinary shares have been taken up. £10 per share has been called up on 29,200 preference and 2,500 ordinary, and £317,000 has been received. £483,000 is considered as paid on 10,800 preference and 37,500 ordinary. Mortgages and charges, nil.

SOUTHERN ELECTRIC FREE WIRING CO. (LTD.)—Return to May 3, 1909, gives capital as £5,000 in £1 shares, of which 1,510 have been taken up. £1,510 has been received. Mortgages and charges, nil.

WOKING ELECTRIC SUPPLY CO. (LTD.)—In return to April 17 capital is £100,000 in 50,000 preference and 50,000 ordinary shares of £1 each, of which 34,098 preference and 20,552 ordinary have been taken up. £54,650 has been received. Mortgages and charges, £46,175.

MORTGAGES AND CHARGES.

NEW IGNITION SYND. (LTD.) Issue on June 3 of £500 debentures, part of series created Nov. 12, 1908, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £3,500.

ELECTRIC LANDAULET CO. (LTD.)—First mortgage debenture, dated June 2, 1909, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. Holders, London Joint Stock Bank.

JOHNSON & PHILLIPS (LTD.)—Particulars of £50,000 debentures created June 10, 1909, filed pursuant to sec. 93 (3) of the Companies (Consolidation) Act, 1908, amount of the present issue being £37,000. Property charged, Company's undertaking and property, present and future, including uncalled capital. No trustees.

LIMITED PARTNERSHIP.

F. BURKS & CO. (199).—Reg. June 10; manufacturers of electrical machines, apparatus and devices (37, Port-street, Manchester); partnership commencing June 6, 1909, terminable at six months' notice after May 31, 1914, or earlier under certain conditions. General partners: F. Burks, 37, Portland-street, Manchester, and F. C. Poulton, 78, Belgrave-road, New Moston, Manchester. Limited partner: V. Bramall, Shade House, Pendlebury, near Manchester, contributing £125 in cash.

CITY NOTES.

MEMORANDA (June 24).—Bank rate 2½ per cent. (since April 1, 1909). Price of silver, 24⅛d. per oz. Consols $84\frac{3}{16}$—$84\frac{5}{16}$ for money and 84¼—84⅜ for account. Consols Pay Day, July 1; Stock and Shares Continuation Day, July 12; Ticket Day, July 13; Pay Days, June 25 and July 14; Mining Shares Carry Over Day, June 22.

PRICES OF METALS (London).—*Copper*, cash, 58⅝; three months 59½. *Lead*, English, 13⅜; foreign, cash, $13\frac{1}{16}$; three months, $13\frac{5}{16}$. *Spelter*, cash, 21¾—21⅞; three months, 22⅛. *Tin*, English, 132—134; foreign, cash, 133; three months, 133⅝—134½. *Iron*, Cleveland, cash, 48/3 and three months, 48/11. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the four weeks ended May 28, 1909, were 693,479, compared with 552,698 units in the corresponding four weeks of 1908.

EASTERN TELEGRAPH CO. (LTD.)—This company announce the payment on July 15 of a dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending June 30, and a first quarterly interim dividend of 1¼ per cent. on the ordinary stock (tax free) in respect of profits for the year ending Dec. 31, 1909. The transfer books of the ordinary stock will be closed from July 7 to 14 inclusive.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The directors have declared an interim dividend for the quarter ended March 31 last of 2s 6d. per share (tax free), payable 15th prox. The share register will be closed from July 7 to 14 inclusive.

GREAT NORTHERN TELEGRAPH CO. (LTD.)—The directors have declared a dividend of 5 per cent (less tax) for the past half year.

NATIONAL ELECTRIC SUPPLY CO (LTD.)—An interim dividend of 3s. per share (less tax) has been declared on the ordinary shares for the past half year.

PROVINCIAL TRAMWAYS CO.—The directors have resolved to pay an interim dividend of 3s. per share (less tax) for the year ending Sept. 30.

VICKERS, SONS & MAXIM (LTD.)—Col. T. E. Vickers, C.B., has resigned the chairmanship and managing directorship of the company, and the board have elected Mr. Albert Vickers (who has been a managing director) as chairman, and Lieut. A. Trevor Dawson as managing director.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.		Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
			£	£		£	£
Aberdeen Corporation	June	16	1,418	+ 1	2	3,365	− 28
Airdrie	,,	11	222	− 4	23	4,979	− 90
Anglo-Argentine	,,	17	39,146	+ 5,089	24	914,650	+ 54,198
Ayr Corporation	,,	19	337	− 38	5	1,459	− 96
Baker St. & Waterloo Ry.	,,	19	3,325	+ 3 5	24	80,215	+ 7,030
Barnsley	,,	11	148	− 79	23	3,838	− 138
Barrow	,,	11	246	− 73	23	4,912	− 325
Bath Electric Trams, Ltd.	,,	16	761	+ 14	21	15,732	+ 587
Birmingham Corporation	,,	19	6 200	+ 62	12	75,405	+ 254
Birmingham & Mid.	,,	4	1,213	+ 370	22	18,035	+ 497
Blackburn Corporation	,,	16	1,140	+ 107	12	13,860	− 124
Blackpool and Fleetwood	,,	19	631	− 200	...	...	...
Bolton Corporation	,,	20	2,262	− 216	12	27,943	− 343
Bombay	May	20	R37,762	+ R1,929	20	R769,900	+ R50,463
Bournemouth Corporation	June	16	1,178	− 61	11	13,549	+ 231
Bradford Corporation	...		...	...	...	...	...
Brighton Corporation	,,	20	933	+ 23	12	10,849	+ 718
Bristol Trams & Carriage	,,	18	5,403	+ 621	4	23,423	+ 1,326
Burnley Corporation	,,	19	1,220	+ 70	12	15,438	+ 398
Burton Corporation	,,	20	218	− 9	12	3,068	− 72
Bury Corporation	,,	20	1,136	− 213	†12	14,428	− 302
Calcutta Tramways Co.	,,	19	R49,226	+ R11,680	24	R1,189,310	+ R100,252
Camborne-Redruth	,,	19	133	− 10	25	3,012	− 60
Cardiff Corporation	...		...	...	...	...	...
Cavehill	,,	11	110	+ 2	23	1,698	− 175
Central London Railway	,,	19	5,749	− 1,342	24	133,252	− 15,312
Charing C., Euston & H'stead	,,	19	3,920	+ 630	24	93,260	+ 15,420
Chatham & Dist. Lt. Rys.	,,	17	803	...	24	18,335	+ 1,226
City & South London Rly.	,,	20	3,134	+ 36	24	78,040	+ 1,160
City of Birmingham	,,	11	2,560	− 723	23	62,719	− 840
Colchester Corporation	,,	16	193	− 103	...	...	...
Cork Electric Trams Co.	,,	17	514	+ 25	24	9,452	+ 926
Croydon Corporation	...		...	...	...	...	...
Devonport & Dist. Trams	,,	11	351	− 200	23	8,465	− 1,637
Dover Corporation	,,	19	198	− 13	12	2,304	− 139
Dublin & Lucan Railway	,,	18	161	+ 25	24	3,021	+ 262
Dublin United	,,	13	5,581	+ 164	23	122,852	+ 847
Dudley-Stourbridge	,,	11	764	− 715	23	17,744	− 395
Dundee Corporation	,,	16	1,190	− 6	†5	5,459	− 238
East Ham Council	,,	19	1,019	+ 142	§11	11,763	+ 1,869
Exeter Corporation	,,	18	326	+ 13	12	4,186	+ 593
Gateshead & Dist. Trams	,,	11	962	− 138	23	22,626	− 48
Glasgow Corporation	,,	19	17,990	− 92	‡13	40,398	+ 1,844
Glossop Trams	,,	5	130	− 7	23	2,714	− 100
Gravesend—Northfleet	,,	11	199	− 98	23	4,411	− 151
Great Northern & City Rly.	,,	19	1,331	− 151	24	35,993	− 4,336
Gt. Northern, Piccadilly, &c.	,,	19	5,855	+ 415	24	139,030	+ 9,100
Greenock & Port Glasgow	,,	11	613	+ 65	23	11,531	+ 124
Hartlepool Tramways	,,	11	238	− 97	23	4,903	− 127
Hastings Elec. Trams Co.	,,	17	977	− 36	24	20,651	− 528
Hong Kong	,,	19	$8,450	+ 1,803	...	...	...
Huddersfield Corpn.	,,	19	1,630	+ 50	11	19,391	+ 569
Hull Corporation	,,	19	2,303	− 74	11	28,345	+ 39
Ilford District Council	...		...	...	...	...	...
Ilkeston District Council	,,	13	125	+ 1	11	1,451	− 140
Ipswich Corporation	,,	19	392	− 4	12	4,410	+ 22
Isle of Thanet Co.	,,	19	655	− 42	§23	12,103	+ 285
Jarrow	,,	11	114	− 16	23	2,544	− 253
Keighley Corporation	,,	17	171	+ 22	11	1,919	+ 64
Kidderminster & District	,,	11	82	− 173	23	2,183	− 116
Kilmarnock Corporation	,,	19	150	− 1	5	747	− 55
Lanarkshire Trams Co.	,,	17	1,275	− 7	24	29,0.1	− 1,756
Lancashire United	,,	16	1 319	− 139	24	30,379	− 146
Leamington	,,	11	148	− 172	23	3,584	+ 132
Leeds Corporation	...		...	...	...	...	...
Leicester Corporation	,,	19	2,151	+ 21	...	...	...
Leith Corporation	,,	12	605	+ 83	4	2,520	+ 264
Lincoln Corporation	,,	19	112	+ 2	12	1,493	+ 71
Liverpool Corporation	,,	12	10,441	− 1,231	‖23	244,496	− 2,689
Liverpool Overhead Rly.	,,	20	1,420	− 4	25	32,868	− 2,263
Llandudno & Colwyn Bay Ry	,,	18	309	− 29	23	4,856	+ 1,611
*London County Council	,,	5	39,666	+ 2,958	§3	341,965	+ 24,078
London United	,,	19	6,859	− 514	‖27	138,217	− 11,420
Lowestoft	...		...	...	...	...	...
Maidstone Corporation	,,	19	188	− 4	11	2,118	− 153
Manchester Corporation	,,	19	14,956	− 235	12	174,332	− 62
Mersey Railway	,,	19	1,899	− 99	24	47,354	+ 1,341
Merthyr	,,	11	225	− 75	23	4,8.0	+ 4
Metropolitan Dist. Railway	,,	19	10,951	+ 1,553	24	237,204	+ 22,758
Metropolitan Elec. Trams	,,	11	5,795	− 2,382	23	134,073	+ 12,180
Middleton	,,	11	452	− 80	23	7,493	− 337
Nelson Corporation	,,	19	135	− 2	†12	1,632	− 57
Newcastle-on-Tyne Corp.	,,	19	3,703	+ 2	11	41,5.4	+ 499
Newport (Mon.)	,,	19	639	+ 5	12	7,944	− 145
Northampton Corporation	,,	18	475	+ 26	§12	5,553	+ 156
Oldham, Ashton & Hyde	,,	11	592	− 109	23	12,652	− 852
Oldham Corporation	,,	20	1,735	− 384	12	24,003	− 1,426
Perth (N.B.) Corporation	,,	16	117	+ 1	4	710	− 15
Perth (W.A.) Elec. Trams	,,	18	1,335	+ 127	24	34,747	+ 155
Peterborough	,,	11	103	− 90	23	2,162	− 191
Portsmouth Corporation	...		...	...	..	...	...
Potteries	,,	11	1 649	− 416	23	40,187	− 1,268
Preston Corporation	,,	16	703	− 13	11	8,021	+ 13
Rotherham Corporation	,,	17	558	− 24	11	6,833	− 216
Rothesay	,,	11	255	+ 9	23	2,2.5	− 36
Salford Corporation	,,	21	4,410	− 236	‡12	54,561	− 1,435
Sheerness	,,	11	54	− 19	23	1,057	− 137
Sheffield Corporation	,,	20	5,511	− 47	§12	70,146	− 1,218
Singapore Trams	,,	19	$9,207	+ $453	24	$329,785	+ $2,713
South Metropolitan	,,	11	740	− 517	23	17,055	− 47
South Staffs	,,	11	747	− 547	23	18,977	− 1,200
Southend Corporation	,,	16	464	+ 33	11	6,101	+ 818
Southport Tramways	,,	11	317	− 216	23	5,922	− 92
Stalyb'dge, Hyde, &c., Jt. Bd.	,,	19	755	− 36	§11	9,012	− 197
Sunderland Corporation	,,	20	1,125	− 34	12	13,243	− 398
Sunderland District	,,	16	432	− 10	33	14,747	− 476
Swansea Trams	,,	11	883	− 400	23	20,963	+ 491
Swindon Corporation	...		...	...	...	...	...
Taunton	,,	11	35	− 18	23	824	− 75
Tynemouth and District	,,	11	252	− 168	23	3,835	− 5
Tyneside Trams Co.	,,	16	430	+ 48	24	9,804	+ 767
Wallasey District Council	,,	19	935	− 14	§11	10,761	+ 411
Walsall Corpn.	,,	19	492	...	24	12,109	− 976
Warrington Corpn.	,,	17	357	− 45	11	4,139	− 135
West Ham Corporation	,,	10	2,140	− 616	10	24,315	+ 1,634
Weston-super-Mare	,,	11	147	− 238	23	1,681	+ 204
Wolverhampton Co.	,,	11	362	− 436	23	9,400	− 1,069
Wolverhampton Corpn.	,,	16	743	− 591	24	17,587	− 1,764
Worcester	,,	11	270	− 162	23	5,874	− 61
Wrexham	,,	11	89	− 52	23	2,165	− 95
Yorkshire W.R. Trams	,,	20	1,114	− 91	25	28,940	...
Yorkshire Woollen District	,,	11	821	− 358	23	20,135	− 561

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shrs	Last Dividend	Name.	Price Wed. June 23	Rate % Yield-ed. £ s d.	Dividend Due.	Business Week to June 23. Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½ −10	6 0 0	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞ −10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼ −10¾	5 11 6	Feb, Aug	.	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 −105	4 5 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½ −4½	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8½ −9	5 11 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	8 −8½	4 2 0	Mar, Sept	..	—
St.	4%	Cent. l Elec. Sup. Co. 4% Guar. Db. Stock	97 −100	4 0 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾ −4¼	5 11 0	Feb, Aug		..
5	2/3	Do. 4½ per Cent. Pref.	4½ −4⅞	4 12 0	Feb, Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	96 −99	4 1 0	Jan, July	..	—
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 102	4 5 0	..	101½	100½
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ −4¼	5 5 6	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3⅞ −4½	4 0 3	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	102 −105	4 7 6	June, Dec	.	—
10	7/0	City of London Electric Lighting Ord.	10¾ −11	5 10 0	Feb, Aug	10⅞	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾ −12½	4 13 0	Jan, July	12	12¼
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	101 −104	4 6 6	Jan, July	102½	102¼
5	..	County of Durham Elec. P.D. Ord.	1¼ −2¼	—	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3¼ −3¾	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅜ −8⅝	5 15 6	Feb, Aug		..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞ −11⅛	5 8 0	Mar, Sept	10	10
St.	4½%	Do. 4½% Deb. Stock (red.)	106 −109	4 2 9	Jan, July	107¼	..
St.	4½%	Do. Second Deb. Stock	100 −103	4 7 6	May, Nov	102¼	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ −5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 −5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	98 −101	4 9 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7½ −7⅞	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord.	6⅝ −7⅛	5 2 0	Feb, Aug	..	—
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ −6⅜	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 −100	4 0 0	..	—	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85 −89	5 1 0	Jan, July	..	..
8	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛ −5¼	5 11 6	Mar, Sept	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Deb.	90 −94	4 5 0	Jan, July	—	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅞ −4¾	5 13 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾ −5⅛	4 7 6	Jan, July	4	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	107 −110	4 2 0	June, Dec	—	—
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	85 −88	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 −98	4 12 0	June, Dec	..	—
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4¾ −5	4 2 1	Feb, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	84 −86	5 5 11	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅝ −4¾	2 13 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞ −5⅛	5 0 0	Feb, Aug	—	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 −101	4 0 0	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 19 0	..	99⅜	99½
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	91 −93	4 17 10	Jan, July	—	..
10	8/0	Notting Hill Electric Ord.	11⅓ −12½	5 12 0	March ..	—	..
5	4 6	Oxford Electric Ord.	6 −6½	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 −97	4 2 6	Jan, July	..	—
5	5/0	St. James' & Pall Mall Elec. Ord.	8¾ −9¼	5 8 0	Feb, Aug	9	8⅞
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 6	Feb, Aug	7½	7⅜
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	88 −90	3 18 0	Jan, July	..	—
5	..	Smithfield Markets Electric Sup. Ord.	[illegible]	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¼ −3⅛	6 8 0	April	—	..
St.	..	Do. 5% 1st Mort. Stk. Red.	102 −104	..	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	—	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.	1⅛ −1⅜	5 7 0	Feb, Aug	.	
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −103	4 7 6	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	⅝ −1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1⅞ −2⅜	11 15 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 −84	5 7 3	April, Oct	81	81⅛
5	5/0	Westminster Elec. Sup. Ord.	8⅞ −9⅜	5 7 0	Mar, Sept	8⅝	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛ −5½	4 11 0	Jan, July	5⅜	..
		ELECTRIC RAILWAYS & TRAMWAYS					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	93 −100	4 0 0	Jan, July	99¼	..
1	..	Bath Elec. Trams Pref. Ord.	¼ −⅜	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝ −¾	6 13 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 −91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	89 −93	4 18 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	7¾ −8¼	7 9 8	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ −8¾	4 11 6	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100 −101	3 19 2	Feb, Aug	..	—
10	..	British Electric Traction Ord.	[illegible]	—	June, Dec	⅝	..
10	3/0	Do. 6 per Cent. Cum. Pref.	2⅞ −3⅜	8 13 0	Feb, Aug	2½	2¼
St.	5%	Do. 5 per Cent. Perpetual Debs.	92 −95	5 5 0	April, Oct	93	92
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 −72	6 5 0	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	64 −66	4 18 0	Feb, Aug	66	65
St.	4%	Do. 4 per Cent. Pref. Stock	85 −87	5 12 0	Feb, Aug	—	..
St.	2½%	Do. Deferred Stock	49 −51	4 18 0	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	102 −104	3 16 6	Jan, July	103½	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 −94	4 5 0	Jan, July	94	93
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼ −5¼	4 15 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31 −33	4 15 6	Feb, Aug	32½	31
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 −112	4 9 0	Feb, Aug	—	..
St.	5%	Do. (1896)	105 −109	4 11 [illegible]	Feb, Aug	.	..
St.	5%	Do. (1901)	103 −105	4 15 3	Feb, Aug	104	—
St.	5%	Do. (1903)	93 −96	5 4 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 −101	3 19 0	May, Nov	.	..
10	6/0	Dublin United Trams. Ord	—	4 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.	13 −14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ −1	..	Feb, Aug	1	.
10	..	G. Northern, Picc. & Brompton 4% G. Pf	84 − [illegible]	—	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	94 −95	4 3 6	Jan, July	95¼	95
5	2/0	Hastings & District Elec. Trams. 6% C.P.	2 −2½	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	82 −87	5 3 6	April, Oct	..	—
10	6%	Imperial Tramways Ord.	4½ −5	12 0 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6¾ −7½	7 13 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	87 −89	5 1 11	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	57 −62	6 9 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	[illegible]	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 −93	5 7 6	Jan, July	92¼	.
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	[illegible] −5	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	1¼ −2¼	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	69 −71	5 1 [illegible]	Jan, July	70	69½
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	—	..
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April.. .	1	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	1	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 −101	4 9 0	Jan, July	100¼	100
St.	½%	Metropolitan Railway Consolidated	38½ −39	1 5 6	Feb, Aug	39¼	38⅞
St.	3%	Do. Surplus Lands Stocks	68 −70	4 5 6	Feb, Aug	70	69
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3 17 0	Feb, Aug	91	90⅞
St	3½%	Do. 3½ per Cent. "A" Preference	82 −84	4 8 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82 −84	4 3 6	Feb, Aug	82⅞	—
St.	3½%	Do. 3½ per Cent. Debenture Stock	93 −95	3 13 3	Jan, July	93½	93

In calculating the yield allowance has been made for accrued interest but not for redemption

* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., June 23.	Rate % Yielded £ s. d.	Dividend Due.	Business Week to June 23 High-est.	Low-est.
		ELECTRIC RAILWAYS & TRAMWAYS—Continued.					
St.	3½	Met. ... 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	94	92½
St.	..	Met. Dist. ... District Railway Ord.	17½—17¾	—	Feb, Aug	17¾	17½
St.	..	Do. Extension Pref. (5 per Cent.)	45 —49	..	Feb, Aug	41½	41¼
St.	3½	Do. Assented Ext. Pref. ... Guar. by Und. Elec. Rys. Co. of London, Ltd.	68 —70	5 0 0	Feb, Aug	69	68¾
St	3%	Do. 3 per Cent. Consolidated Rent-charge	78 —80	3 15 0	Jan, July	78½	..
St.	4%	Do. 4 per Cent. Mid and Rent-charge	103 —106	3 15 6	Jan, July	..	..
St.	1½	Do. Guar. Stock 4 per Cent	89 —92	4 7	Mar, Sept	91	89
St	6	Do. 6 per Cent. Perp. Deb. Stock	141 —143	4 3 9	Jan, July	142½	141
St	4	Do. 4 per Cent. Debs	95 —97	4 2 6	Jan, July	96	...
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—1	..	May	..	—
1	..	Potteries Electric Traction Ord.	..	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	...	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	...	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6 per Cent. Cm. Pref	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4% per Cent. Deb. Stock	72 —76	5 5 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	84 —88	5 14 0	Jan, July	..	..
..	..	Undergd. E. Rys. Lon. ... Incds. with coup.	37 —39	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds	101 —102	4 18 0	..	102	..
..	4½	Do. 4½ ... Bonds ... 3	89 —91	4 19 0	..	89½	...
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	...
5	..	Do. 6 per Cent. Cum. Pref.	2½—3	..	—	..	—
St.	4½	Do. 4½ per Cent. 1st Debs.	86 —90	5 0 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	1½ ..	..	..	..	..
1	1 4	Do. 6% Cum. Pf.	..	7 3 2	April, Oct	1½	..
1	2 4	Babcock & Wilcox Ord.	4 —4½	4 14 6	April, Oct	4½	4¼
1	0 7½	Do. Pref.	1⅝—1½	4 6 0	..	..	..
1	6 0	British Insulated & Helsby Cables Ord.	7⅝—7⅞	6 9 6	July, Feb	7⅝	...
5	3 0	Do. 6 per Cent. Pref.	6⅜—6⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 0	Jan, July	..	..
St.	4½%	British Thomson-Houston 4½% 1st Mt. Db	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	..	..	Feb, Aug	..	—
100	6%	Do. 6 per Cent. Prior Lien Dbs. 1d.	97 —99	6 1 0	..	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	40 —41	9 2 0	Jan, July	41	40½
St.	4½%	Brush E. Eng. Co. 4½ Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	29 —33	13 13 0	Jan, July	..	..
1	..	Callender's Cable Con. Ord. ... and bonus	9⅞—10⅛	7 4 0	Jan, July	10⅛	9½
5	2 6	Do. 5 per Cent. Cum. Pref.	5½—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.	106 —107	4 4 0	Nov, May	106½	..
1	1/9	Castner-Kellner Alkali Co.	1⅞—2	6 5 0	May, Nov	2	1⅞
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —106	4 4 0	Feb, Aug	..	..
..	0 7½	Chadburn's Ship Telegraph Ord.	1 —1⅛	6 4 0	March ..	..	—
..	0 7½	Do. 6 per Cent. Cum. Pref.	1½—1⅝	5 14 0	April, Oct	..	..
1	5%	Consolidated Electrical Co.	..	4 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1¼—1⅜	7 15 6	April, Oct	1¼	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	..	..
5	3/9	*Crompton & Co. Nos. 1 to 86,000)	1 —1½	11 16 0	Jan, July	1½	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.	94 —97	5 2 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
1	2/0	Dick, Kerr & Co. Ord.	1⅛—1¼	8 0 0	Sept	—	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	1 16 9	Sept	1⅛	..
St.	4½	Do. 4½ per Cent. Deb. Stock	101 —104	4 6 9	Jan, July	..	..
1	1 6	Edison & Swan United "A" Sh.) (£3 pd.	¼—⅜	..	Feb, Aug	..	..
1	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	70 —75	5 6 8	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 5 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	½—¾	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 3 0	Jan, July	..	—
2	..	Electric Construction Co.	..	..	Jan, July	½	—
2	2/9	Do. 7 per Cent. Cum. Pref.	1½—1¾	8 5 0	July	..	..
St	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59 —63	6 7 0	Jan, July	..	—
St.	5	Ferranti Ltd. 5 per Cent 1st Mt Db.St	71 —77	6 10 0	..	..	..
1	5/0	General Electric 1900 5% Cum. Pref.	7⅜—7⅞	6 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 10 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	15⅞—16⅛	6 2 6	Feb, Aug	16	15¾
5	2/3	Do. 4½ per Cent. Pref.	5 —6	4 3 6	Feb, Aug	5¼	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	101 —106	4 5 0	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Wrks.	14¼—14¾	6 19 0	Feb, Aug	15	15¼
10	..	Do. 5 per Cent. Cum. Pref.	10 —11	..	..	..	..
100	4%	Do. 4 per Cent. Debs (red.)	99 —101	3 19 0	April, Oct	..	—
1	..	National Elec. Construction Co.	⅜—½	..	April	..	—
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—¼	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	½—¾	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	85 —86	5 8 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1¼	..	—	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	33 —33½	5 4 6	Mar, July	33½	33
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1 0	Vickers, Sons & Maxim, Ltd. Ord.	2 —2¼	5 9 3	..	2⅛	2
1	0/6	Do. 5 per Cent. non-Cum. Preference	¾—1	4 0 0	..	1⅛	⅞
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. red	101 —103	3 17 6	June, Dec	102	102
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	102½—104½	4 6 0	June, Dec	104	..
100	5%	Do. 5 per Cent. 1st Mort. Debs Scrip.	105 —107	4 13 0	..	106	..
10	6	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	¼—½	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	3 —3½	9 1 0	Apr, Oct	3¼	3
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	94 —97	5 3 0	June, Dec	96	..
St.	15/0	Anglo-American	16 —18	5 13 3	F,My,Ag,N	—	..
St.	30/0	Do. Preferred	99 —100	6 0 0	F,My,Ag,N	99½	99
St.	5 0	Do. Deferred	15 —15⅝	2 11 0	F,My,Ag,N	16⅛	14⅜
St.	4%	Commercial Cable 4 per Cent. Deb. Stk	90½—92½	4 6 0	Jn,Ap,Jy,O	40½	..
10	10/0	Cuba Submarine Ord.	8¾—9¼	6 1 ..	Feb, Aug	8¾	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2 0	Direct Spanish Ord.	2⅝—3⅜	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½—9	5 9 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100½—101½	4 7 6	Jan, July	..	..
20	4/0	Direct United States Cable	12 —13¼	6 5 9	Ja,Ap,Jy,O	12⅞	12½
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.	101 —103	4 7 ..	June, Dec	..	..
St.	65/0	Eastern Ordinary	132 —135	5 1 6	Ja,My,Jy,O	133	132
St	17 6	Do. 3½ per Cent. Pref. Stock	85½—87	4 0 6	Ja,My,Jy,O	86	85¾
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 16 0	May, Nov	104	104
St	6/0	Eastern Extension	11⅛—11⅜	5 13 0	Ja,Ap,Jy,O	11⅜	11⅛
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	103½	..
25	4%	Eastern & S.Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	..	..
10	20 0	G. N. of Copenhagen ... Coupon 76	27 —28	6 5 0	Jan, July	27½	27
100	4%	Halifax & Bermudas 4% 1st Mt. Db. red.)	101 —104	4 7 6	June, Dec	..	..
25	52 6	Indo-European	61½—63½	5 1 9	May, Nov	62	61½
100	$1	†Mackay Companies Common	80 —84	4 16 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preferred	74 —79	5 1 0	Ja,Ap,Jy,O	—	..
1	..	Marconi's Wireless Teleg. Co.	⅜—⅝	..	April	..	½
1	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	100½—102½	3 17 6	June, Dec	—	..
25	1/3	West Coast of America	1⅛—1⅜	4 12 0	May	—	..
100	4%	Do. 4 per Cent. Debs.	100½—102½	3 17 6	Jan, July	..	..
10	..	West India & Panama	¾—1¼	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref	4¼—4¾	6 17 0	May, Nov	..	..
10	1 0	Do. ... 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	102½—104½	4 15 6	Jan, July	..	..
1	3/0	Western Telegraph	15½—16	5 0 0	Mr,Jn,O,D	15¾	15½
St.	4%	Do. 4 per Cent. Deb Stock (red.)	102 —104	3 16 0	June, Dec	103	..
...	4½	Western Union Telegh. $1,000 4½% Bonds	93 —96	4 6 0	..	..	..

Share	Last Dividend	Name.	Price Wed., June 23	Rate % Yielded £ s. d.	Dividend Due.	Business Week to June 23 High-est.
		TELEPHONES.				
100	2⅜	Amer. Telephn. & Telegh. Cap. St.	143½—144½	6 13 9	..	143½
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98½—100½	3 19 6	Jan, July	99½
St.	5%	Anglo Portug'se Tel. 5% 1st Mt. Db. Stk.	100½—102½	4 17 6	Mar, Sept	..
5	3 0	Chili Telephone	8 —8⅝	4 16 9	August ..	8½
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..
1	0/6	Do. 5 per Cent. Pref.	1⅛—1¼	5 7 0	May, Nov	1¼
St.	6%	National Co. Pref. Stock	107 —108½	5 10 6	Feb, Aug	107⅝
St.	6%	Do. Def. Stock	119½—120½	4 19 0	Feb, Aug	120⅝
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11	5 9 0	Feb, Aug	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —10⅜	5 11 6	Feb, Aug	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 —5½	4 8 3	Feb, Aug	5⅝
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	99¼
St	4%	Do 4 per Cent. Deb. Stock (red.)	100½—102½	3 17 6	Jan, July	102
1	1/0	Oriental	1⅛—1¼	5 7 6	April, Oct	1⅛
1	0 7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 17 6	April, Oct	.
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85 —90	4 9 0	Jan, July	82½
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk. (red.)	100½—102½	4 7 6	Jan, July	.
5	3/0	United River Plate	6⅞—7⅛	5 13 3	July	6⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	June, Dec	..
St.	4½%	Do. 4½ Deb. St. Red.	101 —105	4 5 6	Jan, July	105
		FINANCIAL INVESTMENT, &c.				
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜—3⅝	8 5 0	Jan, July	..
10	2 0	Globe Telegraph & Trust	10¾—11¼	5 2 0	Sp De Mr Ju	1 ¼
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp De Mr Ju	13
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.				
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	6⅜—6⅝	4 14 0	April, Oct	..
5	5/0	Do. 10% Non-cum. 2nd Pref.	9⅜—9⅞	5 2 6	Jan, July	9
St.	4%	Do. 4% Deb. Stock	94 — 96	4 3 6	June, Dec	91⅛
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102½—104½	4 15 6	Jan, July	..
5	3 6	Brisbane Electric Trams. Invest. Ord.	9⅜—9½	4 19 0	May	9⅜
5	2 6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	103 —107	4 4 0	Jan, July	.
St.	8%	British Columbia El. Ry. Df. Ord.	1.1 —148	5 5 0	Mar, Sept	..
St.	6%	Do. Pref. Ord. Stock	122 —125	4 16 0	May, Nov	121½
St.	5%	Do. 5% Cum. Perp. Pref. Stock	110 —113	4 8 6	Jan, July	110
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	99 —101	3 19 0	—	99⅞
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98½—100½	4 19 6	Mar, Sept	99
St.	6%	Buenos Ayres Port & City Tram. 1st Mt Deb. Stock	98 —100	6 0 0	Feb, Aug	..
5	2.0	Calcutta Tramways (1 to 137,610)	4⅜—4¾	4 14 9	Mar, Sept	4⅜
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅜	4 18 0	Jan, July	4
1	4½%	Do. 4½% 1s Deb. Stock (red.)	100 —103	4 7 0	Jan, July	..
St.	..	Cape Electric Tram Shares	⅛ —⅜	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904, Sh.	5⅝—5⅞	4 5 6	F,My,A,N	5
St.	4%	Do. 4 per Cent. Deb. Stock	100 —103	4 2 6	June, Dec	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 —96	5 4 0	Feb, Aug	..
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..
..	—	†Do. 5 per Cent. "A" Deb. Stock	87 —90	5 11 0	Jan, July	89
100	5%	†Do. 6 per Cent. "B" Ditto	63 - 67	9 0 0	Jan, July	..
5	6	Lisbon Elec. Trams. Ord.	1⅛—1¼	4 14 0	July	..
5	1/0	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Jan, July	—
100	0/7½	Do. 5 per Cent. Reg. Mort. Debs	90 -94	5 7 0	Jan, July	—
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —96	5 4 0	Jan, July	..
St.	5%	Manila Elec. Ry. $1,000 Gold Bonds	91 —95	5 4 0	Feb, Aug	95
.	5%	Mexico Trams Co. Com. St.	1.8 —132	3 11 0	..	131
100	$1½	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92½—93½	5 7 0	..	93½
..	5%	Montreal St. Ry. Sterling 4½ per Cent.				
St.	4½%	Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..
		Do. do. (Nos. 1 to 4,600)	102 —1 1	4 6 6	..	..
St.	4½%	†Perth Elec. Trams Ord.	⅜ —⅝	8 0 0	May	.
1	1/6	Do. 1st Mt. Db. Stock	105 —106	4 15 0	Jan, July	..
St.	5%	Rangoon Elec. Trams & Supply Co. 6				
5	3/0	Cum. Pf.	5½—5⅞	5 2 0	..	..
		Do. 4½% 1st Mort. Deb. Stk.	100 —103	4 8 0	..	.
St.	4½%	Rio Janeiro Tram, Lt. & P. Co.	91 —93	..	..	97
100	..	Do. 30 yr. Gold Bnds.	95½— 96½	6 2 6	..	96
..	5%	Do. 50 yr. Mt. Bnds	83 — 85	..	..	5.8
100	5%	Sao Paulo Tramway, Light & Power Co.				
—	$½	$100 Stock	148 —151	6 17 9	..	15..
		Do. 5 per Cent. 1st Mt. $500 Db.	96½—98½	5 1 0	June, Dec	95
..	5%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..
100	4½%					
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.				
5	3.0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅜—5⅝	5 11 0	Mar, Sept	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 —97	4 13 0	Jan, July	..
1	4,9	†Calcutta Elec. Supply Ord.	5½—6¼	6 8 0	April, Oct	5½
100	$1¾	Canadian Gen. Elec. Co. Com. St.	120 —123	5 14 0	..	121⅝
100	$3½	Do. 7% Cm. Pf. Stock	121 —123	5 14 0	..	121½
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97 —101	4 19 0	Jan, July	..
500	5%	Elect. Development Co of Ontario	87 — 89	5 12 0	..	88½
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	..	..	Feb, Aug	..
St.	5%	Do. 5 per Cent. Deb Stock	...	5 8 0	Jan, July	—
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	83 —91	5 10 0	Jan, July	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	..
10	4	Kalgoorlie Elec. Power & Ltg. Ord.	¼ — ½	..	..	¼
1	0/7½	Do. 6 per Cent. Cum. Pref.	¾ —⅞	6 17 0	April, Oct	¾
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	82½—84½	5 18 0	..	84½
St.	$1	Mexican Lt. & Power Co. Com. St.	63 —71	5 13 6	—	7 ½
500	5%	Do. 5% 1st Mort. Gold Bnds.	85½—87½	5 11 0	..	85½
100	$1¼	Montreal Lt. Ht. & Power Co. Cap. St.	121 —125	4 15 0	F,My,A,N	123¼
1	1/7½	River Plate Electricity Co. Ord.	1⅜ - 1½	5 6 8	April	1
1	1 2⅜	Do. 6 per Cent. non-Cum. Pref	1¼—1⅜	5 4 0	May	1
St.	5%	Do. 5 per Cent. Deb. Stock	103 —107	4 15 6	Jan, July	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅜—5⅝	5 7 6	April, Oct	...
100	$1	Shawinigan Water & Power Co. Ca	93 —95	4 5 0	—	95
..	5%	Do. 5 per Cent. Bds.	108 —108	4 12 6	Jan, July	107
St.	4½%	Do. 4½ Per. Con. Mt. Db St.	96 — 98	4 12 0	—	97½
..	6d.	Victoria Falls Power Co. Pref.	½— ¾	5 18 0	Jan, July	½

* In ... the price allowance has been made for accrued interest but *not* for redemption. Ex dividend. ‡ The London Stock Exchange Committee have declined to quote the

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.

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The Works of the Lancashire Dynamo & Motor Co. . . .

THE Lancashire Dynamo & Motor Co. is now so well known, and justly known throughout the electrical engineering world for the excellence of its products, that some description of the works where its various manufacturing operations are carried on will doubtless be of interest to our readers. The value of a visit to an engineering works is much increased if the visitor has some idea beforehand of what he is going to see. For this reason we hope that the following description will prove useful to those members of the Municipal Electrical Association who visit the works of the Lancashire Dynamo & Motor Co. at Trafford Park during the course of the Annual Convention at Manchester.

The works were erected in 1899, but have since been considerably extended, until they now employ upwards of 1,000 men. The railway accommodation is very good, inasmuch as the railway trucks from seven railways can be taken directly into the shops, electric capstans being used for this purpose. Electric power is, of course, used throughout the works for both power and lighting, being purchased from the Trafford Power Supply Co. The energy consumption last year was about 700,000 units.

The works are divided into four main sections—viz., machine, winding, assembling and testing departments. All these departments are provided with overhead electric travelling cranes, varying in capacity from 5 to 50 tons. There are 13 cranes of this type in all, in addition to several small jib cranes. The machine shop comprises two bays, in which are erected a number of excellent examples of machine tools, the larger portion of which are driven by variable speed motors. The largest tool is a boring mill of 18 ft. diameter, which is driven, of course, by a variable-speed motor. The same class of tools are, as far as possible,

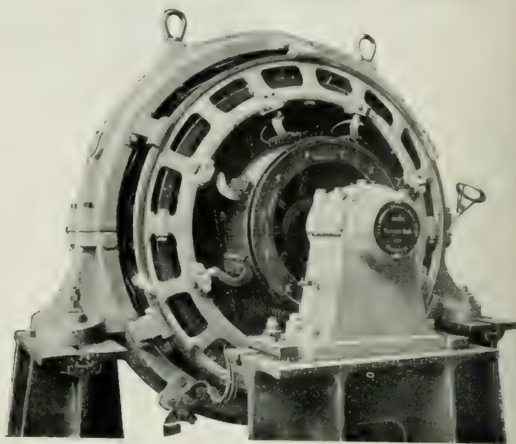

Fig. 1.—500 kw. Multipolar Generator.

grouped together, so as to facilitate production. An interesting instance of separate motor drive is a side planer. The motor driving this is coupled direct to the screw shaft operating the head, and is reversed by means of tappet gear, controlling a reversing switch, at each end of the stroke. This planer cuts in both directions and operates at 80 ft. a minute. This machine was previously driven by an open and cross belt, and the speed under these conditions was 25 ft. a minute. Even at this speed the clutch gave trouble,

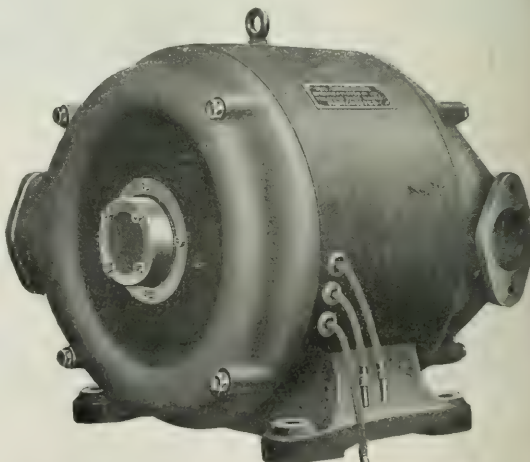

Fig. 2.—Squirrel Rotor Type Induction Motor, Pipe Ventilated.

so it will be seen what an immense advantage is separate driving by means of a motor on a tool of this description. There are also three large high-speed planers in this shop, in addition to a number of small ones. A planer-miller fitted with two motors, one for the cutting and one for the feeding drives, will be of interest, as this arrangement gives a very great increase of production, owing to the fact that

the feed can be changed instantaneously when the machine is in operation. A series of three multiple spindle drilling machines, each driven with a separate variable-speed motor, are found both useful and economical.

All armature shafts produced by the company are rough turned and afterwards ground, so as to ensure absolute accuracy. These shafts are afterwards pressed into the armature sleeves in a large hydraulic press. An interesting feature of the Trafford Park works is the large number of jigs and special tools which have been provided in order to ensure accurate and economical work.

At right angles to the machine shop there are three bays, known as the armature department. This department is confined to the carrying out of such operations as armature and field winding, insulating, taping, commutator building, &c. It is fitted with a complete set of hydraulic presses for the manufacture of micanite rings, troughs, &c. Three vacuum impregnating and drying tanks are also installed.

In the next three bays, known as the assembling department, all the parts are put together to form complete machines. This department is regulated by a stores, to which all items are sent as completed, and, after being checked and stamped with the inspector's initials, are passed out to be assembled.

A separate building has been erected close to the main machine shop in which are conducted the operations of armature plate stamping, testing and packing, one bay being devoted to each operation.

The Hopkinson method is used for testing wherever possible, while a motor-generator is provided for testing of

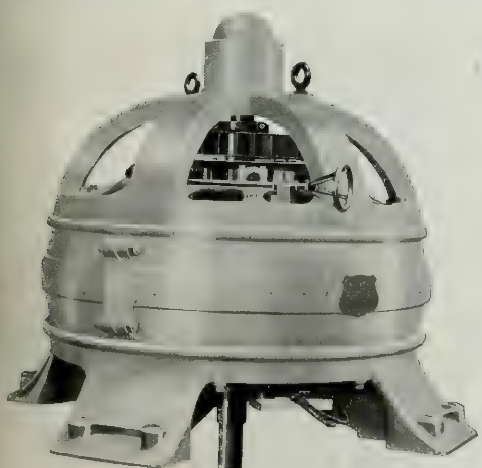

Fig. 3.—300 H.P. D.C. Vertical Pump Motor.

alternating-current motors. This motor-generator consists of a variable-speed motor coupled to a generator of the revolving-field type. The stator is divided into sections, so that practically any voltage can be obtained without the use of a transformer. Transformers, however, are provided for testing high-voltage multiphase motors. This department is also equipped with high-tension apparatus, which gives any pressure up to 30,000 volts. All insulating material is also thoroughly tested in this department before being assembled in the works into the various machines.

The bay adjoining the testing department is fitted up for the manufacture of armature plates, and all armature plates up to 50 H.P. are here stamped at one blow, thus

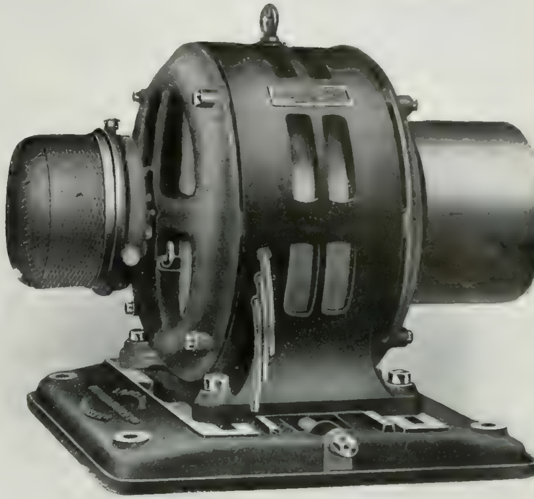

Fig. 4.—Standard Three-Phase Induction Motor.

ensuring absolute accuracy. Under these conditions no filing at all is required after assembling. Varnishing of the armature plates is done in a separate building on account of fire risks.

A few of the special points in the design of the Lancashire Dynamo & Motor Co.'s productions may be of interest. Direct-current generators and motors of all sizes are invariably built up on a cast-iron sleeve, so that they are quite independent of the shaft. It is, therefore, a simple

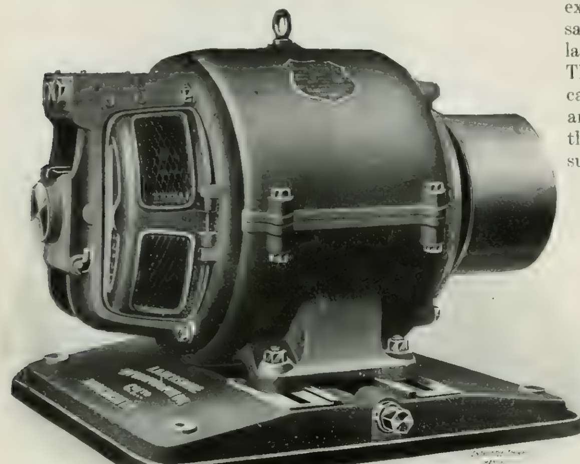

Fig. 5.—Standard Four-pole D C. Motor.

and inexpensive matter for the armature shaft to be changed at any time in case of damage. All machines are fitted with the firm's patent box type brush gear, unless finger type is specially preferred. As regards induction motors, a new type of squirrel-cage rotor has recently been patented, in which the end rings consist of a number of copper or brass stampings in the form of armature plates, with a quarter twist on each tooth, each tooth being fastened into the corresponding rotor bar. Usually about six plates are used for the end connections spaced about $\frac{1}{4}$ in. apart. This ensures very good ventilation and cooling, and more resistance to be put into the end connections, thus giving a better starting effort. No bolts whatever are used in the building of either the rotor or stator cores. A patent short-circuiting and brush-lifting device is also fitted on slip-ring motors when required. This short-circuiting device has one movement only and is extremely simple.

The "Lancashire" automatic reversible booster (Turnbull & McLeod patents) is one of the specialities of this firm. There are over 50 of these at work on various tramway undertakings at the present time, and it is interesting to note that this firm has just secured the order for the booster required for the new battery installation for the Manchester Corporation. This battery is the largest which has yet been installed in this country, and will, no doubt, be the forerunner of many others.

E.P.S. Batteries.

IN the last issue of the INDUSTRIAL SUPPLEMENT we referred to the advances which accumulator traction was making, and showed that under certain conditions this method had great advantages in spite of the fact that it is very generally looked upon as rather out-of-date and much too expensive.

We are able to illustrate and describe herewith a means whereby such economies as those described are possible. That well-known firm, the Electrical Power Storage Co., have devoted themselves for many years entirely to the manufacture of accumulators, and as a result of their long experience are able to turn out cells which will be found satisfactory in every way. The O.L. type of cell contains the largest type of plate at present manufactured by the company. The weight of each positive plate is 48 lb., and the cell is capable of giving 165 amperes for half an hour or 115 amperes for one hour per positive plate per cell. It will therefore be seen that such an equipment is very well suited for heavy work of all kinds.

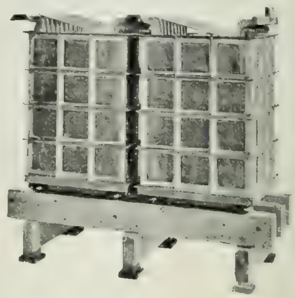

Fig. 1.

In Fig. 1 we illustrate a somewhat similar cell, the weight of the positive plate in this case being 40 lb., while each positive plate is capable of giving 140 amperes for half an hour, or 100 amperes for one hour.

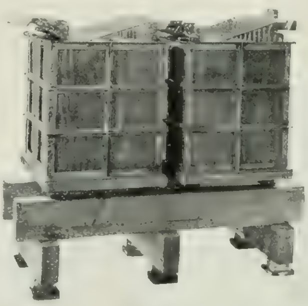

Fig. 2.

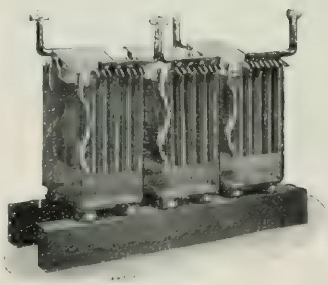

Fig. 3.

Fig. 2 shows the P type of cell, which is the smallest of the three sizes supplied for heavy work, such as would be found in large central stations or power circuits. Each positive plate weighs 22 lb., and is capable of discharging at 55 amperes for one hour. Any of these types can be supplied with either planté or pasted positives as desired.

A lighter type of cell is shown in Fig. 3. It is designed for private installations and house lighting. Other cells which are made by this company and possess many advantages are those intended more especially for traction purposes and ignition work on motor cars.

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Copy for Text or Advertisement pages for next issue, publishing on **July 23rd**, *should reach the above address by Tuesday*, **July 13th**.

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Relation of Load Factor to Power Costs.

At the present time the question of tariffs is one which is exciting and worrying the minds of supply engineers. They have had put before them lately methods by whose use it is contended energy can be sold at a low cost per unit to the consumer, while at the same time the supply engineer will be able to recoup himself for the inconveniences of the "peak." These methods have applied more particularly to the energy supplied for domestic purposes, but the question of what charge should be properly allocated to a large power consumer is not without interest. It is probably pretty generally agreed that any rate to be equitable should be made up of a primary fixed charge and a variable operating charge, the first of these depending on the maximum demand and the second on the amount of energy consumed. It is, therefore, to the consumer's advantage to reduce his maximum demand to the lowest possible. If he be a manufacturer this should sometimes be feasible, for by arranging the various operations so that "peaks" of one fit into the valleys of the other a levelling up of the whole load would be obtainable. When a railway is the consumer this does not hold, for the time of the "peaks" is practically dependent on the wants of the public, and the case seems irremediable. American ingenuity has come to the rescue, at any rate in practice, and the Chicago City Railway, who purchase their energy from the Commonwealth Edison Co., have got over this difficulty by installing a large storage battery. This arrangement is delightful in theory, and has, in fact, been suggested for "chopping the peak" even in this effete country; and in practice also it appears to have worked well in this case, for the annual saving amounted to the very respectable sum of £7,500. Even taking into account the rapid depreciation of the battery and other disadvantages attendant on the use of this equipment, the result justifies the means. The industry as a whole seems to be finding a more extended use for the erstwhile neglected storage battery, and if by its means the hills and dales of the load curve can be smoothed out its introduction will be welcomed both by engineer and consumer. Such a result would practically do away with the fixed charge part of the rating, and thus bring about a much-to-be-desired simplification in power tariffs without any sacrifice of equity, a sacrifice which is necessarily made at the present time when a flat rate is used.

Hydro-Electric Disabilities.

The *laudator temporis acti* school of critics are fond of drawing attention to the disabilities under which the electrical industry suffers in this country through the non-existence of water powers which are suitable for generating purposes. As a matter of fact, this is scarcely the right way of looking at the question. Experts inform us that there is really an abundance of water-power available in these islands, but that its development for general purposes would not pay owing to the distance of most of the falls from industrial centres. Large electro-chemical works, which can be transplanted into the neighbourhood of the falls, are therefore practically the only concerns which can take advantage of the power thus naturally made available. But in spite of this we are not really so badly off; in fact, astonishing though it may seem, the conditions existing in this country for the generation of power are the envy of less happier lands. This view was expressed by Mr. Sam Eyde in his recent lecture before the Royal Society of Arts on the manufacture of nitrates from the atmosphere. Although for such processes cheap power, such as is made possible by water falls, is absolutely necessary he was willing to give up these advantages in exchange for such facilities as are present in such industrial areas in this country as the Newcastle district. Apart from the fact mentioned above, that the inaccessibility of the sources of hydraulic power often make a general service from such sources impossible, the question of reliability has also to be considered. In America, where water power is in some cases used for operating railways, it is found that what with low water in the summer and frozen penstocks in the winter, the provision of some sort of steam stand-by plant is absolutely necessary to ensure that continuity of service which is so essential for a railway. It, therefore, comes to this in such a case; either steam locomotives have to be used when the electricity supply is insufficient through want of water or steam-driven generators must be installed to take the load in case of need. Both arrangements are uneconomical, and until we can tie down Dame Nature to the terms of a penal contract the employment of water powers for railway working will have distinct disadvantages in countries suffering extremes of heat and cold. In this country we have practically no choice, and we must therefore obtain a reliable service by installing steam-driven plant without having to withstand the temptation of employing water power.

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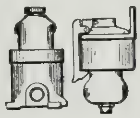

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Some Notes on the Wolf Locomobile.

AN interesting piece of apparatus, at the present time when economy is all the vogue, is the locomobile made by Messrs. R. Wolf, Laurence Pountney Hill, London, E.C. It consists essentially of a boiler and engine combined into one, so that not only is floor space saved, but the losses in the piping are quite avoided. It is, therefore, perhaps scarcely surprising to learn that a coal consumption of just over 1 lb. per horse-power hour is guaranteed, though we understand that independent data have shown that even this figure has been reduced on test.

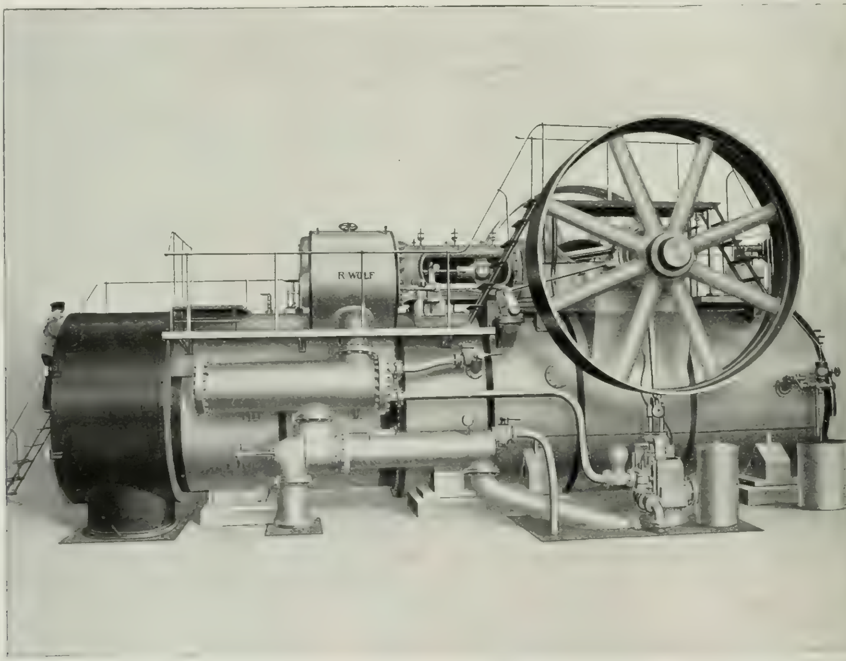


Fig. 1. -130 H.P. Wolf Tandem Compound Condensing Locomobile in Works Central Station at Acton Green.

Numerous types of this engine are made, but one which we recently had the pleasure of inspecting at Acton, and which we illustrate herewith, may be taken as quite representative of this firm's products. This locomobile is used for driving the dynamos supplying power to the shops and current for lighting, and in this connection a rather interesting arrangement has been put down. The firm had on its hands a number of dynamos of various outputs of which it determined to make use. The engine, therefore, drives a countershaft by a main belt, and from this belts are "tapped off" to each of the machines, whose aggregate output is sufficient for the firm's requirements. This equipment is shown in Fig. 1.

The locomobile used is of the patent superheated steam tandem compound condensing type. It is fitted with a feedwater heater, jet condenser, removable furnace tubes and intermediate superheater; and is capable of giving out up to 130 B.H.P. continuously and up to 150 B.H.P. for short periods. With this class of locomobile Messrs. Wolf guarantee a coal consumption of 1·17—1·3 lb. per brake horse-power per hour, and a steam consumption of 9·25—10·6 lb. per brake horse-power per hour. The locomobile is a complete and compact steam plant having engine set on top of boiler, and is entirely self contained.

The boiler is constructed of best Siemens-Martin steel, of extra heavy dimensions, fitted with corrugated furnace and flat fire grate. The tubes are screwed and expanded into the front tube plate, a number of heavier section than the others forming stay tubes with nuts on both sides of plates. The furnace and tubes are, on undoing a few nuts, easily removed from the boiler for cleaning and scaling when necessary, leaving the boiler shell open for inspection and cleaning.

Both superheaters, which are made of coils of best solid drawn steel tubes, are placed in the smokebox immediately behind the tubes where the heat is utilised to utmost advantage and where they are easily accessible when necessary. The main superheater supplies the steam to the high-pressure cylinder, while the intermediate superheater is placed directly behind it and heats the high-pressure exhaust steam before it enters the low-pressure cylinder. A special steam jet apparatus is fitted for cleaning the soot and dust from the superheater coils and also from the fire tubes, thereby maintaining the efficient working. Cleaning can be effected while the engine is running, thus obviating any necessity for stopping or putting out the fires. The chimney is set on a branch of the smokebox, and is of wrought iron and provided with rain shield, wire rope stays and other fitments.

The cylinders are arranged in tandem and are placed in the smokebox where they are heated by the hot gases on their way to the chimney. These gases pass through special jackets to effect this. The high-pressure cylinder is placed in front of the low-pressure cylinder and is fixed to a forked frame, which acts as guides to the crosshead and connects with the crankshaft bearing, taking up the load from cylinders to crankshaft directly, thus permitting no

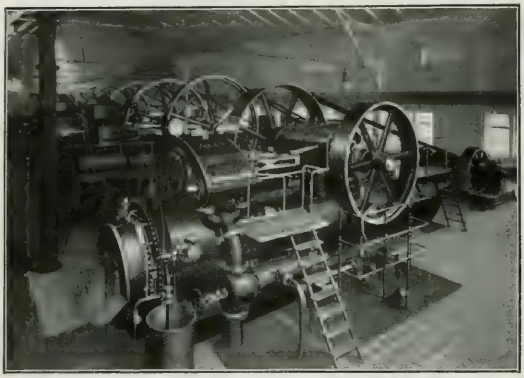


Fig. 2.—Municipal Central Station, Eisenach, Germany. Four Wolf Locomobiles. Total H.P. 765.

stresses to pass through boiler shell. The pistons are easily removable, and the high-pressure piston can be taken out either through the guides or through the low-pressure cylinder, while the other is easily removed on undoing the cylinder cover. All stuffing boxes are fitted with best metallic packing, and this substance has proved to be exceedingly durable.

Piston valves are fitted, one to each cylinder, the high-pressure valve being directly controlled by the governor. The valve gear is of the simplest possible construction, as it has the fewest possible moving parts, and is consequently very durable and reliable. The crosshead is a steel casting fitted with shoes of hard cast iron which run in cylindrical guides. The connecting rod is fitted with hard bronze adjustable bearings for crosshead pin and for crankpin with bushes lined with best antifriction metal having large wearing surface. The crankpin, eccentrics and governor are efficiently lubricated by means of centrifugal lubricators, oil being supplied from oil cups of large capacity. The governor is of the axial type, set on the crankshaft, and is very sensitive yet powerful. It is, further, easily capable of keeping the speed of the engine well under control, and limiting the variation in speed to less than 0·5 of one per cent.

The crankshaft, forged of best mild steel, is carried in bearings provided with continuous chain lubrication and attached to a heavy cast-iron bedplate which spans the boiler shell and is firmly riveted to same. This forms a substantial and very steady arrangement for supporting the crankshaft and transmitting power.

The flywheel, which is of an exceedingly substantial pattern, is of cast iron; its weight is ample, and it is turned outside and inside to ensure steady running, and is crowned to receive the belt. Barring gear is fitted for conveniently turning the engine by hand.

The exhaust steam from the low-pressure cylinder passes through a tubular feedwater heater on its way to the condenser. A diverting valve is fitted to condenser to allow the engine to run non-condensing when required.

The jet condenser is of ample capacity and fitted with a regulating valve for controlling the amount of condensing water admitted. The condenser is provided with drain cock, snifting valve and vacuum gauge. Air and feed pumps are provided and set on the boiler foot, being driven from an eccentric on the crankshaft. The feed pump draws water from the feed tank and delivers it through the feed heater, where it is heated before entering the boiler. As an auxiliary feed, a patent self-starting injector is fitted and provided with its own feedwater tank.

Platforms of ample dimensions and provided with ladders for easy access are fitted for convenience in operating the locomobile.

The boiler is fitted with two lever safety valves of ample area. A safety valve is also placed between the superheater and cylinder and the usual water gauge glasses, test cocks, steam pressure gauges and blow-off valve are fitted. Stop valves are placed between the boiler and superheater and between the superheater and engine, and the cylinders are fitted with drain cocks. A special plunger pump for continuously supplying the cylinders with lubricating oil is fitted. The necessary screws, keys, oil cans, firing and boiler scaling tools are also provided.

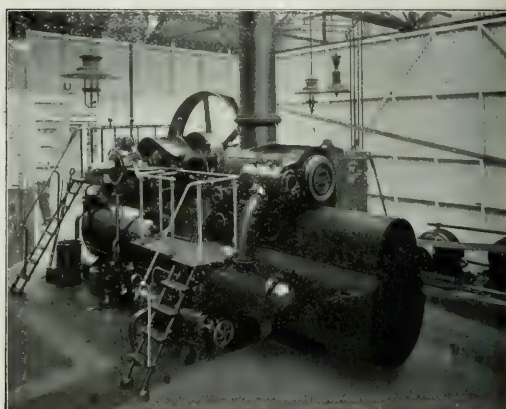


Fig. 3.—500-650 H.P. Patent Superheated Steam Compound Condensing Locomobile.

All parts are easily accessible and can be kept under the constant supervision of the attendant.

From the above short description of the Wolf locomobile, it will be seen that it forms a complete self-contained and compact power plant, easily accessible, of highest class workmanship, durable, absolutely reliable, and is guaranteed to be unequalled for economy.

"Metalik" Lamps.

THE well-known "Metalik" lamp has just recently received a new recruit to its ranks, in the shape of a new type, which enables, it is claimed, low candle-power at high voltages to be obtained. These lamps are made in the 16 c.p. size for voltages between 100 and 130 volts and in the 32 c.p. size for voltages between 200 and 260 volts. This "Metalik," it is claimed, will save 70 per cent. of the consumer's present electric light bill and give him a beautiful white light. It is manufactured by Messrs. G. M. Boddy & Co., of London and Liverpool.

B.C.-H. Oil Switch Panels.

A NOT uninteresting study for the historically-minded electrical engineer would be the evolution of the present-day switch from its earliest days. At first these instruments were, to put it mildly, rather crude, but at the present time there is probably no electrical apparatus on which more care and thought is expended. These remarks apply very accurately to the switchgear designed and manufactured by the British Thomson-Houston Co. Among their specialities are oil switches, and a very useful type of these is that illustrated in the accompanying Fig. 1, which shows a 200 ampere oil switch, with its oilcan removed. These switches are being used on B.T.-H. oil switch panels, one of which we show in Fig. 2, a piece of apparatus which has been developed for use on individual motor installations or for controlling feeders. Switch panels can, of course, also be furnished, mounted together to form a continuous switchboard by adding 'bus-bars, and providing access to the back. These panels are

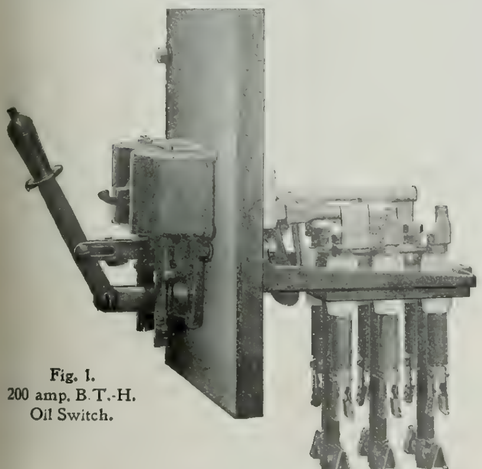


Fig. 1.
200 amp. B.T.-H.
Oil Switch.

made up in two forms, one in which the apparatus is mounted on a slate panel, while in the other the whole equipment is constructed of iron throughout.

When slate panels are used, they are mounted on angle iron supports; and these supports also carry a perforated metal sub-base, while the uprights themselves are supported from the wall by means of tie-rods. In a case such as this it is, of course, necessary that accidental or other contact with the live parts should be avoided, and this is realised by side screens of expanded metal. The iron plate panels above mentioned are made all complete with side and top screens, with arrangements for being suitably mounted against the wall. As the new Home Office Regulations come into operation on the first of next month, it is of interest to note that these B.T.-H. oil switch panels comply with them in all particulars.

Each pole of the switches used on these panels has a double break under oil, the break taking place between the copper cross bar and contacts of a controller type. The ammeters and voltmeters used are of the dead beat pattern, with which current transformers are supplied when the voltage exceed 600 volts.

The switches provided with these panels can either be operated by hand, or electrically, as desired. In the latter case series or transformer coils are used for working the switches. These switch panels are made in three standard sizes, suitable for a maximum of voltages of 600, 2,500 and 3,500 volts. Low voltage arrangements can, if desired, be supplied with any electrically tripped switch, and in cases

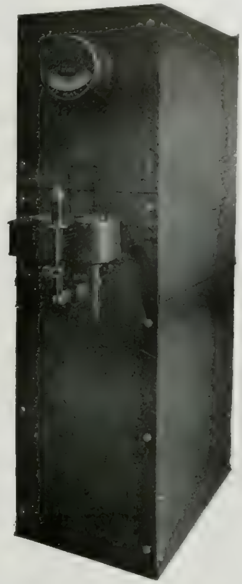


Fig. 2.
Three-phase Oil
Switch Panel,
Iron Plate Type.

where these panels are used in conjunction with motor starters or controllers, interlocking arrangements can be provided, which prevent the switch being closed, except when the starter is in the "off" position. The illustrations herewith indicate that this equipment is safe in working, and can, without danger, be left to the care of the ordinary British workman. Any live parts are safely out of the way, and are not in a position to be interfered with.

Henley's Cables at Bahia Blanca. . .

THE cable question is one which is of great interest to electrical engineers at the present time, principally from the economical point of view. The problem has, however, its engineering side, and this side is all important, especially in countries where the climate is not so benevolent as ours. Special factors have to be taken into consideration, and on the way in which these are overcome depends the success of the work. Probably no firm have had more experience in cable work abroad than Messrs. Henley's Telegraph Works Co., of Blomfield-street, London, E.C. It is therefore interesting to note how they do their work, and for this reason we give some account of a cable system they have recently laid down at Bahia Blanca, Argentina.

The whole of the cables, troughing, &c., required for the new lighting and tramway systems in this city will be supplied by Henley's, who will also carry out the laying and fixing, and make all the necessary joints. They will, further, supervise the whole of the work during the installation of the complete network. The cables employed on this work have a total length of 130 km., made up as to 83 km. of high and low-tension paper-insulated feeder and distributor cables, 38 km. low-tension vulcanised bitumen insulated tramway and telephone cables, and 8,000 metres of vulcanised rubber insulated service cables.

The high-tension feeder cables have a total length of about 55 km., and are of the three-core three-phase type, designed for transmitting current at a working pressure of 6,600 volts, the sizes employed being 0·2, 0·1 and 0·05 sq. in. sectional area. The conductors are of plain copper (Henley's patent "Laminæ" conductor) and are insulated with paper impregnated with special insulating compound. The cores are then laid up, further layers of impregnated paper, covered with an earth sheath composed of copper strips being laid on spirally, and the whole being finally sheathed with a continuous tube of lead.

The arc lighting cables, of which there are some 20 km. in all, are of the high-tension single core type of 0·025 sq. in. sectional area. They are insulated with impregnated paper for a working pressure of 2,250 volts and are lead covered overall.

The distributor cables are of the four-core low-tension type, of similar construction to those already described, with the exception that the conductors are composed of ordinary circular wires made up into circular or triangular shaped conductors according to the size of the cable. The sizes employed vary from as large as 0·5 sq. in. area down to 0·05 sq. in., the neutral conductor in all cases being half the section of any one of the other cores. The telephone cable, about 31 km. of which is used, is of twin construction and is insulated with vulcanised bitumen. It is then taped, laid up, taped again, braided and waterproof compounded overall. The tramway feeders are of the 0·5 sq. in. single type and are insulated with vulcanised bitumen. They are protected with four coats of heavy taping, prepared with waterproof compounds. The service cables are of low-tension twin construction, insulated with pure and vulcanised indiarubber, then covered with a continuous tube of lead, armoured with a close spiral of galvanised-iron wires and double taped and compounded overall. Among these services we should like to make special mention of 8,000 metres of cable, which will be so prepared that it will withstand the intense heat of the sun, which often reaches the very high temperature of 140°F. in these parts.

With regard to the laying of these cables, for the most part it is proposed that they should be laid in earthenware troughing on bitumenised wood bridge pieces, filled in solid with refined Trinidad bitumen, and covered with earthenware tiles. The tiles over the troughing holding the high-tension cables being so marked that they are easily distinguishable from those covering the low-tension cables, a rather important point from the testman's point of view; the total length of troughing that will be required being about 100 km.

The joining up of the manufacturing lengths and the making of all the tee joints will be effected by means of lead sleeve joints on the paper-insulated cables, and taped joints on the vulcanised bitumen and indiarubber cables. The house services will be tapped off the distributors by means of specially designed porcelain boxes, which boxes are equal in length to a section of troughing and being provided with spigot and socket ends fitted into the troughing adjoining, thereby making a continuous run of earthenware covering leaving no part of the cable exposed. Extra precautions are rendered necessary when fixing all underground apparatus owing to the streets of Bahia Blanca being liable at all times of the year to be flooded to a depth of 3 ft. for periods of 48 hours and more. About 750 service boxes will be supplied as well as an equal number of house disconnecting fuse boxes which will also be of special design.

The total value of the cables is estimated at between £40,000 to £45,000.

Fortiter D.C. Starting Switches.

THE problem of motor control, especially when the motors are of the continuous-current type, is one which is becoming well-in-hand at the present time. It is always interesting to see how things are done, and for this reason we illustrate herewith some direct-current starters which the Union Electric Co. are now placing on the market.

Fig. 1.—Starter with Oil-cooled Resistance.

Fig. 1 shows a starting switch fitted with an oil-cooled resistance. These starting switches are fitted with a no-volt release and are provided with a small hold-on magnet, excited by the shunt current of the motor. Should this magnet lose its magnetism through any cause the lever immediately flies back to the "off" position. In the starter illustrated the resistance coils are immersed in oil, while the whole apparatus is covered in with protective sheet iron.

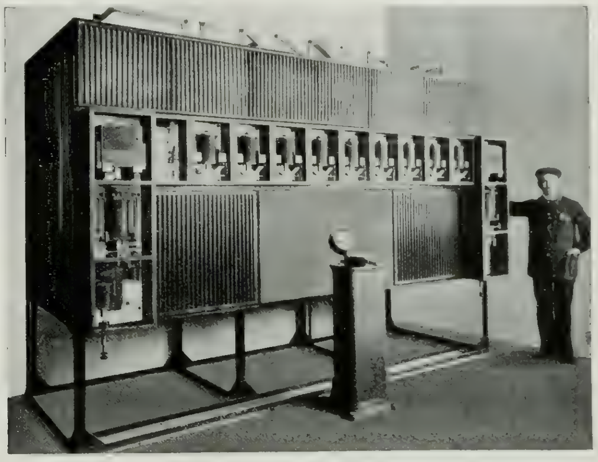


Fig. 2.—Motor Control Panel.

Fig. 2 shows another type of motor control panel for direct-current motors. This comprises a starting switch, a double pole knife switch, and two single pole porcelain handle fuses. A dead beat electro-magnetic ammeter is fitted or not as required. All current carrying parts are protected by means of sheet-iron covers. Fig. 3 shows an interesting piece of equipment. It is a remote control starter for a 700 H.P. compound haulage motor. The controlling switch is mounted upon a cast-iron panel, shown in the foreground, while the main circuit-breaker and the solenoid switches are mounted upon marble slabs arranged within the front of the rolled steel frame. The circuit-breakers on the right and left of the board are used for making and breaking circuit respectively. The solenoid coils remain under current only during the starting period.

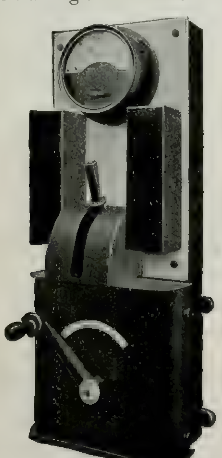


Fig. 3.—Remote Control Starter for 700 H.P. Motor.

Another interesting direct-current starter is one specially suitable for mounting behind switchboards. The contacts, which are placed on the opposite side of the starter to that which touches the switchboard, are arranged in exactly the reverse order to those on the standard type of starter with the contacts on the front. The starter is operated from the front of the panel by means of a nickel-plated hand-wheel fixed to the spindle passing through the panel, which, of course, is moved in a clock-wise direction for starting-up purposes. These can be fitted with no-volt and over-load release exactly the same as the standard type starter.

Yet another type of starter is fitted with a water-tight case, which makes it specially suitable for use in collieries or under other severe working conditions. The starter is completely enclosed in a cast-iron case, which is fitted with a water-tight and dust-proof cover in such a way that it can be quickly detached from its case by simply removing four screws. The contact arm on this type of starter is operated by an external lever through a claw coupling so that the difficulties often met in disconnecting the actuating lever are entirely avoided.

We are only able in this article to notice very briefly some of the starters made by the Union Electric Co. A very wide range of this apparatus is, however, made, and we recommend those interested in the subject to communicate with the company and take the benefit of their advice.

"THE ELECTRICIAN" TABLES OF

No	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected	Largest Motor on Circuit. H.P.	Max. demand Kw.	H… mo… (… ar…
1	**Aberdeen Corporation**	J. Alex. Bell	Granite quarries, eng. works, shipyards, ice factories, fish-curing and preserving works, paper wks., woollen and jute wks.	400	220, 440 three wire 230 2 wire	4,043 31,5/09	681	104	750 at 11.0 a.m.	
2	**Acton Council**	J. Martin Blair	Laundries, motor works, dyeing and cleaning, printing	...	230, 460 three-wire	606 31/5/09	61	170	174	
3	**Aston Manor Corporation**	R. Foster	General	400 3-phse 50 ~	460 three-wire	4,365¾ 1 o 09	210	500	1,600	
4	**Ayr Burgh Council**	Roland Marshall	Principally residental, building trades, laundries, small eng. works, shipyard carpet works, boot factory	100, 200 Single phase	250 500	345 30/4/09	101	30	...	
5	**Barnes Urban District Council**	C. S. Davidson	Gas mantle works, sawmills, brewery golf club making, laundries printers	.	210, 420 three-wire	639 31/3/09	60	60	470	
6	**Barnsley Corporation**	E. A. Barker	Foundries laundries builders and joiners, linen manuf'ters, paper mill, &c.	...	230 460	685	114	30	878	
7	**Barrow-in-Furness Corporation**	H. R. Burnett	Shipbuilding, iron, steel and engineering works	220, 440	970	150 30/9,08	50	...	...	
8	**Bath Corporation**	Francis Teague	Engineering, cabinet - making, clothing and corset factories	110 single-phase	220, 440 three-wire	476 31/3/09	141	72	.	
9	**Battersea Borough Council**	F. A. Bond	Soap and candle works, engineering works, millers, railway goods yards, stone yards	...	230*, 460†	2,138 18/5/09	..	40	500 day load	
10	**Belfast Corporation**	T. W. Bloxam	Shipbuilding, spinning and weaving, ropeworks, handkerchief making.	...	220, 440 three wire	4,695 31 3 09	550	70	*	
11	**Birmingham Corporation**	R. A. Chattock	Metal, cycle and jewellery trades	5,000	220, 440 three-wire	14,365 31/3 09	1,958	350	8,645 l. & p 5,040 tr	1 0 1
12	**Blackburn Corporation**	P. P. Wheelwright	Cotton manufacture and general industries	220	220 440	2,324 25/3/09	580	50	..	
13	**Blackpool Corporation**	C. Furness	Joinery works, bakeries and bottling stores and laundries	200	500	1,078	156	80	...	
14	**Bolton Corporation**	Arthur A. Day	Cotton spinning and engineering works	100, 200* 400†	230, 460	9,219¼ 31/3/09	816	300	4,925	
15	**Bootle Corporation**	T. Dawson Clothier	Timber, engineering, dyeing, pumping and general	...	220, 440 three-wire	1,989 31/3/09	...	40	1,252	
16	**Bradford Corporation**	Thomas Roles	Textile works, dye works, mechanical and electrical engineering, miscellaneous	230, 400 50 ~	230 460	*7,276 26,5/09	*1,528	110	2,174	
17	**Brighton Corporation**	J. Christie	Engineering works, breweries, sawmills, laundries, foundry, &c.	...	230, 460	1,641 22/5/09	388	40	..	
18	**Bristol Corporation**	H. Faraday Proctor	Tobacco, cocoa, printing, leather, confectionery and clothing	105 & 210 93 ~ 210-50 ~, 360 3-phase 50 ~	250 500	10,179	1,118	120	2,130	N ie
19	**Burnley Corporation**	Jas. E. Starkie	Cotton weaving, foundries, &c.	...	220, 440	591 20/3,09	195	30	440	N ie]
20	**Burton-on-Trent Corporation**	P. J. Pringle	Breweries, timber mills, engineering works	200, 100	500 (tramways only)	816 22/5/09	131	45	505*	
21	**Bury Corporation**	S. J. Watson	Textile, engineering, paper, &c.	...	220, 440	2,129½ 26/5/09	280	80	...	
22	**Carn Brea, R.S.O. (Urban Electric Supply Co.)**	L. A. Hards	Mining and foundries	...	240, 480 three-wire	1,719 Dec., '08	121	30	758	Nne }
23	**Canterbury Corporation**	C. A. Blascheck	None	...	220, 440	297 31/3/09	74	50	390	
24	**Cardiff Corporation**	Arthur Ellis	Ship-repairing yards, engineering works foundries, laundries, printers, brewers millers cold storage, &c.	200 400	200, 400 three-wire	2,825 30,4 09	445	80	...	Nne
25	**Carlisle U.D.C.**	S. T. Allen	Cotton factories, tinplate printers, engineering works and railway shops (7 companies)	...	L. & P. 230 460, 3 wire, traction 500	543 31/5/09	72	57	L. & P. 433 traction 250	
26	**Charing Cross, West End & City Electricity Co.**	H. W. Kingston J. M. Gatti (*Mn. D.*)	Printing	10,000	100, 200, 400, 1,000	Ex bulk sup. 13,227, 31/3/09	...	250	...	
27	**Chester Corporation**	S. E. Britton	Engineering, flour mills and printing	...	210, 420 three-wire	503 27/5/09	119	25	1,320	
28	**Chesterfield Corporation**	R. L. Acland	Printing, brewery, furniture-making, foundries		240, 480 three-wire	716 31/12,08	150	30	...	
29	**Clyde Valley Electrical Power Co.**	D. A. Starr	Steel works, rolling mills, collieries, paper mills, brickworks, foundries shipyards, &c.	11,000 transformed to 400 for power	...	19,700 30/4/09	...	500	4,910	
30	**Colne Corporation**	A. G. Cooper	Weaving, spinning, loom making, foundries, bell monuments and electric crane making	...	240, 480 three wire	366 15/2/09	138	20	...	
31	**Cork Electric Tramways & Lighting Co.**	H. H. Nalder	Breweries, butter factories, laundries, bacon curing, leather purifiers, printing, tanneries, milling, &c.	.	460	2,066 3/6/09	294	40	...	N-
32	**County of Northampton Electric Power & Traction Co.**	W. J. S. Jones	Boot factories, engineering works and joineries	...	230, 460 three wire	120	26	15	...	
33	**Coventry Corporation**	George Tough	Cycle and motor cars, toolmaking, weaving, watchmaking	200 two-phase	...	5,029 25/5/09	546	120	2,101	
34	**Darlington Corporation**	J. R. P. Lunn	Engineering, yarn spinning and school furniture	...	230, 460	1,287 31/5/09	166	125	790	
35	**Derby Corporation**	T. P. Wilmshurst	General engineering, foundries, motor cars, silk mills	200	460, 230 three-wire	1,805	260	75	780	
36	**Derbyshire & Nottinghamshire Electric Power Co.**	A. E. Loos	Iron works, collieries, lace and hosiery works, engineering works, brickworks, &c.	440	500 550	2,323 1/4/09	...	200	600	
37	**Dewsbury Corporation**	R. H. Campion	Woollen manufacturers, rag grinding, printing, laundries, clothing manufacturers, wool shaking, iron cutting	...	220 440	per 526 1/2/09	106	30	100	
38	**Dublin Corporation**	M. Ruddle	Saw mills, factories, elevators in stores, &c.	200 S.P. 3-phse. 346	...	1,620 1/4/09	364	20	...	

ELECTRIC POWER SUPPLY.

No.	Method of Driving: Group. H.P.	Method of Driving: Indiv. H.P.	Rates: Per unit.	Rates: Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g = Gas. sg = Suction Gas. s = Steam. H.P.	Remarks. (NOTE.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
	...	...	2½d. and 1d. M.D.	...	...	...	Long hour consumers, ½ hour M.D. Short hour consumers, 1 hour M.D.
2		...	1¾d. flat 2½d.&1d.M.D.	Under consid'n	..	150g, 220sg, 200s	Includes new scheme of electric pumping at Council's sewage works, auto. plant; in operation one month
3	...	...	*2d to ¾d. according to load factor	On application	...	...	* Sliding scale.
4	200	100	2d. to 1½d. Load factor basis	...	200	150g, 50sg, 200s	Shipyard agreed to take supply for 400 H.P. of motors. Supply not commenced yet.
5	89	550	1½d. with dis. to 33⅓ p.c. 1½d. motors	On application	*	55g. 500s†	* Most of our consumers are new to the district. † Includes plant at sewage works
6		...	3½d. flat, lighting 7d & 1½d. D.I.	...	..	...	Discount (lighting only) 5 per cent. Sliding scale for motive power.
7	...	...	3d. & 1d.M.D. 2d.–1½d. F.R.	...	...	...	....
8		...	1¾d. to 1d.	...	...	*	* Isolated plants using gas, suction gas and steam are in operation, of which there are no particulars.
9	...	...	Flat rate1d.‡	Terms by arrangem'	...	...	* Up to 3 H.P. † Above 3 H.P. ‡ Or £4 per kw. per annum and ½d. per unit.
10	...	...	1½d. & 1d. M.D., accord. to cons	On application	.	...	* Lighting and power 3,443, traction 3,300.
11		...	1·35d. to 1·10d.	1d. to 0·7d.	10,500	...	....
12	...	...	Sliding scale	Sliding scale	...	..	Total B.H.P. does not include traction.
13	..	..	3d. and 1d. M.D.	...	...	..	....
14		..	2d. 1st 1,000, 1d. after less 10%	...	.	. .	* Single-phase. † Three-phase.
15		.	2d. to 500 per qtr., 1d. allowed	...	1,000	1,502g, 8[illegible]sg, 4,510s	....
16	.	...	2d to 1d. 2d. to ¾d.	£3 per kw.†	...	...	* These figures do not include the following:—3 500 kw. motor-generator sets, property of Bradford Dyers' Assn., used for converting current supplied to Corpn. at 6,600 volts, 3-phase, 50 periods, to direct current at 230 and 460 volts. † Plus ½d. per unit, less discounts
17	.	...	1d. restricted hours, 1½d. unrestricted	...	..	...	Special terms to large users.
18	...	...	1½d. & dis., 1½d and ⅝d. *M.D. with discount	On application	...	800sg	* To avoid as far as possible the use of max. demand indicators a flat rate is usually agreed upon.
19	1,990	..	Lighting 3½d. flat Pwr. 1¾d. 1st 30 hrs. per ¼. 1d. aftr	None	...	...	....
20	195·5	620 5	3d & 1d. also 2d & 1¼d. 1d. to ¾d restricted hour	...	266	30sg	67·5 per cent. of total power is on restricted hour system. 80 per cent. of total power units sold on restricted hour system. * Includes lighting.
21	About 1.800	About 329½	1¾d., 1d. and ⅝d.	On application	850	About 40,000	....
22	...	126	4d.& 1d. M.D. or 2½d. flat	...	...	50g, 10sg	Power supply includes driving stamps, pumps and other mining machinery.
23	...	297	1½d. flat 5 p.c. dis. cash 28 days	...	.	..	Max. demand during year ended March 31, 1909, 390 kw. on feeders, includes light and power.
24	...	...	1½d. flat, 4d. & 1d. M.D.	Spl. rates to large consumers	...	...	Most of the engineering works on private property, from which Corporation are at present debarred from entry.
25	50	447	1d. and 3½d. Also £7 kw. per ann. of M.D. 1d. unit cons'd	Special terms	40	...	Power supplied to tramway company, also to Council for sewage pumping.
26	..	...	3d. to ¾d.	On application	...		... .
27	164	339	1½d. 1st 200 units per qtr., 1d. after	Above 25,000 p.a 1d. flat rate	...	...	.. ..
28	...	...	1½d. –1d.	...	...	...	....
29	...	...	On application	On application	...	...	....
30	62	76	2½d. flat, 3d. and 1d M.D.	On application	195	...	Several of ¼ H.P. and less not included in return. Motors let out on hire.
31	1,266	800	.d, 1½d., 1¼d., 1d. sliding scale	None	500 steam 450 gas	500g, 200sg, 2,000s	Competing with gas at 2s. 8d. per 1,000 c.f. with 25 per cent. discount when annual bill exceeds £50.
32	...	...	1½d. flat and spl. agreem'ts	...	100	...	....
33	300 about	246 about	1¾d. 2,500 units per quarter and 1d. after	...	4,000	...	....
34	...	...	½d. to ¼d.; £1 kw M.D. and ½d. unit	...	...	...	.. ..
35	...	...	1d. for all day use	...	800	...	....
36	...	...	1⅝d. to 0·4d.	...	...	...	Two large electric pumps being installed in place of an existing steam pump. Steam engine at present driving ventilating fan being displaced by an electric motor. Total H.P. about 250.
37	Both		2½d. (1)—1d.	Two Tramway Companies	...	..	Maximum demand system or 1d. restricted hour.
38	Both		1¼d.	...	2,200	...	Large additions in hand.

"THE ELECTRICIAN" TABLES OF

No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max. demand Kw.	H.T. moto (if any
39	**Dundee Town Council**	H. Richardson ...	Jute mills, shipbuilding, foundry	...	400	1,950	404	65	...	..
40	**East Ham Corporation**	W. C. Ullmann ...	Printers for motors, otherwise district is purely residential	...	240, 480	Pte., 269, *Stn., 13½, 1/6/09	Private, 97 Station, 5	15	...	..
41	**Edinburgh Corporation**...........	F. A. Newington .	Printing, joiners, masons, engineers, brewers	...	230, 460	9,400 15/5/09	2,250	50	...	..
42	**Fulham Borough Council**	Arthur J. Fuller	Engineering works, woodworking machinery, laundries, paper mill	200 two-phase above 5 H.P.	...	1,211	193	80	500	..
43	**Frome U.D. Council**	F. H. Merritt......	Cloth, silk and india-rubber mills, iron foundries, engineering and motor works, breweries, mill furnishing, dairies, bacon curing, printing	...	240, 480 three-wire	715 30/3/09	191	35	150 approx	.
44	**Glasgow Corporation**..............	W. W. Lackie......	Engineering, clothing, printers, butchers and bakers	6,500	250/500 three-wire	29,351 30/4/09	4,270	250	...	..
45	**Govan Council**	T. C. Parsons ...	Shipbuilding and engineering ...	...	500, 250	4,761 15/5/09	...	165	1,485	..
46	**Grantham Urban Electric Supply Co.**	J. E. Edmundson	Brickwork, foundries, timber merchants, engineering works, blouse factory, malting	..	240, 480 three-wire	346 31/12/09	98	13½	...	.
47	**Greenock Corporation**	J. A. Robertson ..	Shipbuilding, engineering, sugar refining	...	500	5,085 31/5/09	363	545	1,500 Appx.	
48	**Grimsby Corporation**.............	W. A. Vignoles ...	Docks, timber yards, foundries and engineering works	...	230, 460 three-wire	1,032 13/5/09	154	90	1,065	
49	**Guernsey Electric Light & Power Co.**	C. Lakin-Smith ...	Laundries, stoneworks and quarries, joinery works, foundry	...	210, 420	2,200	150	80	800	.
50	**Hammersmith Borough Council**	G. G. Bell	Engineering works, electric lamp works, small laundries, &c.	110, 220, 440 2,300 H.T.	.	2,614 19/12/08	336	200	...	3 [illegible] 2 [illegible]
51	**Hanley Corporation**	C. H. Yeaman ...	Brickworks, *potteries, iron works, collieries, *earthenware and china manufactories	Single-phase 100 v, 100-200, 400	35	876 31/3/09	129	60	1,102	1 [illegible]
52	**Heckmondwike Council**	G. H. Carter	Woollen manufacturers, rag grinders, foundry, boot and shoe, factory, coachbuilders, &c.	...	230, 460 three wire	953 30/4/09	115	150	..	
53	**Hereford Corporation**..............	W. T. Kerr.........	Cider making, breweries, mills (flour), farm work, joinery	...	220, 440	335 5/6/09	90	50	355	.
54	**High Wycombe Electric Light & Power Co.**	W. E. Brandreth	Chair and cabinet making, paper mills, engineering	...	420 210	592	158	30	...	
55	**Hove Electric Lighting Co.**	C. B. Smith.........	Purely a residential district excepting shops	...	220	321	113	12	..	
56	**Huddersfield**	A. B. Mountain ...	Cloth manufacturers	Three-phase One phase	... ...	1,577 1,371	50 384	150 35	800 2,000	
57	**Hull Corporation Electricity Department**	H. Bell	Engineering, shipbuilding and oil mills	...	220, 440 three-wire	6,135 31/3/09	540	75	4,513	
58	**Ilford Urban District Council** ...	A. H. Shaw	Photographic apparatus, chemical works, paper mills	...	230, 460 three-wire	645 22/1/09	97	60	...	
59	**Islington Borough Council**	Albert Gay	Bakers, brewers, builders, clothiers, coach and van builders, engineering works, confectioners, printers	Single-phase 50 or 100 200 and 400	...	2,178½ 31/3/09	431	50	3,600	
60	**Kettering Council**	W. A. Walker... ..	Boot and shoe and clothing factories	...	230, 460 three-wire	690¼ 30/4/09	144	30	230	
61	**Kidderminster & District Electric Lighting & Traction Co.**	A. Charlton.....	Carpet manufacture	..	460	984	...	21	469*	
62	**Kirkcaldy Corporation**	O. F. Francis	Linoleum, engineering, furniture, malting works, linen, &c.	..	230 460	786 15/5/09	...	130	811	
63	**Lancaster Corporation**	W. A. Tester	Timber yards, builders' yards, foundry, linoleum works	..	230, 460	425 1/12/08	105	50	200	
64	**Leeds City Council**.....	H. Dickinson	Numerous	200 400	...	10,174 31/5/09	1,753	100	5,465	.
65	**Leith Council**...........	A. Peden Rutherford	Engineering and general...	..	230, 460	3,267 30/4/09	415	100	672	.
66	**Liverpool**	Alfred Clough ...	....	...	230, 460	10,025 31/3/09	2,434	12, 80	...	.
67	**Lincoln Corporation**	Stanley Clegg	Engineering works	. .	230, 460 and 500	1,112¼ 1/6/09 excld. traction	164	45	425	.
68	**Loughborough Corporation**	W. H. Allen	Hosiery and engineering	.	220, 440 three-wire	370 30/10/08	67	43	120, for pr. only	.
69	**Luton Corporation**	W. H. Cooke ..	Straw hat making, motor cars and lorries, hydraulic and general engineers, foundries, printing works	...	500	1,612 10/12/08	268	65	759	.
70	**Maidstone Corporation**	E. E. Hoadley ..	Building, brewing	...	230, 460	1,245 30/5/09	174	60	...	
71	**Mansfield Corporation**	E. Holcombe Hewlett	Boots, hosiery, cotton doubling, founding, tin box, motor bodies, sand and stone quarries, coal mining	...	240, 480 500-600	260 15/6/09	80	12	...	.
72	**Metropolitan Electric Supply Co.**	J. S. Highfield, *En.* J. Conacher, *Gn. M.*	Ordinary shops	200	200	3,443 25/5/09	930	60	...	.
73	**Middlesbrough Corporation**	H. M. Taylor......	Iron and steel works, shipyards, joiners shop	...	220, 440 three-wire	1,694	303	50	450	..
74	Motherwell	S. Williams... ...	Engineering and steelworks	..	230, 460	About 3,000	...	3 of 120	943	..
75	**Newcastle and District Electric Lighting Co.**	W. D. Hunter ...	Engineering and shipbuilding, steel and lead works, &c.	100	240, 480 three-wire	8,643 25/9/08	...	150	4,300	..
76	**Nelson Corporation**	D. Helme...........	Cotton manufacturing	...	230, 460 three-wire	280 1/4/08	63 On hire	40	...	..
77	**Newport Corporation**	H. Collings Bishop	Coal, iron, clothing, nails, brickworks, millers, ship repairs, &c.	Not permitted	230, 460 three-wire	1,737·75 31/5/09	213	100	Cannot give	[illegible]

ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g = Gas. sg = Suction Gas. s = Steam. H.P.	Remarks. (NOTE.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
9	500 approx.	1,450 approx.	2½d. downwards	On application	...	...	....
10	...	..	2d. All units over 600 per ¼ at 1½d.	...	...	...	*Motors used in gen. stn. for cooling towers, artesian well, driving machinery, &c.
11	...	...	1⅓d. flat, ⅞d. Stch' R., 1d. 5hr. M. D'	...	...	..	... .
12	...	...	1d. flat	...	...	...	Power and lighting on same mains, 500 kw. day-load motors only.
13	43 approx.	672 approx.	2½d. flat; 4d. and 1d. M.D.	On application	150, also 365 private electric plant	50g, 20sg, 900s, 10 water (approx.)	....
14	...	...	1½d. & ¾d. M.D. 1d. flat rate for restricted hours	¾d.	...	...	... .
15	...	...	Sliding scale 2d.—¾d.	...	...	290s, 200s, 4,000s	.. ..
16	.	...	4d. and 1d. M.D.I. 2½d. flat.	Special rates	...	No record.	....
17	...	...	2½d. to 1d.	1d.	...	...	....
18	..	...	2¼d. to 1¾d. with dis., 1·025d. T.S.	...	...	...	Number and horse-power of motors does not include the docks or Admiralty supply.
19	...	...	*	To sub-stations	1,00	...	* Lighting: 7d.-3d. M.D.. 6d. flat 5½. Power 4d and 1½d. M.D., 2d.-2½d. flat.
50	...	.	1½d. with dis. to max. of 33⅓ p.c.	...	...	...	....
51	...	..	3d., 1d., ⅝d. and ½d.	On application	...	...	Power load rapidly growing and especially favoured with the many small and diverse trades subsidiary to staple industries of district. *Local for magnetting.
52	...	...	2d. to 1d. Sliding scale	Special terms	...	...	....
53	50	285	*3d. to 1d.	...	..	20g, 160sg, 300s	* With discount on hours of running.
54	...	..	4d.—1d. M.D system, 2½d. flat rate or on 2 rate meter	..	...	16g, 200sg	All motors are hired out by this company, and are maintained and inspected.
55	...	...	3d. two hrs. 1½d. after	...	...	...	Radiators are at power rates but are not included in this return.
56	...	...	2d. and 1d. less discount	...	...	...	....
57	...	...	2d.—1d. per sliding scale*	On application	.	..	Hired motor system in operation. About 405 H.P. connected. * Subject to 2½ per cent. dis., for payment within 14 days.
58	..	...	1d. flat, 2d. & 1d. M.D. 2d. to 1d. sliding scale	...	.	...	....
59		...	1d. flat	Nil	1,220	...	....
60	660¾ approx.	30	2d. to 1d.	On application	565	...	... .
61	...	...	1½d.	...	...	No information available	*This is a combined figure for lighting and power.
62	...	.	2½d. to ¾d. sliding scale	...	...	...	1 large engineering works, 1 large colliery, 1 large malting works received entire power supply from Corporation.
63	...	...	2½d. sliding scale to 1d.	By contract	425	330g	....
64	..	...	0·8d. to 1·75d. less 5 per cent.	...	...	..	... .
65	.	...	1½d. to 1⅛d.	...	...	...	....
66	...	..	*2d., 1½d., 1d.	...	..	...	* 2d. up to 3,000 per qr., 1½d. from 3,000 to 10,000 per qr. 1d. all units in excess of 10,000 per qr.
67	...	...	2½d., 2d. & 2d. & 1d. M.D	On application	...	...	....
68	219	151	1d. flat	...	158	49g, 25sg, 492s	Two private plants, total 1,200 kw., running.
69	About 1,312	About 300	*2d., 1½d., 1d.	...	About 400	About 200g 100sg, 250s	*2d. first 1,000 per qr., 1½d. second 1,000 per qr., 1d. remainder.
70	Both		Various......	. .	500	...	....
71	...	...	4d. & 1d. M.D. 1d. daylight	..	214	450s*	Town gas sold at 1 6 1,000 for power. Tramway supply 1,200 H.P. not included. * Not including collieries.
72	...	. .	3d. and ¾d. M.D.	...	...	...	....
73	...	...	2d. & 1d. M.D. Sp. on app'n.	...	1,500	...	Largest installation, shipyard, max. demand 400 kw.
74	...	...	1d. and ¾d.	...	...	...	....
75	...	...	Max. 1½d.	According to load factor, &c	...	...	Largest consumer, Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick Works.
76	Both		*	...	...	...	* Motive power—2⅛d. for 1st hour per day, 1⅛d. every subsequent hour, less 5 .
77	About 600	1,172	2d. and 1d acc. to quan.	On application	...	...	In negotiation for several large consumers.

"THE ELECTRICIAN" TABLES OF

No.	Supply Authority	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit.	Max. demand. Kw.
78	North Wales Power and Traction Co., Ltd.	G. K. Paton (Chief Elec. Eng.)	Slate quarries	500 3-phase	..	3,050 6/09	60	200	1,000
79	Norwich Corporation	F. M. Long	Boot and shoe, mustard, printing, breweries	...	220, 440	2,662 31/3/09	485	50	750 at station
80	Nottingham Corporation	H. Talbot	Lace, hosiery, tobacco, engineering, leather	...	200, 400 three-wire	3,820 31/3/09	954	60	...
81	Nuneaton Corporation	S. C. Gibson	Hat making, hosiery wool, cotton, elastic web, foundry, quarries and collieries	...	220, 440 three-wire	229 2/6/09	56	60	120
82	Partick Council	W. Sillery	Shipbuilding and engineering works	...	240, 480	2,569 15/1/09	249	60	1,915
83	Peterborough Corporation	J. C. Gill............	Engineering, brickworks, railway	...	200, 400	259 31/12/08	65	15	468
84	Reading Electric Supply Co.......	E. Rowley Hill ...	Printers, engineers and iron founders, saw-mills	200	200, 400	1,711 4/6/09	258	65	1,377
85	Redditch Urban District Council	Wm. J. Ferguson	Needle trade, fishing tackle, cycle factories	200	...	775 17/11/08	97	40	...
86	Rochdale Corporation	C. C. Atchison ...	Textile and engineering............	3,000 220	220, 440, 500	1,267 31/3/09	217	50	...
87	Rotherham Council............	E. Cross	Iron, steel and brass works	...	230 460	583 20/5/09	81	33	436
88	Salford Corporation	V. A. H. M'Cowen	Textile and engineering	200	220, 440 three-wire	9,766 31/3/09	955	300	...
89	Sheffield Corporation	S. E. Fedden	Steel and iron works, cutlery works, foundries, general engineering works	2,000 200	..	11,545 25/3/09	1,219	350 H.P.	6,667
90	Shoreditch orough Council.....	C. N. Russell	Printing, shoemaking, cabinet and furniture manufacture	...	240, 480 three-wire	3,900 31/12/08	800	...	...
91	Shrewsbury Corporation	C. M. Johnston ...	....	...	210 420	158 31/12/08	70	20	383
92	Smithfield Markets Electric Supply Co	Edgar Dowling ...	Cold storage.....	...	100 200	515 8/12/08	33	130	736
93	South Shields Corporation	J. H. Cawthra ...	Shipyards, docks and marine engineering works	110, 220	550	1,420	73	50	...
94	Stalybridge, Hyde, Mossley and Dunkinfield Electricity Board	Robert Blackmore	Textile, paper mill boiler works bleach works, engineering works, iron works	400 230	460 230	6,500	250	375	4,250
95	Stamford (Urban Electric Supply Co.	J. E. Edmundson	Brickworks, laundry, foundry, engineering works, flour mills, printing works, timber yard	..	240, 480 three-wire	532 8/6/09	...	35	...
96	St. Helens Corporation	E. M. Hollingsworth	Chemical, glass and bottle works	...	230, 460 three-wire	1,630 30/4/09	241	60	300
97	St. Marylebone Borough Council	F. A. Wilkinson	Printing, building, small workshops (various trades)	...	240 480	2,534 6/5/09	629	110	7,406 whole supply
98	Stockton-on-Tees Council	J. J. Smith.........	Shipbuilding, engineering and ironworks	...	230, 460 three-wire	986 31/3/09	123	50	..
99	Stoke-upon-Trent Corporation	P. J. S. Tiddeman	Potteries, engineering works......	None	240, 480 three-wire	825 30/4/09	75	60	387
100	Sunderland Corporation	A. S. Blackman...	Shipbuilding, marine engine and boiler makers, coal mining	5,000 220	220	10,887 9/6/09	725	110	4,032
101	Swansea Corporation...............	C. A. L. Prusmann	Metallurgical, coal exporting &c.	220, 440 three-wire	220, 440 three-wire	1,796 31/5/09	..	60	1,067
102	Uxbridge and District Electric Supply Co.	A. Randall Bell...	Flour mills, printing, engineering, brickmaking	200	..	426 4/12/08	49	60	320
103	Wakefield Corporation	H. A. Nevill ...	Engineering, woollens, coal, printing, laundries	200	..	1,264½	163	110	...
104	Walsall Corporation	A. S. Barnard ...	Saddlery, harness, leather, clothing, iron founders, tubes, brushes and rolling mills	..	105 210	634 31/5/09	141	35	..
105	Warrington Corporation	F. V. L. Mathias..	Wire mills, printers, saw mills, tanneries, engineers, corn mills, gas stove manufacturers, boilers, mineral water manufacturer &c.	380 3-phse. 50 periods	460	5,000	...	215	...
106	West Bromwich Corporation .	W. A. Jackson ...	Spring works, steel rolls, hollow ware foundries, edge tools, tubes, school furniture, corn mills, wire nails	...	230, 460	1,212 30/4/09	142	110	About 350 (motors only)
107	West Ham	A. Hugh Seabrook	Chemical, engineering, flour mills, ink mills	100,200,400	500,200,100	6,512 kw. 31/3/09	833	115	...
108	West Hartlepool County Boro'..	H. F. Friederichs	Blast furnaces, steel wks., ship yds., engine wks., paper mill, saw-mills and joinery wks	...	230, 460 three-wire	1,756 31/3/09	211	120	500
109	Whitby (Yorks) District ouncil	L. H. King	Fishing	...	460	175	32	18	400
110	Whitehaven Corporation	B. Sankey	Tannery, flour mill, printing and machinery works, &c.	...	420, 210 three-wire	136 31/12/08	31	20	234
111	Wigan Corporation	Jas. Slevin	Coal mining, cotton mills, engineering works	.	230, 460 three-wire	1,614 31/11/08	220	50	921
112	Windsor Electrical Installation Co.	A. E. Farrow......	Brewing	220	220	231	76	12·5	55
113	Wolverhampton Corporation ...	C. E. C. Shawfield	Ironwork, edge tool works, corn mills, paint works, cycle and motor works, saw-mills, &c.	6,000, 400	440, 220 three-wire	3,388 31/3/09	330	100	...
114	Worcester Corporation	C. M. Shaw . ..	Porcelain, glove, leather, flour, engineering, various, buttons, confectionery, printing, horse-hair cloth, &c., works	100, 200	230, 460 500	825 31/3/09	146	2 40's	954
115	York Corporation	J. W. Hame	Confectionery, printing, railway works, flour mills	...	230, 460 three-wire	1,117 30/4/09	217	35	960
116	Yorkshire Electric Power Co,	W. B. Woodhouse	Textile mills, iron works, collieries, calcium carbide factory	2,000, 400	500	13,000 25/5/09	350	140	3,400

LECTRIC POWER SUPPLY.—*Continued.*

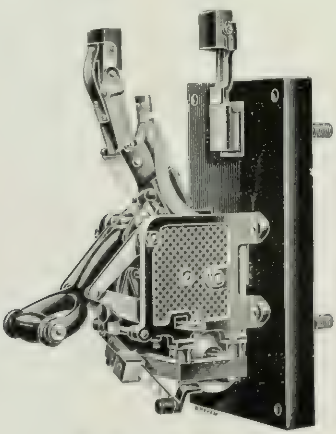
	Method of Driving.		Rates.		Approx. H.P. of other power displaced by electric motors	Isolated Plants at present Operating. g—Gas. sg—Suction Gas. s—Steam.	Remarks. (NOTE.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
	Group. H.P.	Indiv. H.P.	Per unit.	Bulk supply.		H.P.	
	575	2,475	1½d.—⅞d. and under sliding scale	...	3,050	...	Slate quarry load mostly winding, pumping, air compressor and mills. Transmission at 10,000 volts three-phase, all overhead, bare wire. 10 000 and 20,000 volt transmission
	...	...	2d. to ¾d.	...	...	...	A 150 B.H.P. motor-driving sewage pump will shortly be installed.
	...	...	1¼d.	...	...	...	....
	...	196	2½d to 1d. on sliding scale	On application	...	50sg, 100s, 20 oil	....
2	...	...	1d. flat rate	...	...	...	....
3	...	...	1½d. flat.	...	..	...	Quarterly accounts
4	About 1,400	300	1½d. flat	...	400	50g, 125sg	....
5	...	...	2d. to 1d. sliding scale.	...	...	...	....
6	Practically all group driven.	...	2d. to 1d sliding scale*	On application	St'm 705 Gas 122	333g, 20sg, 190s	Isolated plants on present route of mains (approximate only). *Special terms for special conditions.
7	...	...	1½d. and 1d.	On application	458	...	....
8	...	...	*	...	...	...	* Flat rate.—1½d. first 1,000 units per qr., 1d. a'l in excess. Fixed charge system £1 per qr. per E.H.P. demanded and ⅓d. per unit consumed
9	...	...	Lht 4d., Heat 1d., Power 2d. to [illegible]d.	...	15,000	...	Great expansion of use of power supply in rolling mills and cutlery works.
90	...	...	¾d.*	...	...	..	* Plus £3 per E.H.P. demanded.
91	...	...	*6d., 4d. & 2d. or flat 5d.	...	...	...	* Power—3d., 2d. and 1½d., 5 and 10 per cent. discount.
92	...	...	1½d. and 1d.	...	...	...	....
93	Both		1½d. 1st 5,000 per qr. 1d. after	...	...	...	Also traction supply.
94	...	..	2½d.—·45d.	On application	2,000	300g, 1,700s.	....
95	...	...	2½d. flat, 4d. and 1d. M.D.	On application	..	...	....
96	...	...	2d. and 1d. with disc'nts	...	1,000	100sg	....
97	...	...	2d. and 1d. M.D.	...	220 since Aug., 1905	703g, 10sg, 1,109s 160 oil	....
98	...	..	Sliding scale 2d. down to 1¼d	On application	...	...	One works take about 250,000 units per annum, and the total amount sold per annum for power purposes amounted to 371,738 units.
99	Both		1½d. to 0·8d.	...	...	...	The potteries all require steam for heating, and this is generally the drawback to electric driving.
100	...	...	2½d. (dis. to 2d.) ½d. & 1¼d. M.D.	On application	..	...	A large flour mill owned by E. C. Robson & Sons, Ltd., at present being converted to electric driving.
101	...	...	2d. (1st hr.) & 1½d. M.D.*	...	...	...	Motor hiring scheme in operation. * 200,000 per annum and over special rates.
102	300	126	2½ to 1½ flat or 3 & ¾ M.D.	...	...	50g, 1,200sg, 500s	....
103	...	...	2d. to 1d.	...	623	...	....
104	257	377	(See remarks)	On application	...	...	2d. up to 100, 1¾d. up to 200, 1½d. up to 500, 1¼d. over 500; 10 per cent. discount for over 10,000 per annum, 12½ per cent. discount for over 15,000 per annum.
105	...	...	0·6d. to 2d. according to conditions	...	7,000	...	....
106	About 600	About 642	1½d. to ¾d.	..	About 700	...	76 motors on hire = 492 H.P. Application in hand for 65 H.P.
107	Partly both		1d. max.	On application	4,520 kw.	...	....
108	100	1,600	2d.—1½d. flat with disc.	1d.—¾d	1,650	510g, 230sg, 5,375s	....
109	115	60	£5 per kw. per an. at 1d. unit	...	...	...	....
110	...	...	1½d and 4½d. or 2 rate, 2d. for small motors	...	...	...	....
111	564	About 1,050	Up to 1,000 units per annum 2d., over 1,000 1d.		300	...	....
112	...	...	£3 per H.P. installed per ann. and 1d. per unit	None	...	...	....
113	...	...	1d.	Various	...	...	....
114	572	253	2½d. & 1d. M.D. ¾d. sewerage P. 1d. & 1¾d. restricted hour	...	900	200g, 450sg 1,889s	Power load arisen during last three years.
115	...	...	1¼ downwards	On application	...	..	....
116	...	...	Sliding scale	...	...	...	....

"General Electric" Progress.

SINCE last we had occasion to refer to the productions of the General Electric Co., it would seem that they have been steadily making improvements, which make still more for reliability and excellence of quality in their particular types of apparatus.

Sumpner Portable Combined Wattmeter and Voltmeter.

The recent twelfth edition of the instrument catalogue has found much favour, and of the various types of instruments shown therein the Sumpner wattmeter seems worthy of special mention. It is made in two types, switchboard and portable, the latter being a combined standard wattmeter and voltmeter. It is interesting to note that these instruments are doing good service in the test rooms of many central stations.

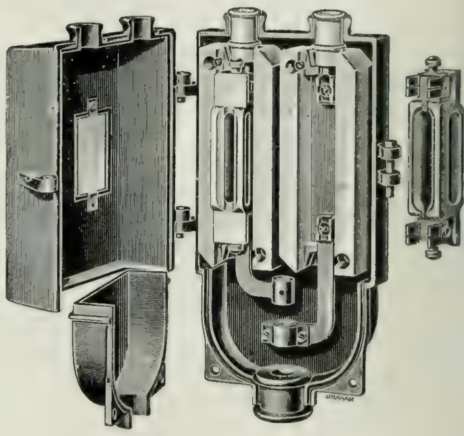


The "Record" Circuit-breaker.

Amongst the circuit-breakers made by this company a new type, the "Record," has been designed to take the place of the well-known "Edgewise" pattern of current capacity of 200 to 2,500 amperes. The principal improvement in this circuit-breaker is that it can be used with either direct or alternating current, whereas the "Edgewise" type was only suitable for direct current. The smaller types of circuit-breaker, namely "Dwarf," carrying 2 to 25 amperes, and the "Junior," carrying 30 to 400, are still in favour, and seem to be very much in demand.

While dealing briefly with the circuit-breakers made by the General Electric Co., passing reference to their various patterns of quick make-and-break switches might be made. The name "Peel" has now become well-known, and the Peel switches form a series which for ample and practical construction, combined with excellent finish, are all that can be desired in a "knife" switch. Here, again, every likely demand is catered for, as "Peel" switches are made either "single-pole" or "double-pole," and both in the change-over type.

Turning to the varied series of cut-outs made by this company, as the majority are already well known, reference to the latest type need only be made. In their new cut-out which has lately been designed, very careful attention is paid to the matter of insulation, a feature which,



D.P. Single Box Cut-out.

unfortunately, does not always receive the amount of care necessary in a first-class article. This cut-out is designed for "House Service" work, the two poles being contained in a single box, which is made suitable for either twin or concentric service. The interior is fitted with single-pole porcelain cut-outs mounted side by side with detachable fuse holders, as shown in the illustration. These few short descriptions give an idea of the "progressiveness" of this company, which keeps them well to the forefront as makers of electrical apparatus of every description.

Evershed's Instruments.

AN important part of every electrical installation for power purposes worthy the name is its various recording and indicating instruments. Not only do these allow the actual energy consumed over a period of time to be ascertained, but it is also possible thereby to check the proper working of the apparatus. To do this with accuracy is of course essential; and strength and attention to detail in manufacture are very necessary features of the recording instruments. These desiderata are certainly to be found in the instruments turned out by Messrs. Evershed

& Vignoles, of London, whose wide experience in this class of work gives them a right to consideration in regard to any order intended to be given out for electricity measurement instruments.

In certain classes of work, especially in installations where a large number of motors are installed, the portable instrument is a very useful piece of apparatus. Portable

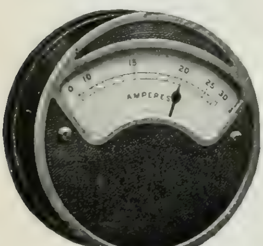


Fig. 1 —Moving Iron Ammeter. Fig. 2.—Moving Coil Ammeter.

instruments made by Messrs. Evershed & Vignoles include cell testers and moving coil ammeters and voltmeters for general continuous-current measurements on circuits whose voltage does not exceed 1,000 volts and where the current is not more than 1,000 amperes. Moving iron instruments designed for the measurement of either continuous or alternating currents are also made. Three types of the moving coil voltmeters manufactured by Messrs. Evershed & Vignoles are turned out, each suitable for use over six ranges of voltage. In one of these the maximum voltage readable is 130 volts and in another 1,040 volts; the third type is arranged for six ranges in accordance with individual requirements. These instruments are by now so well known that further description is needless, but attention may be drawn to the neat self-contained switch which alters the sensibility. The moving coil ammeters are very similar to the voltmeters, but are of course used in combination with suitable shunts and are not fitted with a sliding switch for adjusting the ranges; an alteration in the shunt employed being alone necessary in this case. A very useful instrument of this class is the well-known Evershed portable combined ammeter and voltmeter recently redesigned and improved.

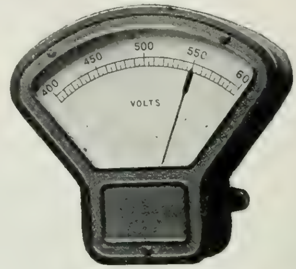


Fig. 3.—Sector Type Voltmeter.

A typical portable moving iron instrument is shown in Fig. 1. It is a three-range ammeter, and, like all of its class, can be used on either alternating or continuous-current circuits. It is compact, its overall dimensions being only 11 in. by $8\frac{3}{4}$ in. by $3\frac{3}{4}$ in. and the weight is the not excessive one of 7 lb. The instrument as shown is provided with two scales, and can be arranged to indicate, according to the type, from 0 to 6, 5 to 20 and 10 to 60 amperes; or 0 to 10, 5 to 30 and 10 to 100 amperes. A long range is thus secured without the additional weight and cost of transformers and the instrument can be used for continuous or alternating current.

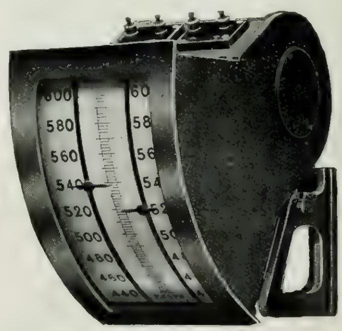


Fig. 4.—Synchronising Voltmeter. Double Scale.

Switchboard instruments of various shapes and sizes and of both the moving coil and moving iron types are another Evershed speciality. We illustrate a moving coil round type ammeter of this class in Fig. 2, and a sector type voltmeter in Fig. 3. It is claimed for the moving coil type of instrument that it is made with such a strong magnetic field that it is practically free from external disturbance, a disadvantage often present in this class of instrument, and that it is extremely dead beat. The moving iron instruments are fitted with cast-iron cases to prevent external interference. The round pattern instru-

ments are made in two sizes with scale lengths of 5 in. and 7 in. respectively; the scale radius is either $3\frac{1}{2}$ in. or 5 in., and the overall diameter $7\frac{5}{8}$ in. or $9\frac{5}{8}$ in. The sector pattern instruments are made in three sizes, their diameters being 9 in., $12\frac{1}{2}$ in. and 20 in. respectively; edgewise instruments similar in all but external characteristics to the other types of instrument described are also made.

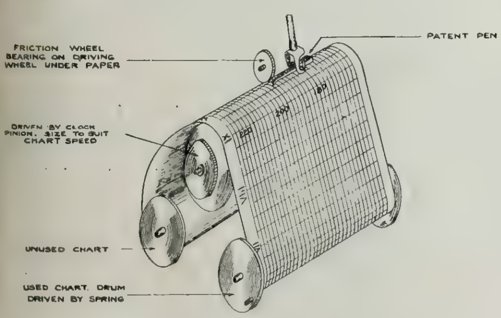


Fig. 5.—Chart on Evershed Recording Instruments.

An interesting instrument is that shown in Fig. 4. It is an edgewise duplex paralleling voltmeter which is made in either the moving iron and moving coil type. It possesses all the essential features of the Evershed instruments and the bold way in which the figures are placed on the scale should prove a great boon to those who have to use it.

For recording purposes, Messrs. Evershed & Vignoles supply an instrument which is certainly of novel design. Its mechanism is of the simplest and strongest construction and there are no delicate parts. The system of moving the chart, which is of the continuous roll type, lasting over a month, will be understood from Fig. 5. The paper driving axle carries at its centre a wheel having a milled edge, against which the paper is pressed by a spring friction wheel seen near the pen. The paper is consequently driven forward with perfect uniformity, and no irregularities can occur even at high speeds. The normal speed is 1 in. per hour. Other speeds, such as 2 in. and 6 in. per hour, can also be arranged. The pen is quite novel. It resembles somewhat a drawing pen held nearly horizontally, and it is carried on knife edges in a stirrup at the extremity of the hand. The motion of the latter being at right angles to that of the paper, the pen has to mark equally well in either direction, which it does perfectly. A study of a record will show that it results from this arrangement that the co-ordinates of the chart are *rectangular* instead of curved as usual, which makes the record easy to read.

It is claimed for this form of pen that it is very strong and will work for months without any attention other than that necessary for cleaning, an operation performed in a moment with great facility. The clock is of the eight-day type, and a spring escapement is used. This instrument can be of either the moving coil or moving iron type, according as continuous or alternating current is employed.

The new series of catalogues, published within the last few weeks, contains matter of interest to all electrical engineers. Readers should send for the new lists, which are very well got up, and we notice that the prices are fixed at a comparative level.

Ferranti Switchgear on Shipboard. . .

IN recent years considerable activity has been shown in the development of switchgear for marine and Admiralty purposes, and the well-known firm of Ferranti Limited is to the fore in this as in other branches, with their standard lines of apparatus as well as with specialities.

The new features introduced by the above-mentioned firm in the switchgear supplied for the Cunard turbo-steamship "Mauretania" are well worthy of special note, and will be of interest to members of the Municipal Electrical Association, owing to the visit which they paid to this mammoth on Wednesday last. The switchboard (Fig. 1) is in duplicate, the two halves being coupled by cables which pass through a dividing bulkhead in watertight glands. Each half consists of two generators and 12 feeder panels, all circuits being controlled at the main switchboard by automatic circuit-breakers. The circuit-breaking devices are of a particularly simple and mechanical design, and are characterised by an entire absence of complication. In spite of this they embody a time element overload reverse and other features which are, it is claimed, only obtained in other makes of circuit-breakers at the expense of very great complexity of the various parts. The time limit overload or reverse action is here obtained by entirely independent relays of the well-known Ferranti type, but modified to suit the conditions met with at sea. In case of emergency the relays can at a few moments' notice be put out of action, and the circuit-breakers can be used as ordinary non-automatic carbon break switches. Again, should a relay become damaged it can readily be removed and replaced without casting adrift heavy cables or disturbing the circuit interrupting devices. Such points have a great bearing on the question of continuity of supply—a matter of paramount importance in marine work.

A novel feature introduced by the makers is to be found in the main generator circuit-breakers, which are designed to carry 5,000 amperes, and which are placed as high up in the panel as possible while the operating lever is at the most convenient level for manipulation. The relays connected to these breakers are of the combined time limit overload and reverse type, adjustable both as regards time limit and operating current. The feeder circuit-breakers (Fig. 2) are equipped with double trip coils—viz., a series and a shunt solenoid. The series is set high, so as to come into operation only when the overload is practically a short circuit. In such cases the action of the circuit-breaker is instantaneous, and the tripping is independent of the 'bus bar voltage. The shunt solenoid is arranged in combination with a time limit overload relay, and is intended to provide an "inverse" time element for all ordinary overloads. This combinition is a speciality introduced by Messrs. Ferranti, and there is much to be said in its favour.

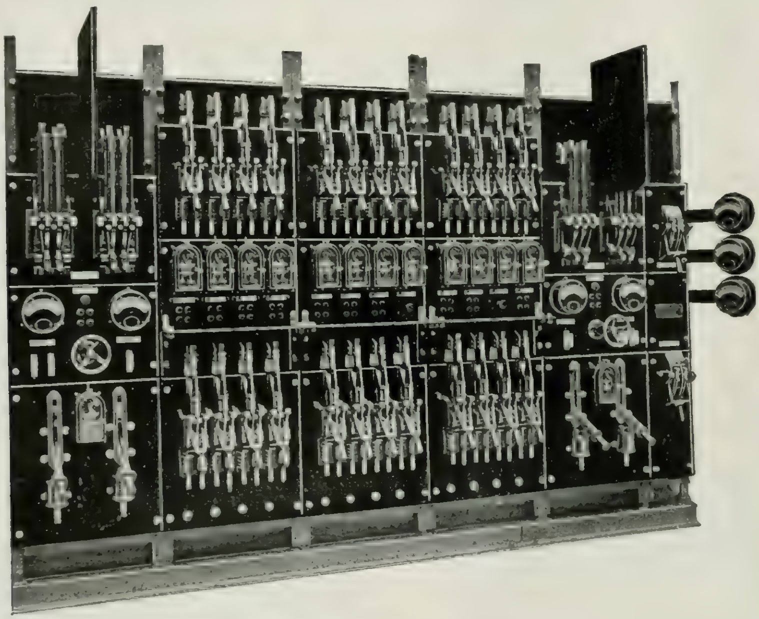


Fig. 1.—Ferranti Switchboard on the "Mauretania."

We understand that the circuit-breakers for this board were tested by the makers by being mounted on a vertical panel secured to a light springless trolley which was wheeled rapidly over the very uneven cobblestones in the makers' yard. It was found that there was no tendency for the breakers to be released under the heavy vibration thus transmitted to it, but that they instantly responded to the normal energisation of the trip coils. It was, therefore, safe to assume that the breakers would satisfactorily withstand any vibration to which they might be subjected at sea without operating incorrectly.

In contrast to the gear supplied for the Cunarder, the switchboard (Fig. 3) built by the same makers for the ss. "Orsova" is devoid of circuit-breakers. This switchboard is designed for four generators and 32 feeders. There are four sets of 'bus bars, and any generator or feeder can be connected to any 'bus bar by means of an ingenious and simple change over device interlocked with the main quick

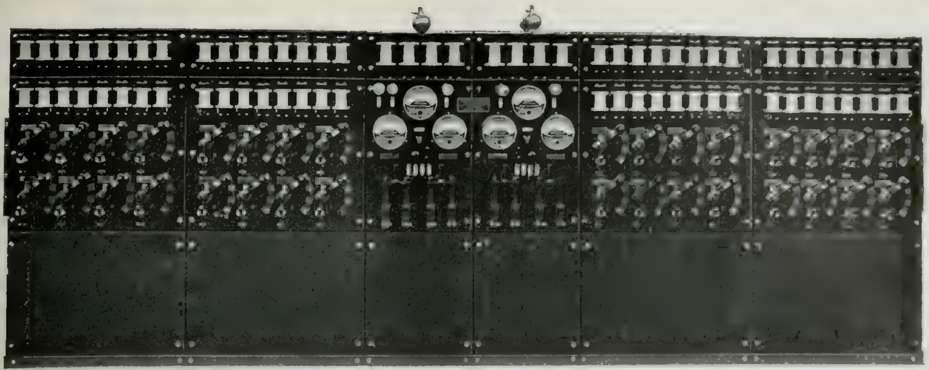


Fig. 3.—Ferranti Switchboard on the "Orsova."

break switch. The interlocking is arranged so that the change over switch cannot be moved so long as the main switch is closed. The circuit protection is afforded by switch fuses (Fig. 4) of the Ferranti pattern as will be seen from the illustration.

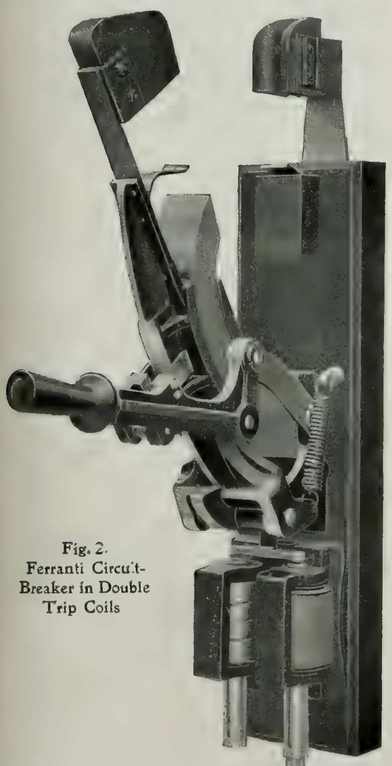


Fig. 2. Ferranti Circuit-Breaker in Double Trip Coils

We regret that we are unable to reproduce a view of the back of this board to illustrate the clever design by which all connections are immediately accessible, all crossings or confusion avoided and the four separate 'bus bars in the form of copper tubes are carried from the contacts on the face of the board to which they are connected. The back of the board appears as it should do, like a diagram of connections drawn out in the most straightforward form.

Another speciality of Messrs. Ferranti is the colliery switchboard designed for placing in a fiery mine. The switches are three-phase 500 volt automatic breakers of the oil type, being designed for currents of from 1,500 to 300 amperes per phase. The ammeters and trip coils are supplied with low-tension current from transformers so as to avoid all possibility of any sparking however small unless under oil. The lamp and other fittings are in gastight enclosures, and the whole is ironclad from top to bottom and supplied with a strong sloping roof designed to protect the gear from dripping water and falling masses. All sweating sockets have been avoided, suitable clamps of ample contact area being employed. Access is obtained to the back of the board by means of the iron doors at each end, so that everything is very get-at-able.

A demand has arisen of late for ironclad high-tension switchgear occupying a small amount of space. The room taken by an automatic switch, trip coils, current transformers, ammeter and connections of the ordinary type

Fig. 4.—Ferranti Switch Fuse.

must necessarily be somewhat large. If crowded up, a very grave danger is at once introduced. Some makers are putting forward high-tension trip coils to render the gear more compact and incidentally cheaper. There are obvious and grave objections to high-tension trip coils which need not be enlarged upon. It will be at once admitted that the ideal arrangement is to bring the insulated leads direct to the sockets on the top of the switch main insulators, and to have all other live switch portions as simple and mechanical as possible and under oil.

Electrically-driven Vacuum Cleaners.

UNDOUBTEDLY the best method of removing all dust and dirt is by means of a vacuum cleaner, as the dust, instead of being merely stirred up into the surrounding atmosphere is entirely removed, the result

Fig. 1.—Removing Liquid by Means of Siemens Vacuum Cleaner.

being not only clean furniture, carpets, hangings and so on, but a pure and healthy atmosphere. This method has the further advantage that it does not damage the furniture or upholstery, as is unavoidable in the long run where ordinary dusters or brushes are used.

Siemens electrically-driven vacuum cleaners are of substantial design, requiring very little attention, and are being installed in ever-increasing numbers in private houses, theatres, hotels, hospitals, churches, lecture halls, public libraries, &c., for cleaning furniture, upholstery, carpets, hangings, book shelves and stage scenery. They are also largely used for removing dust from motor cars, carriages,

Fig. 2.—Cleaning Carpet in Private House with Siemens 1 H.P. Portable Vacuum Cleaner.

tramcars, railway carriages, ships' cabins and so on, and are invaluable in warehouses and industrial works where large quantities of dust are produced, such as in saw mills, printing works, dye works, weaving sheds, cloth, paper and tobacco factories.

A special advantage possessed by the Siemens vacuum cleaners is that they can be employed to remove small quantities of liquid, provided it is fairly clean (*see* Fig. 1); thus floors may be quickly dried after washing. This property is also valuable in the case of ships and yachts for removing

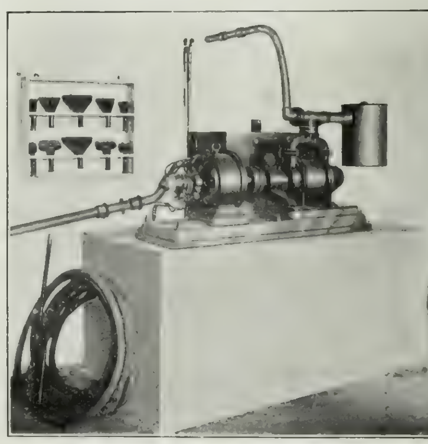


Fig. 3.—Stationary Vacuum.

any sea water which may have found its way into the cabins. The vacuum cleaners are made in three sizes, driven by a 1, 2 or 5 H.P. motor respectively. The 1 H.P.

and 5 H.P. sizes can be supplied either as stationary or portable vacuum cleaners, but the 2 H.P. size is at present only made in the stationary type. A portable vacuum cleaner is shown in Fig. 2.

A complete vacuum cleaner, as illustrated in Fig. 3, consists essentially of an electrically-driven vacuum pump, which is connected by a suitable pipe or a hose to the nozzle-holder with a nozzle, which is held by the operator and slowly moved over the furniture, &c., to be cleaned. The nozzles are made in various shapes and sizes suitable for different purposes and kinds of material. They are also supplied with cloth edging for cleaning delicate goods, or combined with brushes for loosening the dust or dirt. The dust, which is drawn in through the nozzle, passes through the hose to the vacuum pump. The latter is of the rotary type and of a very simple and substantial design. It consists of a spindle carrying vanes which rotate inside a casing containing water. Before the pump is set to work it is filled with water. When the pump is working, the centrifugal force acting on the water causes it to form a layer on the inner surface of the pump chamber, thus ensuring a very efficient airtight seal. The dust-laden air entering the pump comes into intimate contact with the water, which is constantly renewed during working. No filter of any kind is necessary. Any large particles sucked into the nozzle are carried into an intercepting box, which is periodically cleaned out. The outgoing dirty water is emptied into the drains, if this is possible, otherwise into a portable tank. In the case of stationary pumps, the water for replenishing may be taken from the water mains; in the case of portable vacuum cleaners the make-up water is obtained from a small tank which is supplied with the set. The clean water required for replenishing purposes is from 22 to 26 gallons per hour for the 1 H.P. size, 44 gallons for the 2 H.P. size and 65 to 80 gallons for the 5 H.P. size. Where a stationary plant is employed a permanent system of piping may be installed having branches at convenient places for attaching the flexible hose with nozzle. The nozzle-holder, nozzle and hose are provided with well-fitting conical plug and socket connection pieces, an airtight joint being obtained by simply pushing corresponding parts together. By using a two-way socket piece, two lengths of hose may be connected to the 5 H.P. size pump, and two nozzles employed at the same time for cleaning. A settling box is fixed at the bottom of the permanent vertical piping to prevent the passage of any substance (such as string or rag) liable to damage the pump. An inspection glass may be placed at some convenient point in the hose, through which the dust-laden current of air may be observed, to indicate whether the installation is working satisfactorily.

The "Ordnance" Time Limit Device for Circuit-Breakers.

ON many circuits liable to frequent momentary overloads it is desirable to introduce a time element before the circuit-breaker strip, thus obtaining the necessary continuity of service, without endangering the safety of the plant.

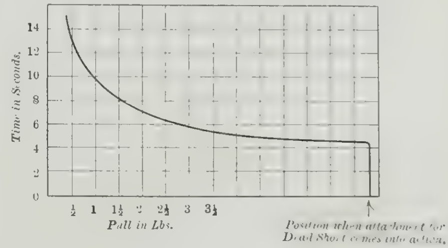


Fig. 1.—Characteristic Curve of "Ordnance" Time Limit Device.

The "Ordnance" time limit device, which is manufactured by the Electric & Ordnance Accessories Co., of Birmingham, consists essentially of a partially toothed quadrant gearing with an escapement, which allows the quadrant to move only at a certain speed, until it becomes

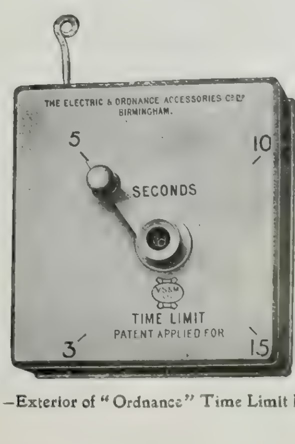


Fig. 2.—Exterior of "Ordnance" Time Limit Device.

disengaged, so releasing the breaker, or until the load becomes normal again. The time element is practically constant for any pull, as can be seen by reference to the

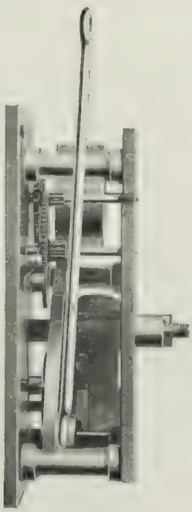


Fig. 3.—Partial Interior view of "Ordnance" Time Limit Device.

characteristic curve (Fig. 1). Should it be desirable, however, to release the breaker instantaneously by a dead short-circuit, the device can be fitted with an attachment to effect this. This latter arrangement does not, of course, operate on ordinary overloads, the required time lag being introduced before the circuit-breaker is released.

The general exterior appearance of the instrument is shown in Fig. 2, while Fig. 3 partially shows the interior. Fig. 4 is a "Cee Bee" circuit-breaker (2,500 ampere) fitted with one of these time limits. It will be seen by reference to Fig. 1 that the device is calibrated for four time lags, this being a feature unobtainable in any other time limit device at so low a price as the "Ordnance." This is an

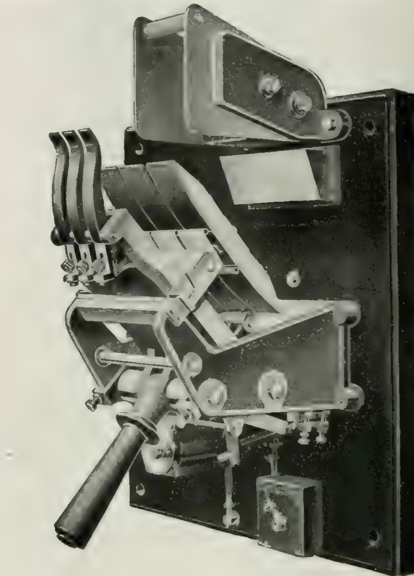


Fig. 4.—"Cee Bee" Circuit-Breaker.

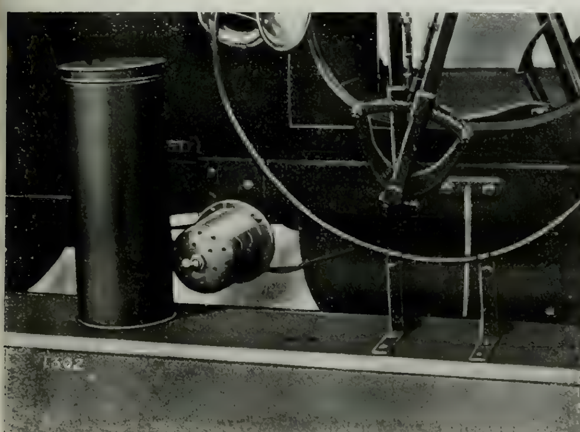
important feature, as it enables the user to choose any time limit the conditions of service may require at the time, and to alter it when he deems it advisable, without reference to the manufacturers. The instrument, of course, can be calibrated for any other periods than those shown in the illustration. It is claimed for the instrument that it is extremely simple, compact and reliable, and that it will always operate after the same interval of time to within a small percentage.

Excess Speed Alarms of Motor Vehicles. . . .

THE motorist being a person who is rather apt to underrate than overrate the speed of his car, it has been decreed that all public service vehicles in the metropolitan area shall be fitted with a device giving an audible indication whenever the legal limit of speed is exceeded. In order to enable proprietors of public service vehicles to comply with this regulation, an instrument has been designed by Mr. Leslie H. Hounsfield, and the manufacture of it has been entrusted to Messrs. Crompton & Co.

The device consists of a gong or bell mounted on some part of the car where the noise which it makes can be heard both by the driver and by persons passing. Inside the bell

is a spindle running in ball bearings and driven in such a way that the speed of this spindle always bears a definite relation to the speed of the car. Mounted on the spindle is a lever, pivoted so as to fly outwards when the car accelerates, but restrained by a spiral spring the tension of which can be adjusted. This pivoted lever is provided with a hammer which strikes projections on the bell and causes



Motor Cab showing Alarm fitted.

it to give an audible and continuous indication when the car attains a speed above the limit laid down in the regulations. Special arrangements have been introduced to prevent intermittent action or hunting when near the speed limit, and to ensure a definite setting, so that the alarm can be relied upon to give warning immediately the car attains the speed limit provided for in the regulations and cease to do so when the speed falls below the limit.

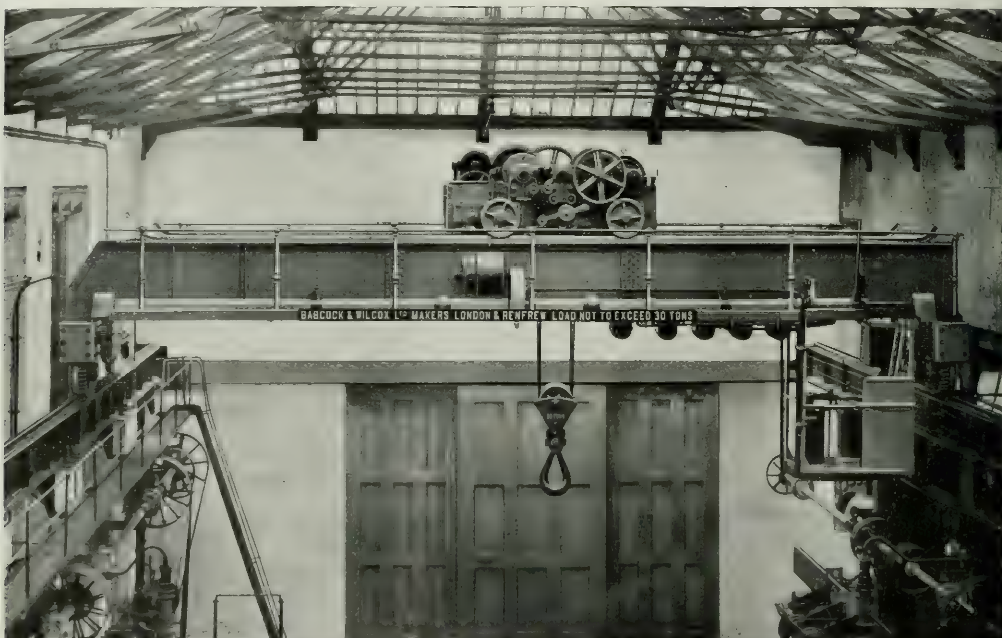
The instrument is capable of adjustment so that it can be set to suit any speed of engine and size of wheel, and any speed limit which may be necessary, and when once adjusted it can be sealed by the authorities, after which its adjustments cannot possibly be interfered with without breaking the seal.

The instrument requires a simple transmission gear to communicate driving power from the cardan shaft or other part of the car. This will generally take the form of a pair of bevelled wheels, a short shaft and a universal joint, but a flexible shaft may in some cases be more suitable. One of these alarms has been fitted to a motor-driven cab, as shown in our illustration, and submitted for approval to the police authorities, who have expressed themselves as being satisfied that it fulfils the required conditions. A reliable device of this description will doubtless fill a long-felt want in materially checking reckless driving.

Babcock's Cranes.

Messrs. Babcock & Wilcox (Ltd.), of Oriel House, Farringdon-street, London, E.C., the well-known firm of water-tube boiler makers, some three or four years ago acquired the old-established firm of Wimshurst, Hollick & Co. (Ltd.), manufacturers of all types of electrically-operated cranes, and in order to obtain the best results have built and equipped at their Renfrew works, in Scotland, large modern shops for the exclusive manufacture of cranes of all types and descriptions operated by electricity.

Among the recent installations which they have carried out is the supply of a large overhead travelling crane for the Dunston power station of the Newcastle-upon-Tyne Electric Supply Co. (Ltd.) This crane has a span of approximately 62 ft., and a lifting capacity of 40 tons at 5 ft. per minute, and is fitted with an auxiliary hoist capable of handling 5 tons at a speed of 40 ft. per minute. They have also supplied to the same station two electrically operated ash hoists, which elevate and tip the trucks containing the ashes automatically.



One 30-ton Electric Overhead Travelling Crane, span 36 ft. Supplied to the British Admiralty for H.M. Dockyard, Devonport.

Messrs. Babcock & Wilcox (Ltd.) have also supplied to the British Admiralty for Devonport Dockyard at various periods 17 overhead travelling cranes, ranging from 2 tons to 40 tons capacity, and in addition have converted a large number of hand-operated jib cranes into electrically operated cranes. The overhead travellers were tested to

a 50 per cent. overload. The type of crane is illustrated in the accompanying figure. Amongst recent orders, Messrs. Babcock & Wilcox (Ltd.) have also received one from the Great Western Railway Co. for the supply of three special cranes for use in the goods sheds which have just been erected at Newtown, Cardiff. These cranes are a combination of a jib crane and an overhead traveller, and are designed so that they are capable of slewing in a complete circle, to enable goods being handled on any part of the goods shed floor with ease and facility. They are each capable of lifting 1 ton at a jib radius of 13 ft. and 18 ft. respectively, the spans of the overhead travelling girders being 59 ft. 4 in. and 47 ft. respectively.

The Auckland Harbour Board recently called for tenders for 12 large jib cranes on high under-carriages, and Messrs. Babcock & Wilcox (Ltd.) were successful in obtaining the order for the complete equipment. This consists of 12 cranes, 10 of which are capable of handling 5 tons at a radius of approximately 44 ft., one crane capable of handling loads of 5 tons at a radius of 34 ft., and one capable of handling 3 tons at a radius of 34 ft. They are a very special design, owing to the fact that the under-carriage is of an exceptional height, the distance from the level of the quay to the top of the under-carriage—on 10 of the cranes being 36 ft. and on two of the cranes 24 ft.

As Messrs. Babcock & Wilcox (Ltd.) are not themselves manufacturers of the electrical portion of the cranes, they are in a position to offer clients electrical equipment manufactured by any firm that may be called for. The following are a few of the more recent orders which have been placed with Messrs. Babcock & Wilcox (Ltd.): The Metropolitan Water Board, General Post Office, Agents-General for the Cape of Good Hope and New South Wales, the Inter-Colonial Railway of Canada, Great Cobar (Ltd.), Electrolytic Refining & Smelting Co. of Australia (Ltd.), and many other clients.

Economy!

THE technical journalist at the present time gets rather tired of saying that this is an age of economy; but feels obliged to make this remark before calling attention to any method whereby a saving in cost, energy or labour—the first, of cost, being the greatest—can be effected. We will, therefore, make an exception in this case, and, "cutting the cackle," at once call the attention of our readers to an arrangement whereby, it is claimed, great economy in steam consumption can be effected. This is Wolf's locomobile. Though our policy would not be to recommend its use in those parts of the country where a public electricity supply is available, it should, and is, finding a wide application in out-of-the-way places for driving dynamos, and thus supplying workshop plant. This machine, as will be seen from a description, is essentially engine and boiler combined. Steam piping—a great cause of loss—is, therefore, at once done away with, and saving in floor space is also effected. The steam is further superheated, a feature in this plant which in no small way adds to the economy of steam consumption. Apart from the fact that with the Wolf plant we have much power in little space, the "one man one plant" principle can be practised to the full, as when the "washing out" process is necessary, the ample clearances allowed in fire tubes, &c. make this a simple matter. Such a plant is very nearly ideal for a small station, as each unit is self-contained, and the whole equipment can be kept under the thumb of one man.

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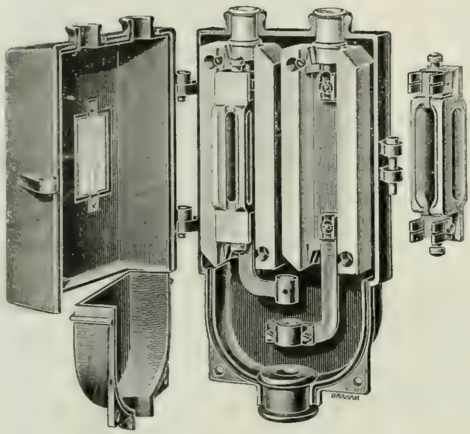

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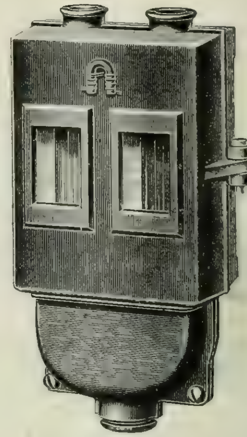

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NOTES.

Small Candle power 200-volt Metal Lamps.

We are reminded of the warning uttered by one speaker at the I.M.E.A. Convention last week, that many central stations have not yet felt the full effect of the introduction of metal lamps, by the arrival of a 16 c.p. 210 volt 25 watt "Leuconium" lamp. The credit for this new departure belongs to the Stearn Electric Lamp Co., and at the present time we have on trial, in the offices of The Electrician, a Stearn lamp of the above-mentioned candle-power, whilst we understand that Mr. Stearn himself is testing 200 volt lamps of a candle-power so low as 12 and of similar efficiency. There is little doubt that the advent of these lamps will provide considerable food for reflection on the part of the engineers of continuous-current supply undertakings, the consumers supplied from continuous-current circuits having hitherto maintained, to a considerable extent, their consumption of energy whilst obtaining a much increased amount of light, because a low candle-power metal lamp for high pressures was not obtainable. To maintain the output is certainly a desirable policy, but the fact must not be overlooked that there are many places, such as halls, passages, cellars, &c., where a 16 c.p., or even an 8 c.p., lamp provides sufficient illumination, and when lamps in such positions burn for many hours daily, considerable economy is possible by the use of metal filaments. Nevertheless, we think that the majority of lamps installed by consumers, except by the truly economical, will, in future, be of greater candle-power than 16, since the present tendency is for increased illumination.

The small candle-power of the new Stearn lamp, which is, of course, of English manufacture, is rendered possible by an improved, and at present secret, method of treating the filament after drawing. The filament. which consists largely of tungsten, is arranged in the 16 c.p. lamp in nine loops, its total length being about 40 in., whilst the efficiency of the lamp is from 1·5 to 1·6 watts per *English* candle. We are pleased to see that the English standard has been adopted, in spite of the fact that the efficiency appears less satisfactory than if the lamp had been marked in Hefner units; but what we consider a more important feature of the lamp is that a bulb of similar shape and approximately the same size as the customary carbon filament lamp has been adopted. This results in the filaments being to some extent screened from view when the lamps replace those with carbon filaments, for which latter type the majority of shades now in use have been designed. Where attention is not paid to this point the effect on the eye may be harmful. Since the manufacture of the new lamps has only just begun, sufficient time has not yet elapsed to obtain any particulars as to life tests, but the filaments are said to be mechanically strong and to stand a large amount of vibration, so that the enterprise of the Stearn Electric Lamp Co. will doubtless gain its reward.

Cable Rates.

The question of reduced rates for Empire newspaper telegrams was discussed at the meeting of the Press Conference on Friday last, and a full report of the proceedings will be found on another page of this issue. Although we can sympathise with this desire for lower charges, if they can be brought about justly, it was not inspiriting to watch our Empire Editors grappling with a subject on which their knowledge was obviously inadequate. One of the impressions conveyed by the discussion was that the Editors would not greatly relish Government control in

international telegraphy, and primarily would rather that a way were found which would enable reductions in cable rates to be made without destroying existing rights and property. By way of bringing pressure to bear upon existing organisations, the cue seems to be to represent cables as on the eve of supersession by wireless telegraphy. But, notwithstanding that Mr. MARCONI is to be congratulated upon the steady and marked progress he is making scientifically and in ship-to-ship and ship-to-shore working (leaving the question of shore-to-shore out of consideration), much remains to be done before the many and complicated scientific, telegraphic and commercial problems involved in long-distance radio-telegraphy are solved. We see no reason to change our view that wireless and cable communication will each fulfil its own function in the development of our means of communication. Everything is relative, however, and events move with extraordinary rapidity. There never was a time when the effects of coming events were discounted so long in advance. The Empire press may be strong enough to bring about State competition in submarine telegraphy, but we cannot approve the methods adopted. The newspaper press is run commercially, and it seems peculiar that one of the most successful branches of industry should agitate for reduced cable rates on the somewhat specious plea that such reductions will "consolidate the Empire." The deputation which waited upon the Prime Minister on Wednesday appeared pleased with the result of their interview, but to us Mr. ASQUITH'S attitude represented but cold comfort. He apparently realised the magnitude of the question.

Electric Furnaces.

GENERALLY speaking, there are four main methods of heating electric furnaces—viz., by resistance heating, by arc and resistance, by arc simply, and by induction. In the case of electric steel furnaces the resistance method of heating is somewhat difficult, owing to the fact that molten metal has a comparatively high conductivity, and therefore this method can be easily applied only to the case of the induction furnace, where the metal takes the form of a somewhat elongated ring, so that the resistance becomes very much greater than if the metal were contained in the smallest possible volume, and no question arises as to the transmission of heavy currents. Thus, if the induction furnace method is not applicable, resort is generally had to the arc method, or to the arc and resistance method. The advantages and disadvantages of these methods are well known. In the arc method the heat efficiency is lower, but there is less trouble from contamination. In the arc and resistance method the arcs strike into the molten metal through the slag, and the latter plays a not unimportant part in the heating process, the heating due to resistance proper being comparatively small.

ELSEWHERE in the present issue will be found an abstract of a Paper by Mr. C. A. KELLER, who is well known for the active part he has taken in the application of the electric furnace to iron and steel making. He now proposes to use a conducting hearth made up of iron bars embedded in clay, the iron bars forming one electrode of the furnace, and the hearth so formed being cooled beneath by a current of water. We doubt very much whether such an idea will appeal favourably to the average steel maker. If such a hearth were to crack for any reason and the metal were to find its way down into the water the result would be very disastrous. A conducting hearth of any kind reduces the resistance of the metal to a minimum, so that, even neglecting other difficulties, production of the necessary heat would require heavier currents. No doubt the heat is more distributed throughout the metal by such means, but two arcs in series separated by a constriction in the furnace, as used by Mr. KELLER, would seem a better solution of the problem. Apart from obvious difficulties and objections, Mr. KELLER'S Paper is disappointing because, although it is written by a metallurgist of great experience and one who has every means of putting his ideas to a practical test, the Paper appears to be inconclusive and to have been written without any very definite practical results having been previously obtained. In electro-metallurgical questions, where success depends even more upon practical working than on theoretical considerations, this is somewhat unfortunate.

Personal.—We understand that Sir Alexander B. W. Kennedy has been appointed consulting engineer to the Ordnance Board, in the place of the late Sir Benjamin Baker.

Prof. Ernest Wilson has been elected a Fellow of King's College, London.

University of Sheffield.—A committee has been constituted by the Royal Society, in conjunction with the University of Sheffield, for the establishment and administration of a Sorby Fellowship for scientific research. The funds were bequeathed to the Royal Society by the will of the late Dr. H. C. Sorby, F.R.S., and the value of the fellowship, which will be for periods of five years, will be about £500 per annum.

Submarine Signalling.—It is announced that the London & North-Western Railway Co. propose to instal submarine signalling apparatus on its steamers from Holyhead to Ireland. The City of Dublin Steam Packet Co. has already equipped its steamers running between Kingstown and Holyhead with such apparatus, whilst various lightships round our coasts are now fitted with submarine bells.

Electric Headlights.—According to the "Electrical World" an interesting situation has arisen in the State of North Carolina over the recent enactment of the Legislature requiring that all locomotives be equipped with electric headlights of at least 1,500 c.p. The Atlantic Coast Line has asked for total exemption, and the Seaboard for exemption for day trains and branch lines, while the engineers are making a strenuous effort to have the law carried out to the letter.

German Cable Makers' "Kartell."—According to the "Electrical World" the combination which existed among German cable makers was dissolved some months ago in consequence of inability to arrive at an agreement with an outside competitor, the Bergmann Electricity Works Co., which had recently started the production of cables for lighting and power purposes. The rivalry which immediately ensued became so keen that the price of cables for heavy work declined, it is stated, even to 30 per cent. less than cost of production. The result has been the announcement of the reconstitution of the trust with the addition of the former outstanding firm as a member—presumably on terms satisfactory to the latter. The agreement as to prices will only apply to German consumers.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Dakar—Conakry	May 13, 1909	-
Tangier—Cadiz	May 19, 1909	—
Cayenne—Salinas	June 7, 1909	June 28, 1909
Paramaribo—Cayenne	June 8, 1909	June 27, 1909
Tourane—Amoy	June 17, 1909	—
Trinidad—Demerara	June 21, 1909	—
Fort de France—Paramaribo	June 28, 1909	—

Extraction of Radium.—The Acting British Consul at Stockholm reports that a company has been formed for the extraction of radium from the ore known as "Kolm." It is reported that a contract has already been entered into with a Paris firm with regard to the sale of such radium as shall be extracted.

Improved Microphone.—The Acting British Consul at Stockholm also reports that the local press have published accounts of a discovery in telephone apparatus recently made by two Swedes, Messrs. C. E. Egner and J. G. Holmström, the former being chief engineer in the Stockholm telephone administration, and the latter the president of the telegraph company's training establishment. By this invention, to which we referred briefly in a recent issue, they claim that telephonic communication can be obtained over a distance of 2,500 miles with perfect clearness.

The Electron.—The May issue of this journal, which has come to hand rather late in the day, contains information regarding important developments. If the negotiations in progress eventuate there will be in future on the literary side three editors, who will in turn take charge of one number of the magazine, whilst on the financial side two members are appointed. Also one month's issue will be dropped between the volumes, so that the next issue will be for July, and will be published in the last week of that month. The articles in the present issue include: "The Bristol Corporation Electrical Supply Undertaking," by Mr. C. R. Palairet; "Large Gas Engines," by Mr. E. A. Watson, B.Sc.; and "Rolling Mills," a Paper read by Mr. C. A. Ablett, B.Sc., before the Siemens Stafford Engineering Society; whilst the doings of the various Siemens clubs, &c., are fully reported.

Royal Society's Conversazione.—At the conversazione held on Thursday evening last week, the exhibits were, to some extent, a repetition of those shown at the conversazione a short time ago, and were not so interesting from the electrical point of view. Among those which were new, attention may be called to the model compounded alternator shown by the Hon. C. A. Parsons, a description of which appears in another column. Mr. W. M. Mordey showed the effect of condensers in preventing or extinguishing electric arcs, as described recently before the Institution of Electrical Engineers. Electric splashes on photographic plates were shown by Mr. A. W. Porter, and a permanently luminous watch dial and military night compass by Mr. C. E. S. Phillips; the watch dial is transparent and the figures are painted upon it, the dial, being backed with a compound containing a minute quantity of radium bromide, becomes luminous, so that indications can be seen in the dark.

Birthday Honours.—The following are among those upon whom honours were conferred last week in connection with the celebration of the King's birthday:—

New Baronet: Hubert Harry Longman, partner in Longmans, Green & Co., scientific publishers.

New Knights: Francis Galton, F.R.S., D.C.L., the author of many books on science and exploration.

Joseph Larmor, D.Sc., F.R.S., well known as the secretary of the Royal Society and Lucasian professor of mathematics at Cambridge.

Thomas Matthews, M.Inst.C.E., chief engineer of Trinity House.

Thomas Edward Thorpe, C.B., F.R.S., an eminent chemist and a director of Government laboratories.

Edwin Grant Burls, C.S.I., who is well known as director-general of stores at the India Office.

New C.I.E.'s.: Sir Robert Hunter, solicitor to the General Post Office.

Hy. Alexander Kirk, director-in-chief of the Indo-European Telegraph Department.

John Newlands, deputy-controller of British Post Office Telegraphs and officer on special duty in connection with the reorganisation of the Indian Government Telegraph Department.

New C.I.S.O. (Companion of the Imperial Service Order): Jas. Kennedy Logan, superintendent of electric lines in the New Zealand Post and Telegraph Department.

"The Absolute Value of the Mechanical Equivalent of Heat in Terms of the International Electrical Units."—A Paper with the above title was recently read before the Royal Society by Prof. H. T. Barnes. It is pointed out that the Clark cells used by the author in his determinations of the mechanical equivalent of heat in terms of the electrical units were prepared according to the old specifications. The absolute measurements of the Clark cell now being carried on with such precision in the various Standardising Laboratories were expressed in terms of the new form of cell with specially prepared mercurous sulphate. There was an important difference between the cells, which Wolff and Waters had shown amounted to 0·30 millivolts. The author compared a number of modern cells set up according to the old specifications and found the same constant difference. Taking 1·4330 Int. volts as representing the modern cells at 15°C., then the cells made by the old specifications must be taken as 1·4333 Int. volts at 15°C. The author's measurements of the mechanical equivalent at different temperatures were calculated on the basis of a value for the Clark cell equal to 1·4342 Int. volts at 15°C. Recalculating on the new basis, the value of the mean calorie was found to be 4·1849 joules. This agreed with Reynolds and Moorby's directly determined mean value which, expressed accurately for temperatures between 0°C. and 100°C., came to 4·1836 joules. Rowland's mean value between 5°C. and 35°C. was 4·185 joules, while the author's value between the same limits of temperature was 4·1826 joules. Thus, assuming the variation of the specific heat of water to be correctly determined, the value of the Clark cell, equal to 1·4330 Int. volts, brought the electrically determined mechanical equivalent into excellent agreement with the same constant measured by mechanical means.

Electricity Supply in Berlin.—According to the "Elektrotechnische Zeitschrift," the various central stations in Berlin sold in January last 655,929 units less than during the same month of 1908. The company which supplies energy to the suburbs of Berlin, however, increased its output during the month by 372,182 units. The Berlin central stations, which have usually an average increase in output of 2·6 per cent., thus suffered a reduction in January of 4·1 per cent., and while the company supplying the suburbs has, it is true, increased its output, it has done so in a much smaller proportion than is usual. The present depression is clearly shown in the results obtained by the two companies, though less in the case of that supplying the town, than in that supplying the suburbs. The building craze has affected the suburbs more than the town, while the regulation forcing the town shops to close at eight o'clock, which does not apply to the suburbs, has also had its effect. The employment of metal filament lamps is more extensive in the centre of the town, though this latter cause of reduction is only considered temporary. A reduction in the energy supplied to the railways is put down to the fact that the drivers are becoming more skilful and are taking more account of the economical side, for the traffic on these lines is steadily increasing.

The Employment of a Battery in an Alternating-current Generating Station.—In a recent number of the "Elektrotechnische Zeitschrift." A. Lowit describes the advantages which can be obtained by employing a battery of accumulators in a central station generating alternating current. Such a course cannot be recommended except when the load is very variable, as would be the case on a traction system. In certain cases economy can be effected in spite of the losses in the transformers, owing to the fact that the costs for wages, fuel and oil are reduced, while the efficiency of the motors is increased. The author studied the savings which can be obtained in an installation consisting of 1,500 lamps, 1,000 of which are alight at the same time, as well as 75 lamps which burn throughout the night, another 75 burning half the night, and four arc lamps, which also burn half the night. The total energy consumption is 48,920 units. The annual expenses in the case of an ordinary generating station would be £800, of which £418 would be for wages. In the case where a battery is employed the cost would be reduced to £660, of which £254 would be for wages. This includes charges for upkeep of the battery, charging apparatus and depreciation. The saving obtained in this case is £136, though each case must naturally be considered on its merits, for it is only by judiciously proportioning the capacity of the battery and the charging machinery that large economies can be obtained.

ELECTRIC FURNACES AS APPLIED TO THE MANUFACTURE OF IRON AND STEEL.*

BY CH. A. KELLER.

Summary.—If the electrical production of steel is carried out in electrode furnaces fitted with conducting hearths, the material used must not carbonise the metal produced. The various classes of conducting hearths described are: (*a*) Those made entirely of metal, water-cooled; (*b*) those consisting of one or more metallic poles embedded in a non-carbonising masonry; (*c*) those consisting of a hearth of refractory material rendered conducting by a carboniferous substance; (*d*) furnaces with a hearth made up of a mixed conducting material: this is the type devised by the author. The construction and performance of various furnaces erected by the author are also described.

The application of the so-called "electrode" electric furnaces to the production of those metals which must be obtained in a molten condition, or free from carbon, and even more especially the search for a solution to the problem of the electrical production of steel, necessitates that the furnaces, if fitted with hearths of conducting material, should not thereby carbonise the molten metal produced. The hearths of conducting material used in those electric furnaces employed at the present day for electrometallurgical operations, such as the manufacture of calcium carbide, ferro-silicon, ordinary ferro-chromium, &c., have been, from the very beginning, composed of a layer of agglomerate carbon or of a bundle of electrodes. This layer of carbon is connected on its upper side, and in various ways, to one of the poles of the source of energy, the other pole being connected with one or more vertical electrodes. Although until the last few years conducting hearth furnaces had not been used industrially unless the hearth was of carbon, it must be remembered that conducting hearths made without carbon and of several varieties have been invented for some time, and that if no industrial furnace has followed this invention, it is simply because the construction of a

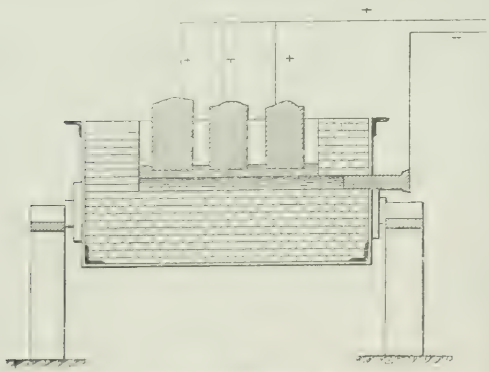


FIG. 1.—GIROD FURNACE.

metal hearth, or of a hearth fitted with a metallic pole, gives rise to very great difficulties from the industrial point of view, while the construction of a carbon hearth is an exceedingly simple matter. Further, the necessity of preparing a hearth of carbon is not present in electrometallurgy except in some cases of small importance, where the systems employed include certain tricks which are not divulged by those using them.

At the present time conducting and non-carbonising hearths can be divided into the following classes—(1) *Simple Conducting Hearths*: (*a*) obtained by an entirely metallic furnace bottom, (*b*) obtained by one or more metallic poles embedded in masonry of a non-carbonising nature, (*c*) obtained by means of a conducting clay. (2) *Hearths of Varying Conductivity.*

The author first describes briefly the features of the simple hearths.

1. (*a*) Several types of furnaces with soft steel hearths, which are cooled by circulating water, have been proposed, but have received no industrial application. The high temperature of the liquid metal does not allow the metal hearth to be maintained, even when it is cooled, without an excessive loss of heat, and disaster is ever present.

(*b*) This type of conducting hearth is characterised by the fact that the pole, or poles, only are conducting, while in the later case they are separated by masonry which only serves to prevent them from being destroyed by the liquid metal. The first furnace of this type was that due to Siemens. A second, and very characteristic, furnace belonging to this class is that due to Borchers. In 1905 Girod took out a patent for a furnace with poles embedded in the hearth, and which he claimed could be constructed in three different ways. The poles can be either of graphite or of metal. If of the former they are, before being put into service, covered with a coating of metal which preserves the substance treated in the furnace from the carbonising effects of the graphite. The second arrangement contains one or more wholly metallic poles, whose lower parts are kept cool, and whose upper parts are fixed in channels cut in the masonry of the hearth. These channels are previously filled with the metal it is desired to obtain in the furnace. The third arrangement suggested by Girod consisted in placing the metallic pole in the masonry laterally across the lower part of the furnace. Under these circumstances the hearth of the furnace, properly speaking, is not fitted with any conductor (Fig. 1).

(*c*) In this system the hearth contains no metallic conductor, but is formed of a refractory material (magnesia, silica, &c.), which is

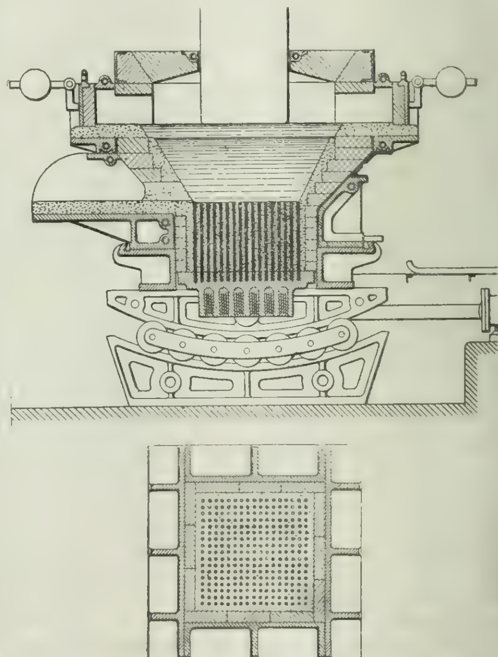


FIG. 2. KELLER FURNACE.

rendered conducting by the introduction of carbon or a carboniferous substance, such as tar. The percentage of carbon present can be varied progressively through the thickness of the hearth in order to be able to utilise at the beginning of the operations the variations in electrical conductivity of the material. The Firminy steel works who designed this furnace have only constructed up to the present time one of small capacity.

(2) *Furnace with a Hearth made up of a Mixed Conducting Material (Keller Furnace).*—Two years ago I designed and put into industrial operation an electrical furnace whose conducting hearth is made up of "reinforced clay" arranged as follows: Iron bars 25 mm. to 30 mm. in diameter are placed vertically at regular intervals of about 25 mm. to 30 mm. apart, and fixed solidly in the bottom of the furnace, thus constituting a bundle which fills the whole of that part of the furnace containing the molten steel. A clay of some agglomerated material, magnesia for preference, is closely rammed when hot between each group of four rods. These latter form quite a mould which allows, on account of its mechanical strength, the mixture introduced to be considerably compressed. The clay thus formed should be driven home by blows from a ram (Fig. 2). An extremely compact mass is thus obtained composed of iron and refractory material in regularly alternating layers. It is a conductor when cold as far as its metal parts are concerned, while both these parts and those made up of the refractory material are con-

* Abstract of a Paper read before the Faraday Society.

ductors at high temperatures. The whole is contained in a metal case which is used as a covering, and can be cooled by a current of water. The lower conducting base and all the iron bars are connected by convenient means to one of the poles of the source of energy.

The conducting hearth thus obtained allows the furnace to be started very easily. For it is a conductor over the whole of its transverse section on account of the iron bars, which are close together and which rise to the level of its upper surface. The small distance between the bars, and the conductivity of the clay, puts them in parallel throughout their length when the furnace is starting up. The current is, therefore, distributed equally over the whole surface of the hearth. The bunches of current which are produced in a furnace fitted with isolated metallic poles are absolutely non-existent in this arrangement; for the current on leaving the upper electrode crosses the whole section of the molten metal and leaves in the same regular way over the whole surface of the hearth. The electrical resistance of a conducting hearth like that described is practically negligible, as the surface of the furnace-bottom allows a large number of bars to be used, whose cross-section is, therefore, considerable, while the conductivity of the clay must also be taken into account. As a result the loss is very small. On the other hand, the employment of metal conductors of small section gives rise to a more rational distribution of the alternating current than does that of larger sections.

This type of hearth has no masonry on its bottom. The whole of the bottom of the furnace is made up of a block, which is partly metal and partly refractory material. It is a conductor, and is practically infusible at all working temperatures of the furnace. The liquid metal does not then rest on a masonry bottom, but on a combination which is to the arrangement of masonry fitted with metallic poles as reinforced concrete is to the ordinary substance. The mechanical resistance of the hearth to the subsidence of the metallic bath is thus very considerable, and no deterioration by swelling, or the occurrence of any flaw or fissures need be feared. Lastly, the mechanical connection of the lower part of the bars and their close welding together by the clay render the bottom of the furnace absolutely indeformable, a condition which does not exist when metal blocks free in the middle of masonry are used. When the furnace is empty the whole of the furnace bottom allows restarting to be effected, and this can be done with certainty and without loss of time.

The conducting hearth constitutes the original part of the furnace, whose working section is made up, as is usual, by a metal vessel double-lined with refractory basic material and securely braced. The shape of this vessel is conical, and in order to give the necessary solid foundation a basin of magnesia clay is placed at the bottom of the furnace. This clay is easily repaired after the melt when necessary. The furnace casing is cooled up to a level of the upper part of the hearth in order to protect the junction of the melting chamber with the hearth. The furnace is closed by an arch through which the electrode passes. The regulation of this electrode is effected by hand or by an automatic regulator, though the latter arrangement is the simpler. In order to obviate the stoppage necessary when changing the electrodes, the latter are fixed at the end of a turning arm, and can be displaced by rotation. Another electrode ready for use is fixed at the end of a similar arm, and thus an electrode can be changed in two or three minutes.

The electric furnace described can, of course, be fitted with one or more vertical electrodes connected in parallel to the same pole or to different phases of a polyphase circuit. A three-phase electric furnace would contain three electrodes, and if star distribution were used the neutral point would be connected to the conducting hearth. I have noticed that the hearth of a 1,500 kg. furnace, which was specially taken to pieces for inspection after many months' service, was in absolutely the same condition as when it started. The clay connecting the bars had become extraordinarily hard, like rock, and turned the edge of a graving tool. I am persuaded that this method of construction realises in as simple and sure a way as possible a conducting and non-carbonising hearth, thus allowing a certain and very simple metallurgical operation to be effected, and suppressing all the ordinary annoyances of furnaces and their upkeep and repair. At the same time an electrical conductivity is obtained without any appreciable loss.

The relative advantages of a furnace with a conducting hearth, and one with vertical electrodes in series, are next considered by the author. He believes that the electric furnace with a conducting hearth has metallurgical advantages over the furnace with series electrodes, when the power used is small or moderately large. In fact, the method of heating the conducting hearth furnace, whereby the current must traverse the whole depth of the mass, is more favourable to the production of a homogeneous metal. To sum up, the electric furnace with a conducting hearth will necessitate that greater precautions are taken in its practical use and construction than the furnace with series electrodes. But the engineer well skilled in alternating-current work will be able to circumvent and avoid the difficulties present, and will be able in large-sized furnaces to obtain a satisfactory power factor. Further, if this engineer is able to design a complete method of working for the electrometallurgical installation, he will not forget to employ a low frequency, say 20 per second, thus leading to a great simplification in the circuit, owing to the fact that the self-induction is thereby much reduced. For example, with a frequency of 20, it is possible to obtain with a 1,000 kw. furnace a power factor equal to 0·9. Such a furnace applied to the purification and manufacture of molten steel would have a capacity of from 10 tons to 12 tons. A furnace of greater capacity could be obtained by connecting several similar furnaces together, the electrodes being in parallel; and there is then no reason why the power factor should drop.

Series Electrode Furnaces and their Improvements.—After a series of different industrial tests I patented in 1900 in France, and in certain other countries, a furnace with vertical electrodes for the entry and exit of the current, in order to obtain the products by means of a draw-off cock. The characteristic of this furnace was the separate regulation of the two fires created by each electrode. In 1902 I erected at the Livet works a two electrode furnace with a capacity of 2,500 kg., and in 1905, as a consequence of the results obtained at

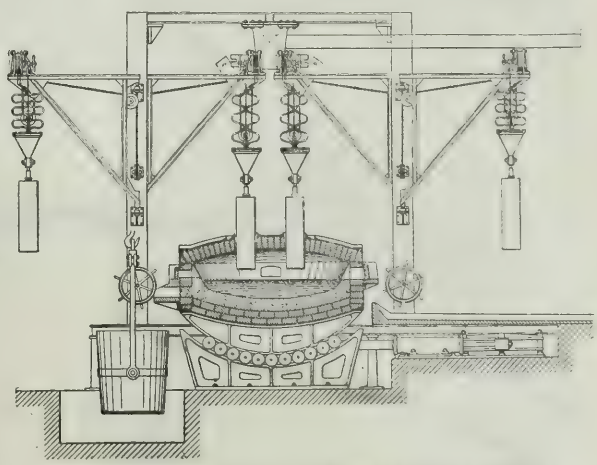


FIG. 3.—KELLER FURNACE OF MESSRS. J. HOLTZER AT UNIEUX.

Livet, it was decided to erect an 8-10 ton furnace at the Unieux steel works. This was the first electric furnace adopted in France by a steel works, and it was, and probably is still, the most important which had ever been put in operation.

This electric furnace at the Holtzer steel works at Unieux (Loire) has four movable electrodes which serve to bring up the current and carry it away. A furnace in which the quantity of heat can be regulated corresponds to each of the four electrodes. Each pole consists of two electrodes. This furnace is divided into four groups, as shown in Figs. 3 and 4. These consist of (*a*) the movable crucible, which is a simple metallurgical receptacle carrying no electrical connection and fitted with its support and hydraulically worked movement; (*b*) the revolving supports of the electrodes with their suspending arrangement and their connection to the main switchboard. These supports are completely independent of the crucible, whose cover can easily be lifted when they are turned outward; (*c*) the upper set of distributing cables with their fixed branching circuit from which connection is made to the turning brackets; (*d*) the regulating position for the electrodes, carrying valve-control apparatus, so that they can be distance-controlled, and the measuring instruments. The movements which the electrodes can make are the following: simultaneous raising of the two electrodes on the same pole, or of the four electrodes together; simultaneous raising of the two electrodes on the same pole and the simultaneous descent of the two electrodes on the other pole; raising of one electrode and the simultaneous descent of the other electrode on the same pole, and the separate movement of each electrode.

The regulation of the electrical circuits is effected very simply in the following manner:—In order to regulate the voltage the two electrodes on the same pole are manœuvred simultaneously. If there is any inequality in the voltage between the two poles, the two electrodes on each pole are displaced one up and one down. The current is equally distributed over each of the four electrodes by means of their separate adjustments. If there is any difference in the current in the two electrodes of the same pole, a simultaneous and opposite movement of them is made so that the current in each is changed. This method of regulation by altering the voltage or current respectively of a group of four electrodes, between the electrodes in the same group, allows the use of a very simple and rational regulating system.

To distribute the current to the furnace I have used an arrangement called "radiating electrical distribution" by which the self-induction of the apparatus is reduced to the lowest possible limit. The two electrodes on the same pole are in parallel, and the whole of the current is brought to the centre of the furnace by a number of laminated copper bars connected to a central block strongly clamped by metallic supports which are fixed to the framework of the furnace. From this block four electric circuits radiate, carrying the current in duplicate to each electrode. One of these sets of connections is used as a stand-by (Fig. 5). These connections are made up of bars of copper, each set consisting of 11 bars 250 mm. × 5 mm. The electrodes are suspended from the ends of articulated arms which carry arrangements for connecting them to the conductors from the central block. The method of distribution employed allows the electrodes to be replaced while working. It also results in a very small self-induction. In fact, tests made at the Holtzer steel works have shown that the power factor is about 0·97 when 12,000 amperes are passing. With this arrangement, therefore, very large currents can be utilised under favourable conditions without any fear of the power factor being lowered.

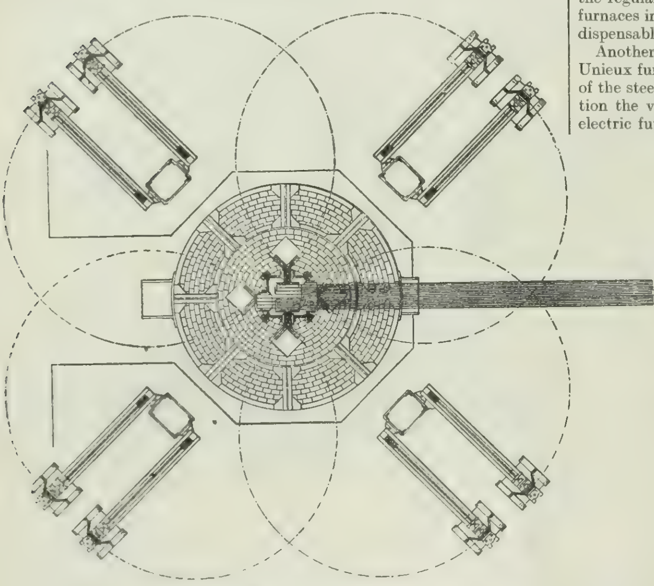


FIG. 4.—PLAN OF KELLER FURNACE AT UNIEUX.

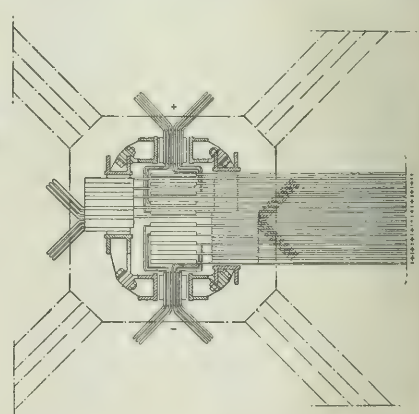


FIG. 5.—SET OF CONNECTIONS FOR FURNACE AT UNIEUX.

To avoid any short-circuit between the two poles in the movement of the electrodes, and on account of, in this case, close proximity of the electrodes, several flexible and very thin bars, say ½ mm. thick, are connected at one end with the fixed conductors from the central distributing position, and with the electrode support. These flexible bars are divided into two sets which are interconnected at various points along their length by an appropriate connection. These points determine the formation of the separate flexion bends which contract or spread out according to the position of the electrode. The whole is guided by means of cylindrical spindles on which slide rings fixed to the flexion bends. This arrangement makes a flexible connection between the distributors and the electrodes without taking up more room than does the electrode itself, so that the space between the electrodes is kept quite free. The four electrodes enter the furnace through a spherical arch which covers them.* The crucible containing the steel is circular, and is treated inside with magnesia-mortar. It is supported by strong steel trunnions on which it can roll owing to the presence of rollers running on turn-tables.

At Unieux the steel is worked up in a Martin furnace, then melted in a crucible which is immediately emptied into an electric furnace. The molten steel is then put in circuit, and the reducing, purifying, and adding operations are carried out. As an example of a standard operation the following results, taken officially and independently, may be cited:—Weight of charge 7,500 kg., average load during the operation 750 kw., length of the operation 2 hours 45 minutes. Composition of the molten charge—C=0·15, S=0·06, P=0·007. Purity desired C=0·45 to 0·50. Analysis of the cast steel—C=0·443, S=0·009, P=0·008. Energy used per ton 275 kw.-hour. Wear of the electrodes = 18 mm. per hour for four electrodes 400 mm. × 400 mm. in section, which corresponds for a continuous operation, taking the electrodes as costing 35 fr. per working, and also costs of preparation, to an expenditure of about 4 fr. per ton of steel. The staff for the furnace, including the provision of the necessary materials, is made up of three labourers and one founder. The regulation is effected by hand by one of the three labourers, who also looks after the upkeep of the furnaces and the electrical connections.

This regulation could be equally well effected automatically, but the regular nature of the operations, thanks to the presence of two furnaces in parallel per pole, does not make automatic regulation indispensable.

Another result of the metallurgical operation obtained by the Unieux furnace is given in the Paper. This shows that the qualities of the steel from the purity point of view, and taking into consideration the various mechanical tests made on it, are a proof that the electric furnace is a piece of metallurgical apparatus in every sense of the word, and a flexible equipment which allows accurate metallurgy to be undertaken.

The author draws attention to how simple and all-embracing are the metallurgical properties possessed by the electrodes and of how small importance is the consumption of the electrodes per ton of steel produced. The electrical furnace with electrodes should principally find its place in metallurgy in the direct application of three-phase currents, as many steel works already have central stations generating this current, and electric power transmission is not considered at the present time, except in this form.

These consideration have led the author to study a three-phase furnace for the manufacture of steel. This furnace can operate with the electrodes either connected in mesh or in star. In the first case one of the three electrodes is connected respectively to each phase. In

* I have experimented with and put in operation on a large scale at the Livet works an improvement in the electric series-electrode furnace (Fig. 6). This improvement consists in placing each electrode, or each series of electrodes, of different polarity in a separate compartment, the two compartments thus formed being connected underneath by a channel filled with the metal under treatment, and which may be according to circumstances in the solid, pasty, or liquid state. When the metal contained in the lower canal is solid, the furnace has a lateral metallic pole very like those described above and notably that shown in Fig. 1.

the second case the armoured clay hearth of the furnace is connected to the middle point of the three-phase system. The three-phase electric furnace contains a great number of the qualities possessed by series electrode furnaces and furnaces with conducting hearths, if the star connection is used, because the molten steel is then only traversed by part of the current. It is possible without exaggeration at the present time to realise the construction of a three-phase furnace with a capacity of 20 tons. This furnace would necessitate the employment of a power of about 1,800 kw. Such a furnace would be capable of purifying from 250 to 300 tons of ordinary steel per day obtained from a Thomas converter by means of operations which take about an hour and a half each, and would lower the percentage of sulphur in the molten steel as it leaves the converter to about 0·08 to 0·02, at the same time reducing and carbonising it as required. The expense of an operation of this kind varies from 15 fr. to 20 fr. per ton of steel transformed, taking electrical energy at 0·15d. per kw.-hour, a price which could be obtained by using gas engines working on blast-furnace gas and taking into account the other financial factors and their current values. The passage of the steel through the electrical furnace, where, under the influence of the high temperature, it is submitted immediately and by rapid operations to intense desulphuration, allows cast-iron containing a high percentage of sulphur to be employed in the manufacture of steel. This advantage may lead to the establishment of methods taking advantage of this circumstance and the use of minerals which have hitherto been rejected. The introduction of an electric furnace into such an establishment should be a double and considerable economical advantage.

The possibility of economically introducing the electric furnace into the general cycle of the great metallurgical operations should open up a new era; and by introducing into the present-day steel

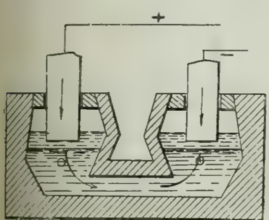


Fig. 6.—Keller Furnace with Electrodes in Series.

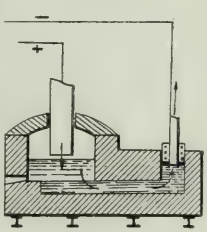


Fig. 7.—Chaplet Electric Furnace.

employed in construction work and for rails the complementary qualities of safety, the electric furnace should have contributed to the realisation of a better civilisation by the reduction to a great extent of the chances of accidents due to insufficiencies in the quality of the material.

DISCUSSION.

Mr. J. Härdén considered a water-cooled electrode beneath a furnace hearth far too dangerous an arrangement to be generally adopted. He thought electrode furnaces would be of limited application on account of the difficulty of procuring electrodes. The variations of power, 30 to 35 per cent., in these furnaces were very great.

Mr. E. Ristori, Mr. Cobb and Mr. W. Murray Morrison all agreed with the last speaker in his criticism of the water-cooled bottom electrode. The last-mentioned speaker, however, did not consider there was any difficulty with regard to procuring electrodes, the consumption of which was comparatively very small.

CHEAP UNITS.*

BY COUNCILLOR ALEX. SINCLAIR.

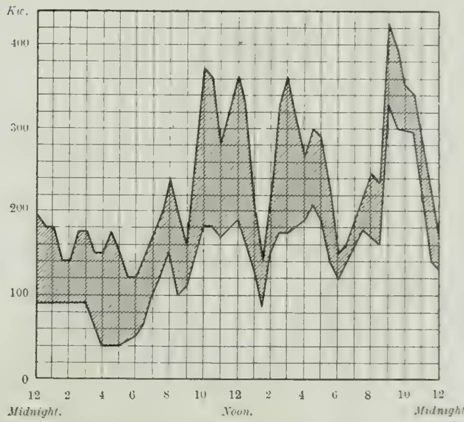
(Chairman of the Electric Lighting and Tramways Committee, Swansea.)

Summary.—The author splits up the costs of a generating station so as to arrive at a fair cost per unit for energy supplied to various classes of consumers. He believes that the consumer's load factor should be the basis of determining the share of the capital charges, and finally gives what he considers to be the fair selling price per unit for the different consumers.

The author's attention was recently drawn to the effect produced on a supply undertaking by several large consumers temporarily ceasing to take their ordinary supply. On investigating the actual works costs per unit generated, it was found that the increase was out of all proportion to the decreased output, which led the writer to conclude at once that the units supplied to those users were generated very cheaply, hence the selection of the title for this Paper. "Cheap units" is a comprehensive term, covering, as it does, all classes of supply; under certain circumstances 6d. per unit may be cheap, whilst in others even 1d. per unit may be dear. It is the intention of the author to try to analyse the various classes of supply, so as to arrive at something like a basis from which to calculate on its merits the selling price of each class of unit. On a previous occasion the author read a Paper† at Edinburgh on the subject of "Load Factor." He considers that the figures then given for high load factors were not sufficiently favourable and under-stated the case. This Paper may, therefore, be regarded as a sequel.

The diagram herewith shows graphically a typical June day load, including two comparatively large power users taking energy during the 24 hours with the ordinary day's output for lighting, power and heating. The lower curve denotes the latter alone, whilst the upper portion shows the large power supply when in use. The reason for selecting a June day was because the large consumers were shut down for their annual overhaul, thus affording an opportunity for differentiating between the two classes of supply. Close investigation of the load curves for the year has shown that the present one, between midnight and 4:5 p.m. (the varying peaks of the remainder interfering with any time division) is characteristic of the whole period, excepting from 1 p.m. on Saturdays to 6 a.m. on Sundays, when only small amounts of power are required; this also holding good for holidays and stoppage of the works as above noted.

The advantage to the station of a power supply is apparent by the number of units generated in both instances—viz., 5,705 and 3,524 respectively—leaving 2,181, which, without the large power user, would be lost to the undertaking. Although perhaps of little



value in forming any conclusions, the day load factors were 55·9 and 44·5 per cent. respectively. A further advantage is clearly set out by dividing the units into four equal parts of the day, thus: 12 to 6 a.m. (with) 937, (without) 406; 6 a.m. to 12 noon (with) 1,475, (without) 825; 12 to 6 p.m. (with) 1,625, (without) 981; 6 to 12 midnight (with) 1,668, (without) 1,312. So that, with the exception of meal times, the machinery in use is for three-fourths of the 24 hours running at a comparatively high state of efficiency. The benefit of the additional load is clearly seen between the hours of 10 a.m. and 5 p.m., when, except at meal times, the machinery is well employed, whilst the output during the night is practically doubled.

In considering the manifest advantages of such a load as that under consideration, the drawback of a demand being made on peak load must not be forgotten, but as this occurs on only a few evenings in the year, and then only for half an hour or so, it is not of so great importance as it appears at first sight. Taking the case in point, it is found that the maximum peak for the year (1,076 kw.) included only 130 kw. for the large power users. The importance of having plant to meet this demand cannot be denied, and it is only fair that it should not be lost sight of. Opinions differ on this question, some holding that the 25 per cent. overload on engines and dynamos may be depended upon in such circumstances, but the writer thinks that this overload should not be counted on as an asset, but treated entirely as being there for emergency purposes only. He is, therefore, fully convinced that the plant capacity required to meet the demand on peak load should be the measure taken for allocating the capital charges to a power user of large amount.

* Abstract of a Paper read before the Incorporated Municipal Electrical Association on Tuesday last week.

† The Electrician, June 30, 1905, p. 411.

Some question may arise as to the multiplication of large users overstepping the advantages herein stated, but in the author's opinion such a contingency is almost impossible, for no matter how the large user's demands increased it is obvious that what may be called the useless portion of a load curve—the unused part between the body of the curve and top peak—would be filling up whilst the peak itself would be but slowly increasing, and out of all proportion to the volume of output created by the added demand. In dealing somewhat exhaustively with the advantages of having customers who are large users of energy the writer does not lose sight of the equal advantages of filling up the curve by smaller users—viz., heating, public lighting, &c.—which may also be regarded as coming within the designation of cheap units.

A careful scrutiny of the costs of the station during the periods dealt with shows that units for large power were generated for less than ½d. per unit—of course, exclusive of capital charges. Although this low cost is literally true, it is hardly a fair conclusion that it is the actual cost, as it is based on an assumption that the ordinary units for lighting, &c., remained the same whether large power users were on or off. The author is of opinion that such units as these under consideration should in no way be looked upon as by-products, but that they should each bear a fair proportion of the costs incidental to the generation of the whole; for this purpose he has taken as an illustration a typical station having an annual turnover of 2,000,000 units, and by splitting up the costs for the various supplies he arrives at the fair cost per unit for each. The divisions taken are: (*a*) Early closing shops and offices, (*b*) late closing shops and offices, private houses, theatres, hotels, &c., (*c*) small users of power, (*d*) public lighting, and (*e*) large users of power.

In the early nineties Col. Crompton showed a somewhat novel way of depicting the ideal cost per unit by taking the best result for each division of cost from the then published electricity supply accounts. Following this example, the ideal figures would now be: Coal, 0·20d.; oil waste, &c., 0·01d.; wages, 0·06d.; repairs, 0·04d.; works cost, 0·31d.; rent, rates, &c., 0·02d.; and management, 0·03d.; making the total costs 0·36d. per unit. This may seem utopian, but the figures of the Stalybridge undertaking have shown that it can be done for 0·45d. It cannot, therefore, be considered as being beyond the possibilities of the near future. It is not, however, the intention of the writer to deal with such very low costs, but to take, as a fair present-day practice, an average of 1·11d. per unit as total costs on a 20 per cent. load factor for a station having an output of, say, 2,000,000 units per annum.

It is now generally conceded that the station costs per unit sold, on a load factor of the whole supply, cannot be taken as a fair basis for fixing the selling price, but that the load factor of each individual supply should be the determining feature; unfortunately, this cannot be carried to a logical conclusion, as the load factor of each customer is not readily obtainable. Perhaps it is as well that this is so, as any attempt to add further difficulty to the consumer understanding his account would make "confusion worse confounded." The author fully realises the great difficulties in the way of classifying the various consumers' requirements, but will endeavour to do so as far as those already mentioned are concerned. Although the figures quoted are only approximately correct, still they are based on actual practice.

In class (*a*)—early shops, &c.—it is found that the year's consumption is 330,000 units, with a maximum demand of 358 kw., load factor 10·5 per cent. In class (*b*)—late closing shops, &c.—there are 464,000 units on a maximum demand of 396 kw., load factor 13·38 per cent. In class (*c*)—small users of power, &c.—400,000 units for 160 kw. maximum, load factor 28·50 per cent. In class (*d*)—public lighting—226,000 units for a maximum demand of 56 kw., load factor 46 per cent.; and in class (*e*)—large users—580,000 units for 130 kw. maximum, load factor 50·90 per cent. These total 2,000,000 units, with a load factor of 20·75 per cent.

From a table* given in the Paper, differing slightly from the table given by the author in his 1905 Paper, the costs are allocated to these demands as follows, the total cost being given in brackets: (*a*) 2·02d. (£2,778), (*b*) 1·64d. (£3,171), (*c*) 0·85d. (£1,416), (*d*) 0·54d. (£508), and (*e*) 0·49d. (£1,184). Total, 1·08d., or £9,057—say £9,000.

In regard to the allocation of capital charges: First, where a large power consumer is cut off during peak load, thus preventing him from overlapping with the bulk of the other consumers. In this case the capital charges on the maximum demand of the station do not come into the problem of his supply, unless he is on cables already laid, when he should bear their share, or that new cables had to be laid some distance to meet his requirements. In either of these cases the value of such cables should be the determining factor in allocating his share of the capital charges, and bearing in mind that he may at some date cease to take supply, a sufficiently high rate of interest should be charged to this amount to meet such risk.

Secondly, where the supply authority looks upon the demand for large power users on peak load as being covered by the 25 per cent. overload of engines and dynamos, and is, therefore, of little consequence. In this case the same arguments as in the first instance are applicable, with the added advantage to the consumer that he could have his energy at all times. The writer is of opinion that such a position is untenable, for it would appear that the ordinary consumers would be penalised by having to pay the whole of the capital charges of the undertaking.

In the third case, where a time switch is used and a comparatively high tariff is charged for period of peak, and a low one for the rest of the day. Of this system the author has no experience, and only mentions it with the object of obtaining the opinions of those who use it.

Lastly, he takes the view that all units should bear their fair share of the whole of the capital charges. Opinions differ as to what this fair share should be. The writer adheres to his previously expressed opinion that the consumer's load factor should be the determining feature. With this end in view, a table has been drawn up, and is given in the Paper, showing the capital cost per unit for different load factors; it is based on a charge of 7 per cent. to cover interest, sinking fund, &c., on a capital outlay of £120 per kilowatt of maximum demand. From this table, considering our above classes of consumers, the capital charge per unit works out at (*a*) 2·19d., (*b*) 1·72d., (*c*) 0·81d., (*d*) 0·5d., and (*e*) 0·45d. The total is, therefore, 1·108d., or £9,233.

By adding the two sets of charges together we arrive at the total cost, including capital charges, of each unit, thus: (*a*) 4·21d., (*b*) 3·36d., (*c*) 1·66d., (*d*) 1·04d. (public lighting is for current only), and (*e*) 0·94d. The 2,000,000 units collectively at an average price of 2·188d. give the total of £18,233. Objection may be taken to the fact that in this instance the risk of large users ceasing to take supply is the same as in the other cases quoted. This is so, but the author considers that by their bearing their share of the whole capital charges it is more than compensated for.

In the circumstances under discussion it would appear that a fair selling price per unit for such supplies, whilst leaving a margin of profit, would be: (*a*) 4½d., (*b*) 3½d., (*c*) 1¾d., (*d*) 1⅓d. to 1¼d., (*e*) 1d. to 1¼d. The author's investigations of the maximum demands of all these phases of supply brought to light a peculiar coincidence—viz., the sum of all the maximum demands was almost exactly twice the actual maximum demand of the station, which would seem to prove two things: First, that the top peak is not the only determining feature in fixing a price, and, secondly, that the diversity factor of a power and heat load is good.

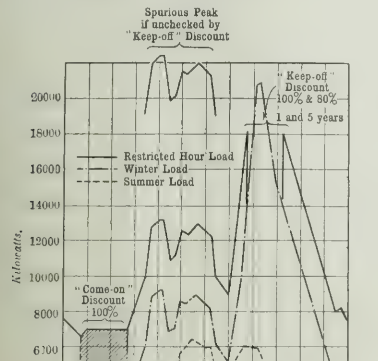
Manufacturers, both large and small, can only be induced to take energy from a public supply undertaking when the price is sufficiently low to be attractive, and the object of this Paper is to show that such figures can be quoted, and still leave a fair margin of profit; a further object is to bring to the notice of chairmen and members of committees that good business is often lost by trying to obtain too high prices.

DISCUSSION.

Mr. A. M. Taylor (Birmingham), in opening the discussion, mentioned that of the three classes of power load considered by the author, he (the speaker) only proposed to consider those consumers who kept off the peak altogether. It could not be too often emphasised that the annual costs on account of fixed charges consisted almost equally of charges to pay interest and sinking fund on extra plant and charges which depended on the employment of the said extra plant at the generating station. Such latter charges were: Wages, management, repairs, rates, taxes, standby-coal and depreciation, and they frequently represented in large stations £4 per kilowatt of maximum demand per annum. Some or all of these costs were included in the author's table, and therefore in his 0·5d. per unit. The speaker's proposal was that a consumer who kept entirely off the peak should be charged his *actual* cost to the station (plus, say, 25 to 50 per cent. for profit), but no fixed charges of any sort in addition. He next considered how far they could carry the night load consumers into the day without extra plant or mains being involved in order to cope with this load. In the diagram shown herewith it would be seen that it would be safe to allow the load to continue to, say, 3:30 p.m., and to come on again at 6:30 p.m., if only they could be sure that spurious peaks would not be created at other portions of the day. The way in which he would suggest that the station engineer should protect himself against these spurious peaks was to offer a "keep-off" discount of, say, 100 per cent. (off fixed charges) to consumers who were willing to have the "keep-off" period revised (*i.e.*, to have their time switches re-set) *every year*, and to offer, say, 80 per cent., or even 60 per cent., to those who preferred a five-yearly revision. The consumer would, of course, pay all *true* running costs as an extra, plus the £300 alluded to above, plus 50 per cent. for profit. As to how he would get over the three hours' break in his supply, the speaker had already indicated a

* The cost per unit for any load factor at any particular station can be obtained from the table by simply dividing the figure contained in the table for its particular factor and multiplying the dividend by the table's figure for the factor required.

means in a Paper read before the Institution of Electrical Engineers two years ago. There was no injustice whatever to existing consumers in the scheme indicated, because they would reap the benefit of the 25 to 50 per cent. "net profit" which the new consumers would bring in; and because if the restricted hour consumers did not come on (which they would not do without sufficient inducement) the existing consumers would have to go along on existing rates, without this benefit, and again, because additional "interest-paying" consumers, on the ordinary terms, would be attracted by the general increase of business done in the town and the better terms that could be offered to ordinary consumers consequent on profit made off the "restricted-hour" consumers (0·01d. per unit would bring in £6,000 per annum of net profit). It was grossly unjust that a potential consumer who would only cost the station some £300 per annum on fixed charges should be forced to pay £30,000 per



annum, just because existing consumers, who were unwilling to suffer the inconvenience of being cut off during the peak, were obliged to pay this figure. The scheme indicated would, if intelligently applied, amply protect the station from spurious peaks and the consumer would himself take the risk of these spurious peaks on to his own shoulders.

Mr. H. Richardson (Dundee) said there seemed to him an unreasonable desire for "cheap units." He would advise them to use caution. Each large consumer should be considered on his merits, and dealt with in the same way as in any other business, and as high a price as possible should be obtained. Were they not being bluffed in many cases into supplying current too cheaply? He suggested that simplicity should be sought for both in plant and charges.

Ald. Higham (Accrington) said, speaking from the manufacturers' point of view, and as a fairly large power consumer, that they were in a false paradise if they thought Lancashire manufacturers were going to take supply at anything like the prices hitherto asked. In Accrington during the past four years they had given a large power supply at 0·68d. per unit. Before that time there was a deficit, but they had now a surplus, entirely owing to this low price. But this price was of no use to the cotton trade of Lancashire, as private steam plant could produce power as cheaply. With a load factor of 20 per cent. and coal at 10s. a ton, no station engineer should be satisfied if his coal costs exceeded 0·25d. per unit.

Mr. E. E. Hoadley (Maidstone) said he had made a careful investigation into the costs of various classes of supply and, although he agreed generally with the figures in the Paper, there were one or two conclusions from which he differed. The author's prices were in some cases too high. It was hopeless to go to a large and regular user of power with a price anything like 1d. per unit. If any example were wanted as to the bearing on the financial aspect of a municipal generating station, he thought the example referred to in the presidential address might be cited with great advantage. He referred to West Ham. Some of the prices given to manufacturers would delight the heart of the chairman of the Accrington committee. The author would, he thought, be more accurate in his investigations if he took out the actual kilowatts on the peak load of each class. This could be done fairly accurately. The supply at Maidstone included ordinary lighting, street lighting, traction and general power supply. By taking the load on Christmas Eve he eliminated the power supply, and by comparing six Saturday nights with six Thursday nights, between 6 and 10 p.m., it was a simple matter to arrive at the cost of producing the extra units on Saturday nights over those produced on Thursday nights. They should work out these charges before going to the large power consumer. The only equitable system of charging, from the point of view of the consumer as well as the supplier, should be a fixed charge per annum per kilowatt demanded of actual peak load, and a very low price per unit.

Mr. Ashton Bremner (Burslem) said the author had indicated how cheap units could be supplied by a large station. He would endeavour to show how cheap units could be produced and sold to the advantage of a small station, such as at Burslem. At Burslem [illegible] 1s. per 1,000 cubic ft., and electricity could hold its own even against that. Last year at Burslem the total output sold was 585,000 units, with a load factor of 15 per cent., and non-condensing, yet the total costs were 0·88d. They had since taken on a large consumer at [illegible] per unit, and their costs had gone down to 0·44d., and the total costs, including the whole of the capital charges, for the six months represented 0·87d. per unit. As showing what a large consumer did for the station, he said that on Sunday, June 7, last year, they generated 652 units compared with 1,520 units on Sunday, June 6, this year. These additional 868 units could be produced at the price of a by-product, there being no additional standing charges or wages to pay, only coal, oil and water, which at Burslem were 0·272d. with a 15 per cent. load factor and [illegible] of 0·87d. He worked out the relative costs for 10, 20, 30 and 50 per cent. load factors at Burslem as 1·25d., 0·656d., 0·486d. and 0·297d. Referring to the author's tables, he thought £120 per kilowatt of maximum demand too high. The cost at Burslem was £50. Going back to the 50 per cent. load factor, this brought the cost for capital charges to 0·187d., or a total of 0·484d. They charged 0·58d.

Mr. W. W. Lackie (Glasgow) referred to the author's statement that the consumer's load factor should be the determining feature in fixing the price, but he should not like this to go out as an expression of the Association's opinion on the subject. He was of opinion that all consumers should bear a fair share of the whole of the capital charges.

Mr. G. Seaton (Messrs. Willans & Robinson) said the author had called "cheap units" anything from 1d. to 6d., and had referred to Col. Crompton's utopian figures. He was at Stalybridge last week, and Mr. Blackmore gave him the following remarkable figures: Coal 0·18d., oil waste 0·01d., wages 0·06d., repairs 0·04d., rent, rates, &c., 0·04d., management 0·04d., total 0·37d., or practically the utopian figures referred to.

Mr. R. B. Leach (Farnworth) said the question of time rate meters had been mentioned. He had had some little experience of the time rate system, and a very sad one. It was to the effect that they obtained a false peak at 9:10 instead of between 5 and 7 p.m. It was dangerous, in his opinion, to differentiate between various classes of consumer, as they had no right to penalise any consumer. They must meet their competitors, the gas people, with the same weapons and arguments as far as possible. For the largest consumer they must give the best terms, always, of course, keeping the load factor well in mind.

Mr. F. W. Purse (Watford), like Mr. Richardson, protested against the craze for cheap units. He knew of a case where a manufacturer had induced an engineer to give supply at 1d. per unit, and that particular station was losing money on the guaranteed quantity taken. What would the Burslem engineer do if a manufacturer asked for a 1,000 kw. load? It was not a business proposal to charge a man with a load factor of 100 per cent. for 1 kw. the same as the man with 100 per cent. and 100 kw. They must have a business price for the man who wanted 5,000,000 units and who did not want to be bothered with load factors, maximum demands, "keep off" discounts, &c. Every unit should bear its ratio of standing charges. He advised them to get the best price from the large consumer and a fair proportion of capital charges, and not to be drawn on by the figure of 0·38d.

Mr. S. E. Fedden (Sheffield) disagreed with a good deal of the author's Paper. Demand meters, regulating switches, &c., should be done away with. He did not believe in "get on" and "keep off" discounts. If they had a special consumer with a special load, they should go carefully into the matter and make a special discount. Before very long he believed they would get their costs down so that they would be able to sell at about ½d. for any power with a big load factor, but generally there was a miserable load factor of 5, 7 or 13 per cent., and rarely over 20. These bad load factors levelled up at the station.

Mr. H. Faraday Proctor (Bristol), referring to the author's statement that all units should bear a fair share of the capital charges, asked "What was the fair share?" The president, in his address, had drawn attention to the fact that the power load was a newer load in many towns than the lighting load, the lighting load being supplied by plants of small units, whereas the power load was supplied by up-to-date plant. He therefore thought it right, in order to get the power consumer, to charge a small price per unit. It was not necessary to allocate the whole of the capital charges evenly per kilowatt. The power load was more recent, and therefore the power load capital charges were on a much lower basis than lighting capital charges in the generating station. This was worthy of their attention.

Ald. Bruce (Sunderland) said he was not prepared to see business that would be done by a company pass out of the hands of a municipality. Councillor Sinclair's prices were not at all tempting to power users. He thought the true basis of arriving at the legitimate price was upon kilowatt demand and load factor. They now supplied at Sunderland at £4 per kilowatt and a low charge per unit, but the £4 per kilowatt had to be paid whether the consumer took anything or not.

Councillor Sinclair, in replying briefly, said the object of his Paper was to invite discussion. Mr. Taylor, to get people on in the middle of the night, was prepared practically to give away his current, but his Paper was diametrically opposed to that. The consumer should pay a proportion of the capital charges whenever he came on. In regard to the figure of £120 per kilowatt of maximum demand being too high, they would find this a fair average figure, taking the figures generally throughout the country. He deferred any further reply for publication in the "Journal."

NOTES ON CONDENSING AND WATER COOLING PLANTS.*

BY E. LUNN

(Assistant Electrical Engineer, Corporation Electricity Supply Station, Huddersfield.)

Summary.—The author describes the various types of condensers and the advantages and disadvantages of each. After considering the question of pumps he finally discusses water cooling plants.

The condensing plant has always been an important part of a steam power installation, and since the introduction of the steam turbine the importance of this portion of the equipment has been greatly increased. The chief points to be taken into account when considering whether it would be advisable to instal a condensing plant are the load factor, and the cost of obtaining condensing water. As a general rule, it is not worth while installing condensing plant unless the saving to be effected thereby will amount to more than 10 per cent. on the cost of such plant, as about that amount would be required to cover the cost of interest, depreciation, repairs and attention. In some cases the increase in the maximum output of the engines might be a valuable consideration.

The following types of condensers are in more or less general use:—Surface, evaporative, parallel flow jet, counter-current jet low-level, counter-current jet barometric, and ejector. These types are then described by the author. The ideal condenser, of course, is the one in which the condensing water attains the same temperature as the steam in the condenser, for the amount of condensing water is then reduced to a minimum, and the temperature of the water in the hotwell is the highest obtainable. The efficiency of a surface condenser is governed by the amount of heat transmitted per unit area of surface in a given time, from the exhaust steam to the water. The result of the heat having to be transmitted through metal surfaces is that the temperature of the condensing water in an ordinary type surface condenser seldom approaches nearer than 15°F. to that of the exhaust steam, approximately three times the difference obtained in a counter-current jet condenser, in which no metal intervenes between the steam and water. The theoretical gain possible by the absence of metal casing has been stated as $\frac{1}{10}$th of 1 per cent. Where water is plentiful and syphonic action can be obtained, the difference in the power required by a larger or smaller amount of water is practically negligible, but where the expense of obtaining condensing water necessitates the erection of a cooling tower, to the top of which the water will require to be lifted, the difference is appreciable. The author considers a practical case which showed that the amount of water in the case of a 15 deg. difference in temperature between the exhaust steam and the condensing water was 54 per cent. more than the amount required in the case of a 5 deg. difference, and this is the ratio of the powers required by the circulating pumps in the two cases. The higher the vacuum and the inlet temperature of condensing water, and the more marked does this difference become. In addition to the extra power required in the first case, the increased capacity of the cooling tower, pump, and pipes, means a corresponding increase in the capital expenditure.

The evaporative type of condenser is unsuitable for high vacua, as the position of the condenser outside the engine room necessitates a long line of exhaust pipe, and the number of joints where a leakage may occur is considerable. A parallel flow jet condenser with wet air pump is a most inefficient type of condenser, as the steam comes at once into contact with the coldest water, and the bulk of the condensing takes place immediately. For small powers, and vacua not exceeding 26 in., the first cost is less than in any other type of jet condenser. The disadvantage of the low level counter-current jet condenser is the remote possibility of flooding the condenser and exhaust pipe, due to the simultaneous failure of the float actuated throttle valve on the injection pipe, and of the emergency vacuum breaking valve. The author has, however, been in constant touch with a condenser working on these lines for the last two years, and has never known the slightest trouble from this cause. The amount of condensing water is less than in the surface type. The first cost of a plant of this size is from 70 to 80 per cent. of the cost of a barometric or surface type, the lower percentage where a cooling tower is required, and the higher percentage where water is obtained from a river or canal at a constant level.

A barometric counter-current jet condenser requires an expensive steel structure, and strong foundations for its support; the exhaust pipe is long; and the expense of erecting the plant is large. Against these disadvantages, however, must be set the advantage of the barometric action, derived from the elevated position of the condenser. If the area of the discharge pipe, and the height at which the exhaust pipe enters the condenser, are correct, the possibility of flooding the exhaust range is very remote. The plant is rather simpler in operation than the low level type, and the power required to drive the pumps is practically the same in each case. The first cost of a plant of this type is practically the same as a surface type in the smaller sizes, but in the larger sizes the cost is considerably less.

An ejector condenser gives the best results when provided with an ample supply of cold water with a natural head, as it then becomes an exceedingly simple plant, requiring no moving parts in the form of air or circulating pumps. These conditions are seldom available, and in practically all cases a centrifugal pump must be provided, in order to obtain the necessary head of water. The author's experience of ejector condensers is that the injection water must be as free from air as possible, and that the best results are obtained where the water is pumped into a tank, providing 15 to 20 ft. head at the injection inlet. This arrangement ensures a steady flow of water, and also allows any air to escape that may be carried forward by the water from leaky joints, or the bearings of the pump. As this type of plant works without an air pump it is not as suitable for high vacua as the surface and counter-current jet type, but it may be used with advantage in stations with a low load factor, as the cost is considerably less than any other type.

Where a more complete vacuum than about 93 per cent. is desired, the balanced slide valve type of air pump will give the best results, but for lower vacua the Edwards type is the cheaper, both in first cost and power required. The maximum speed in air pump working is usually fixed at 400 ft. per minute, but the author considers this too high in the majority of cases. In an 18 by 18 air pump designed to run at 350 ft. per minute, it was found that better results were obtained when this was reduced to 300 ft., and still further improvement at 250 ft. per minute.

Circulating Pumps.—Both the reciprocating and centrifugal types are used, but the field of the latter has become more extended of recent years, due to the constant steady flow obtained, and to the higher efficiencies now obtainable, together with the lower cost and simpler construction.

Steam and Electrically Driven Pumps.—The author contends that the possibilities of a failure occurring in the vacuum are less with steam than with electric driving. With the latter method the number of stages of transition, from the steam to the applied power at the pumps, in each of which an interruption is possible, is greater than with the former method. Steam driven pumps require from 50 to 100 per cent. more steam than electrically driven pumps, but this may be counterbalanced to a great extent by the large percentage of the total heat of the steam it is possible to return to the boiler, by employing a feed water heater, even after allowing for the reduced efficiency of the economiser. Steam driven pumps ought not to exhaust into the main condenser, for while a possible 10 per cent. reduction in the steam consumption of the pumps is effected, the reduction of the available capacity of the condenser, caused by this arrangement is a more serious item. A preferable arrangement is to pass the exhaust steam through a feed water heater.

A careful consideration of existing conditions and requirements is necessary before the most advantageous type of condensing plant can be decided upon. It is necessary for instance to know whether the initial cost of plant, or low running costs is the most important. Where the load factor is low it is advisable to keep down the capital cost of the plant, even if the power taken by the plant is increased somewhat; and where the load factor is high the running costs are of the first importance, and more can be expended on the plant in order to reduce the running costs. The advent of the low pressure exhaust steam turbine has increased the importance of the condensing plant, for with its aid it is possible in many cases to effect considerable economy, besides increasing the capacity of practically any steam plant already in operation. The increased output obtainable by the installation of a plant of this type, together with condensing plant where not already installed, is from 25 to 100 per cent. of the present output. A 500 kw. exhaust steam turbine with steam pressure of 15 lb. per square inch absolute, and 28 in. vacuum at turbine, will require 33 lb. of steam per kilowatt-hour at full load, and 40 lb. at half load.

Water cooling plants of the natural draught open type, the natural draught chimney type, and the fan draught chimney type are finally considered by the author. For central station work the second type is the most common owing to the necessity of economy in ground space, and in order that the vapour, issuing from the plant, may be carried away at a height at which it will not become a nuisance to any inhabited buildings in the vicinity of the tower. The area of ground required is approximately 1 sq. ft. for 20 lb. of steam con-

* Abstract of a Paper read before the Incorporated Municipal Electrical Association. This Paper was submitted in competition for the travelling studentship, 1909, value £10, which has been awarded to the author.

densed (allowing 30 lb. of water per lb. of steam), and the height varies from 40 to 80 ft. Where these objections do not exist the open type may be installed at a less cost, the maintenance will be less, and as the height of the plant is usually about 20 ft., the operating costs will be the lowest. An approximate figure for area of ground and steam condensed is 1 sq. ft. per 12 lb. of steam. The fan draught tower is only used in special cases as the upkeep, attendance, and power required by the fan make the operating costs very high. A tower of smaller proportions is required with this arrangement than with the natural draught chimney type, the height varying from 40 ft. to 50 ft., and 1 sq. ft. of ground is sufficient for 40 lb. to 50 lb. of steam. Depreciation will vary according to the method of construction, and the care taken in erection. It is now possible to obtain water cooling plants in which the wooden laths simply lock each other in position, and the rate of depreciation will be much less with this arrangement that where nails are used. The amount of water lost is usually found to be 75 per cent. of the water required for boiler feed, but owing to varying climatic conditions, this quantity is not constant.

Where it is necessary to instal plant of this nature, it is essential that the temperature of the water discharge from the condenser be as high as possible, conducive with economy in the condensing plant, as the conditions are then more favourable for the dispersion of the heat contained in the water. From this it will be plainly evident that surface condensers should only be used for high vacua when other considerations, such as boiler feed water, outweigh the factors of heat dispersion.

A STANDARD OF WAVE-LENGTH FOR THE CALIBRATION OF CYMOMETERS.

BY J. A. FLEMING, D.SC., F.R.S.

At the present time three methods are employed at the Berlin Reichsanstalt for the calibration of wave meters which have been described by Dr. Diesselhorst, *see* "Jahrbuch der drahtlosen Telegraphie und Telephonie," Vol. I., Part 2, p. 262. "Absolute Messung der Wellenlänge Elektrischer Schwingungen." One of these depends upon the determination of the internodal distances in a pair of Lecher wires, the second upon the use of a rotating mirror to photograph the oscillatory spark, and the third upon the determination of the frequency by measurement of the capacity and inductance of a reference circuit. For ordinary laboratory work I have found that the simplest method of obtaining a circuit in which oscillations of known frequency can be set up is to combine together a condenser consisting of metallic plates in desiccated paraffin oil, the oil being the dielectric, with a rectangular wire circuit, of which the inductance can be predetermined. If paraffin oil is dried completely by shaking up in it fragments of metallic sodium we can obtain a dielectric with no sensible leakage, which also has the same dielectric constant at high frequency as at low. This may be safely assumed to be the case, since the optical index of refraction is so nearly equal to the square root of the dielectric constant determined for low frequency.

If metallic plates are inserted in this oil we can construct a condenser, the capacity of which can be determined for a low frequency of 100 or 200 by means of a revolving commutator and taken to have that value for high frequency.

A circuit can then be constructed by laying one single turn of insulated wire laid in a groove round a rectangular wooden frame and bringing the ends of the wire close together in the centre of one side and terminating them in spark balls. The dimensions of the rectangle formed by the axis of this wire can then be determined by measurements of the length and breadth at various places, and the inductance can be calculated with very approximate accuracy by a formula

$$L=9{\cdot}2104\left\{\overline{A+B}\log_{10}\frac{4AB}{d}-A\log_{10}\overline{A+D}-B\log_{10}\overline{B+D}-\frac{A+B-D}{1{\cdot}1513}\right\}.$$

Where A and B are the sides of the rectangle and D is its diagonal in centimetres, whilst d is the diameter of the wire composing it. This formula is deduced on the assumption that the current is distributed equally around the surface of the wire which is very nearly true when the rectangle is not very small.

For instance, a rectangle so constructed of No. 14 S.W.G. wire 0·2 cm. in diameter and 12 ft. long by 3 ft. wide has an inductance of nearly 12,000 cm. In the case of such a rectangle there is no correction for capacity. It was necessary, however, to be sure that the proximity of the wooden frame did not create an error. To test this the inductance of a bare No. 14 copper wire held on a skeleton frame and bent into the form of a rectangle was compared with that of an I.R. insulated No. 14 wire laid in a groove around a rectangular frame, the rectangle formed by the wire being the same in both cases. No sensible difference was found to exist between the two cases. The oil condenser associated with this rectangle consisted of 23 plates of sheet tin, each 21 cm. by 16 cm., kept 5 mm. apart, by being set in saw cuts in slips of ebonite. Twelve of these plates were bound together to one leading-in wire and 11 to another, these leading-in wires being kept near together and enclosed in glass tubes. These plates were placed in a glass box filled with desiccated paraffin oil. The condenser so formed had its capacity taken with a commutator, and was found to be 0·0026 mfd.

The inductance used for one standard consisted as described of insulated No. 14 S.W.G. copper wire 0·202 cm. in diameter laid round a rectangular frame, so that the mean lengths of the sides of the rectangle formed by the axis of the wire were 91·08 cm. and 365·18 cm. respectively. Hence the length of the diagonal was 367·35 cm., and the inductance calculated by the above formula was 11,930 cm. The proof of this formula is given in my "Principles of Electric Wave Telegraphy," p. 98.

Hence when this condenser and inductance were joined in series by inserting the condenser in the centre of one of the short sides of the rectangle, the spark balls being in the centre of opposite side we have a circuit having an oscillation constant equal to $\sqrt{11{,}930\times0{\cdot}0026}=5{\cdot}57$, and this corresponds to a wave 322 metres or 1,106 ft. in wave length.

By placing any cymometer or wave meter alongside, and loosely coupled to this circuit of known oscillation constant, the correctness of its scale reading can be checked.

Similar rectangular inductances can be made, which, when associated with condensers, made as described will give various oscillation constants suitable for calibrating wave meters as used in radio-telegraphy.

Rectangular circuits of the above kind are preferable to spiral wire or closely wound circuits as standards of high-frequency inductance, in that there is no sensible correction for the capacity and the various elements of the circuit being so far apart the disturbance of equi-current distribution round the periphery of the wire is insensible.

These rectangular circuits are also preferable to long circuits composed of parallel wires near together, since in this last case the exact calculation of the inductance for high-frequency can only be achieved by the use of somewhat complicated formulæ, which take into account the disturbance of equi-peripheral distribution of current in the two wires caused by their proximity. It is quite easy, however, to construct associated rectangular circuits and oil condensers which shall give circuits equivalent to wave-lengths from 500 ft. to 10,000 ft

MAIN LINE ELECTRIFICATION IN BADEN.

Where railways are converted to electrical operation, whether electric locomotives or motor coaches will prove the more satisfactory depends on the particulars of each individual case, but there is no doubt that electric locomotives are being extensively employed. The problem of designing powerful electric locomotives is therefore one of considerable interest, and the following brief description of the single-phase installation on the Baden State Railways will no doubt be welcome to all students of electric traction.

The State of Baden intends this year to begin the electrification of the railway in the Wiesenthal, hitherto worked by steam. This railway runs from the Badischer Bahnhof, in Basel, through Schopfheim to Zell, and a branch line runs from Schopfheim to Sackingen (*see* Fig. 2). On this railway

there will be a daily service of 12 express trains, 51 slow passenger and local trains, and 15 to 21 heavy goods trains. It is necessary that the rolling stock belonging to the State should be used for working this traffic, and in consequence the line will be operated in future by electric locomotives.

The electrical equipment of the railway is being carried out mainly by Messrs. Siemens-Schuckert, of Berlin, and the arrangement of the plant for supplying the electrical energy is particularly interesting. Current is taken from one of the power stations on the Rhine near Augst-Wyhlen, which gives a three-phase supply at 6,800 volts, 15 frequency. In order to convert this energy to single-phase current at 10,000 volts 15 frequency, for supplying the line, a converter sub-station has been erected at Basel. In this sub-station there will be installed two converters, each of which comprises a single-phase generator for a continuous output of 2,100 k.v.a. Each generator is coupled on one side to a three-phase asynchronous motor, which takes current from the power station supply, and is coupled on the other side to a direct current machine connected to a buffer battery. When the output to the railway is greater than the average, the direct-current machine works as a motor and supplies the extra motive power for the single-phase generator. When the output is less than the average the direct-current machine acts as a generator and charges the buffer battery. The battery is able to discharge momentarily at the rate of 2,800 kw. In this case, therefore, the supply of energy to the railway, which varies rapidly between wide limits, a disadvantage common to both alternating and direct-current systems, is equalised by means of the battery, so that the load on the power station is more or less uniform.

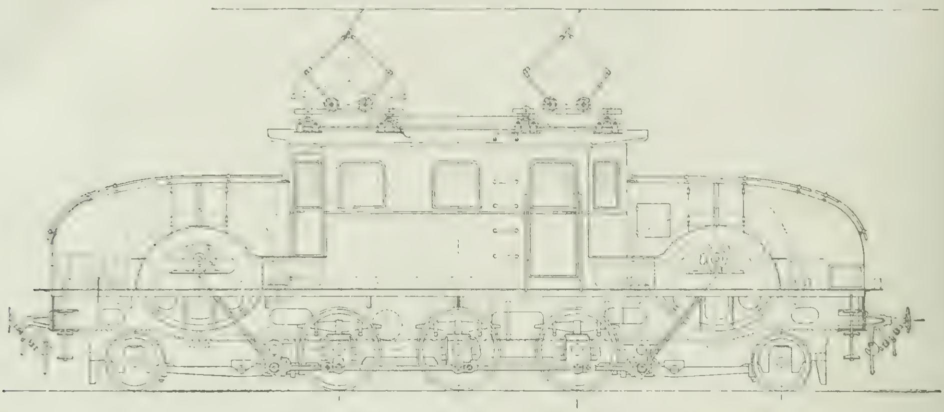


Fig. 1.—Siemens Single-phase Locomotive for Baden Railways.

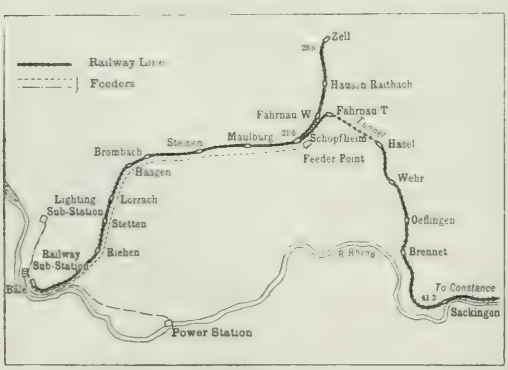


Fig. 2.

The 10 locomotives, which have been ordered from Messrs. Siemens-Schuckert, of Berlin, will be designed so as to be suitable for working both passenger and goods traffic. The weight of a passenger train to be hauled by one of these locomotives may amount to 230 tons, exclusive of the locomotive itself, whilst the weight of a goods train may be as much as 500 tons. The average gradient between Basel and Zell is 1 in 175, and the maximum 1 in 100. The locomotive, as shown in Fig. 1, contains three central driving axles coupled together, and one pony axle at each end. The driving axles are connected by means of coupling rods, as shown, to two single-phase motors mounted on the locomotive frame above the centres of the wheels. These motors are of the multipolar series-wound type, each motor being capable of giving a continuous output of 390 H.P., an output of 525 H.P. for one hour, or a maximum of 800 H.P. for short periods, at a pressure of 300 volts.

The operation of this equipment will be watched with great interest by engineers, in view of the extensive experience of Messrs. Siemens in single-phase railway electrification, as can be judged from the fact that up to December, 1908, they had equipped no less than 591·4 miles of track on the single-phase system, besides supplying the equipment for 32 electric locomotives and 85 motor coaches. It will be remembered that we gave, in our issue of February 19th last, details of the various single-phase railways equipped with Siemens apparatus.

COMMUTATION IN D.C. GENERATORS.

BY W. E. HIGHFIELD AND R. LIVINGSTONE.

Reactance voltage is usually regarded as an excellent criterion of the commutating properties of a machine. Many examples will be found, however, in which the reactance voltage is low and the commutation bad, and examples can also be found where the reactance voltage is comparatively high and the commutation good, this in machines of comparatively the same output. Again, taking a line of machines varying from 100 kw. at 600 revs. per min. to 1,500 kw. at 160 revs. per min., the limit of reactance is found to vary from 3 volts in the small machines to $7\frac{1}{2}$ volts in the largest size. It is evident that some reasons exist for this variation of permissible value. The *principal* reason is the reduction, or increase, of the reactance voltage due to the variation of the number of lines of the main field enclosed by the short-circuited coil. In most cases the cutting of the main field will reduce the reactance voltage, and this *corrected reactance* can be regarded as a safer criterion of the commutating properties of the machine than reactance voltage alone.

The reduced reactance will be influenced by the following :—

1. Field distribution in the interpolar gap—(*a*) at no load, (*b*) at full load.
2. Speed of the armature.
3. Ratio of armature to field ampere-turns.
4. Degree of saturation of magnetic circuit.

The *exact* calculation of the influence of each of the above factors is extremely difficult, but the following approximate method has been found to give results which are sufficiently close for practical purposes.

The no-load distribution curve can be found as follows :

Let g = air-gap in inches,

g_1 = equivalent gap, assuming that all the field ampere-turns are spent in the gap,

B = maximum gap density in lines per square inch,

L = half the distance between pole tips in inches.

Then
$$g_1 = \frac{\text{Field ampere-turns at no load}}{\text{Gap ampere-turns}} \times g,$$

and in Fig. 1,
$$y = \frac{B \cdot g_1}{\sqrt{x^2 + g_1^2}} \times \cos \frac{\pi x}{2L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This formula gives the effective distribution of the field, assuming straight paths for the lines, and also assuming that the angle between the lines entering the armature and a radial line is $\frac{\pi x}{2L}$ radians. The dotted line is the curve given by

$$y = \frac{Bg_1}{\sqrt{x^2 + g_1^2}}$$

and will be referred to later.

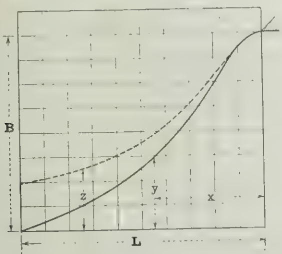


Fig. 1.

From the curve shown in Fig. 1 the position of the short-circuited coil at no load can be found.

Let B_x = density at the position occupied by the coil during commutation,

l = active length of the coil in inches,

v = velocity of armature in feet per minute,

and e = E.M.F. generated in the coil.

Then
$$e = \frac{B_x l v}{5 \times 10^8} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Now, the value of e for carbon brushes should not exceed 4·5 volts, or sparking will result, so that

$$B_x = \frac{22{\cdot}5 \times 10^8}{l v} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For modern requirements it is necessary to assume a fixed position of the brushes from no load to full load. The effect of the armature ampere-turns is to distort the main field, and the amount of this distortion can be approximately calculated as follows. In Fig. 2 the heavy line shows the value of the flux density due to the armature, assuming a uniform air-gap around the armature, the maximum value being equal to $\frac{A.T._a}{A.T._f} \times B$, when $A.T._a$ = armature ampere-turns, $A.T._f$ = field ampere-turns.

Due to the existence of the larger gap between the poles, this flux is reduced in a similar way to the main flux. In this case, however, the armature is the seat of the M.M.F., so that a distribution similar to the dotted curve in Fig. 1 must be assumed. We must then correct this straight line curve in Fig. 2 by multiplying by the corresponding value of z B from Fig. 1. This will give the dotted curve in Fig. 2.

The algebraic addition of the ordinates of this dotted curve and the full line curve in Fig. 1 will give the resultant field at

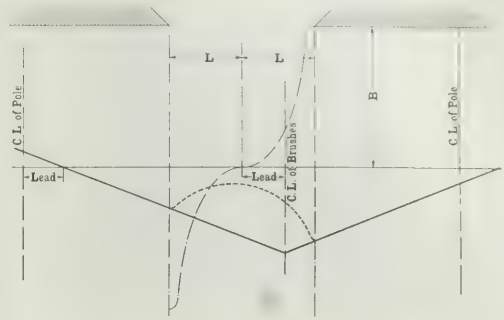


Fig. 2.

full load, as shown in Fig. 3. The density of field cut by the short-circuited coil can now be read off Fig. 3, and the E.M.F. due to this flux calculated from equation (2). If the density has the same sign as the main field, this E.M.F. must be subtracted from the reactance voltage, but if of opposite sign it must be added.

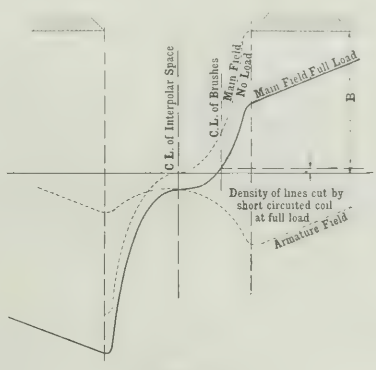


Fig. 3.

This corrected reactance ought not to exceed 4·5 volts for any size of machine if the reactance voltage is calculated by a method similar to that described in The Electrician of January 15, 1909.

The foregoing methods can also be applied to machines with compensated windings by treating the compensating winding in the same way as the armature winding and adding the three curves.

THE NEW TELEFUNKEN APPARATUS.

In our issue of June 18th we described the theoretical and technical features of the new system recently designed by the Gesellschaft für Drahtlose Telegraphie, as dealt with by Count Arco in his lecture before the Verband Deutscher Elektrotechniker. The interest which this new sending spark system has aroused in the wireless world is very great, and we are, therefore, pleased, through the courtesy of Count Arco, to be able to publish some photographs illustrating this apparatus.

Fig. 1 shows the variometer used in this system. One of these apparatus is capable of dealing with a considerable

amount of energy. As will be remembered, it consists of a fixed and a movable circular plate. On both these plates are placed windings, which can be connected either in series or in parallel. If the discs are so arranged that the fields of the four coils can be added together the self-induction is a maxi-

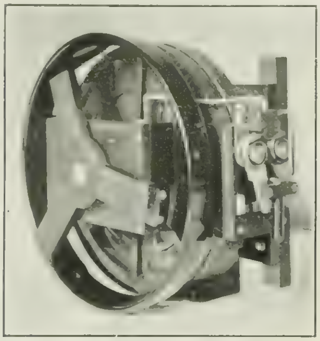


Fig. 1.—Sender Variometer.

mum, while in the opposite position it becomes a minimum. A continual variation between these limits allows any desired value to be easily obtained. This variometer, which was designed by Herr Rendahl, of the Telefunken Company, can be altered through an arc of 360 deg. and by changing over

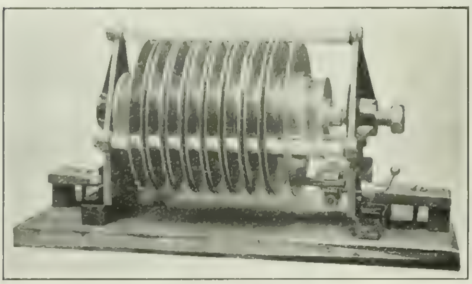


Fig. 2.—Singing Spark Gap.

the windings from parallel to series gives a variation of self induction of 1 to 16.

It will be remembered that Count Arco dealt very fully in his lecture with the spark-gap used in the singing spark system. This part of the apparatus is of great importance,

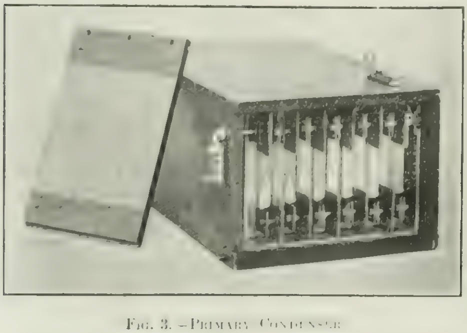


Fig. 3.—Primary Condenser.

and it has been found that metals with specially good heat conductivity must be used to give a sharp quenching. In Fig. 2 we show a multiple singing spark-gap. It consists, as will be seen, of a number of spark-gaps which can be regulated as required. This large number of gaps gives rise to no complications, as they require a very infrequent inspection, and a regulation of the sending energy is obtainable by cutting out one or more of the gaps, or by inserting resistances in series with them. A very small portion of the full load energy may thus be used when short-distance working is being undertaken without altering the sound or damping of the oscillation.

While the question of the spark-gap gave rise to a good deal of trouble, the condenser, on the other hand, was very quickly designed. The one in general use in the primary of the new system is shown in Fig. 3. Low efficiency paper con-

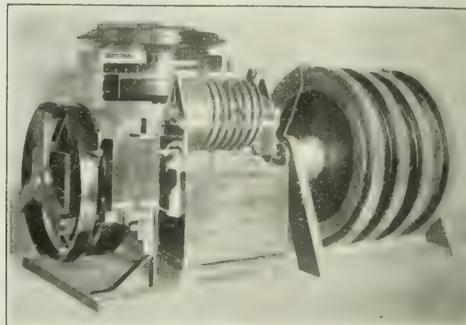


Fig. 4.—2 kw. Sender.

densers have been used without any difficulty, and no trouble is experienced from edge discharge, as the short primary waves only slightly ionise the surrounding atmosphere.

The apparatus just described makes up the greater part of the singing spark sending station. A sending station of 2 kw. size is shown in Fig. 4. The efficiency of the generator used with a frequency of 500 is about 75 per cent., that of the induction coil about 80 per cent., and that of the high frequency exciter 85 per cent., so that the overall efficiency of the sending station is 50 per cent. With a larger station the efficiency would, of course, be greater. Wireless telegraphy is now being used to such a large extent for military purposes

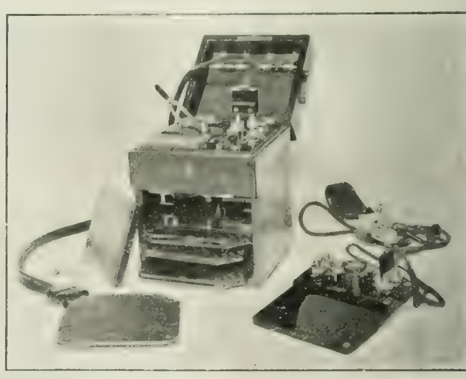


Fig. 5.—Complete Wave Measurer.

that any reduction in weight without at the same time reducing the capacity is a very desirable state of affairs. This desideratum has, it is claimed, been reached in the new system, and it should, therefore, be specially suitable for military work. An equipment which has been designed for such working is shown in Fig. 7.

At the conclusion of his lecture in Cologne, Count Arco made several experiments to show the capabilities of the new system. The apparatus used by him is shown in Figs. 5 and 6. The sender (Fig. 5) consisted of a closed oscillation circuit in the form of a wave measurer. It was made up essentially

of a number of adjustable coils and a standardised plate condenser, which could be so altered that a continuous wave scale between 250 and 2,500 metres could be obtained. The wave measurer was supplied with "impact energy" from a sparkless and very rapidly working interrupter. The receiver used was

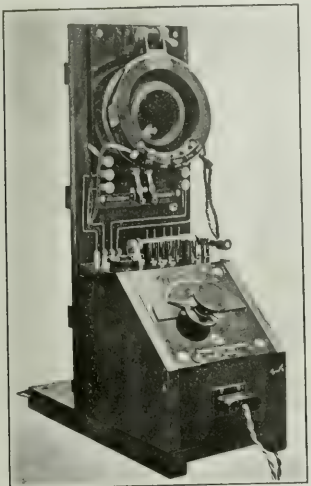


FIG. 6.—ACOUSTIC RECEIVER FOR ALL WAVE LENGTHS.

that shown in Fig. 6 with a contact detector and a continuous wave scale between 250 and 2,500 metres. The coupling between the sender and receiver was very loose and the sender energy was only 2 watts. The detector, therefore, received a very small amount of energy, and a current of only

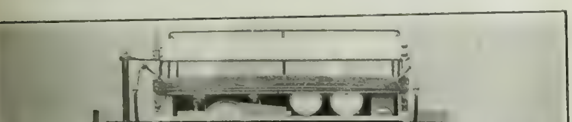


FIG. 7.—MILITARY SENDING APPARATUS.

about 10^{-7} amperes was received in the detector. By means of the three resonance relays, which were described in the Paper, the telephone current was stepped up to 10^{-2} amperes and audible working obtained. The resonance of the apparatus was also demonstrated by these means.

PARSONS' PATENT COMPOUNDED ALTERNATOR.

The difficulties in keeping a constant voltage on an alternating-current supply system when the load is subject to sudden and large fluctuations, as in the case of a supply of power to collieries and other large works, are well known; and such drops in pressure, in addition to causing annoying fluctuations in the brilliancy of any lamps connected to the system, also mean that the motors supplied have to take a heavier current in order to do their load at the lower voltage, this resulting in a still further lowering of the voltage. In many colliery power stations it is found necessary to keep an attendant for the sole purpose of adjusting the voltage by hand, but this method is both expensive and far from efficient, since in such cases the "human regulator" cannot hope to follow the variations of

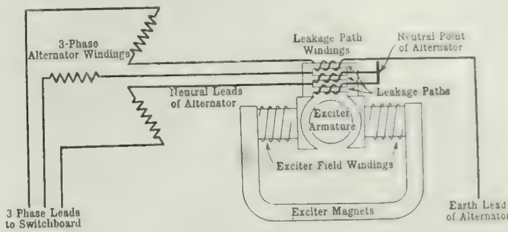


FIG. 1.

load quickly enough to prevent heavy fluctuations of voltage. It has for a long time been the aim of electrical engineers to produce an alternating-current generator embodying an arrangement similar to the compound or series winding in a direct-current dynamo, and many arrangements have from time to time been proposed to enable an alternating current so to act on the magnetic field as to cause it to increase with the load.

One of the simplest and most satisfactory methods of compounding an alternator is that referred to by Messrs. Stoney and Law in a Paper read a little more than a year ago before the Institution of Electrical Engineers on "High-Speed Electrical Machinery." It will be seen from the abstract of the Paper in our issue of April 3, 1908, that the authors refer briefly to a method of compounding which obviates the difficulties experienced in systems where the alternating current has to be commutated. One of the most interesting exhibits at the Royal Society's conversazione last week was a working model of a three-phase alternating-current generator and exciter fitted with this compounding device, the set being driven for demonstration purposes by a direct-current motor.

The principle made use of is that while an alternating current cannot directly produce a unidirectional magnetic field, it can be made to diminish such a field. If an iron core or "leakage path" of suitable cross-section be laid across the pole pieces of a dynamo and the magnets be powerfully excited, lines of force will be diverted from passing through the armature, and the iron of the leakage path will be saturated. Now, if the core carries a winding through which alternating current is passing, it will be seen that when the current is passing in one direction, it cannot appreciably increase the "leakage flux" through the core, owing to this being already saturated; but when it reverses and flows in the other direction it will reduce the leakage flux. Fig. 1 shows the arrangement for a three-phase alternator. The "leakage paths," which are of laminated iron, are seen bridging the magnets of the exciter; when load comes on the alternator the leakage flux is choked back and the flux through the exciter armature increased, thereby raising the voltage of the exciter and increasing the excitation of the alternator. The action is practically instantaneous, since the load current of the alternator is used directly to effect the regulation, without the intervention of any mechanical apparatus, the action being wholly magnetic.

The leakage path windings are placed between the windings of the alternator and its neutral point, which is usually either "earthed" or at a potential differing but little from earth, but in spite of this they are insulated for the full working voltage of the alternator. In a few special cases current transformers are used instead of passing the main current round the leakage paths. Fig. 2 shows the char-

acteristic curves of a 1,000 kw. alternator with and without the leakage path compounding. The curve marked A shows the effect on the voltage when a very inductive load is thrown on: by the time the full load current of 220 amperes is reached the volts have fallen to 2,300, so that the load on the plant is really only 700 kw. The curve marked B shows that when the compounding is in use the voltage remains practically constant, or, if required, a slight increase in voltage can be arranged to compensate for pressure drop in feeders. The curve marked C shows the effect when full load (inductive) is removed, without the corresponding arrangement.

A further advantage of this system of voltage regulation is that the alternator may be designed for a much smaller short-circuit current. It is well known that where close inherent regulation is required of an alternator—that is, when it is required that its voltage shall remain as steady as possible with varying loads—the current which passes when the alternator is accidentally short-circuited is very much greater than in the case of a machine designed for poorer regulation. These heavy short-circuit currents not only cause considerably more damage at the point of breakdown, but also are liable to damage the windings of the alternator, and cases have even been known where the main cables conveying the current have been wrenched from their supports. By using the above method of compounding an alternator the short-circuit current which passes when the machine is short-circuited can easily be reduced by one-third.

In conclusion, it may be pointed out that all extra apparatus required on a compounded alternator of this type is entirely electromagnetic—there are no moving parts whatever nor any electrical

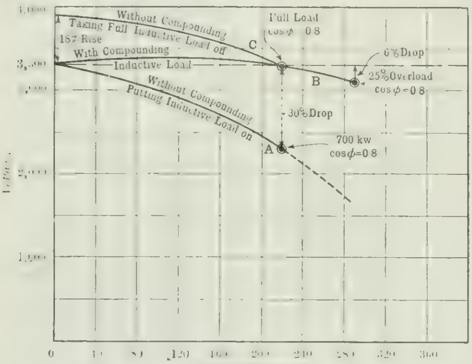


FIG. 2. VOLTAGE REGULATION CURVES OF TURBO ALTERNATOR WITH AND WITHOUT PARSONS PATENT ALTERNATOR COMPOUNDING.
1,000 kw. machine. 3,300 volts. 3-phase.

contacts to be made and broken, nor are there any complications such as solenoids and electrical condensers. There is no commutator to change the alternating current into direct current, and all the parts required for the compounding are fixed on the exciter. Thus, if, in spite of the great simplicity of these parts and the care taken to prevent breakdown, trouble should occur in this part of the machine, it is only a matter of a very few minutes to remove the compounding apparatus, when the machine can be run as an ordinary un-compounded plant.

As to fixing this arrangement to existing plants, in most cases it is necessary to fit a new exciter in order to do this, but in stations where the voltage regulation is bad, a motor-generator exciting set can be installed with the compounding fitted. One such plant in an existing station would make considerable improvement in the voltage regulation, and could in most cases be arranged to work on any one of the generators. In this form it would also act as a spare exciter in the case of breakdown of the ordinary exciting system.

Lead-covered Overhead Mains.—"The Times" Engineering Supplement states that the newly formed Niagara-Oswego Power Co. proposes to use for distribution purposes in Fulton, N.Y., a system of overhead lead-covered cables, working at a potential of 6,600 volts. Three No. 6 stranded copper conductors will form a cable, and the cables will be suspended by steel messenger wires. Existing telephone poles will be utilised to carry the cables so that the line can be constructed with the least delay and expense, and with the maximum of security.

RESEARCHES IN RADIOTELEGRAPHY.*

BY PROF. J. A. FLEMING, D.SC., F.R.S.

(*Continued from page 391.*)

Before leaving the subject of the antenna we may notice some recent improvements in directive antennæ—that is, in devices for more or less confining the radiation to one direction, and for locating the position of the sending station. In a previous discourse explanations were given of the property of a closed or partly closed antenna of radiating more in some directions than others, and the action of Marconi's bent antenna was described. Two other inventors, Messrs. Bellini and Tosi, have taken advantage of this fact to construct antennæ of a very interesting character. They erect an antenna consisting of two wires, each bent into a triangular form, the top ends nearly meeting, the planes of these triangles being at right angles to one another, and both of them vertical. The nearly closed antenna circuits are then inductively coupled with a condenser circuit, which is capable of being swivelled round in various directions. If the said condenser circuit is placed in such a position as to be coupled with one of the triangular antennæ, it will cause the maximum radiation to take place in the plane of that antenna, but none at all at right angles to it. If it is coupled with the other antenna, it will cause radiation to take place to a maximum degree in the plane of that second antenna. If, however, the oscillatory circuit is placed in an intermediate position, so as to act inductively upon both the nearly closed triangular antennæ, then it can be shown both mathematically and experimentally that the radiation of the combined system is a maximum in the direction of the plane of the oscillatory circuit which is coupled with the antenna. Hence, with such a combined antenna, we have it in our power to create radiation most strongly in one direction, although not entirely suppressed in all other directions. By combining together, however, a

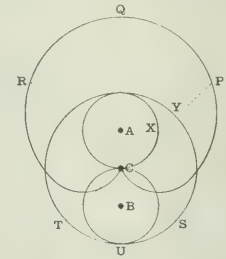


FIG. 12.

single vertical antenna with two nearly closed circuit antennæ at right angles to one another, Messrs. Bellini and Tosi have constructed a complex antenna which has the property of producing radiation almost entirely limited to one-half of the circumjacent space (*see* Fig. 12). It therefore corresponds to a certain extent in effect to the optical apparatus of a lighthouse, with catoptric or dioptric apparatus, which projects the light from the lamp largely in one direction. It is not yet possible to make with electric radiation of long wavelength that which corresponds precisely with a beam of light wholly concentrated along a certain cone or cylinder, but it is possible, by the use of a complex antenna, as described, to limit greatly the diffusion of the radiation. Since radiating and absorbing power go hand in hand, it is obvious that such a directive antenna also enables the position of a sending station to be located. Messrs. Bellini and Tosi have accordingly applied their methods in the construction of a radiogoniometer and receiving antenna, by means of which they can locate the direction of the sending station without moving the antenna, but merely by turning round a secondary circuit into a position in which the maximum sound is heard in a telphone connected with the receiver (*see* Fig. 13).

The space occupied by such closed antennæ has hitherto prevented their employment on ships. There is still, therefore, an opening for the invention of apparatus capable of being used on board ship, which will enable one ship to locate, within narrow limits, the direction of another ship sending signals to it, and therefore of ascertaining immediately the direction from which some call for help is proceeding.

* Lecture (slightly abbreviated) delivered on June 4th before the Royal Institution

Closely connected with this part of the subject is the question so frequently discussed as to the isolation or secrecy of radio-telegraphic communication. Up to the present moment the only really practical method of isolating any particular receiver so as to make it sensitive only to signals coming from a certain direction, is to avail ourselves to the utmost of the principle of resonance and to tune the sending and receiving circuits to exact correspondence. The question then arises what is it which determines the effectiveness of this tuning. If waves of one particular wave-length are impinging on a receiving antenna and creating signals, by how much can the wave-length be varied or the tuning of the receiver upset or changed without preventing these signals being received ? It is clear that the narrower this range the more perfect the isolation of the receiver. It can be shown that it depends upon the form of the resonance curve of the sending and receiving circuits. If the sending station is emitting waves of a certain constant wave-length and damping or decrement, then in the receiving circuit of all other stations within range there will be produced oscillations having a certain mean-square value measurable by appropriate instruments. If any receiving circuit is gradually brought by adjustment of its capacity and inductance into exact syntony or tune with the sending station, then this receiver current reaches its maximum value and there is a definite lesser value of

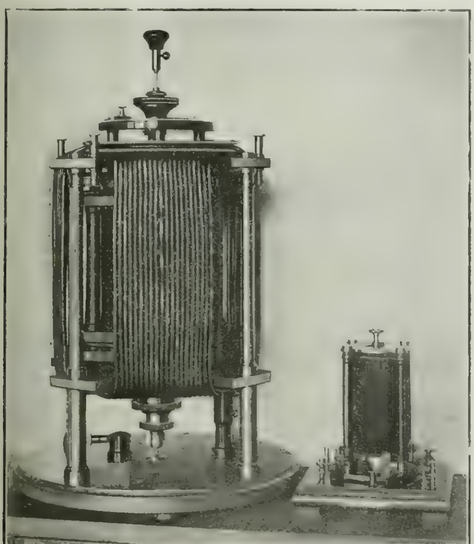


Fig. 13.—Bellini and Tosi's Radiogoniometers for Directive Radio-telegraphy.

the receiver current for every particular degree of want of tuning or dissonance between the two. The curve which by its ordinates expresses this receiver current corresponding to each particular tuning or natural frequency of the receiving circuit, is called a resonance curve (see Fig. 14). If this curve has a very sharp peak, then it clearly indicates that a slight want of tuning or syntony between the stations will greatly reduce the receiver current. The peakiness of the curve depends upon the sum of the decrements of the sending and receiving circuits. By the term decrement of a circuit is meant the logarithm of the ratio of the amplitudes of two successive oscillations in the train.

To obtain very sharp tuning we have, therefore, to employ either undamped oscillations or very feebly damped oscillations in the transmitter, and also a receiving circuit in which there is as little dissipation of energy by resistance and other causes as possible. It is then possible to cause a change of even less than one-half of 1 per cent., or five parts in 1,000 in the wave-length of the received waves to cease to actuate the receiver. This means that we can distinguish between two waves 1,000 ft. and 1,005 ft. or 1,010 ft. in length respectively, and that our receiver may be tuned to respond to one and not to the other. The persistent or undamped oscillations created by the arc transmitters have, therefore, an advantage in this respect over spark transmitters, in that the damping or decrement of the transmitter is less ; but it should be borne in mind that the damping of the receiver circuit has also a large influence on the form of the resonance curve, and that good isolation cannot be obtained unless the receiving circuit also has a small decrement. Under favourable conditions we can employ a sending key, which does not interrupt the production of the electric waves at the sending station, but simply alters the wave-lengths slightly by about ½ per cent. If, then, the corresponding receiving station has a feebly damped receiver, this change will be sufficient to cut up the continuous record or telephone sound at that station into Morse dots and dashes and so transmit signals. But another station not so tuned will either receive nothing at all or else a continuous unbroken line or sound not having any meaning. There are other methods by which signals not intended for a particular receiver can be rejected by it. Fessenden has described for this purpose an interference detector, in which the impulses it is not desired to receive are made to divide between two paths, the oscillations in which are then caused to neutralise each other's effect on the oscillation detector. On the other hand, the waves of the wave-length it is desired to receive do not so neutralise themselves, but produce a signal by their operation on the detector.

We must pass on to notice in the next place some improvements in oscillation detectors and means of testing them. As already explained, the æther waves sent out by the transmitting antenna fall on the receiving antenna and create in it or some other circuit connected to it very feeble oscillations. These oscillations being very feeble, alternating currents of high frequency cannot directly affect either an ordinary telegraphic instrument or a telephone, but we have to interpose a device of some kind, called an oscillation detector, which is affected by oscillations in such a manner that it undergoes some change which in turn enables it to create, increase or diminish a local current produced by a local battery, and so affect a telephone or telegraphic relay. One kind of change the oscillations can produce in certain devices is a change in their electric resistance, which in turn is caused to increase or diminish a current through a telephone or

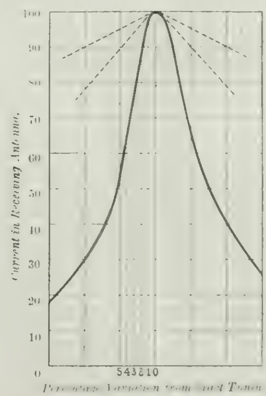


Fig. 14.—Resonance Curves.

telegraphic relay generated by a local battery. To this type belong the well-known coherers of Branly, Lodge and Marconi, which require tapping or rotating to bring them back continually to a condition of sensitiveness. Coherers, however, have been devised which require no tapping. Thus it has been found by Mr. L. H. Walter that, if a short length of very fine tantalum wire is dipped into mercury there is a very imperfect contact between the mercury and tantalum for low E.M.F.s. This may perhaps arise from the fact that tantalum, like iron, is not wetted by mercury. If, however, feeble electric oscillations act between the mercury and tantalum, the contact is improved while they last. If, then, the terminals of a circuit containing a telephone in series with a shunted voltaic cell are connected to the mercury and tantalum respectively, and if damped or intermittent trains of electric waves fall on an antenna and excite oscillations which are allowed to act on the mercury tantalum junction (*see* Fig. 15) then at each train the resistance of the contact falls, the local cell sends current through the telephone and produces a short sound, and if the trains come frequently enough this sound is repeated and will be heard as a continuous noise in the telephone. This sound can be cut up into dot and dash signals by a key in the sending instrument. If the transmitter is sending persistent oscillations, then some form of interrupter has to be inserted in the receiving circuit to enable us to receive a continuous sound in the telephone which can be resolved into Morse dot and dash signals by the key in the transmitter. The operator usually wears on his head a double telephone,

and listens to these long and short sounds in the telephone and writes down each letter or word as he hears it. The reception of signals in modern radio-telegraphy is most usually effected by ear, by means of some type of oscillation detector capable of actuating a telephone. It is important then to notice that, to obtain the highest sensitiveness when using the telephonic method of reception, the spark frequency or number of oscillation trains or the number of interruptions of the persistent train per second must take place at such a rate that it agrees with the natural time period of the diaphragm of the telephone used. An ordinary telephone receiver is most sensitive, according to the researches of Lord Rayleigh and M. Wien, for some frequency lying between 500 and 1,000. Thus Lord Rayleigh (*see* "Phil. Mag.," Vol. XXXVIII., 1894, p. 285) measured the alternating current in microamperes required to produce the least audible sound in a telephone receiver of 70 ohms resistance at various frequencies, and found values as follows:—

Table II.

Frequency	128	192	256	307	320	384	512	640	768
Least audible current in micro-amperes...	28	2·5	0·83	0·49	0·32	0·15	0·07	0·04	0·1

M. Wien found for a Siemens telephone somewhat different results, viz.:—

Frequency	64	128	256	512	720	1,927	1,500
Least audible current in micro-amperes ...	12	1·5	0·13	0·027	0·008	0·013	0·024

Both, however, agree in showing a maximum sensitiveness for currents of a frequency between 600 and 700. This is due to the fact that the frequency of the actuating current then agrees with the natural frequency of the ordinary telephone diaphragm. Hence, alternators for large power radio-telegraphic stations are now designed to give currents with a frequency of about 300 or 600 alternations per second, so that, when producing discharges of a condenser, the number of sparks per second may be at least 600, and

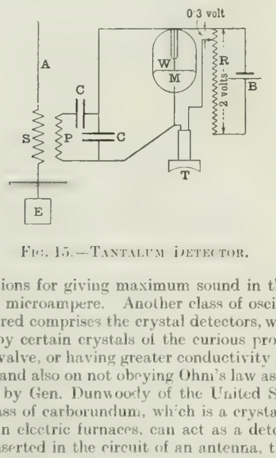


FIG. 15.—TANTALUM DETECTOR.

fulfil the conditions for giving maximum sound in the telephone of the receiver per microampere. Another class of oscillation detector recently discovered comprises the crystal detectors, which depend on the possession by certain crystals of the curious property of acting as an electrical valve, or having greater conductivity in one direction than the other, and also on not obeying Ohm's law as conductors. It was discovered by Gen. Dunwoody of the United States Army, in 1906, that a mass of carborundum, which is a crystalline carbide of silicon formed in electric furnaces, can act as a detector of electric oscillations if inserted in the circuit of an antenna, the crystal mass being held strongly pressed between two spring clips, which are also connected by a shunted voltaic cell in series with a telephone. When feeble oscillations are set up in the antenna a sound is heard in the telephone. This property of carborundum has been carefully investigated by Prof. G. W. Pierce, of Harvard, and he showed that a single crystal of carborundum has remarkable unilateral conductivity for certain voltages when held with a certain contact pressure between metallic clips. Thus, for a crystal held with a pressure of 1 kg., and subjected to an E.M.F. of 30 volts, the conductivity in one direction through the crystal was 4,000 greater than in the opposite direction (*see* Fig. 16). The result of these experiments was also to show that the current voltage curve or characteristic curve of a carborundum crystal is not linear—that is to say, the crystal as a conductor does not comply with Ohm's law, for the resistance of the crystal decreases as the current is increased. Hence the conductivity of the crystal is a function of the voltage acting on it (*see* Fig. 17). Accordingly, if we pass a current from a local cell through a crystal under a voltage, say, of 2 volts, a telephone being inserted in series with the cell, and if we apply an oscillatory voltage also to the crystal, which varies, say, between +0·5 and −0·5 volt, then the crystal is alternately subjected to a voltage of 2·5 and 1·5 volts; but the corresponding currents would be, say, 8·4 and 1·8 microamperes, as shown by an experiment with one particular crystal employed by Prof. Pierce. The mean current would then be 5·1 microamperes, whereas the steady voltage of 2 volts would only pass a current of 4 microamperes. Hence, apart from the unilateral conductivity, and merely in virtue of the fact that the characteristic curve is not a straight line, we find that such a crystal, or even a confused mass of crystals, can act as a radio-telegraphic detector. There are, therefore, two ways in which a crystalline mass of carborundum can be used as a radio-telegraphic detector. It consists of a conglomeration of crystals arranged in a disorderly manner, or not so symmetrically as to neutralise one another's unilateral conductivity. Hence the mass of crystals, like the single crystal, possesses unilateral conductivity, and also a

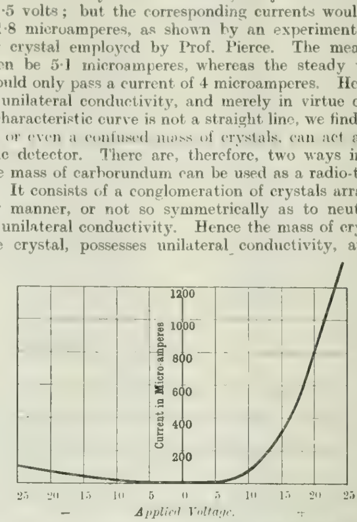


FIG. 16.—CHARACTERISTIC CURVES OF CARBORUNDUM CRYSTAL.

conductivity which is a function of the voltage applied to it. We may then use it without a local cell, and avail ourselves of its valve property to rectify the trains of oscillations in the antenna and convert them into short unidirectional trains which can affect a galvanometer or telephone; or, secondly, we may place the crystal between the ends of a circuit containing a telephone and a shunted voltaic cell, and then on passing oscillations through the crystal we hear sounds in the telephone due to the fact that the conductivity is a function of the voltage, and is, therefore, increased more by the addition that it is diminished by the subtraction of the E.M.F. of the oscillations to or from the steady voltage of the local cell. The telephone, therefore, detects this change in the average value of the current by a sound emitted by it. Prof. Pierce has discovered that several other crystals possess similar properties to carborundum—for example, hessite, which is a native crystalline telluride of silver or gold; an anastase, which is an oxide of titanium; and

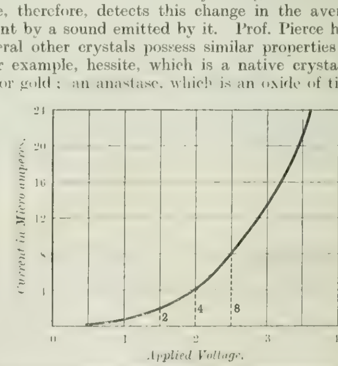


FIG. 17. CHARACTERISTIC CURVE OF CARBORUNDUM CRYSTAL (Prof. Pierce).

molybdenite, which is a sulphide of molybdenum. As regards the origin of this curious unilateral conductivity, it seems clear that it is not thermoelectric, but at present no entirely satisfactory theory of the action has been suggested.

A number of forms of oscillation detector have recently been invented which depend on the curious fact that a slight contact between certain classes of conductors possesses a unilateral conductivity, and can therefore rectify oscillations. One such detector now much used in Germany consists of a plumbago or graphite point, pressed lightly against a surface of galena. It has been found by Otto von Bronk that a galena-tellurium contact is even more effective. To the same class belongs the silicon-steel detector of Pickard. If such a contact is inserted across the terminals of a condenser placed in the receiving circuit, and if it is also in series with a telephone, the trains of oscillations are rectified or converted into more or less pro-

longed gushes of electricity in one direction through the telephone. These, coming at a frequency of several hundred per second, corresponding to the spark frequency, create a sound in the telephone which can be cut up by the sending key into Morse signals. According to the researches of Prof. Pierce and Mr. Austin it seems clear in many cases that this rectifying action is not thermoelectric, since the rectified current is in the opposite direction to the current obtained by heating the junction.

(*To be concluded.*)

THE PRESS CONFERENCE AND THE TELEGRAPH SERVICES.

The adjourned sitting of the Imperial Press Conference was resumed on Friday last week, in the hall of the Institution of Civil Engineers, at Westminster. The first business of the Conference was to receive the report of the Committee, appointed by the Conference at its last meeting, to report on Submarine Cable Rates. Particulars of this appointment and the names of the committee were given in THE ELECTRICIAN for June 11, p. 355.

After the preliminary business, the following resolutions of the Committee were submitted for approval by the Conference :—

1. That in the opinion of the committee it is urgently necessary that the Governments of the British Empire take steps to increase the means and to reduce the cost of the electric communication between the different parts of the Empire, and the committee recommends the Conference to ask the Prime Minister to receive a deputation upon the question.

2. The committee takes the opportunity to draw attention (1) to the high charges made by the Indian authorities on all cable messages to and from the United Kingdom placed on the Indian wires, and (2) to the present scale between the ordinary and Press cable rates, and invites the Conference to pass a resolution calling the attention of the India Office and the Colonial Office, and also the Eastern Telegraph Company, to these matters, with a view to securing some immediate relief in both respects, and recommends that the attention of the Colonial Office and the companies be called to the prohibitive rates at present obtaining in the West Indies.

3. That this committee urges upon the Governments concerned the desirability of establishing a chain of wireless telegraph stations between all British countries, because these are necessary both for the cheapening of electrical intercommunications and for the safety of the mercantile marine.

After Mr. J. C. INGLIS, president of the Institution of Civil Engineers, had welcomed the delegates, the chairman (Hon. H. L. W. LAWSON) read the above resolutions and the following further resolution :—

4. That the secretary be instructed to write to the Pacific Cable Board to ask whether they are prepared to give a reduced Press rate and at what rate per word, and that a similar letter be addressed to the Eastern Telegraph Company.

The CHAIRMAN then said they had had at the committee's meeting that day Sir H. Babington Smith, of the Post Office; Mr. Johnson, representing the Colonial Office; Mr. Kirk, representing the India Office; Mr. A. S. Baxendale, of the Pacific Cable Board; and Mr. G. Marconi. Mr. Baxendale had stated at once that the Pacific Cable Board would reduce their charges for Press messages to one-half, and he (Mr. Baxendale) understood the New Zealand Government would do the same in regard to their terminal or land charges. He had also reason to believe the Government of the Commonwealth would do the same. When a proposal from the Eastern Telegraph Co. was submitted to the committee it seemed the unanimous opinion that nothing short of a general reduction of cable rates for Press purposes would meet the necessities of the case.

Mr. KYFFIN-THOMAS (Australia) proposed that the committee be requested to continue their negotiations.—Adopted.

Resolution No. 1 was then adopted, and the Cable Rates committee were appointed as a nucleus of the deputation, with the following: Lord Northcliffe and Messrs. J. W. Dafoe, C. Woodhead, H. A. Gwynne, R. Donald, Clifford, and Harold Spender.

Resolution No. 2, after a few remarks from Mr. Roles (Ceylon) and Mr. Cunningham (Australia) was carried unanimously.

Mr. STANLEY REED (India) proposed resolution No. 3, and said that, although wireless telegraphy might not supersede the cables, it would be a most potent factor in the reduction of cable charges.

Mr. DOUGLAS (New Zealand) seconded, and the resolution was carried unanimously.

Mr. MOBERLY BELL moved the adoption of resolution No. 4. He said the 1s. Press rate from England to Australia consisted of 5d. from England to Canada, 1d. across Canada to Vancouver, 5d. from Vancouver to Australia, and 1d. the terminal rate in Australia. The portion the Pacific Cable Board had to deal with was that between Vancouver and Australia, and for that portion they were willing to accept 2½d. The reduction was, therefore, from 1s. to 9½d., and they were trying to induce the Canadian and Australian Governments to make some concession.

Mr. TEMPERLEY (Australia) seconded, and said he was surprised the Pacific Cable Board carried the messages so far for such a small sum. Although 15 words of ordinary intelligence were carried round the Commonwealth for 1s., there was a Press message charge of 2d. per word on cable messages landed at Queensland and carried through Australia.

The motion was then carried.

Mr. ROSS (Canada) then re-introduced the resolution proposed at the first meeting of the Conference in favour of state-owned communication across the Atlantic. He said he had not used the words "Atlantic cable," as they had now arrived at a practical stage of wireless telegraphy, and the words of his resolution were, therefore, "State-owned electric connection." His resolution affected Great Britain and the Dominion of Canada, and they asked those two Governments to consider the question at once. There ought to be at least one line of State-owned electric connection around the world and around the British Empire. He desired to start with the Atlantic connection and the connection across Canada.

Mr. MARCONI (who was invited to speak on the motion) said, after referring to the completeness of the wireless telegraph equipments in many parts of the world, a certain amount of message work was carried on between England and Canada, and a complete service would be completed about the end of August. He should consider it injudicious for the Governments to enter into a scheme of State-owned cables without first having investigated the capabilities of a wireless connection between Canada and England. At present they had certain difficulties, which mainly concerned the transmission and distribution of the messages over the land lines on the North American Continent, but he thought that trouble could be entirely obviated if the delegates would consider what was being done by wireless telegraphy itself. The cost of two stations capable of communicating over distances which had already been proved practicable (about 3,000 miles) would be about £50,000 for each station. That was, of course, subject to variation—improvements might decrease it or local conditions, such as transport, might increase it. It might be possible in the near future to communicate over much greater distances—say 6,000 miles or perhaps even more; but that had to be proved. There was an interesting point in connection with distances over 6,000 miles, and that was when the equator had been passed these wireless waves might begin to converge again, and it might occur that at the Antipodes messages might be received more easily than half-way to the Antipodes; but that, again, remained to be proved. At present they were prepared to take a limited amount of "Press" across the Atlantic at 2½d. per word, and when their stations were complete they would be able to take 15,000 or 20,000 words per day, and if the amount of "Press" by that system were considerable his company would be prepared to give a service at 2d. per word from Canada to England. The present speed of wireless across the Atlantic was 25 words a minute. They hoped to introduce duplex, which would bring that to 50 words a minute, and perhaps further improvements would greatly increase that. He was not a cable expert, but there was a general belief that about 50 words a minute would be the limit across the Atlantic over a cable of 2,000 to 3,000 miles in length. It was obvious that five wireless stations would do five times the speed of one station, and, with the latest improvements he thought there should be no fear of any interference between 5, 10 or 20 stations installed on the coast of Ireland or Great Britain.

Mr. KYFFIN-THOMAS (Australia) said if it were a question of taking over the existing cables he would ask the Conference to consider what that meant. The value of the cables might come to something like 50 millions. They could not ask the companies to part with such portions of the lines as it might suit the Imperial and Colonial Governments to take, so if they considered the purchase of the cables they must consider the purchase of the whole, and that was a proceeding which he did not think the Imperial or Colonial Governments were likely to face. If the Governments agreed to assume the control of wireless telegraphy, would that be likely to promote the further improvement of that system. Most of them would agree that it was not under Government control that the greatest progress was made in inventions and improvements, and he thought if this matter were left in the hands of the great inventor who was working at it so strenuously and those who assisted him they were much more likely to get the best results. He should, therefore, oppose the motion.

Mr. FINK (Australia) said he did not understand that the motion suggested the purchase of the cable companies. He thought the time had gone by for that. There was a Pacific cable owned by the State, and its management was not inferior nor its benefits less to the community than those of any company-owned cable. His recollection was that in the House of Commons some official information stated that the amount involved in the purchase of the cable companies was about three times the amount mentioned by Mr. Kyffin-Thomas. The day was quite gone by when they need talk tenderly about the expropriation of private interests. British Governments did not expropriate private interests without giving full value.

Mr. HUDSON BERKELEY (Australia) supported the resolution. The land telegraphs in England, Australia, New Zealand and, he thought, S. Africa, were State owned, and if the telegraphs were State owned to that extent, why should they not have the cables and complete the whole service. He believed the Government of Great Britain and the Naval authorities were the largest customers of the cables, and surely if they had their own service it would be of great advantage to them. He did not think the Government should buy out the cable companies. They had to thank the Eastern Extension Telegraph Co. for the good service they had given to Australia, but, at the same time, new circumstances had arisen in which it should be altered.

Mr. CUNNINGHAM (Australia) asked if the resolution contemplated the purchase of existing rights. ("No, no.") Then it contemplated the confiscation of existing rights. He thought they should say they meant that resolution to refer to cable communication, because they had not yet reached the point at which they could regard the wireless system as

being practicable, and unless they were to pose as dreamers and idle speculators they should limit themselves to practical considerations, and they should say there should be State-owned cable communication between the British Isles and Canada. They either meant to set up competition with or to buy out existing private interests.

Mr. COHEN (N.Z.) said there was no suggestion in the resolution that they should lay down a cable on the Atlantic side now or he would not have supported that.

Mr. WARD (Australia) said he thought they should have unanimity if possible, and he suggested that Mr. Ross should restrict his resolution to wireless telegraphy. They had one State-owned cable, and, in its financial aspect at least, it had been rather a disappointment. He could not vote for the resolution under the circumstances.

Mr. DAFOE (Canada) said the shortest route to get a 5 cent. rate across the Atlantic was to have a State-owned cable. The question was by no means a Canadian one. It was Imperial in its widest aspect and consequences. The proposal was to have a line from England to the extremest western point of Australia. He did not believe in State-owned concerns doing business at cost to cut the throats of private companies. He thought the mere fact that the Pacific Cable Board were operating a line three times as long as the cables across the Atlantic and were to-day proposing to carry Press messages, though they had comparatively few as against the Atlantic companies, for half the rate the privately-owned cables were charging for messages across the Atlantic was in itself a conclusive argument for a State-owned cable across the Atlantic, or its equivalent in the way of a wireless system.

Mr. CUNNINGHAM said he would like to feel that they were not passing a resolution which committed him personally to a policy of confiscation, because if they were going to establish, with the long purse of the Government, a rival service to some private enterprise which was now in the field, without compensation, they were confiscating it. (Cries of "No.") He asked what would happen to a newspaper already in the field if another newspaper published with the long purse of the Government came in, without any desire to make a profit. He liked to feel that he was acting with some regard to principle. He and some of his friends were anxious not to be committed to anything that looked like the confiscation of existing rights. They would have had lower rates but for the Pacific cable.

Mr. J. A. MACDONALD (Canada) said he was prepared to vote for the resolution, knowing that Mr. Marconi would be ready for the Press service long before the Government.

Mr. CHARLES BRIGHT said he had risen to correct two figures. The effective working speed of an Atlantic cable was 97 words per minute, and the cost of an Atlantic cable was half a million, not a million.

In reply to a question, Mr. MARCONI said, as an engineer, he really did not care whether his invention was exploited by the State or by a company; but, as a director of a company, of course he would have to consult his colleagues on the board, but he expected any Government of the present day would compensate private interests if it stepped into their place. With regard to speed of cable work, Mr. S. G. Brown had put it rather low in a Paper written by him and other experts put it higher.

The CHAIRMAN then read Mr. Ross's resolution :—

"That for the achievement of better and cheaper electric communication in the Empire it is one of the essentials that there should be State-owned electric communication between the British Isles and Canada across the Atlantic, and also State control of electric communication across Canada between the Atlantic and the Pacific cable services."

The motion was carried.

Mr. MAITLAND PARK (S. Africa) moved a resolution that "a State-owned system of electric communication was desirable between Great Britain and British South Africa." He said in the case of South Africa they had had no reduction, and, as far as he could make out, there was not even the promise of a reduction. The Press rate was 1s. a word, and he thought that was ridiculous after half a century of submarine telegraphy. The resolution did not commit them to either a cable or the Marconi system. The physical difficulties for wireless telegraphy over 6,000 miles were, perhaps, less there than anywhere else, because they had Tenerife, St. Helena, Ascension and Table Mountain, which would, he thought, as sites for stations lend themselves very easily to the Marconi system. South Africa was important from a strategical point of view, and the way to prevent its being cut off in time of war was to have a State-owned system of electrical communication.

Mr. MARCONI said they hoped wireless telegraphy would be applicable to greater distances than they had already covered, and that they might some day cover the distance from Great Britain to South Africa. A peculiar advantage of wireless would be that by alteration of wave-length one could not only communicate from South Africa to England, but also with Canada direct, the distance being practically the same.

Mr. Maitland Park's proposal, to which the words "and that representations to this effect be made by the deputation appointed by the Conference to wait upon the Prime Minister" were added, was carried.

Mr. NELSON (Canada) proposed that, "In view of the announcement by the management of the Pacific Cable Board that they will greatly reduce the charges for Press messages passing over its lines between Canada and Australia and New Zealand, provided the Governments of the latter Dominions make a corresponding reduction in their terminal rates, the Governments of Australia and New Zealand be at once communicated with acquainting them with the terms of the concession made by the Pacific Cable Board, and asking for their co-operation in reducing the cost of these messages."

This was carried, and concluded the discussion on the subject.

(A report of the interview between the Prime Minister and the deputation appointed by the Conference will be found on a subsequent page.)

PHYSICAL SOCIETY.

At the meeting held on June 11th at the Imperial College of Science, Dr. C. CHREE, F.R.S., president, in the chair, a Paper by Dr. Russell and Mr. Arthur Wright, on

"The Arthur Wright Electrical Device for evaluating Formulæ and solving Equations,"

was read by Dr. RUSSELL. In this device special slide resistances are used. If R be the resistance of one of these and a metallic finger make contact with it at a point where the scale reading is x, the resistance between this finger and the terminal of the slide is R/x. The scales of the slides are graduated logarithmically as in the ordinary slide rule. Hence the processes of multiplication and division can be done mechanically by sliding them against exactly similar fixed scales. If we connect a number of these slide resistances in parallel, since the current is inversely proportional to the resistance, the sum of the currents through them will be proportional to the sum of the readings of the contact fingers. We can easily balance by a null method this current against the current going through a single slide resistance X by means of a Wheatstone's bridge arrangement. In this case the reading on X when there is a balance gives the sum of the readings on all the other slides. Similarly, we can subtract numbers by putting slides representing these numbers in parallel with X and then obtain a balance by altering the reading on X. It is also shown how the variable arms of the bridge can be usefully employed in making the calculations. By clamping the contact fingers inclined at certain angles to a rod which can be moved at right angles to the slides, it is easy to obtain the values on X of $f(x)$ when

$$f(x)=ax^m+bx^n+cx^p+\ .\ .\ .\ ,$$

where the indices m, n, p, . . . may be positive, negative or fractional, and the coefficients may be positive or negative numbers. In particular, if the reading on X be zero when x is x_1, then x_1 is a root of the equation $f(x)=0$.

A model of this device for solving an equation of any degree consisting of not more than four terms was shown. In this model the slide resistances are fixed on a rigid framework and the contact fingers are wires which can be fixed at any desired angles $\cot^{-1} m$, $\cot^{-1} n$, and $\cot^{-1} p$ with the slides, where m, n and p are the indices of the powers of x in the equation. A few dry cells and a lecture-table galvanometer were employed. Moving the framework until there is no deflection of the galvanometer, the pointer attached to it indicates at once a root of the equation. The inaccuracy of the results found by means of this model is of the order of 1 per cent. It is explained how approximate values of the imaginary roots of numerical equations can be found by the device. It is also explained how it can be employed to solve very complicated equations. It is shown, for instance, that a device with four slide resistances like the model exhibited can be used to find approximate values of the roots of numerical equations of the form

$$a/x^m+b/f(x)=cx^n+dF(x),$$

when the values of $f(x)$ and $F(x)$ have been computed or found experimentally for various values of x. The same device also can be used to find approximate values of x which satisfy the equation

$$a_1l_1^{b_1x}+a_2l_2^{b_2x}+a_3l_3^{b_3x}+a_4l_4^{b_4x}=0,$$

when the numerical values of the constants are known.

Prof. C. H. LEES expressed his interest in the device and referred to the large number of calculations that could be performed with it.

Dr. W. H. ECCLES congratulated the authors, and, referring to the fact that the machine could be used to solve a bi-quadratic, asked if it was possible to determine the two quadratic factors by means of it.

A Paper on

"The Echelon Spectroscope, its Secondary Action and the Structure of the Green Mercury Line"

was read by Mr. H. STANSFIELD. The Paper describes an investigation of the action of an echelon spectroscope and the results obtained as to the structure of the green mercury line given by an Arons lamp. The echelon spectroscope employed was arranged so that the auxiliary prism could be mounted next to the echelon. The dispersion of the prism may be added to or subtracted from the dispersion of the echelon and the change of 4 per cent. in the dispersion thereby obtained gives a method of determining whether two lines in the spectrum belong to the same order. The theory of the primary action of the echelon in the reversed position, when the light leaves by the largest plate, is compared with the theory of the echelon in the usual position.

A Paper entitled

"The Proposed International Unit of Candle-Power"

was read by Mr. C. C. PATERSON. The Paper discusses the units of candle-power at present officially accepted in Great Britain, France, the United States of America and Germany. The numerous intercomparisons which have taken place during the past five years between these units show that the candle, as interpreted in France,

Great Britain and the United States respectively has practically the same value in the three countries. The authorities in the gas and electric interests in the United States are prepared to adjust their units of candle-power to bring them to a single value which is to be the same as the British and French units. The Paper gives the results of comparisons showing that within the limits of experimental error the British and French units are identical. The change involved in the unit at present maintained at the Bureau of Standards, Washington, is shown to be 1·6 per cent. The agreement thus established forms the subject of an official memorandum from the National Physical Laboratory (with the concurrence of the Metropolitan Gas Referees), the Bureau of Standards, Washington, and the Laboratoire Centrale, Paris. The proposal to call the common unit of light to be maintained jointly by the National Standardising Laboratories of America, France and Great Britain the "International Candle" has been submitted to the International Electrotechnical Commission, and through it to all the countries of the world which are represented on that Commission. The Hefner unit is shown to be almost exactly nine-tenths of the new unit. The comparisons between the units have been made by two methods: (1) The direct comparisons of the flame standards in France, Germany and Great Britain. (2) Through the medium of electric sub-standards which have had values assigned to them in the National Laboratories of the four countries. The agreement between the ratio values by the two methods is very close, and is shown by a table giving the results of the various comparisons which have been made.

Dr. FLEMING said that it was interesting to hear that the chief Powers had come to an understanding with each other as to the unit of light. It must be remembered, however, that this proposed International unit had no objective existence, and no greater value as a unit of comparison than the Hefner or pentane units, to which it was related by an arbitrary definition. He greatly regretted that the National Physical Laboratory authorities had acquiesced in the adoption of a flame standard of light, with all its difficulties and variabilities. Influenced as they were by atmospheric pressure, moisture, CO_2, height of flame, composition of fuel, and number of persons in the photometric room, these flame standards could not possibly be considered as a final solution of the problem of obtaining a primary standard of light. What was really required was the concrete realisation of a permanent primary standard, which would be the standard of reference for secondary standards like the Fleming Ediswan large-bulb glow-lamp standards, which he (Dr. Fleming) had introduced seven years ago. Mr. Paterson had made only a very brief reference to M. Violle's work on the platinum standard, and ignored altogether the careful work of Prof. Petavel, carried out in 1899 in the Davy-Faraday laboratory. Prof. Petavel's conclusions were that with suitable precautions the unit of illumination could be reproduced within 1 per cent. by means of the molten platinum standard. He asked Mr. Paterson if any attempt had been made at the National Physical Laboratory to repeat or extend Prof. Petavel's work, and if not why not? Investigations of this kind, which were difficult to carry beyond a certain point in private laboratories, were peculiarly the province of a State-aided institution like the National Physical Laboratory. He was pleased to see that Mr. Paterson endorsed the conclusions which he (Dr. Fleming) had stated seven years previously in a Paper read before the Institution of Electrical Engineers—viz., that properly prepared (large bulb) glow lamps constituted the best secondary standards. He (Dr. Fleming) had now employed for 14 years secondary standards of this type, and had not found anything to surpass them in convenience and accuracy. The flame standards were unequally affected by changes in atmospheric pressure and moisture. Hence, any figures for ratios such as were given in Mr. Paterson's Paper were true only under certain accurately defined conditions of surrounding atmosphere which were very difficult to reproduce. Accordingly elaborate experiments to ascertain how many Hefners were equal to 1 pentane were not a matter of nearly such importance as the construction of some final constant primary standard of light, and in his (Dr. Fleming's) opinion the most satisfactory form for this primary standard of light was to derive it from the light emitted normally by a defined area of some substance in a state of incandescence at a known fixed temperature. He was sure that many practical photometrists, especially those connected with the electric lighting industry, were not at all convinced that the best primary standard was a flame standard, or that the pentane or Hefner units were a completely satisfactory solution of the problem of obtaining a primary standard of light.

Dr. RUSSELL complimented the author on his experimental results. The bougie décimale was the unit adopted by the International Congress of Electricians in 1889, and was defined to be the 20th part of the Violle standard. He was not prepared to accept that it was equal to 1·11 Hefner unit. Lummer's and Petavel's results rather discounted the importance to be attached to Violle's number. In connection with Dr. Fleming's remarks, he stated that the unit suggested by Waidner and Burgess had many advantages. They proposed to adopt as the unit of intensity the radiation from a square centimetre of a black body maintained at the temperature of the fusion of platinum. He referred also to the unit suggested by Steinmetz, and as Mr. Dyott was present he asked if he could give any information about this unit.

Mr. DYOTT said that his experiments had been made exclusively in connection with Prof. Steinmetz's magnetic arc. He had made no experiments on his photometric unit.

Mr. DOW said the pentane lamp as a standard was not very inferior to the Violle standard. He did not think we could as yet accept as a standard an area of a black body at a high temperature.

Dr. DRYSDALE thought the international agreement arrived at was most welcome. As he understood the Paper, however, it was simply an attempt to obtain agreement between present existing units rather than standards, and left the matter of the best form of standard perfectly open. He thought that everyone having experience with flame standards would thoroughly agree with Prof. Fleming's condemnation of them, and there could be no doubt that the primary standard should be an incandescence one. He, however, did not agree with Dr. Fleming's suggestion of reviving the Violle standard. What was wanted in an incandescence standard was a definite area of a definite substance at a definite temperature. When the Violle standard was suggested they had little knowledge of the radiating properties of substances or high temperature measurement, and therefore the only suitable thing was to take a very pure substance, using its melting point as a bench mark of definite, though unknown, temperature. But everyone who had studied the history of the Violle standard was aware of the great difficulties of setting it up, and it had the disadvantage, according to Petavel, that the surface was dependent on the gas mixture used, besides an extremely short period of constancy and high expense. In the meantime they had realised that a perfectly black body was easily obtainable, and that it had perfectly definite radiating properties; they had the laws of Stefan and Wien, and optical pyrometry had advanced to a high degree of accuracy, and it therefore seemed decidedly preferable to suggest a unit area of a black body at a definite temperature. Mr. Jolley and he had come to the conclusion that a square centimetre of a black body at a temperature of 2,000 deg. absolute would perhaps be a good unit, and would be probably of the order of 100 c.p. This temperature was probably pretty close to that of the ordinary carbon filament glow lamp, so that there should be no colour difficulty, and it should not be exceptionally difficult to maintain constant. If the temperature were measured by an optical pyrometer of, say, the Féry form, based on the Stefan law, the deflection would be proportional to the 4th power of the absolute temperature, while the light, according to Lummer and to integration from Wien's law, was proportional to T^{12}. Hence the light would be proportional to the cube of the deflection only, and the probable error would not be large. Finally, a point in favour of the black body was the perfectly definite character of its spectrum, which made it a standard of colour as well as of intensity, and suitable for spectro-photometric comparison. As the surface would be that of a solid, it would be unnecessary to maintain it in a horizontal position, as with the Violle standard, and the amount of light could be easily varied by a diaphragm. Dr. Drysdale said that he thought Mr. Dow had slightly misunderstood the nature of Prof. Féry's results, and it would be unfortunate if this should militate against the idea of the black body as a standard. There was no difficulty in obtaining a perfectly black body either by an enclosure or reflector. What Prof. Féry's recent experiments had shown was not that Kurlbaum's black radiators were at fault, but that he had been in error in assuming the perfect absorption of platinum-black with which his receiving bolometer was coated. This had necessitated an increase of the constant in the Stefan formula from Kurlbaum's value of 5·32 to 6·32, but this was a point which could easily be settled, and did not indicate any real difficulty in the use of the black body or the determination of its temperature, which could be simply extrapolated from known temperatures by the aid of the Stefan law.

Prof. C. H. LEES said that Prof. Petavel's recent work on the radiations from heated platinum strips suggested that he was not altogether satisfied with the Violle standard.

Mr. PATERSON expressed his interest in Dr. Fleming's remarks, and said he had probably misunderstood the object of the Paper, which dealt with the relations existing between the various units now in use. He agreed with his observations on the flame standard. He had not referred in his Paper to the work of Dr. Fleming and Prof. Petavel on the Violle standard, as it hardly came within the scope of the Paper. They had not tried to reproduce the Violle standard at the National Physical Laboratory. With regard to Dr. Drysdale's remarks about the use of a black body, he did not think it would be possible to keep the temperature sufficiently constant to enable it to be used as a standard.

A Paper on

"Inductance and Resistance in Telephone and other Circuits"

was read by Dr. J. W. NICHOLSON. A general formula for the effective inductance of a circuit consisting of two long parallel wires has been given by the author, and is suitable for cases in which the current distribution in either wire is greatly affected by the frequency of alternation. In the present Paper certain important cases are examined in detail, and formulæ are obtained capable of immediate use. Attention has been mainly directed to that of the simple telephone circuit, in which the leads are not twisted round each other in order to annul the inductive effects of the earth and of neighbouring circuits. Throughout the investigation only iron and copper wires as the two extreme cases are considered. The large permeability of iron completely changes the character of the effect of frequency on its self-induction as compared with other metals. To all metals greatly used in practice, except iron, the formulæ developed for copper wires may be applied with a nearly identical order of accuracy.

A "NOTE ON TERRESTRIAL MAGNETISM," by Mr. G. W. Walker, and a Paper by Mr. A. Eagle, "ON THE FORM OF THE PULSES CONSTITUTING FULL RADIATION OR WHITE LIGHT," were taken as read.

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CHEAP UNITS.

The supply of electrical energy at a cheap rate, and the question as to what is a fair basis on which to charge the various consumers, is a matter that has exercised the mind of every supply engineer. Last week this problem received the attention of the Incorporated Municipal Electrical Association, the exponent in this case being Councillor A. SINCLAIR, whose attention was drawn to the subject by the effect produced on the station costs at Swansea, when several large power consumers temporarily stopped their demand. The result of this cessation was that the daily load factor dropped from 55·9 per cent. to 44·5 per cent., and Mr. SINCLAIR was much surprised at the small cost of producing the lost units—namely, less than $\frac{1}{4}$d. per unit, excluding capital charges.

This effect is, of course, well known to engineers. No one, however, would suggest that these power consumers should have their supply at $\frac{1}{4}$d. per unit, and Mr. SINCLAIR himself advances the sound view that all consumers should bear a fair proportion of the costs incidental to the generation of the whole output. The difficulty is to decide what is fair. In order to solve this question the author divides consumers into various classes, but whether this is a desirable method is doubtful. Some very clear definitions become necessary, and it is often difficult to say where one class ends and another begins. What, for example, is a small power consumer, and what is a large power con-

sumer? Where does the one merge into the other? Also, is there any reason why the smaller power consumer should not be as valuable as the larger one, or, possibly, more valuable under certain conditions?

From the Paper, of which we give an abstract elsewhere, it is not clear on what basis the prices are determined. Presumably they are based on certain load factors, on certain maximum demands and running costs. Diversity factor, however, seems to have received no attention, although this has an important bearing on some of the charges entering into the question. Except in so far as classification enables the smaller consumer to be dealt with easily, there is nothing to be said in favour of this course in preference to the more exact method of a fixed charge per annum per kilowatt of maximum demand and a low price per unit. This meets all ordinary cases of power user without classification, but again diversity factor should be taken into account if the lowest possible prices are to be quoted. The only objection is the tacit assumption that all maximum demands occur at an equally inconvenient time, and thus have the same value from the cost point of view. Theoretically this is not so, but, generally speaking, except in special cases, it may, perhaps, be admitted that there is not much to choose between the times of maximum demand in any one class.

In many stations the lighting peak load occupies an important position, but it is not so important in stations with a considerable power development, and is likely to become less and less so in a few years. The time of the power consumers' maximum load is therefore not necessarily very important. Nevertheless, special cases will always arise and must be taken on their merits. Obviously a consumer with a maximum demand occurring between midnight and 6 a.m. should receive preferential treatment, but should, nevertheless, contribute something towards capital charges. Again, it may happen that a large consumer, as mentioned by Mr. SINCLAIR, may render necessary the laying down of special cables at a heavy cost. In such a case it would, no doubt, be prudent to include something in the price per unit to cover the cost of these cables and the risk of the consumer giving up his demand.

It sometimes happens that new plant is required in order to deal with the demand of new large power consumers, and in such cases this plant may be a good deal more efficient than that hitherto available. Besides higher efficiency the capital cost per kilowatt, if in large units, may be less, and the question arises whether only new consumers should benefit by these improved conditions, or whether all consumers should benefit alike. It seems somewhat hard that the old consumer who has supported the undertaking in the past should not benefit by any improved conditions as the undertaking grows larger. On the other hand, it may be that large new consumers will not be obtained unless the prices quoted are as favourable as possible. We do not think, however, that any hard and fast line can be adopted, for it is really a question of expediency, and many of these questions must be viewed in that light. It is generally a matter of practical politics, and the supply engineer must steer such a course as to give the best general results rather than to aim at an ideal which may be impracticable.

REVIEWS.

Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

A Handbook of Wireless Telegraphy. By JAMES ERSKINE MURRAY. 2nd edition. (London: Crosby, Lockwood & Son. Pp. xvi.—370. 10s. 6d. net.

The first edition of this work appeared in 1907, and was reviewed in these columns on Oct. 4 1907. The call for a second edition in less than two years after the publication of the first shows that there is a considerable demand for a book of this type, and no doubt this demand will grow rapidly in the near future, when regular courses in wireless telegraphy have been established at the principal technical schools and colleges throughout the country.

This new edition is practically the first edition together with 50 or 60 pages of new matter dealing chiefly with recent developments, such as methods for generating continuous oscillations by means of the arc and Marconi's disc discharges; Bellini and Tosi's system of directive telegraphy; and the contributions of Zeneck and Hack to the theory of transmission of electromagnetic waves over the surface of the earth.

One feature of the book, which was referred to in the first review, is the large number of long extracts from original Papers. We notice that one of the longest has been very considerably cut down in the present edition, and we think that many of the others might, without disadvantage, be treated in a similar manner, their length being quite out of proportion to their importance. On the whole, the book is well up to date, and may be recommended to those who desire to take a general survey of the subject in a minimum of time.

Vectors and Vector Diagrams, Applied to the Alternating-Current Circuit. By W. CRAMP and C. F. SMITH. (London: Longmans, Green & Co.) Pp. xvi.—247. 7s. 6d. net.

Students of alternating-current phenomena who use the Steinmetz symbolic notation will have realised its shortcomings when questions concerning power in a circuit have to be considered: the power pulsates with double the frequency of the E.M.F.s and currents. This implies that although an E.M.F. and its corresponding current may be represented by e_1+je_2 and c_1+jc_2 respectively, where $j=\sqrt{-1}$, the real part of the product of these is to be taken for power calculation as $e_1c_1+e_2c_2$, not $e_1c_1-e_2c_2$, as it would naturally be, since $j^2=-1$: this is necessary since the lagging components of E.M.F. and current together give a real positive power.

This book has been designed to obviate this difficulty by a slight modification of the notation: the symbol j is restricted to represent the operation of turning a complete vector through 90 deg., whilst the two components of any vector parallel to and at right angles to the datum line are distinguished by suffixes; for example, the vector which in the Steinmetz notation is e_1+je_2 becomes $e_1'+e_2''$. Thus, $'$ signifies "units of length parallel to the datum line" and $''$ "units of length perpendicular to the datum line." By this means a positive product will be obtained from two vectors, such as e'' and c'', each at right angles to datum, and thus this modified method seems to have distinct advantages. But it is not in this respect alone that the book will appeal to readers of Steinmetz's work. Since the publication of the latter, great improvements have been made in single-phase commutator motors, and the different types of these are carefully considered in a "readable" way, which is clear and not quite so terse as some of the theories published elsewhere.

But the gems of the book are to be found in the last two chapters, which occupy one-third of the whole volume; these deal with locus diagrams and their applications. The best known of these is the Heyland circle diagram for induction motors, and it will come as a surprise to many to find how many and varied are the applications of this type of diagram—in fact, exception might possibly be taken to the fact that some of the problems on complicated circuits containing resistances and reactances have little more than academic interest. But such criticism cannot be levelled at the prac-

tical illustrations given of such circuits, including such problems as the production of a true quadrature flux in induction type meters, whilst the Heyland diagram has been elaborated to show the effect of change of magnetising current with load. Besides this, an interesting Heyland diagram has been evolved for the single-phase induction motor, so often despised by writers of electrical books. The diagram given is a modified form of one due to Heubach.

With regard to criticism of the book itself, it is to be noticed that angles of lag are reckoned counter-clockwise, following some foreign writers, instead of in the more usual clockwise direction. One could wish that some arrangement could be made for uniformity in this respect; one also regrets that the uniform system of notation proposed by the International Congress has not been adopted. Another, and possibly a more serious defect, is that no distinction is made between E.M.F. and P.D., and teachers know to their cost how important it is that this distinction shall be impressed on students of electricity if clear ideas are to be formed. A further but small defect is the use of the term "induction" in the loose sense of the total flux, instead of restricting it to the more usual sense of "flux per square centimetre." But on the whole the book shows that it has been well thought out, and, above all, written by practical men; such books are only too rare.

F. J. DYKES.

Whittaker's Arithmetic of Electrical Engineering. (London: Whittaker & Co.) Pp. VI.—159. 1s. net.

This little book should prove useful to those who are constantly wishing to set arithmetical examples for their students. It deals with the usual subjects in which such examples occur, and is divided into fourteen short chapters, starting with units of length and mass, and ending with generators and motors. Each chapter deals with its subject simply with certain examples, and is then followed by a series of questions taken frequently from examination papers, such as those of the City and Guilds, to which the answers are given at the end of the book. In certain parts we think the author is inclined to rely too much on formulæ. It is better for the student as a rule not to learn a formula, but to know how to get at his results. We notice that the definition of the ohm is somewhat old, that the watt is defined as a volt-ampere, and that a certain quantity of gas gives so many candles per hour. There are also one or two minor misprints, but, generally speaking, the book is correct, and will, no doubt, serve a useful purpose.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

FOURTEENTH ANNUAL CONVENTION.

(*Concluded from page 435.*)

In our last issue we gave an account of the proceedings at the Convention up to Thursday evening, June 24th, including a brief *résumé* of the discussion on the two Papers then read. It was unfortunate that owing to the shortness of the time available, the Paper by Mr. E. Lunn, on "Notes on Condensing and Water-Cooling Plants," an abstract of which is given on p. 458 of this issue, did not receive the attention it deserved and would otherwise have received at the hands of the members. In this connection, however, we may add to the remarks of Mr. I. V. Morison, given on p. 434 of our last issue, some remarks made by him in reference to Mr. Lunn's Paper.

Mr. MORISON said, in regard to the statement by the author that in the ordinary condenser there was a difference in temperature of 15 deg., that they were not representative of the latest type of surface condensers. If a condenser were designed so that there was a gradual increase in the richness of the air mixture and an efficient air pump, and the surface condenser adequate, there was no reason whatever why the difference in temperature should exceed from 5 deg. to 8 deg. In some experiments by Prof. Weighton this had been minimised and brought down to 1 deg. In regard to cooling towers, he had lately been struck with the clumsiness of the formation and distribution of water in cooling towers. His firm had made hundreds of sprayers during the last twelve months, with the object of getting at the secret of the division or atomisation of water, and he handed round photographs illustrating the success they had obtained in this direction.

Mr. Lunn's reply was held over for publication in the "Proceedings."

On Friday morning the delegates and members assembled in the large lecture hall of the Municipal School of Technology, Manchester, for the annual general meeting. The first business on the agenda was the election of officers and council for 1909-10. Mr. W. W. Lackie, of Glasgow, was unanimously elected president, and it was decided that the next year's Convention should be held in Glasgow. Mr. J. Christie (Brighton) was elected senior vice-president and Mr. G. Wilkinson (Harrogate) junior vice-president. The hon. solicitor (Ald. G. Pearson), the hon. treasurer (Mr. J. E. Edgcome) and the hon. secretary (Mr. H. Faraday Proctor) were re-elected, appreciative references being made to their valuable services to the Association in the past.

Of the seven retiring members of the council (four engineers and three chairmen of committees) the following were re-elected: Mr. F. M. Long (Norwich), Mr. C. E. C. Shawfield (Wolverhampton), Mr. T. P. Wilmshurst (Derby), Councillor Sinclair (Swansea) and Ald. J. P. Smith (Barrow-in-Furness). Mr. Chas. Furness (Blackpool) and Bailie Willock (Glasgow) were elected to fill the other two vacancies on the council. The remaining members of the council, whose term of office has not yet expired, are: Messrs. A. A. Cramb (Croydon), A. A. Day (Bolton), Councillor Howarth (Manchester), V. A. H. McCowen (Salford), H. Richardson (Dundee), Ald. C. West (Coventry) and Ald. Wilkinson (Luton).

The annual report was then taken as read, and was followed by a long and interesting discussion. An abstract of this report is as follows:—

In their report the Council mention that the membership of the Association now stands at 390, made up as follows: Committees 167, chief electrical engineers 176, honorary members 3, chief assistants 8, assistants 36, the total showing an increase of three on last year's total. Mr. J. F. C. Snell, a past president, has at the unanimous request of the Council, accepted honorary membership of the Association.

Reference is next made to the Electrical Exhibition last year, to the forthcoming revision of the Institution wiring rules, and to the Electric Lighting Acts (Amendment) Bill.

Financial Organisation and Administration. The Council has been engaged in conjunction with the Municipal Tramways Association in considering the action which is being taken by the Institute of Municipal Treasurers and Accountants (Incorporated), and a Departmental Committee in relation to the accounts of local authorities. Serious attention is directed to the proposals * which are being made. The Regulations have apparently been drawn up without consultation with the heads of any municipal trading departments. It is evident that some accountants at any rate are endeavouring to get supreme control of all work carried out by local authorities. Needless to say, this would be most disastrous, more especially to all the great trading departments carried on by municipalities, such as docks, water, tramways, electricity supply, gas undertakers, &c., &c., where it is essential that for the proper and economical working of the department, the same should be self-contained and each under one head.

The Departmental committee issued its report after receiving evidence from 28 witnesses, including a few Government officers, the remainder being almost entirely accountants and auditors; the witnesses did not include a single engineer manager of any trading department. It is, therefore, imperative that pressure should be brought to bear, so that this matter may not be settled until such representatives of the municipal trading departments have had an opportunity of expressing their opinions, and the same have been fully considered.

Income Tax and Depreciation. The Council has had its attention drawn to the fact that the Institute of Municipal Treasurers and Accountants has approached the Chief Inspector of Taxes and the Board of Inland Revenue with a view to getting standard rates of allowances for wear and tear. The Council feel that in questions of wear and tear of machinery and other works, the technical managers should be consulted, and it has, therefore, taken up the matter with the above named institution, which, however, in this matter also has apparently endeavoured to evade co-operation, although the matters dealt with are essentially questions involving engineering experience. At an interview which the hon. secretary had with the Superintending Inspector of Taxes, the latter stated that the matter had gone too far to be re-opened, but with this the Council cannot agree, and it is incumbent on every municipality to appeal against

* See THE ELECTRICIAN, June 11, 1909.

the proposals as at present drafted, and where possible to withhold the payment of income tax until the matter is arranged upon a satisfactory basis. The following are some extracts from the agreed terms to which exception are taken :—

Cables.—In addition to repairs, allowance for depreciation shall be granted at the rate of 3 per cent. per annum *on the written down value.*

Plant and Machinery.—On all other plant exclusive of loose tools, meters and office furniture depreciation shall be allowed at the rate of 5 per cent. per annum *on the written down value* in addition to the cost of repairs.

Conduits, Meters, Loose Tools and Office Furniture.—No allowance shall be made for depreciation, but annual expenditure on repairs *and renewals* shall be charged as working expenses as and when incurred.

It was explained to the hon. secretary that when renewals take place, worn out or obsolete plant being displaced by new material, the outstanding (*i.e.*, written down) value of the old plant would be allowed as a deduction for the purpose of income tax assessment; this, however, is not made clear in the proof handed to the hon. secretary by the Inspector and the wording of the above extracts would, in the absence of other matter, imply otherwise. Even if the text be altered so that this deduction is allowed, it results in the postponement of the allowances until plant is worn out, and this is perpetuated as regards all expenditure except that on "Tramway Track" relative to which the Tramways Association have had some say.

A table in the Report of the Council shows that the two Government departments go to extremes, the one department allowing for the life of a cable being five times as great as that allowed by the other department. The extremes in each case operating to the disadvantage of the municipalities.

Reference is next made in the Report to the Home Office Regulations for the generation, transmission and use of electrical energy in factories and workshops.

Honorary Treasurer's Report.—A surplus of £42. 4s. 9d. is shown for the year, and a total surplus of £391. 8s. 10d., of which £269.6s.1d. is on deposit, as compared with last year's amounts of £39. 4s. 10d., £349. 4s. 1d. and £266. 4s. 3d. respectively.

Travelling Studentship.—The Council has again to express its regret at the lack of interest shown by the Associates in regard to the scholarship of £10 offered annually for the best Paper on some approved subject. This year two entries were received, one of which was not completed, and only one Paper was received, viz., that of Mr. E. Lunn, on "Condensing and Water Cooling Plants." This Paper received the prize and was read at the Convention.*

DISCUSSION.

Mr. H. FARADAY PROCTOR (Bristol), the hon. secretary, said there were two or three points in connection with the Electric Lighting Acts (Amendment) Bill to which he would like to call attention. There were many clauses in the bill which would be of great benefit to suppliers of electricity, both companies and local authorities; but at any rate to local authorities. They had taken steps to protect the various undertakings from encroachments by companies who might come and threaten the areas and make things uncomfortable in regard to arranging tariffs, and they had adopted the wording of the clause drawn up by Edinburgh in connection with the non-statutory power company that was going to encroach upon the area of Edinburgh and other undertakings. They were taking active steps to get the Select Committee to insert this clause. The council would like to have a general expression of opinion from the meeting in regard to the hiring clause. There was one thing which would have attention. The latter part of the clause provided that "any fittings, &c., let out on hire by local authorities shall not be subject to distress or landlord's remedy for rent, &c.," but did not give protection against a mortgagee. Representations had been made to the Local Government Board and the Board of Trade. The Local Government Board approved, and had themselves approached the Board of Trade, who had signified their approval. They, therefore, might feel happy on this point. Another matter was the amendment proposed by Lord Avebury to clause 15. The clause as originally drafted and put forward by the Board of Trade was to allow local authorities to provide and let apparatus, &c., for hire and to do free wiring; but Lord Avebury had got an amendment through the House of Lords to the effect that local authorities might do that work through a contractor, but not otherwise. They should endeavour to get this amendment thrown out. A great many of them would not carry out the work themselves, but would employ a contractor. If they were tied to the contractors, however, they would have to pay the contractors' terms, and might not get the work done in their own way. He thought the Association should endeavour to get this clause passed in its original form, and without the restriction proposed by Lord Avebury. If they failed in that, the question for the meeting to decide was whether the hiring clause should be struck out altogether, or be accepted in its amended form, or the whole bill be sacrificed.

Mr. A. C. CRAMB (Croydon) stated that he did not believe in supply authorities running hiring departments. The interests of the public should not be sacrificed to two or three contractors in every town.

Mr. G. WILKINSON (Harrogate) said half a loaf was better than no bread, and there was a fair chance of getting a modification. Other clauses in the bill were well worth having. One was the stand-by clause, which would be of great benefit to some of the smaller undertakings, which were suffering great injustice at the present time.

Ald. BRUCE (Sunderland) hoped they would stand by the original clause 15. Sunderland were refused the original clause and were offered a clause similar to Lord Avebury's amendment, which was of no use to them.

Mr. C. E. C. SHAWFIELD (Wolverhampton) said it seemed to him that Lord Avebury's amendment would prevent undertakings fixing their own meters or cutouts on consumers premises without calling in the aid of contractors. He would rather see the clause cut out entirely than accept the amendment.

Mr. E. E. HOADLEY (Maidstone) said they should try to get the clause in its original form, but, failing that, Lord Avebury's amendment should be accepted. Many of them, even if they had powers to do the wiring, proposed to do the work through contractors.

Several other members supported Mr. Hoadley's view.

Mr. J. E. EDGCOME (Kingston-on-Thames) said contractors did work to his specification. The Association wanted to promote a kind of wiring which would be as cheap as possible consistent with good work. An opportunity should not be given to the wiring contractors to form a ring and dictate prices.

Ald. PEARSON remarked that in Bristol there were a good number of contractors, and the Corporation were content to leave the business with them. The clause was not in the original bill, and formed no part of the discussion when talking the matter over with the Board of Trade, and inasmuch as it had been put in by the Board of Trade, he did not think it likely that the Board would sit down under the amendment, but would themselves make an effort to get the clause put right. They should not sacrifice the bill if they could not get this clause, as there were many valuable things in it. They should endeavour to get the bill before a committee, when they would have an opportunity of being heard on the clause. Clause 5 (now clause 6) was extremely useful to many undertakings, as it gave persons having power to supply in a municipal area the right, with a letter of consent from the Board of Trade, to go outside their area, with, of course, the consent of the adjoining area into which they went. In the application to the Board of Trade, the precise area they wished to get into had to be stated, the streets, &c., being set out. Persons having the right to supply, but not giving supply, would be heard, and if supply was not given within a reasonable time the letter of consent would be given to the applicant by the Board of Trade.

After some further discussion, a resolution, proposed by Mr. H. Faraday Proctor, that, "In the event of its being impossible to get clause 15 (now clause 16) passed in its original form, this clause only be, if possible, struck out of the bill; but, failing that, the bill be accepted in its present form with Lord Avebury's amendment," was eventually passed. In answer to questions, Ald. Pearson said that this general bill would not override private bills owned by municipalities.

The proposals of the Institute of Municipal Treasurers and Accountants were also discussed, and Mr. Faraday Proctor read abstracts from reports of the Institute, showing that the sub-committee were acting under the instructions of the general body of members, and that the matter was not dead, but would be further considered by the Institute in October. Several other members took part in the discussion, the feeling of the meeting being that the undertakings should be subject to chartered accountants engaged by the Corporations.

After the report and balance sheet of the Association had been adopted, Mr. F. Ayton (Ipswich) mentioned that it would be an advantage if, instead of long Papers being read on the occasions of the Conventions, a list of subjects for discussion could be got together by the council, and the members be invited to speak thereon. The President replied that if Mr. Ayton would elaborate his proposal and communicate it to the council it would have their fullest attention. The meeting concluded with votes of thanks to the retiring president, the honorary officials, the Manchester Education Committee (for allowing the Association the use of the lecture hall in the School of Technology), the Corporations of Manchester and Salford, and to the various manufacturers who had given facilities to the members to inspect their works. The members then adjourned to the Midland Hotel for luncheon.

In the afternoon special cars were provided to enable members of the Association to visit the Salford electricity works at Frederick-road, Pendleton. A number, however, took the opportunity of inspecting the generating station of the Lancashire Electric Power Co., at Radcliffe, this visit being an alternative to that to the Salford works. These visits brought the official programme to a conclusion, but doubtless many members remained in the neighbourhood over the week-end, in view of the many places of interest within easy reach of Manchester.

* An abstract appears on p. 458 of this issue.

THE FARADAY SOCIETY.

At the meeting held on Tuesday, June 15th, at the Institution of Electrical Engineers, Dr. N. T. M. Wilsmore in the chair, an address was delivered by Mr. E. R. Taylor, chairman of the Conservation committee of the American Electrochemical Society, on

"The National and International Conservation of Water for Power."

The author began by pointing out that the water power capacity of the United States with proper conservation is not less than 150,000,000 h.p., without considering the storage capacity of brooks. The annual stream flow in the same country is 70 million million cubic feet, of which less than 1 per cent. is recovered and utilised for municipal supply and such purposes, less than 2 per cent. is used for irrigation, 5 per cent. for navigation, and less than 5 per cent. for the production of power. From 85 to 95 per cent. is wasted in floods. This illustrates the kind of waste that is going on all over the world, and typical examples of such wasted resources were described and illustrated by the author, who strongly advocates the impounding of flood waters in the uplands, with its accompanying afforestation of the hills, and the simultaneous conservation of sources of power, which are vast in the aggregate and which at present are almost entirely uncontrolled and untapped. Many instances were given of the advantages that have accrued from the proper utilisation of this waste water, both on small farms from the impounding of a mere brook to the damming of great rivers, and the consequent enrichment of vast tracks of country. The electrochemical industries in particular would benefit by the creation of cheap and abundant sources of power, on which their very existence depends. The lecturer strongly urged the necessity for this problem being considered internationally by all the civilised peoples of the world. A beginning will be made in 1910, when an international conference will be held at The Hague.

Mr. Walter Reid pointed out that the conservation of water-power over large areas might be very difficult of accomplishment in England where the value of land was so high, and where there was a large number of cities very close together. Moreover, the question of scenery, which was a national possession, had frequently to be taken into consideration. The Government had, however, recently promised, through the President of the Local Government Board, to take action with regard to the conservation of all British rivers, each of which was to be placed under the control of one central authority.

Mr. W. M. Morrison showed how nothing but good had followed the development of the power schemes at Foyers and Loch Leven, now the centres of a flourishing industry and population. There were many such possible centres of power, especially in Scotland. Water-power was one of the most formidable weapons with which a nation had to fight the modern war of industry.

Dr. H. Borns emphasised the importance of bringing home to the nation the value of the *small* water-power.

The Chairman remarked on the way in which the land was entirely utilised in Germany, where 20 per cent. of the land was forest, and no part, so far as he knew, was given over to waste.

The following Papers were then communicated: "The Formation of Silicon Sulphide in the Desulphurisation of Iron," by Mr. W. Fielding; "A Contribution to the Study of Electric Furnaces as applied to the Manufacture of Iron and Steel," by M. Chas. A. Keller; and "Automatically Circulating Furnaces of the Gin type for the Electrical Production of Steel," by M. Gustave Gin. Elsewhere in the present issue will be found an abstract of the Paper by M. Keller, and we propose to give an abstract of the Paper by M. Gin in a future issue.

CORRESPONDENCE.

MAXIMUM POWER INDICATORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: We beg to draw your attention to a sentence occurring in The Electrician for June 25th on p. 425, in the description of Messrs. Elliott Bros. maximum power indicator in the article entitled "Electric Power Supply and Tariffs."

It is asserted that "hitherto the instruments used for this purpose (*i.e.*, measuring the maximum number of kilowatts taken) have only registered the maximum current taken, which in the case of alternating-current circuits in particular gives no indication of the actual power demanded." We consider that this sentence is calculated to give the reader an entirely wrong impression of the true state of progress as regards the accurate measurement of the maximum demand of power circuits at the present time. For some years past, we have been manufacturing the demand indicator attachment invented by Mr. Merz which exactly fulfils the conditions mentioned in the article referred to.

No doubt the new instrument which Messrs. Elliott Bros. are placing on the market will do the same thing as the Merz demand indicator has been doing for some time, but to say that *all* instruments hitherto used for this purpose have only registered the maximum *current* taken is entirely incorrect, since the Merz demand indicator does actually give the best possible indication of the actual *power* demanded.

We think, therefore, that your readers, if unacquainted with the Merz demand indicator, would naturally conclude from the article referred to, that Messrs. Elliott Bros.' new instrument is the only instrument on the market suitable for this purpose, and we consider that in common fairness the facts we have pointed out above should be brought to their notice.—We are, &c.,

Brighton, June 26. The Reason Mfg. Co. (Ltd.)

DIFFERENTIAL BALLISTIC METHODS OF MEASURING HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It is easy to understand Mr. Wild's feeling that the large differences in the results obtained with straight as against ring test-pieces are attributable to a mistake of some kind having been made. I do not, however, think that, as he suggests, an error has been committed in the "specific loss" method by taking H proportional to the magnetising current. In this method, when applied to straight test-pieces, the true magnetising force, say, at the centre of the specimen, is equal to the difference between the applied magnetising force H_a due to the coil alone and the demagnetising force H_d due to the ends. From this it follows that the area of a true or undistorted hysteresis loop is equal to the difference between the area of a distorted or H_a-B loop and the area of a H_d-B loop. Now the area of a H_d-B loop is zero, since for short bundles, such as those used in the experiments, H_d is proportional to B. Hence the area of a H_a-B loop is equal to that of a true hysteresis loop, and it is, therefore, quite justifiable to plot B against the magnetising force due to the coil alone. Of the proportionality between H_d and B, upon which the possibility of the "specific loss" method rests, I have assured myself by direct measurement of H_d and B (The Electrician, November 6, 1908, p. 138), but it also follows from the experiments of Mr. J. L. W. Gill ("Phil. Mag.," Vol. XLVI., p. 488, November, 1898), who showed that for bundles with a dimension ratio (length/$\sqrt{\text{section}}$) not exceeding 30 and not saturated at the centre the law of distribution of induction remains the same at all stages of magnetisation.

I should have been more inclined to distrust the "specific loss" method had it not given identical results with the "total loss" method. In this latter there can be no question as to the accuracy of the loss measurements, and the only possibility of error lies in the determination of the equivalent uniform induction to which the loss is referred. As a rule, in our experiments the equivalent uniform induction was determined by measuring the actual induction at the centre of the bundle and then multiplying this by 0·75; but in several experiments the mean actual induction was measured (by means of a coil distributed over the whole length of the bundle) and multiplied by 1·03. The agreement was satisfactory. The reduction factors 0·75 and 1·03 were, it is true, arrived at by an application of Steinmetz's 1·6 law; but, as I have already pointed out (The Electrician, January 15, 1909, p. 550), these factors are only slightly affected by variations in Steinmetz's exponent. An increase in the exponent from 1·6 to 2, for instance, only increases these factors by 2·4 per cent. From a fairly wide experience of these methods of deducing the equivalent induction I have every reason for placing entire confidence in them.

One point in the original Paper I may take this opportunity of explaining. On p. 341 it is stated that an alternating-current (wattmeter) method gave the same results with bundles as with rings. It should have been added that the wattmeter results were the same as the ring ballistic.—I am, &c.,

Manchester University, June 28. Robert Beattie.

THE INSTITUTION AND OTHER SOCIETIES.

The Institution of Electrical Engineers.—The annual conversazione of this institution was held at the Natural History Museum, South Kensington, on Wednesday evening last. The President, Mr. W. M. Mordey, and his daughter, Mrs. E. Henrici, welcomed a large and representative gathering. Amongst those present were Sir W. Preece, K.C.B., Sir John Gavey, C.B., Sir Charles Owen, Col. Sir T. Holditch, Prof. Silvanus Thompson, Dr. W. C. Unwin, Dr. G. Kapp, Mr. R. K. Gray, Mr. F. Hill, Major W. A. J. O'Meara, Col. R. E. Crompton, C.B., and most of the officers of the Electrical Engineers (London Division). The occasion was somewhat unique, owing to the fact that the latter appeared in uniform and were presented to the President.

University College (University of London).—An assembly of the College Faculties was held on Wednesday afternoon last at University College, Gower-street, under the presidency of Lord Avebury, at which the names of the successful students in the various departments were announced.

In an exhaustive report on the work of the Session 1908-9 the Dean of the Faculty of Science (Prof. F. T. Trouton) referred to the progress made in the various departments and touched on some of the changes contemplated for the next Session. He also stated that the development of the College laboratories, projected seven years ago, was proceeding apace, with the exception of the new chemical laboratories which had not yet been begun. In the electrical engineering department extensive changes and additions had been made during the past year; new experimental plant had been put down, including an equipment for research, and instruction in wireless telegraphy. Prof. Trouton further mentioned several schemes, by which co-ordination between University College and King's College for the teaching of higher and specialised branches of engineering had been inaugurated. At the conclusion of the reading of the Report the Provost announced the names of the winners of diplomas and medallists, many of whom were presented to the Chairman.

In addressing the students, Lord Avebury said that he trusted for many years to come they would look back with pleasure to that day. He would remind the unsuccessful ones that many of our greatest men had not been those who distinguished themselves at school or college. In this connection he might mention Sir Isaac Newton, Swift, Scott, Clive and, lastly, his old master and friend, Charles Darwin. Referring to the education system of the University of London, he said that it was better than the system of many similar institutions, in that the curriculum was a very wide one and that it was impossible for a student to take a degree without a knowledge of science as could be done elsewhere. The true system of education was first to build a broad platform of general knowledge and then construct a gradually narrowing pyramid of specialisation upon it.

Royal Society of Arts.—A conversazione was held in the Natural History Museum, South Kensington, on Tuesday evening last, the guests being received by Sir William White, K.C.B., F.R.S. Many portions of the museum were open for inspection, and excellent entertainment was also provided by the string band of H.M. Royal Engineers, the "Red Band," under the direction of Mr. Thomas Batty, and an auxetc-gramophone concert, under the direction of the Gramophone Company.

Institution of Mining Electrical Engineers.—The formation of a branch of this new Institution is projected in Scotland, and a meeting for this purpose will take place on Saturday, July 3rd, at 7 p.m., at the offices of the Institution of Engineers and Shipbuilders in Scotland, Elmbank-street, Glasgow, when local officers will be proposed and elected for the Scottish districts.

At the meeting held on Saturday last at Newcastle-on-Tyne, for the purpose of forming a local centre of this newly established Institution, Mr. A. M. C. Field, of Consett, presided, the gathering numbering about 30. Mr. J. Williams, the secretary of the Institution, gave an address in which he described the inception and progress of the Institution, which now has a membership of 152 (including 28 from the Newcastle district) at 12 centres. It was then agreed to form a local centre at Newcastle-on-Tyne, Mr. H. J. Fisher consenting to act as hon. secretary of the branch until the general meeting of the Institution in September next. A committee was appointed to carry out the work of organising the centre, and to approach those interested in mining with a view to filling the positions of president and vice-president. It was also resolved that the hon. secretary notify the local section of the Institution of Electrical Engineers that a branch of the Institution of Mining Electrical Engineers had been formed, and that the new society wished to work in harmony with them.

Iron and Steel Institute—In accordance with previous announcements, the autumn meeting will be held in London on Monday, Tuesday, Wednesday and Thursday, September 27th, 28th, 29th, 30th, and October 1st. An influential reception committee is in process of formation, and arrangements are being made for the entertainment of the members taking part in the meeting. The council of the Institution of Civil Engineers have placed their hall at the disposal of the Institute for the reading and discussion of Papers, and visits will also be paid to works and places of interest in and around the metropolis. These visits will include the Royal Arsenal, the works of Messrs. Siemens Bros., the generating station of the London County Council, the works of Messrs. Fraser & Chalmers, the Lambeth potteries of Messrs. Doulton & Co., the motor carriage works of Messrs. Napier & Son, the Royal Small Arms factory and the National Physical Laboratory. There will also be visits to the Mint, to the halls of several of the City companies, and to places of interest in the city, and it is hoped to arrange an excursion to Portsmouth. On Thursday afternoon, September 30th, the Lord Mayor and the Lady Mayoress have invited the members and their ladies to a reception at the Mansion House. The evening entertainments are to consist of a theatrical performance on one night and a banquet and musical entertainment on another night.

Electrical Association of Victoria.—At the annual meeting of this association at Melbourne on May 7th the report stated that the Council note with satisfaction that the Fire Underwriters' Associations of the various States of the Commonwealth are continuing to adopt the wiring rules of the Institution of Electrical Engineers (London), as that brought about uniformity in practice. Votes of thanks were accorded to the retiring president (Mr. Noel Murray), the Council and officers. Mr. H. R. Harper was elected president, and Messrs. A. H. Jackson and J. H. D. Brearley vice-presidents. Mr. Noel Murray is hon. sec. (pro tem.).

TESTS ON CURTIS TURBINES.

In our last issue we gave a brief account of the discussion at the I.M.E.A. Convention at Manchester in connection with Mr. Blackman's Paper on "Steam Turbines." It will have been noticed that Mr. J. P. Gregory, of the British Thomson-Houston Co., referred to a number of independent tests on Curtis turbines, of which we are now able to give particulars. In the case of a 9,000 kw. turbine, manufactured by the General Electric Co., U.S.A., and supplied to the Chicago Commonwealth Edison Co., the test figures were as follows:—

Load.	Steam.		Vacuum (30 in. bar.)	Steam consumption.
	Pressure.	Superheat.		
kw.	lbs.	deg. F.		lb. per kw.-hr
5,374	162	133	29·43	13·15
8,070	197	116	29·55	13·0
10,156	176	147	29·47	12·9
12,108	182	148	29·34	13·05
13,900	198	140	29·31	13·6

A 5,000 kw. turbine, also of the same manufacture, required 13·52 lb. per kilowatt-hour at a load of 5,195 kw., and 13·73 lb. at 50 per cent. overload; whilst a 4,000 kw. machine manufactured by the A.E.G., of Berlin, required only 11·9 lb. of steam per kilowatt-hour at a load of 4,239 kw., and 11·7 lb. at 2,236 kw., the superheat being 275 deg., the steam pressure 180 lb. and the vacuum 29·3 in. (bar. 30 in.).

The British Thomson-Houston Co., who at present have in hand 25 turbines—all of the impulse type—aggregating 31,900 kw

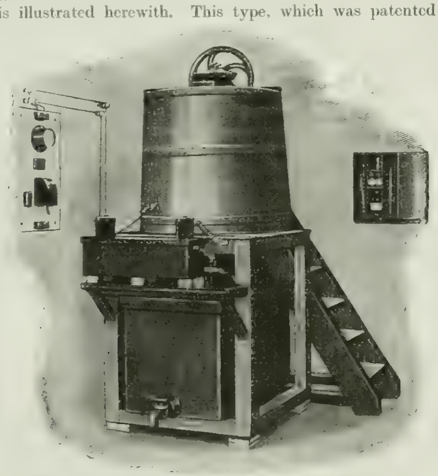
have recently supplied a 1,000 kw. machine which was tested by Prof. Wilson, of King's College, London, and showed a steam consumption of 15·8 lb. per kilowatt-hour at a load of 1,004 kw., with steam at 100 lb. pressure and 100 F. superheat, the vacuum being 28·88 in. (bar. 30 in.), whilst a 2,500 kw. machine of the same manufacture required 16·06 lb. and 18·67 lb. of steam per kilowatt-hour at full and half load respectively, with steam at 150 lb. and 67 F. superheat, vacuum 28·3 in. (bar. 30 in.).

ELECTROLYTIC BLEACHING AND DISINFECTING IN LAUNDRIES.

The New Royal Infirmary at Manchester, to be opened this month by His Majesty the King, will doubtless contain many examples of the application of electricity for industrial and medical purposes. Probably one of the most interesting of such applications is in the laundry, where electrolytic apparatus has been installed for bleaching and disinfecting the linen, and also for sterilising purposes in connection with bacteriological experiments.

The electrolytic treatment of soiled linen is becoming almost universal in German hospitals, prisons, barracks and public institutions, but the Manchester Infirmary is, we believe, the first public institution in this country to adopt the electrolytic treatment, although several laundries have such apparatus in use, with apparently very satisfactory results. It is stated that one of the advantages of the electrolytic treatment of clothes which had great weight with these laundries was the possibility of reducing the mechanical treatment of delicate goods, thus preventing many claims for damage.

The electrolysers chosen by the Board of Management of the Manchester Infirmary for the laundry in that institution are supplied by Messrs. Ernest Grether & Co., of Manchester, and one of the same type is illustrated herewith. This type, which was patented by



Electrolyser by Messrs. E. Grether & Co.

Haas and Oettel, has been extensively employed in many countries for the past 10 years in connection with bleach works, dye works, cleaning establishments and paper mills, as well as in steam laundries. The principle of the electrolyser for bleach is as follows :—

A box-shaped electrolyser, sub-divided by carbons into numerous cells, is placed in a tank containing the brine to be electrolysed. The cells have no communication with each other, but have openings at the bottom and sides communicating with the tank. Close to the top of each cell is an overflow pipe making communication with the liquor in the tank. The latter is filled with brine until it is level with the overflow pipe. On sending electric current through the electrolyser, the liquid in the electrolyser effervesces in a lively manner, which causes it to rise to a higher level than the brine outside ; it consequently flows over through the overflow pipes, and as it flows out at the top there is a corresponding inflow, through the holes at the bottom, of cool brine, which in its turn rises and flows over, thus creating a circulation. The earliest pattern had a lead plate for the negative electrode ; all the rest were made of a preparation of carbon. The positive electrode consisted of two thick plates standing vertically ; all the rest of the electrodes consisted of plates $\frac{3}{8}$in. thick, fitting across the apparatus in slides. These intermediate electrodes did not fill the entire distance from top to bottom ; they rested upon a non-conducting support, and supported a similar non-conducting plate which projected above the surface of the liquid. This arrangement serves a double purpose. The floor of each chamber thus constituted forms a "dead" or non-conducting space, into which dirt and impurities carried in the liquor are deposited without causing short-circuiting, until the apparatus is periodically washed. Again, the electrodes are suspended in the liquid covered with a head of liquor. The bubbles of chlorine gas given off by the electrodes pass through this head of liquor and are absorbed by it, with the result that there is no smell of chlorine in the room where the apparatus works, and also no loss of chlorine.

In the case of the laundry apparatus the brine is mixed in a tank, a given weight of salt being used. The solution is run through the electrolyser with the current flowing, and is ready for immediate use.

The electrolyser specially designed for laundries can be connected to electric supply mains and works with a current of 12 amperes at 110 volts. It can supply in 10 hours from 110 to 132 gallons of washing liquor having a strength of 210 grains per gallon. For use, 70 grains per gallon is the ordinary strength, so the liquor coming from the electrolyser must be diluted with three times its bulk of water. Thus, a washing machine capable of holding 112 lb. clothes (dry weight) will take $3\frac{1}{4}$ to $4\frac{1}{2}$ gallons of liquor 70 grains strength, *i.e.*, 3 tons of clothes will require, say, 220 gallons of liquor 70 grains strength. The smallest size of electrolyser made for this purpose produces in 10 hours 600 litres, or 132 gallons, of electrolytic liquor of 3 grammes per litre strength (210 grains per gallon); this diluted to one-third its strength would give, say, 400 gallons of electrolytic liquor in 10 hours, or 220 gallons in $5\frac{1}{2}$ hours. The cost of production would be : 66 lb. common salt, including carriage and sacks, 6d. ; current, $7\frac{1}{4}$ B.T.U. at 1d. per unit, $7\frac{1}{4}$d.; depreciation of the electrolyser, 10 per cent. (allowing 300 working days per year), 6d. ; total 1s. $7\frac{1}{4}$d. for 3 tons of clothes. This is equivalent to less than $\frac{1}{2}$d. per cwt.

As the electrolyser is only constructed to take 110 volts, two electrolysers have to be coupled in series on 220 or 230 volt circuits.

For bleaching cotton, linen and paper the apparatus is somewhat more extensive than in laundry work. Pumps are avoided by the action of the hydrogen, causing effervescence as mentioned above. For the electrolytic liquor several advantages are claimed—viz., great effectiveness, great and unvarying strength, economy and cleanliness.

ELECTRICAL COMMUNICATION WITHIN THE EMPIRE.

DEPUTATION TO THE PRIME MINISTER.

As arranged by the Conference, a deputation, consisting chiefly of the Standing committee of the Imperial Press Conference, waited upon Mr. Asquith, the Prime Minister, on Wednesday afternoon, to urge upon the Imperial Government the subject of increased means of electric communication between the different parts of the Empire at reduced rates, and also the subject of a State-owned system of electric communication.

The Hon. H. Lawson (chairman of the Standing committee) introduced the deputation, and submitted that it was a Government question to secure good facilities and cheap rates for electrical communication between all parts of the Empire. The complaint of the Imperial Press was that, owing to the cost of cabling, the Imperial news service was inadequate and lifeless, and required improvement all round. The feeling at the Conference was that the only effective method of bringing about what was desired by the editors of the Press of the Empire was the establishment, under Government control, of cheap electrical communication. They had recently received notification of the reduction of the rate over the Pacific cable, but this rather accentuated the anomalies and inequalities of the present system, inasmuch as only New Zealand and Australia would benefit, whereas for India, South Africa and other parts of the Empire the rate for Press messages would remain as before. The deputation were anxious not to prejudge the issue as between wireless and cable communication. Mr. Marconi had stated before the Conference and before the Standing committee that he could now transmit messages across the Atlantic at $2\frac{1}{2}$d. per word, and he hoped by the end of August to be able to send at 2d. per word as many as 20,000 words per day. With reference to the claim of the newspaper Press for reduced rates as compared with ordinary commercial rates, it should be pointed out that the Press were unable to send their messages in cypher, or to take advantage of the elaborate coding facilities which were available to the commercial and social worlds.

Mr. F. D. Ross (Canada) said one reason why there should be State intervention was that there existed a combination amongst the cable companies for what they (the Press) believed to be unjustly maintaining the rates. The argument used at the Conference that State communication across the Atlantic would unfairly reduce the rates of the companies might be met by the expression of the view that the Press representatives did not wish the Government to run the State line at a loss, but on a commercial basis and to pay.

Mr. J. O. Fairfax (Australia) said that in the Commonwealth Parliamentary news, ministerial statements and so forth were carried over the telegraph lines at reduced rates, and he suggested a similar reduced rate for similar English news when sent to oversea dominions.

Mr. FENWICK (New Zealand) said his country favoured an Imperial all-round-the-world cable State-owned. In New Zealand, he said, the more important Parliamentary news was telegraphed free of charge to the various newspapers in the country.

Other speakers having been heard,

The PRIME MINISTER expressed general sympathy with the objects of the deputation. He said the offer which had been made by the Pacific Cable Board had been made with the full concurrence of the Imperial Government. Assuming that the Governments of New Zealand and Australia acquiesce in the proposals, Press traffic would pass between this country and Australasia for 9d. and 9½d. a word instead of 1s., a substantial reduction. But they must all sympathise with the other parts of the Empire which could not participate in the reduction. With regard to the arrangements with Canada, they had been, at the request of Mr. Lemieux, postponed for the present. Mr. Asquith continued: As regards the cable companies—I am speaking now of those existing—the means of action at the disposal of the Imperial Government are very limited. But this influence will be used as far as may be in the reduction of rates. One of the speakers referred to combinations between the companies, which, like other combinations in other departments of life, do not have the effect, as a rule, of cheapening the cost of the particular commodity in which they happen to be interested. One must recognise, however, in fairness to the cable companies, that they have provided a world-wide system of enormous value to the world at large, and that of recent years they have very substantially reduced their rates. But they are commercial bodies, acting on commercial principles, and possibly—I throw it out for your consideration—the most powerful argument representatives of the Press can use in favour of lower rates for their messages along these cables would be the assurance of a largely increased traffic, which I am assuming it would possibly be in your power to give. I was glad to hear from gentlemen who addressed us—what, indeed, we had already gathered from the resolutions passed at the Conference—two things: First, that you think an Imperial line—I use the word line in a perfectly neutral sense—if it is to be brought into operation, should be self-supporting (hear, hear). I take note of that, because I think it is a very important declaration on the part of representatives of the Press, and it is one to which, I need not assure you, his Majesty's Government are prepared to subscribe. The other is that you have carefully forborne, in the language of your resolutions, and in the speeches that have been addressed to us here to-day, any expression of any preference for any of the different modes of communication. I refer in particular to the two possible competing modes—cables on the one hand and wireless on the other. You leave us a perfectly free hand in the matter (cheers). I am glad that that is so, because the development of wireless telegraphy is a matter that one cannot leave out of sight; but it may be premature at this moment to place our reliance upon it as the only means of communication between the different parts of the Empire. Mr. Marconi, I am told by the Postmaster-General, has not yet applied for the facilities which the Post Office is bound to give when he can show that he can carry on a service across the Atlantic with reasonable facility and speed. He has said that he hopes to do this in August. When he has done so we shall be perfectly ready to consider further developments. In the meantime, I can assure you that in our view wireless telegraphy ought to be taken into account in considering the question of communication, as a very important factor, and especially in connection with the discussion of the question of laying fresh State-owned cables, and it has also to be borne in mind that the progress of invention in other ways may considerably alter the carrying capacity of cables, and so somewhat change the position. Your Conference, if I may venture to say so, has very wisely appointed a Standing committee to deal with the matter. The Post Office and other Government departments concerned will be anxious to assist and keep themselves in touch with this committee by information and intercommunication, and in all other ways that may be practicable.

LEGAL INTELLIGENCE.

British Westinghouse Electric & Mfg. Co. v. Braulik.

On the resumption of this case before Mr. Justice Joyce last week Mr. James Swinburne was cross-examined by Mr. Bousfield.

Mr. BOUSFIELD: Now, as regards the general principle of the plaintiffs' lamp. Of course it was well known that what he calls two feeds, one of which is irreversible and feeds the carbon always forward, and the other reversible—that is to say, it can move backwards and forwards a little to give finer adjustment. That, of course, was quite old before the date of the plaintiffs' patent, was it not?—Witness: I am not sure. I do not remember it.

I mean it was a well-known requisite in lamps, was it not, that you should have not merely a rough feed carbon which was irreversible, but that you should also have the arc struck in such a way that there should be a certain variation of the points to or from one another to accommodate itself?—Yes, that was quite well known.

Now I will come to what was old long ago. There were many lamps in which there was the addition of a rough feed which gradually brought the carbons together as they burnt—a retractible motion after the arc struck, or which struck the arc, which was capable of a backward and forward variation so as to increase or diminish the length of the arc quite apart from the irreversible feed?—Yes, that was almost universal.

The learned counsel then referred witness to a Paper by Prof. S. P. Thompson, published in March, 1889,* and also an illustration of the Brockie-Pell lamp. This, said counsel, is not an anticipation. It is simply the principle of the thing. The feed is a gravity feed, is it not?—Yes.

There is a series magnet in this, so that as that feeds down the current gets stronger and the magnet is more energised and therefore pulls with a greater pull?—Yes.

The backward movement must lift them apart?—Yes.

Supposing they burnt to a greater length before you got the irreversible feed of the carbon this gripping movement allows the pencil slowly to approach?—Yes.

And also if from any reason it should want to adjust itself then this gives power of adjustment?—Yes.

That is precisely what the patentee had tried to introduce in this specification to these inclined carbon lamps?—No.

Why not?—Because in the mechanism you have shown the adjustment of the arc is down by the movement of the carbon in the same direction as the plaintiffs', and therefore the mechanism which is to adjust the arc has practically to work a feed mechanism. According to the patent the adjustment is done by movement at right angles to the direction of the feed, and it involves therefore only moving a very small body.

If you take plaintiffs' apparatus and bring these carbons into line you might have the irreversible feed and the adjusting feed in the same line?—I do not think you could without departing from his invention.

Counsel then took witness to Graham's specification, but the witness said the method of attachment was different from plaintiffs' but was like defendant's, there being a separate coil for each carbon. In defendant's there were two chains, one chain going into each carbon holder. There were two independent chains which went round the drum and jammed down the counterbalance weight. There was a separate chain to each electrode. In Graham there was a separate chain to each carbon.

Were there not scores of lamps in which the governing armature of the magnet for the striking gear was in equilibrium between the force of the magnet coil and the force of the spring?—Yes.

What would a skilled lamp maker in 1900 have understood from Bremer's specification of 1902?—He would have found a lamp which struck the arc by means of a magnet, fed when the current fell below a certain definite value, and nothing more. Graham's device could not have been made to act in the same way as Bremer's. The whole difference really between Graham and Bremer was as to whether the armature or coil of the solenoid was in equilibrium or whether it moved.

If, in fact, in Graham the lever was floating in these positions you do not see any substantial difference between that and Bremer?—Yes, whether amended or unamended.

Witness was referred to the specifications of Serrin, Brush, Crompton, Gramme, Siemens, Joel, Thomson-Houston, Abdanck, Maxim and Brockie all before 1882. He admitted that in all of these there was an armature acted on by an electromagnet in such a way that the armature floated and did not stick.

If it did float it would far more satisfactorily fulfil the purposes described on page 1 about obviating the inconvenience arising from irregularity?—Yes, it would be a better lamp in every way.

Referred to Sheridan's United States patent, witness said that there the carbons were allowed to feed by means of cords through drums. The drums there were of different sizes in order to compensate for the different rates of feed of the carbons, and there was also an arrangement of series coil and shunt coil arranged differentially so that they were opposite one another. When that was done the core was necessarily a floating core.

The purpose of it was to have this floating in position?—Yes. It was not only to arrange the feed but also to allow a pull back. As to Crosby, witness said that long before the date of plaintiffs' patent there were plenty of arrangements of the Brockie-Pell type in which the striking of the arc was affected by mechanism which controlled the main feed—practically all commercial lamps had been made that way since 1886 or thereabouts until lately.

What I want to put to you is whether it required any invention to apply that to the known type of lamps with inclined carbons and a striking mechanism which operated horizontally on these carbons?—I think it did. I think there is invention in it. The arc striking was known but not the regulating.

Surely if you told any workman to control the feed mechanism by the striking mechanism which would allow the swinging before the feed came on he would have been able to do it?—If you had told him that you would have made the invention. If you told the man that he was to make his horizontal movement not only to strike the arc but to regulate the arc, keeping the vertical movement for feed only, then you would have made Bremer's invention. He considered plaintiffs' invention was having axial feeding of the carbons and horizontal striking plus horizontal adjustment all worked by one electromagnet or one mechanism.

All that you find in Graham's specification, if it be allowed that the armature or core of the solenoid is floating?—That is really law: all I say, as an engineer, is that if you work that model and it floats, it floats. Whether or not you find the idea in the specification I am not lawyer enough to say. If the true reading of Graham's specification be that the armature or the core of the solenoid does float then it is an anticipation of the unamended claim.

In re-examination Mr. SWINBURNE was taken by Mr. Walter through the various specifications relied upon by defendants as anticipations. He said that in Graham's specification there was nothing more than just

* "Arc lamps and their Mechanism." THE ELECTRICIAN, March 15—April 5, 1889.

bringing to a stop two carbons that were inturned to each other, and, when they were wanted, letting them go again. There was nothing in the prior specifications which would have enabled him as an engineer to have made plaintiffs' invention.

Mr. DUGALD CLERK said that he had examined plaintiffs' specification. The first and main feature was the combination of a striking mechanism with a horizontal adjustment, and the relation between the horizontal adjustment and what might be called the permanent or complete feed. That was, in his opinion, the invention, but there were other features which were important. It was important that the electrode holders that held the carbons should be firmly clipped at the middle, as shown in the first figure of Bremer's specification. It would be seen from that that the electric current entered the carbons by means of a metal connection firmly clipped on to the carbons. That was important, because where they had a sliding carbon it was very difficult to get contact. There were many devices for getting contact with sliding carbons, but the real satisfactory connection was something clipping the carbon firmly. Then it was important with regard to the downward feed mechanism that it should be so connected that the two carbons fed downwardly simultaneously in separate clutch slides. A carbon sliding separately was not satisfactory. To get the carbons to feed simultaneously it was necessary to connect them in some way. That was found in plaintiffs' specification in the cross piece and chain in the centre. If one carbon went the other must go where plaintiffs' device was adopted. The third point was that the horizontal feed mechanism, as operated on by the electromagnet by which the arc was sprung and the resistance of the arc reduced, should be by some device operating not far from the lower ends of the carbons. It was important that the feed mechanism should be relieved of every work other than that. You wanted to relieve the operating electric magneto or operating solenoid of every possible work. It was necessary, however, that there should be connection between the two mechanisms. In the specifications of Brockie Pell and Serrin the mechanism had a great deal of work to do. Neither would have acted the same as plaintiffs' arrangement. In witness's opinion there was room for invention between the lamps described in the prior specifications and plaintiffs' arrangement. In flame arc lamps the difficulty of adjustment was very important. The defendant's lamp had every feature of plaintiffs' that he had referred to.

Mr. Justice JOYCE: They are the same thing, but different. I want to understand. The two mechanisms are different?

Mr. WALTER (to Witness): Is the plaintiffs' mechanism per se new?—New, but perhaps not new per se. In Graham's specification they did not find the floating adjustment. There was no question of floating adjustment.

Mr. Justice JOYCE said he did not understand "floating adjustment."

Mr. WALTER: It is the adjustability at the bottom of the carbon. It moves easily, and is therefore called a float or "swinging adjustment."

Continuing, WITNESS said that reading Graham's would not teach anyone plaintiffs' invention. In his opinion, Graham never intended to have the sliding adjustment. He clearly intended to have what he said in his specification—the instantaneous feed. He saw nothing in the prior specifications that would suggest the plaintiffs' invention.

Cross-examined by Mr. BOUSFIELD, Witness said there was nothing omitted from plaintiffs' specification that would prevent a competent workman from making the invention.

Mr. HERBERT EDMUND MOULD, technical engineer of the Union Electric Co. (agents for Körting & Mathiesen), said that of the flame arc lamps made in this country nearly all had plaintiffs' invention. In the course of his business he saw the lamps of other makers, and he should say that about 11 or 12 out of 16 were constructed on the principle of plaintiffs' invention. His firm sold lamps manufactured under a licence from plaintiffs, and under that licence they had sold some 12,000 or 14,000 lamps in this country. They paid a large royalty to the Westinghouse Co. Plaintiffs' invention was a feature of the flame arc lamp. In his opinion the plaintiffs' invention was the commercial solution of the flame arc lamp. This concluded the case for the plaintiffs.

In opening the case for the defence, Mr. GRAY said his submission was that the points raised on behalf of plaintiffs were destructive of each other. First they alleged that the question was one of principle, and then it was said that the real change was certain mechanical details which did not appear in the specification. His contention was that there was no subject matter whatever in plaintiffs' patent. The expressions that appeared in the specification must be taken as the real subject matter of the patent. Broadly speaking, there were two. They were defined as a horizontal feed and a downward feed. These expressions were illusions and had no real meaning as applied to the lamps. There was neither a horizontal feed nor a downward feed in these lamps.

Mr. Justice JOYCE said he did not think that the expressions were very apt.

Mr. GRAY said he should call the horizontal feed "the adjustment" and the downward feed merely "the feed." The former merely involved the swinging about of the carbon. In 1882, which was one of the dates more or less in dispute, there were a large number of lamps that had an adjustment of feed. His witnesses would prove that such lamps were practically universal. In plaintiffs' patent the steps taken were in the same order. First there was an adjustment of the mechanism and then there was the adjustment of the feed. Unless plaintiffs could prove the contrary, he should maintain that that was the invariable practice in all arc lamps in 1882. It was a cardinal principle in arc lamps of that date to have both operations. It was quite clear that the carbons had to be fed forward to bring the points together as they burned away. All that plaintiffs' patentee had done was to apply these well-known principles to inclined carbons. The patentee had taken the principle of the other arc lamps and used it in the same way and for the same purpose, and in his specification did not describe any mechanism which enabled it to be done. All the operations were the same. The system of adjustment and feed were well known before 1882. There were different methods of finding different results. The method shown by plaintiffs' specification was absolutely and entirely useless, and the defendant was not using it. Apart altogether, however, from non-infringement, the method was useless. He submitted that the patent was hopelessly bad, not only because of lack of subject matter, but also because of want of novelty.

Prof. SILVANUS P. THOMPSON said that in 1882 there was a great deal of activity on arc lamp questions and at that time a number of arc lamps were in existence, some suitable for working singly (as, for example, for lighting a lighthouse or for use in magic lanterns) and others adopted for house lighting, &c., and a great deal of ingenuity had then been exercised in devising an appropriate mechanism to do what was necessary to keep a lamp burning steadily. It was known that in all arc lamps there were certain requirements that must be fulfilled automatically by the mechanism of the lamp itself. After stating what these requirements were witness said that he searched the different patents taken out in 1880 and 1881. He was personally familiar with what was being done in 1882 in the construction of arc lamp regulation and had made a special study of it. It was then perfectly well known that they might have the mechanism in an arc lamp so that the striking mechanism might be brought before the feed back applied or that it might be arranged to be fixed without any return or adjustment and in the majority of cases they were so designed that approach of the carbon points must occur before the feed back applied. In 1900 the state of knowledge was the same, except that it had been more methodically stated in various cases. In 1900 practically all the lamps possessed that feature—that was to say they had the power of return before feed. They were not hard fixed. Floating armature was practically the same thing as the power of return. As he understood it the device described in Bremer's specification of 1902 was that in arc lamps he was proposing to make there would be two movements, a feed movement and a striking movement capable of adjustment, and he specially drew attention to the requirement that the approach during adjustment should occur before feeding began. There was nothing new in that. The only thing that witness found that was new in the specification was his providing a very special and unusual form of electromagnet. Looking at that specification he did not obtain any useful information for the construction of an arc lamp. He considered that Graham's American specification practically described what was described in Bremer's specification.

Cross-examined by Mr. WALTER: He did not know of a single downwardly pointing inclined carbon lamp before the date of Bremer's specification in commercial use in this country. That was a feature in the plaintiffs' specification.

Prof. J. G. CORMACK gave evidence corroborating that of Prof. S. P. Thompson. He said he found in Graham what was described in Bremer's specification. He failed to find any feature of information in Bremer's specification which was new at the date of the specification.

Cross-examined by Mr. WALTER: May I take it that until the Bremer patent such a lamp had never been made or sold?—I have not seen any. He did not agree with the evidence of Mr. Dugald Clerk.

Mr. BOUSFIELD, in summing up defendant's case, submitted that there was a complete anticipation of the alleged invention of plaintiffs in the specifications of Graham and Crosby. Graham's was much nearer to the present case, and he would give most of his attention to that specification because that was a short and simple way out of the case and was the chief thing he was going to rely upon. He did not intend to give away his other points because one never knew what twists might be given to the case by the other side, and the litigation might go further. He contended that there was nothing in the point put forward by the other side as to making flame arc lamps successfully. He contended that all Bremer had done was to apply an old idea to an old form of lamp and that there was no subject matter in applying that form of mechanism to a known form of lamp.

Mr. WALTER submitted that from the evidence it was abundantly clear that until the date of plaintiffs' patent, in 1902, there was never an effective arc lamp on the market with downwardly inclined carbons. Neither Prof. Thompson nor Prof. Cormack had ever seen one. This invention was undoubtedly one of great commercial importance, and he asked his lordship to hold that the patent was a good one and that defendant had infringed it.

His lordship reserved judgment.

Morrison v. British Aluminium Co. (Ltd.)

On Tuesday, before Mr. Justice Warrington, Mr. CAVE, K.C. applied on behalf of plaintiff for the appointment of Mr. A. W. Tait, C.A., as receiver and manager of the company (the managership not to extend beyond Oct. 31), on behalf of the debenture stock holders. The company was incorporated in 1894, and had a capital of over £1,000,000. Of its debenture stock, amounting to a million, £300,000 was reserved to pay off a Loch Leven security. Plaintiffs were the executors of the late Charles Morrison, and held £175,000. A great part of the company's property was the entire share issue of the Loch Leven Electric Power Co. The company had made large sales of aluminium, but the position at present was one of considerable jeopardy for the holders of the large issue of stock. The company had endorsed bills amounting to £100,000 which were due that day, and they had also borrowed from their bankers, who were pressing for the reduction of the loan.

Mr. H. E. WRIGHT (for the company) said they did not oppose the application. He said the company had been very successful, and it was

hoped that with further working capital it would be even more successful in the future. The appointment was asked for in order to facilitate the reconstruction of the company.

The order asked for was made.

Handsworth Tramway Arbitration.

Mr. H. Graham Harris, the arbitrator appointed to ascertain the price to be paid by Handsworth Council to the City of Birmingham Tramways Co. for a portion of their cable tramway, has made his award. The company claimed about £89,000, and it was contended on their behalf that the Council should take over the whole of the Hockley depot, although it supplied power for the Birmingham as well as the Handsworth sections and was not in the Council's district. The details of the award are not yet published, but it is understood that the Council will have to pay £72,000 and about £5,000 costs.

Assessment Appeal.—At Preston Quarter Sessions last week, before Mr. H. Worsley-Taylor, K.C., and a full bench, the Blackpool & Fleetwood Tramroad Co. appealed against the assessment by Fleetwood Council and Fleetwood Improvement Commissioners.

For the Council, counsel raised the preliminary objection that the appeal was out of time, and this objection being upheld, the appeal was dismissed, each side paying its own costs.

Re Uxbridge & District Electric Supply Co. (Ltd.)—Mr. Justice Neville on Tuesday heard a petition by Callender's Cable & Construction Co. for the compulsory winding up of this company. Mr. PETERSON, K.C., in support, said he represented a creditor for £2,210. 7s. 3d. due on a dishonoured bill. The company was called upon to pay, and said they had no assets with which to meet the debt. The Metropolitan Electric Supply Co. were also creditors and supported the petition.

Mr. SARGEANT also said he appeared for creditors for between £40,000 and £50,000, and supported a compulsory winding up.

His lordship made the usual compulsory order.

Millbank Station Award.—In connection with the arbitration proceedings between London County Council and the Westminster Electric Supply Corpn., the umpire (Mr. J. A. Simon, K.C., M.P.) appointed to determine outstanding matters, such as the cost of erecting and fitting up a new generating station, &c., for the Millbank station, has issued his award.

The company originally sent in a claim amounting to £235,105 for a part of the compensation to which they stated they were entitled, but the total claim put forward before the umpire was reduced to £226,622. The figures submitted on behalf of the Council amounted to £147,481. The award amounts to £184,471. It was claimed on behalf of the County Council that the company should pay £3,400 towards the cost of providing certain facilities for condensing water. The umpire has allowed this, bringing the total net amount payable by the Council to £181,071.

PARLIAMENTARY INTELLIGENCE.

Wireless Telegraphy on Passenger Steamers.—In the House of Commons on June 24 Mr. Rees asked the Prime Minister whether, in order to assure the saving of life at sea, he would consider the propriety of providing by law that all passenger steamers shall be provided with Marconi apparatus.

Mr. W. CHURCHILL said the matter was being carefully watched, but it was not considered advisable to propose legislation at present. A large number of passenger steamers were already provided with radio-telegraphic apparatus.

Greenock Corporation Bill.—In the House of Commons on Tuesday Dr. Rainy moved to leave out the part of clause 354 of this bill, which empowers Greenock Corporation to supply electrical energy to the Greenock & Port Glasgow Tramways Co. without the consent of the other local authorities through whose areas the tramways pass. Sir T. Glen-Coats seconded on behalf of the Gourock Council. Mr. C Nicholson (who was chairman of the Committee which recently considered the bill) said if it were necessary to press the matter further a petition could be presented when the bill came before the House of Lords. The amendment was rejected and the bill read a third time.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

London County Council require an assistant visiting teacher of electrical instrument making for one evening a week during the session 1909-10 (commencing September next), at the L.C.C. Shoreditch Technical Institute, Pitfield-street, N. Salary 7s. 6d. for an attendance of about 3 hours. Applications, on official forms to be obtained from the L.C.C. Education Officer, Victoria Embankment, W.C., to whom they must be returned by 11 a.m., July 10. See also an advertisement.

A science master and principal is wanted for the Loughborough Technical Institute. Particulars from Mr. W. A. Brockington, Leicestershire Education Committee, 33, Bowling Green-street, Leicester. Applications by July 14.

Dudley Education committee require a principal of the Technical School, and organiser of evening school work. Salary £200 to £250 per annum. Applications on forms of tender to be obtained from the Director of Education (Mr. J. M. Wynne), to be sent in by July 12.

There is a vacancy for an improver at Watford Council's electricity works. Applications to the chief engineer, Mr. F. W. Purser.

Mr. H. H. Holmes, sales manager at West Ham, has been appointed to a similar position at Marylebone, at a salary of £400 per annum.

Mr. Thos. C. Joyce, B.Sc., of Bristol, has been appointed lecturer and demonstrator in the physics and electrical engineering departments of the Technical College, Sunderland.

Mr. J. M. Jolly has taken up the position of engineer and manager in Melbourne for Messrs. Staerker & Fisher, agents in Australia for the A.E.G., Berlin.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

We have received a copy of a 12 page pamphlet which sets out the character of the instruction given in the departments of the Central Technical College. The pamphlet has been issued in order to give manufacturers and others an idea of the work which the college is doing in training young men in the profession of civil, mechanical and electrical engineering and chemistry. An account of the work of the Old Students Association is appended.

Argentina.—The "Review of the River Plate" says an expert from the United States has been retained to report on the electrification of the suburban service of the Central Argentine Railway.

An application has been made to the Buenos Ayres Provincial Legislature for a concession for the construction of an electric tramway in Florencio Varela.

Owing to the great increase in the demand for trunk-line telephone facilities, the United River Plate Telephone Co. are laying four additional lines from Buenos Ayres to La Plata.

The chairman of the River Plate Electricity Co. (Mr. M. W. Matterson, K.C.) recently visited Argentina to discuss a project by the manager (Mr. V. Lindop) for placing all the company's h.t. feeders underground.

Messrs. A. Clerget & Co. have asked Congress for a concession for an electric or steam railway from Resistencia to Arau, with the option of extending to La Quiaca The gauge is to be 1·435 metres (about 4 ft. 8½ in.) and the length 800 km. to 1,000 km. (496 to 620 miles).

Loberia municipality have obtained tenders for the erection and equipment of electricity works.

Santa Fé Council has not accepted either of the tenders received by them for the conversion of the tramways to electric traction. New tenders are to be invited.

Asylum Lighting.—A L.G. Board inquiry was held at Richmond Asylum, Dublin, on Tuesday, into the application of the joint committee for sanction to a loan of £3,800 for an electric lighting installation. After taking some evidence as to the advantages and economy of electric lighting, the inquiry was adjourned until the 21st inst.

Australasia.—The "Australian Mining Standard" says the Minister of Public Works has recommended the Governor-in-Council to issue an Order authorising Eaglehawk (Victoria) Council to establish electricity works. The proposal has been strongly opposed by the Electric Supply Co., of Victoria, who have already been authorised by an Order in Council to supply in part of the borough. It is stated that the Council will invite tenders without delay.

The general manager (Mr. R. Sticht) in his last half-yearly report to the Mount Lyell Mining Co. stated that the Ilgner electric winding plant, which has a winding speed of 1,500 ft. per minute, and enables the daily output to be lifted in a single shift, has not only quickened but cheapened the cost of handling ore. The four electric pumps which were put in during the period covered by the report are also working in a most staisfactory manner. An electrically-driven air compressor has also been installed.

Freemantle Council are borrowing £30,000 for extensions of their electric tramways.

The Government Railways Department state that the cost to them of re-grading the railway at Moorabool-street, Geelong (Victoria), so as to allow the projected tramway to pass under it, will be £15,000, and they decline to undertake the work unless the municipality or the Tramways Trust contribute £4,000 towards the cost. The Minister for Public Works (to whom an appeal has been made) considers it a liberal offer, as the cost of maintenance of a level crossing if capitalised would amount to £3,775, and he desires to avoid the construction of level crossings.

Launceston (Tasmania) Council has been informed by Mr. R. Hain (acting on behalf of the "London Tramways Group") that the lowest price at which they could undertake the construction of the proposed electric tramways in the town was £65,875, but the City Council, after receiving a report by their own engineers (Mr. David and Mr. Strike) expressing the opinion that the work could be done for £48,289, have decided not to accept the offer.

On May 13 the Windsor (N.S.W.) Land Board considered an application by Mr. C. O. Schulze (on behalf of a syndicate) for the right to construct a dam on the Colo river and to utilise the water for the generation of electric power for Richmond, Windsor and other towns. The scheme was estimated to cost £2,000,000. The Public Works Department opposed, on the ground that the Water Rights Act, under which the inquiry was held, was intended to apply only to works of conservation, water supply, irrigation and drainage, and the Board decided that the scheme was not a work within the meaning of the act.

The N.S.W. Railway Commissioners recently decided to substitute electric tramways for the present steam system in Newcastle (N.S.W.).

Belfast. At a meeting of the Corporation on Tuesday the question of the supply of electricity to the Abbey Sanatorium, which is outside the city boundary, was under consideration, but ultimately a resolution in favour of applying for a provisional order to enable the Corporation to give a supply was rejected.

Birmingham. The Corporation electricity department are about to conduct experiments with arc lamps, in lieu of the present incandescents, in Corporation-street.

An inquiry was held on Wednesday into the application of the Corporation for sanction to borrow, among other sums, £149,350 for extensions of the electricity undertaking.

It was stated that £100,000 was required for extensions of the mains, rendered necessary by the rapid increase in the demand for electric current. Mr. PRIDEAUX, who appeared in support of the application, said that the demand was evidenced by the fact that there was an increase in the sales during the year ended March 31, compared with the previous year, of about 4,400,000 units, and for the first time the Electric Supply committee were able to pay £10,000 in relief of rates. Of the £100,000 about £20,000 had already been expended owing to the rapid extension and urgent necessity to lay down mains; £15,000 was needed for high-tension switchgear, which was necessitated in connection with supplies of current to consumers' premises at a high voltage; £2,000 was required to supply transformers to consumers' premises in cases where consumers desired low-tension current in districts where there were only at present high-tension mains available; and the balance of the loan was wanted for the installation of new plant at Dale End and Summer-lane stations.

Brighton. The overseers have reduced the assessment of the electricity works from £11,160 gross and £7,000 ratable value to £10,480 and £6,000 respectively.

Cheshunt.—The Council have retained Mr. H. W. Wilkinson (at a fee of 15 guineas) to prepare a report on the desirability of applying for a provisional electric lighting order.

Dartford. The Council have sealed the transfer for the tramways from Messrs. J. G. White & Co. to Messrs. Balfour, Beatty Co.

Droylsden. The Co-operative Store, the Parish Church, and a number of business premises are to be wired.

Dublin.—A lengthy L.G. Board inquiry has been held into the application of the Corporation for sanction to borrow (among other sums) £100,705 for extensions of the electric generating plant and mains, and £1,320 for the electric lighting of Drumcondra and the North Circular-road.

The inspector (Mr. P. C. COWAN) mentioned that in addition to the £100,705 for electric lighting there was a small additional sum required under that heading amounting to £3,103.

In support of the electric lighting loan, Mr. F. J. ALLAN, secretary of the Lighting committee, stated that at the last inquiry they asked for a loan of £127,000, but £100,000 was sanctioned, and of that they only raised £96,000. In the present application the remaining £4,000 and the £27,000 not sanctioned formerly were included. The capacity of the existing plant was 6,000 kw, and, allowing for the "stand-by" required, only 4,500 kw. would be available. The original scheme only provided for 3,000 kw. with a capacity of 2,000 kw. Some portions of the scheme had not been profitable. Of the sum applied for, £14,028 represented expenditure in excess of Mr. Hammond's estimate. £5,379 had been expended in extensions, and the total income from those extensions in the past 12 months amounted to £1,669. The class of property in Cork-street, where they proposed to extend the cable, was factory property, and they had had many demands in that district for electric light. The accounts of the department from 1905 to date were submitted and showed that there had been a deficit on the working after interest and sinking fund had been provided for. The witness also gave evidence as to the effect upon the undertaking of the introduction of metallic filament lamps, the system of charging, &c.

The city electrical engineer (Mr. MARK RUDDLE) supplied technical evidence of the proposed extension, &c. He stated that there were demands for electric current in several districts where mains were laid. The expenditure incurred to date since the inquiry of 1905 on the work for increasing the capacity of the plant and other extensions was £71,000, and the estimated amount required to complete the work now in progress was £57,000, including boiler plant (£7,100), Dame-street area (£3,600), Fleet-street switchgear, &c. (£1,800), house services and meters (£2,500), and North and South Circular-roads (£42,000). The loans already applied for amounted to £127,000, and the estimated cost of further extensions for which application was being made was £69,705. He expected the undertaking would become self-supporting within the current year. They were just beginning to get the benefit of the new metallic filament lamp, which up to the present unfortunately told against them. Up to the present the profits out of that improved lamp had been divided between the consumer and the lamp makers, and the unfortunate generating station had reaped nothing. That was a matter which time would rectify. It had been the experience of every place that at first there was a loss, but it could be only temporary, and when they were able to take advantage of the full capital expenditure on the distributing system he was absolutely certain that the station would more than pay its way. Witness was cross-examined at some length on the accounts of the department, and after evidence in opposition had been given on behalf of the Citizen's Association, the inquiry concluded.

Ecuador.—Señor E. Estrada has secured a concession to utilise the water power of the river Chimbo for the generation of electric power, which is to be transmitted to Guayaquil. The terms of the concession can be seen in the "Registro" for March 19, at 73, Basinghall-street, London, E.C.

Electricity in Horticulture.—"The Fruit-Grower" recently contained some further interesting particulars concerning results obtained by the investigators in the electrified glasshouses owned by Mr. Raymond Bomford at Bitton.

The pickings of strawberries at Bitton to May 10 was (neglecting fractions of a lb.):—

House No I.	No. II.	No. III.
Not electrified.	Electrified.	Electrified.
34 lb.	42 lb.	32 lb.

House No. 1 was started a week before No. II. and a fortnight before No. III. The plants were brought in and those most forward got selected for No. I. The difference between No. 1. and No. III. in this respect was marked. House No. I. is nearest to the fires. There is a fair amount of fruit left, particularly in Nos. II. and III., and picking is still going on. The berries from Nos. II. and III. were heavier—fewer to the lb.

It must be remembered that only half the plants in the electrified houses get any electricity, as the houses are narrow, and are, therefore, not suitable for electrification.

In the two houses down to lettuce, carrots and radishes, carrots and radishes have been pulled only within the radius of influence, and very few lettuce have been got outside. The crop inside was quite good.

Generally speaking, for wide (40 ft.) houses electrification will pay handsomely, but in 15 ft. houses it will not, except in special cases, be a financial success, for the reason that it is impossible to electrify the crop in the houses—the current goes to the roof, or, in the case of cucumbers, straight to the ground, without passing through the plants.

At Bitton there have been tried experiments with seed gathered from the electrified and non-electrified wheat fields of 1907 and 1908, and the results obtained are striking and surprising. A number of small plots have been sown with electrified and non-electrified seed, somewhat like this:—

Rows ✱ ✱ ✱ ✱ ⊙ ⊙ ⊙ ⊙ ✱ ✱ ✱ ✱
Rows ⊙ ⊙ ⊙ ⊙ ✱ ✱ ✱ ✱ ⊙ ⊙ ⊙ ⊙

In each case the plants from the seed of the electrified plants are better, bigger, broader, and darker in the leaf. Why? This is a question for a biological botanist to settle.

Exhibition.—Particulars relating to the International Electrical Exhibition to be held at Brescia (Italy) from August to October next can be obtained from the Italian Chamber of Commerce, 4, St. Mary-axe, London, E.C.

Fair Wages Clauses of Government Contracts.—The Treasury have appointed a committee to advise the departments of Government, with a view to promoting uniformity of administration and co-operation between departments in dealing with the fair wages clauses of Government contracts. The committee will consist of:—

Messrs. G. R. Askwith, K.C. (Comptroller-General of the Commercial, Labour and Statistical Departments of the Board of Trade), chairman; R. Bailey, M.V.O. (Controller of the Stationery Office), F. W. Black, C.B. (Director of Navy Contracts), W. G. Butler (Director-General of Stores, India Office), H. D. De la Bere, C.B. (Director of Army Contracts), P. H. Ezechiel (Secretary to the Crown Agents for the Colonies), J. H. Hillier (Controller of Supplies, Office of Works), G. Morgan (Controller of the Stores Department, General Post Office, Sir G. C. V. Holmes, K.C.V.O., C.B. (Chairman of the Board of Works, Ireland). Mr. J. J. Wills, of the Board of Trade, will act as secretary to the Committee.

Farnham.—The local Gas Company have given notice of their intention to apply for a provisional electric lighting order.

Fatality.—An accident occurred at the Clifton pits, Nottingham, on Monday, resulting in the death of two men, named Higgs and Eyre.

It appeared that at about 7 a.m. the two and other men were about to start work at the soft coal face in No. 12 district with an electric coal-cutting machine. Eyre, who was in charge, pulled the lever to switch on the current, and in some way both men came in contact with live parts,

✱ Represents electrified and ⊙ non-electrified seed.)

resulting in their death. Artificial respiration proved unavailing, and an inquest was held on Wednesday.

The inquest was opened on Wednesday. The coroner (Mr. C. L. Rothera) explained that it had been impossible to obtain full and accurate details, and, after evidence of identification was given, the inquiry was adjourned until the 18th inst.

Great Britain and International Exhibitions.—Unusual importance attaches to the British Section of the International Exhibition to be held in Brussels from May to October, 1910. The reasonable discontent of British manufacturers with the character of international exhibitions in general, with the management of former British sections, and with the results of exhibiting, resulted in the creation of a new situation, and for the first time what may properly be called a representative national exhibit is to be attempted; and this is being organised on novel lines.

Exhibitors are no longer to be dependent upon a voluntary committee, or left to instal their goods as best they can, or exposed to the risk of being obscurely placed, or required to defray the cost of a general scheme of decoration, or engaged in a speculation the cost of which they cannot ascertain beforehand. The section is in charge of a new department of the Board of Trade, acting in personal touch with them and taking responsibility for these matters. The new organisation undertakes to do more than is done for the exhibitors of any other country. In these circumstances, Mr. U. F. Wintour, the British Commissioner-General, is approaching all the staple trades of the country with a view to secure at once that arrangements shall be made for an exhibit at Brussels showing the scope and real importance of British manufactures. In the machinery hall the portion allotted to Great Britain occupies the centre, and the total space (203,410 sq. ft.) compares favourably with what has been granted to our trade rivals.

The Royal Commission, which is presided over by the Prince of Wales, has its offices in Queen Anne's-chambers, Westminster, S.W. It is constituted wholly of well-known business men, and the occasion being unique His Royal Highness is giving active help to the Commissioners. A departmental inquiry, concluded two years ago, was the means of opening this fresh chapter in the history of international exhibitions. It was presided over by Sir Alfred Bateman. Taking the opinion of a large number of important manufacturers, the committee found a strong and growing prejudice against exhibitions on the old lines, and came to the conclusion that it was largely justified. But, as it would evidently be ruinous for Great Britain to abstain alone from a form of advertisement which is now established, they recommend effective means of meeting the grievances of British exhibitors. The Exhibitions Department of the Board of Trade, which has been placed under the direction of Mr. Wintour, is the chief outcome. Except in the case of machinery, the only charge made within the exhibition itself is a low charge for space; and tenders will be obtained from Belgian contractors for the installation of machinery. This charge for space covers the provision of showcases, the cost of the general decorative scheme, the handling of exhibitors' goods, the publication of a catalogue (in French and English), &c. "Handling" means that officials of the Commission will take delivery of packages at the exhibition entrance; unload and place them on the space allotted; take away, store and return the packing cases; re-load at the close of the exhibition. Further, the Commissioners will provide (free of cost), as far as possible, an adequate supply of unskilled labour to assist exhibitors with the installation of their goods. Machinery will involve, of course, the additional cost of foundations and shafting; that of main switches, safety fuses and meters for electrical machinery, stop valves for steam, and valves and meters for water; and that of the power used for driving. Crane power is free of charge. The provision of show cases in a uniform style is part of the conception. This will not deprive exhibits of individual character, as exhibitors are not even required to use these cases, or any cases. Samples may be seen at the offices of the Royal Commission, 30, Broadway, Westminster, S.W., where the tariff of charges for space, &c., may be obtained. For motive power, the Royal Commission will defray half the charges made by the Belgian Administration on all machinery driven to illustrate processes of manufacture. Exhibitors will pay: For steam (133 lb. pressure) $\frac{1}{2}$ centime per kilogramme, for gas 1s. 3d. per 1,000 cubic ft., and for electricity (2 × 220 volts d.c.) $1\frac{1}{4}$d. per kilowatt-hour. Water will be supplied free for pumps or condensers.

Not only will there be free crane power, but the laying of foundations by Belgian contractors will be superintended by a competent engineer employed by the Royal Commission. With the above particulars, the railway and shipping freights, and the contractors' tender, an exhibitor of machinery can make his calculations with a degree of confidence not hitherto possible. The special catalogue for the British section will give a free insertion of 12 lines; the general catalogue a free insertion of four shorter lines. All necessary steps will be taken by the Belgian Government for the protection in Belgium of inventions, industrial designs and trade marks.

Another provision made by the Royal Commission is that of a suite of rooms for exhibitors' agents. There will be a reference library and a staff of interpreters attached to the establishment. The Belgian State Railways, charging full rates on the outward journey, will return exhibits to their termini free of charge. The British railway companies will make a reduction of 50 per cent. on returned exhibits not sold, and travelling by the same route to the station from which they were sent out. Twelve shipping companies have also agreed to give a 50 per cent. reduction. A prompt response to the campaign now being carried on throughout the country is advisable in the interests of exhibitors, as well as of the general scheme.

The chairman of the Royal Commission is Lord Lytton and the Vice-Chairman Sir Swire Smith. The interests of machinery and electricity are well represented among the Commissioners, who include: *For Machinery*: Mr. W. J. Crossley, M.P., Mr. John McLaren, Sir William Mather and Mr. T. Hurry Riches. *For Electricity*: Dr. R. T. Glazebrook, F.R.S., and Mr. G. Marconi. The Machinery and Electricity committee has the following co-opted members of the Commission: Messrs. E. B. Ellington, W. H. Allen, Mark Robinson, H. F. Donaldson, J. H. Wickstead, R. H. Fowler, W. Duddell, F.R.S., H. J. Brackenbury, J. E. Kingsbury, W. H. Patchell, W. M. Mordey, Sir John Gavey, C.B., Col. W. Shanks, V.D., W. D. Ford-Smith, J. Allen Baker, M.P., Frank E. Musgrave, Arthur Greenwood, J. G. Barford, John Fielding and W. Harrison.

Halifax.—The Board of Trade have refused to permit the doubling of certain tramway lines.

Col. Druitt, who conducted the recent inquiry, considers that if proper signalling arrangements are erected at either end of the single portion of the line in Northgate, and the cars are run to a schedule timetable, there should be no difficulty in getting the desired service. The Board have also declined to sanction the construction of a tramway in George-street and a loop line in Orange-street.

Hornsey.—The Council have consented to the purchase by the Middlesex County Council from the London County Council of that portion of the Highgate-hill tramways within the borough of Hornsey.

Lanarkshire Tramways.—The new line from Wishaw East Cross to New Mains has been officially inspected, and is now open for traffic.

Leeds.—The extension of the Corporation tramways from Yeadon to Guiseley ($9\frac{1}{2}$ miles from Leeds) was opened for traffic on Wednesday. The line is a double one throughout and has cost £50,000. The Rawdon, Yeadon and Guiseley Councils have each agreed to pay £400 a year for 11 years.

London County Council.—On Tuesday a loan of £3,299 for electric lighting to St. Pancras, was sanctioned.

English & Foreign Work.—The Highways committee brought up their adjourned report recommending the acceptance of various tenders for electric cars amounting to £237,500. The tenders were published in the last issue of The Electrician. One tender recommended was that of Messrs. Hurst, Nelson & Co. of £23,900 for 200 sets of maximum traction swing bolster car trucks, and the tenderers stated that they could supply steel castings of foreign manufacture at £1,000 less.

Mr H. Ward moved an amendment to the effect that foreign castings be employed. He said that if the Council accepted a foreign tender they would affect a saving in the actual price of the castings of 20 per cent. He protested against the handicapping of the tramways by the purchase of those high-priced articles.

Mr. Johnson seconded the amendment.

Mr. Shirley Benn (chairman of the committee) mentioned that the Council had spent £200,000 on rails, and although they had been of English manufacture the price paid had not been more than $4\frac{1}{2}$ per cent. over the price which they would have paid for foreign materials.

Ultimately the recommendation was carried.

London County Council Tramways.—The Bridge House Estates committee of the City of London Corporation have prepared three schemes for the reconstruction of Southwark Bridge over the river Thames, and an alternative scheme for the building of a new bridge with an approach on the south side of the river commencing at the junction of Southwark-street and Southwark Bridge-road, the bridge being continued on the north of the river by a viaduct over Upper Thames-street and Queen Victoria-street to Cannon-street. This bridge, 80 ft. wide, would accommodate a double line of tramways, which on reaching Cannon-street would descend into a subway, emerging in Aldersgate-street and joining the present North London system. The new bridge scheme would cost £1,648,983, and the schemes for reconstructing Southwark Bridge vary from £876,194 to £1,086,225.

L.C.C. Tramway Employés and Conciliation.—The London County Council having asked the Board of Trade to form conciliation boards covering all its tramway employés, the Board have issued posters setting forth the principal points of the scheme, and have taken a ballot of the men to ascertain whether they approve the principle of conciliation boards.

Market Harborough.—The Council have decided to apply to the Board of Trade for an extension of the period of their electric lighting order.

Marylebone (London).—The general manager of the electricity undertaking (Mr. Seabrook) has reported that the sale of current for lighting will seriously decrease when the metallic filament lamp becomes better known, and from other directions the department is likely to experience a decreased revenue.

Mr. Seabrook states that his position was that he had two different and equally important classes of work to do: (1) overhaul organisation and (2) develop supply. It was necessary for the two to go on simultaneously, but he did not feel it would be wise to tackle the two together single-handed, and he asked permission to engage Mr. H. H. Holmes,

sales manager at West Ham, who had great experience in the direction of development, at a salary of £400 a year.

The Electricity committee decided in favour of Mr. Holmes being appointed, subject to a month's notice on either side. Mr. Seabrook pointed out that, although the present cost (about £1,200 per annum) of business-getting will be temporarily exceeded, it will in the course of 12 months or thereabouts be cancelled, and from that time gradually grow into a substantial credit balance. The committee has also agreed to a suggestion of the general manager that an alternative basement rate be laid down of 3d. per unit, applicable to basements whose ceilings are 2 ft. above ground level.

Middlesex Tramways.—The Middlesex County Council have agreed to join the London County Council in promoting a bill for a tramway from Cricklewood to Marble Arch.

Middlesex Council will construct the tramway (on the overhead system) and widen the road from Cricklewood to Netherwood-street at an estimated cost of £80,000. The portion of the line from Netherwood-street to Bridge-terrace is to be constructed by the L.C.C. at an estimated cost of £70,000. From Bridge-terrace to Marble Arch the tram way is to be on the conduit system, and from Netherwood-street to Bridge-terrace on the dual system of overhead trolley and conduit.

The Winchmore Hill Enfield Town tramway route was opened for traffic yesterday.

National Electrical Manufacturers' Association.—A committee meeting of this Association will be held at the Offices (Balfour House, Finsbury Pavement, E.C.), on Tuesday, 13th inst., at 2:30 p.m.

Personal.—On the 26th inst., at the Victoria Hotel, Manchester, a meeting was held of the district managers of the Edison & Swan United Electric Light Co. for presenting a testimonial to Mr. O. H. Bishop, A.M.I.E.E., sales manager to the company, who has resigned after 18 years' service. The presentation took the form of an illuminated address and a service of silver subscribed for by the whole of the district managers, and the heads of departments of the northern works of the company. During the same week Mr. Bishop was present with a gold cigarette case and an address by the sales department staff, and with a gold-fitted dispatch case and a gold-mounted letter case by the heads of departments at Ponder's End Works.

Poplar (London).—Arrangements have been made with Stepney Council for a supply of electricity in bulk to Stepney during removal of plant to the new generating station.

The contemplated demand is for a minimum of 250 kw. running continuously for 24 hours per day, except for a short interval on Sundays, with liberty to raise the demand to 500 kw. The contract is for three months (from July 1 to Sept. 30, 1909), and the price 0·3d. per unit untransformed at Limehouse sub-station, subject to a clause relating to coal strikes. This supply is not to affect the operation of the existing agreement for a stand-by supply to Stepney in case of emergency.

Radcliffe (Lancs.)—Sanction has been received to a loan of £4,336 for extensions of the electricity supply undertaking. The Council offer to supply electrical energy to J. C. Hamer (Ltd.), for their new mill at ¾d. per unit.

St. Anne's-on-the-Sea.—A revised scale of charges for electrical energy for power, cooking and heating has been adopted by the Council.

Shrewsbury. The Council have applied for sanction to a loan of £10,000 for extensions of the plant at the electricity works, laying additional feeders, distributors, &c.

Southampton.—The Council have decided to supply electrical energy to the L. & S.W. Railway Co. for dock premises at 1¼d. per unit, the minimum consumption being 400,000 and the maximum 600,000 units per annum.

Switzerland.—The "Federale Suisse" of June 16 (which can be seen at 73, Basinghall-street, London, E.C.) contains particulars of a decree granting to a committee represented by M. Antonio Soldini (of Bissone) an 80-years concession for the construction and working of an electric tramway from Capolago to Bissone. The line is to be single track and metre gauge.

Uruguay.—The "Review of the River Plate" states that the Government has forwarded a bill to the Chambers, authorising them to enter into a contract for the establishment of a modern telephone system in the Department of Montevideo, and to raise capital by issuing bonds for $1,500,000, at 5 per cent. interest.

Walthamstow.—The Council have adopted a recommendation of the electrical engineer (Mr. G. R. Spurr) as to the lighting of shops by Osram lamps on the following terms:

200 c.p. lamps at a minimum inclusive price for current and maintenance of £2. 10s. per lamp per annum and 100 c.p. lamps at £1. 10s. per lamp per annum, the charges to be based on a consumption of 150 and 80 units per lamp per annum respectively. Where consumers desire to purchase lanterns and wiring on the hire-purchase system the arrangement is to be carried out on lines similar to those in force for arc lighting.

Wireless Telegraph Notes.—The scheme for complete installation of wireless telegraphy which will effect communication between the Canary Islands and Europe, Cape Colony and South America is, according to Mr. Consul Croker, making progress. Communication is first to be established amongst the adjacent islands of the Canaries, and then with Cadiz and Paris, to be followed with Casablanca and Paris, the Canaries and Pernambuco on to Buenos Ayres, then between the Canaries, Senagambia, Dakar and Cape Town. According to the Consul, the work is being undertaken by two companies registered in Paris and Madrid respectively, with capitals of 1,250,000 francs and 1,000,000 pesetas. The main installation is to be at Santa Cruz, Tenerife. As it is considered possible that the distance between Tenerife and Pernambuco may be too great for practical working, it is stated that an installation will be erected at St. Vincent.

Workhouse Lighting.—Acting on the recommendation of their medical officer, Dr. Lock, Uxbridge Guardians are to obtain estimates for the substitution of electric for gas lighting throughout the workhouse premises.

The Electrical Engineers (London Division).—Amongst the athletes representing the various Territorial Corps in the London District, assembled at the Stadium, Shepherd's Bush, on Saturday last, the members of the Electrical Engineers Corps competing acquitted themselves very creditably. That they failed to bring home a challenge cup seems to show that the preliminary training was somewhat neglected, but the fact remains that this corps very closely contested the aggregate challenge cup, being only one point behind the Post Office Rifles, the winners.

Of the various events in which the members competed, second place was obtained by Mr. G. C. Stewart in the high jump, and third places by Mr. W. Cox in the ½ mile and 5 mile cycle races, Mr. A. J. Monk in the 110 yards swimming race and Mr. A. J. Williams in the 440 yards swimming race. Several other places were obtained, and the total number of prizes gained by representatives of the corps during the day was nine. These performances should be satisfactory to all concerned, as this is the first time in the history of the Electrical Engineers that any of its members have competed in the open.

Annual Outing.—On Saturday, June 19, the staff of the Sun Electrical Co. held their 10th annual outing, which took the form of a trip by the Immisch electric launch "Rosalind," from Reading to Maidenhead, calling at Henley for lunch and at Marlow for tea.

In the course of his remarks after lunch, Mr. A. G. Beaver, the manager of the company, said that the progress of the firm continued on the upward grade, notwithstanding the present general low state of trade; and he anticipated that this year's turnover would eclipse all previous years.

Sports.—The sixth annual athletic festival of Manchester Corporation Tramway Employés' Social and Athletic Society was opened on Wednesday in the presence of over 2,000 spectators. 700 entries were received for the various events.

Birmingham Corporation Tramways Social, Athletic and Thrift Society held their second annual sports at King's Heath on Wednesday. About 1,500 persons were present, and the events were well filled.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Burnley.—The traffic revenue of the tramways department during the past year was £61,911, against £63,580 in 1907-8.

Gross profit was £21 718 (£24,620) and £10,625 (£10,570) was required for interest and sinking fund. 12,176,782 (12,355,958) passengers were carried and 1,229,224 (1,202,330) car-miles run. Receipts per car-mile were 12·22d. (12·83d.) and working expenses 7·99d. (7·92d.). Traffic receipts per street mile (£5,817) are stated to be exceeded by Manchester (£7,480) and Sheffield (£7,903), but in nine other cases (Birkenhead, Blackburn, Bolton, Bradford, Bury, Halifax, Leeds, Salford and Oldham) the route-mile traffics are less. The report of the general manager (Mr. Hy. Mozley) states that the cost of alteration of overhead equipment to suit top-covered cars (£275) and the provision of time meters for double-deck cars (£109), which are items of the nature of capital expenditure, have been charged to reserve fund. With the object of obtaining a more economical car than the four-motor equipment, a trial was made with the Simpson & Park radial trucks, which proved unsatisfactory, and the trucks were then converted to simple pony-wheel trucks, but with a new arrangement of the carrying body springs and king pins, the whole of the weight of the body being carried on the driving axle, thus increasing the adhesion compared with the Brill maximum trucks under the double-deck cars, and the king pin, by being placed in the centre of the axle, greatly reduces the work of the pony wheels, which act as guides to the truck. So far the result is very satisfactory, as the tyre sections, after nine months' service, are practically perfect, and the car runs more smoothly and noiselessly than with the four-motor equipments; and, moreover, there is a reduction of about 3 tons in dead weight and an improvement of about 9 per cent. in speed, the new type using 20 per cent. less energy. The current consumption per car-mile during the past year, during which the time meters were in use, was 10·89 per cent. less than in the year ended March, 1907, when no time meters were used. For the

first time a sum of money (£2,381) has been voted from net receipts to the borough fund, after placing £6,000 to reserve. Illustrations of rail sections accompany the report, and show that the wear of the rails is equal where the braking is done through the wheels only, but on the Manchester-road (1 in 9·8 gradient) the wear is greater on the up or driving side than on the down side where the braking is chiefly done with c.i. track-brake shoes.

Coventry.—The accounts of the electricity department were adopted by the Corporation last week.

Capital expenditure is £237, 872 (an increase of £18,964 during the year). There are 1,133 consumers (increase 113), representing the equivalent of 204,037 8 c.p. lamps connected. 4,559,105 units were sold (against 4,822,114). Revenue was £31,994, working expenses £13,107. 2s. 9d. (against £15,388. 5s. 6d.), gross profit £17,499. 14s. 4d. (against £16,895. 18s. 3d.). Capital charges were £13,770. 5s. (against £11,195. 8s. 9d.) and net profit £3,765. 5s. (against £5,647. 4s. 6d.). £1,000 has been paid in aid of rates, £2,598 has been placed to reserve and transferred from that fund to capital account and applied in payment of the following amouunts, in lie of a loan: £2,098 representing expenditure in excess of sanctions on extensions carried out in 1907 and £500 meters. The balance (£167. 5s.) has been carried forward.

Devonport (Tasmania).—The annual report of Mr. G. H. Lofts, city electrical engineer, states that the supply of current from the municipal electricity department has been maintained for five years without a failure, although the machinery is frequently overloaded, and the battery is not of sufficient size to take the lighting load.

78,580 units were sold during the past year (against 57,571 in the previous year) and the maximum load was 95 kw. (89 kw.). Although the street lighting was subsidised to the extent of £100 out of the receipts of the private supply department, the undertaking shows a net profit of £297.

Dover.—The accounts of the electricity supply department for the year ended March 31, have been approved by the Council.

The total revenue was £19,247. 2s. 2d. Expenses were £9,199. 18s., and the gross profit £10,047. 4s 2d. After paying interest on loans (£7,102. 4s. 5d.) and sinking fund (£4,407) there was a deficit of £1,980. 13s. 3d., against £2,147. 12s. 4d. With £1,190 9s. 3d. disallowed by the L.G. Board as capital expenditure, the net deficit at date is £5,318. 14s. 10d. It is anticipated that, in view of the commencement of the contracts for large supplies of current to the Admiralty Harbour, the Duke of York's school, &c., the current year's accounts will show a substantial reduction of the deficit. The total expenditure per unit sold was 2·00d., against 2·08d., and the total revenue 4·19d., against 3·96d. 1,101,070 units were sold (427,262 for traction, 528,270 for private and 135,538 for public lighting); there are 64 arcs and 444 8 c.p. equivalent incandescent lamps for public lighting. The total maximum supply demanded was 420 kw. alternating and 250 kw. direct current. The capital expended is £186,588. 18s. 4d., an increase of £2,973. 3s. 10d.

Finchley.—During the year ended March, the electricity department sold, for private lighting, 580,750 units (against 485,060 in 1907-8) and for public lighting 233,725 (244,700).

The income from private lighting was £9,433 (against £8,000), the receipts for power increased from £642 to £797, while public lighting revenue was £1,678 (£1,685). Gross profit was £6,809 (£5,550) and, after paying interest, sinking fund, &c., the net profit was £86, against a deficit of £292. The capital expended during the year was £13,405.

Manchester.—The accounts of the tramways department (which were approved by the Tramways committee on Tuesday) state that the capital expenditure is £1,837,090 (increase £60,461).

During the year ended March last traffic revenue was £774,035 (against £760,994 in previous year), parcels revenue £1,716 (£1,220) and total revenue £784,556 (£769,073). Working expenses were £508,072 (£500,023), gross profit £276,484 (£269,050) or with bank interest £279,108 (£271,153). Interest, instalment for redemption of debt, rent, &c., of tramways, proportion of outlay for leaseholds, income-tax and Parliamentary expenses amounted to £128,267 (£124,255), leaving a balance of £150,841 (£146,898). 155,011,884 (151,477,138) passengers were carried, 17,316,753 (16,974,955) car-miles run and 30,276,365 (29,955,070) units of electrical energy used = 1·748 (1·76) per car-mile. Traffic revenue per car-mile was 10·728d. (10·76d.) and total revenue 10·874d. (10·87d.), working expenses 5·216d. (5·05d.) or 7·043d. (7·07d.) including power. The average fare per passenger was 1·19d. (1·21d.) and the average journeys per head of population 182 (178). There are 104 miles of track open and 567 cars in stock. The total amount devoted to relief of rates since 1901 is £377,000 (against £307,000 at March, 1908), the total amount of the sinking fund is £232,814 (£191,543) and the amount of sinking fund applied in reduction of debt is £227,587 (£188,913). £400,779 (£382,327) has been provided for renewals and depreciation.

Northampton.—The tramway department accounts for the year ended March show capital expenditure £131,452, the same as in 1908.

Income was £24,186 (including £882 from omnibuses), working expenses £13,601, gross profit £10,584. After providing for interest on capital, instalments of loans and tax on profit, £1,250 has been contributed to relief of rates, £1,200 placed to reserve and £345 carried forward. 612,628 car-miles were run and 5,637,660 passengers carried, 1·64 units per car-mile were used and the cost per unit was 0·65d., or 0·94d. including capital charges. Total revenue was 9·64d. per car-mile on the electric and 6·49d. on the horse service, and total working expenses (including power) were 9·07d. per car-mile.

Nottingham.—The accounts of the electricity department for the year ended March last, show capital expenditure £458,502 (increase £7,557.)

Revenue was £93,836 (against £92,794), working and general expenses £47,322 (£47,088), gross profit £46,514 (£45,706). After paying interest, providing for instalments for sinking fund and for repayment of loans, and placing £670 to reserve, the surplus is £17,250 (£11,500), which has been contributed to relief of rates. The reserve fund stands at £46,006. 12,370,790 (12,005,704) units were generated, 114,059 (165,481) supplied to public lamps and 11,338,747 (10,951,354) to private consumers. There are 92 public lamps (against 152), and the total maximum supply demanded was 6,385 kw., against 6,156 kw.

Oldham.—At the meeting of the Electricity committee last week the chairman (Ald. Bolton, J.P.) reported that the net profit for the year ended March 25 last was £3,451.

West Ham.—The capital expenditure of the tramways department at March last, was £514,032, compared with £508,785 at March, 1908.

Traffic revenue during the past year was £113,293 (against £117,949 in previous year) and total revenue £115,814 (£123,040), working expenses £77,583 (£76,718), interest £18,243 (£14,592), sinking fund instalment £10,429 (£8,549), bank interest, &c., £3,636 (£6,717), and net balance £5,923 (£16,000). 33,773,713 (34,712,220) passengers were carried, 2,797,817 (2,716,723) car-miles run and 4,594,621 (4,195,930) units used, or 1·64 (1·54) per car-mile. Traffic revenue per mile of track was £4,183 (£4,461) and per car-mile 9·71d. (10·41d.). Working expenses (including current) were 6·656d. (6·775d). Average fare per passenger was 0·805d. (0·815d.), and average fare charged per mile 0·57d. There are 27 miles 6·88 chains of (equivalent) single track worked electrically and 100 cars are in use.

The report of Mr. H. E. Blain (general manager) states that 20 additional cars have been fitted with top covers during the year, 12 more cars are having roof covers fitted, bringing the total to 59. The diminution of traffic receipts is attributed to motor 'bus competition and the failure of the L.C.C. to connect up their routes with the eastern district. Under the bonus scheme the employés received £593. 3s. 4d. for the year, and the holiday pay for the outside staff (under the scheme which gives all employés nine days holiday with pay) was £1,199. 17s. 7d. (against £1,167. 19s. 10d.).

Weymouth.—The accounts of the electricity department for the year ended March 31, were approved by the council last week.

The total income for the year was £6,210. 3s. 4d., including £4,276.7s.6d. from the sale of current by meter and £1,869. 10s. from public lighting. The expenses amounted to £2,838. 18s., and the gross profit was £3,371. 5s. 4d. After paying interest, sinking fund, &c., there was a net profit of £101. 14s. 5d.

The report of the borough electrical engineer (Mr. Jos. H. Bolam) stated that various extensions of the generating plant and distributing network were made during the year. 48 new consumers, with an aggregate of 3,952 33-watt lamps, were added, against 59 consumers with 3,658 lamps in 1907-8. 388,051 units were sold, against 353,415, and this seemingly small increase is stated to be due to the almost universal adoption of metallic filament lamps. The total cost of production has been reduced from 1·63d. to 1·51d. per unit. The power load increased from 27,243 to 38,543 units.

TRADE NOTES AND NOTICES.

TENDERS INVITED

Tenders are invited for the supply of 13¼ miles of bare hard-drawn copper cable, and also for the supply of 6,410 yds. of single conductor lead-covered cables and 1,400 yds. of concentric lead-covered cables to the City Council of MELBOURNE. Specifications, tender forms and conditions from the Agents for the City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., with whom tenders must be lodged by Friday, July 23. See also advertisements.

Tenders are invited for supply of 18 transformers to the MELBOURNE (Australia) Municipal Council. Tender forms, conditions, &c., may be obtained from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co., Proprietory, (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by Wednesday, July 7.

The City of MELBOURNE Municipal Council invite tenders for the supply of 80 alternating-current flame arc lamps. Specifications, tender form, conditions of tender, &c., from the agents of the City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by Wednesday, July 7.

SWANSEA Corporation require tenders by noon July 7 for supply of enclosed arc lamps, resistances, &c., and plain lead-sheathed two-core conductor, fibre-insulated 660 volt cable, suitable for drawing in, and rubber-insulated and braided single conductor arc lamp cable for 550 volts; also tenders, by noon July 14 for arc lamp lowering gear,

pillars, brackets, &c., and arc lamp feeder pillars, with switch and fuse gear, time switches, &c. Specifications from the Borough Electrical Engineer.

Tenders are also invited for supply of a 15 ton overhead travelling hand crane to the city of MELBOURNE, Victoria. Tender forms, conditions, &c., from the agents of the City Council, Messrs. McIlwraith, McEacharn & Co., Proprietary (Ltd.), Billiter-square Buildings, London, E.C. Tenders to the Chairman of the Electrical Supply committee, Town Hall, Melbourne, by 2 p.m. of August 4.

LONDON County Council want tenders by 11 a.m. July 6, for supply of 2,350 steel tyres for driving wheels and 1,500 for pony wheels of tramcars. Particulars from the chief officer, L.C.C. Tramways, 62, Finsbury-pavement, E.C.

PONTYPRIDD Council want tenders by July 12 for the supply of independent surface-condensing plant, with circulating pump, air pumps, pipe work, &c. Specification, &c., from the Electrical Engineer and Manager.

The PORT OF LONDON Authority require tenders by 10 a.m., July 12, for supplies of materials and stores, including arc lamp carbons, incandescent lamps, glassware, ironmongery, castings, oils, &c. Specifications from the Stores Dept., 106, Fenchurch-street, E.C.

EDINBURGH School Board want tenders by July 12 for electric lighting at Gorgie School. Specifications from Mr. G. Thomson, 11, Randolph-place, Edinburgh.

WALLASEY Council want tenders by July 12 for supply and fixing of a battery of accumulators, reversible booster and switchboard. Specification from Mr. J. A. Crowther, Sea View-road, Liscard.

Tenders will be received by the GENERAL POST OFFICE until noon, August 9, for supply of telegraph poles of (a) home-grown larch or fir; (b) Swedish, Norwegian, Finland or Russian red fir, to be delivered at one or more of the ports set out in an advertisement, the poles to be felled during the winter of 1909-10, and to be delivered during the following summer. Forms of tender, &c., on application to Mr. G. Morgan, Controller of Stores, Stores Department, G.P.O., 17-19, Bedford-street, London, W.C.

Chinese Contracts.—In our Contracts Open pages there will be found an invitation from the Chinese Government through its representatives, for sealed proposals for the erection and completion of a group of buildings to be used as a Bureau of Engraving and Printing in Peking, China. It will be noted that the plans and specifications are on file at, amongst other places, the Chinese Consulate-General, 88, Fenchurch-street, London, E.C. Tenders from European contractors must be filed with the Chinese Legation at Washington, D.C., not later than July 15 next. The conditions of the contract are instructive.

TENDERS RECEIVED AND ACCEPTED.

Southampton Corporation recently received the following tenders for the supply of cable :—

W. T. Glover & Co. (*accepted*), (*a*) 3,000 yds. 1 sq. in. single-conductor (1) lead covered **£1,826. 8s. 5d.**, (2) non-lead covered **£1,794. 0s. 9d.**; (*b*) 1,500 yds. 0.5 sq. in. single conductor cable, (3) lead covered cable, **£484. 6s. 1d.**, (4) non-lead covered **£470. 18s. 5d.**; I. Frankenburg & Sons, (*a*) (1) —, (2) £1,770, (*b*) (3) —, (4) £465; St. Helens Cable & Rubber Co., (*a*) (1) £1,862, (2) £1,817, (*b*) (3) £503, (4) £477; Johnson & Phillips, (*a*) (1) £1,850, (2) £1,820, (*b*) (3) £490, (4) £476; W. T. Henley's Telegraph Works Co., (*a*) (1) £1,850, (2) £1,825, (*b*) (3) £493, (4) £477; Western Electric Co., (*a*) (1) £1,847, (2) £1,828, (*b*) (3) £491, (4) £478; British Insulated & Helsby Cables, (*a*) (1) £1,853, (2) £1,830, (*b*) (3) £492, (4) £480; Siemens Bros. & Co. (*a*) (1) £1,873. 10s., (2) £1,840, (*b*) (3) £495, (4) £484; Callender's Cable & Construction Co., (*a*) (1) £1,950, (2) £1,900, (*b*) (3) £540, (4) £530; Craigpark Electric Cable Co., (*a*) (2) £2,200, (*b*) (4) £480; New Gutta Percha Co., (*a*) (2) £3,180, (*b*) (4) £843.

For the construction of authorised tramways along the Victoria Embankment east of John Carpenter-street, Blackfriars-road, and Southwark-street, London County Council received the following tenders :—

R. C. Brebner & Co. (*recommended*) ...	£11,420	6	0
John Mowlem & Co.	14,707	0	0
W. Manders	13,598	13	10
A. N. Coles	12,945	5	5
Dick, Kerr & Co.	12,055	4	5

The chief engineer's estimate, comparable with the tenders, was £11,953. 8s. 4d. The successful tenderers are to be allowed to sublet to Doulton & Co., porcelain insulators; to the Anderston Foundry Co., cast-iron work; to Bayliss, Jones & Bayliss, steel and wrought-iron work; to the Improved Wood Pavement Co., wood block paving; and to John Fyfe & Co., paving setts.

The contract for supplying and laying the l.t. cables for the Cambridge-road tramway route has been let to W. T. Henley's Telegraph Works Co. at a reduction of 1½ per cent. off the company's existing contract for cables.

Stepney (London) Council received the following tenders for two years' supply of demand indicators :—

Reason Mfg. Co. (*accepted*), **£563. 5s.**; Chamberlain & Hookham, £311; Engineering Instruments (Ltd.), £400. 9s. 4d.; British Insulated & Helsby Cables, £405. 10s.; Electrical Co., £1,669. 10s.; General Electric Co., £2,397. 9s. With one exception the tenders were informal, and of informal tenders three did not comply with the specification. In the two other cases (Engineering Instruments and Electrical Co.) no samples were submitted. For two years' supply of time switches the tender of Venner & Co. at £813 was accepted. The Reason Mfg. Co.'s tender was £559. 10s.

Barking Council have accepted the tender of Crompton & Co. for a three-phase alternator at £340, and that of Siemens Bros. Dynamo Works for a switchboard at £102, and motor at £80. 5s.

Ten firms tendered for the whole of the work and one for the switchboard only. The highest tender for the alternator was £536 and the lowest £340; the highest switchboard tender was £175 and the lowest £102; the highest motor tender was £113 and the lowest £80. 5s.

The Westinghouse Electric & Mfg. Co. have received an order for the supply of 24 electric locomotives for the New York tunnels of the Pennsylvania Railroad. Each locomotive will consist of two units permanently coupled together, and the complete machine will have 16 wheels—*i.e.*, there will be a truck of four wheels on each end of each unit. Each engine will have a capacity of 4,000 H.P.

Middlesex County Council have placed an order with Dick, Kerr & Co. for the construction at an estimated cost of £45,500 of the Southbury-road (Enfield) tramway. The work is to be done on the contract price on which the firm are constructing the Regent's Park-road, Ballard's-lane, and the Cricklewood-lane tramways.

Burnley Education committee have accepted the tender of Simpson Bros. for an electric lighting and power installation at the new technical schools at £1,425.

Southampton Corporation have placed an order with P. Rutherford for an air compressor at £60 for the tramways department.

Eltham Guardians have accepted the tender of C. W. Dixon for supply of electrical fittings.

Margate Council have accepted the tender of Stuart & Moore for electric fire alarms at £68.

Hounslow Council have placed an order with Babcock & Wilcox for a mechanical chain-grate stoker at £310.

Walsall Electricity committee have accepted the tender of Doulton & Co. for stoneware troughing.

Electricity Meter Contracts.—Greenock and Hornsey Corporations have placed orders with the Bastian Meter Co. for supply of meters.

BUSINESS NOTICES.

Fras. T. and John E. Edmunds, electricians, engineers, &c., 260A and 240B, Christchurch-road, Boscombe, Bournemouth, and Christchurch, have dissolved partnership. Mr. F. T. Edmunds continues the Boscombe and Mr. J. E. Edmunds the Christchurch business.

The address of the Buenos Ayres branch of the India Rubber, Gutta Percha & Telegraph Works Co. has been changed to 469, Calle Florida.

We are asked to state that, in view of the increase of business in their large gas engine department and of their intention to take up the direct sale of their Diesel oil engines in England, the Maschinenfabrik Augsburg-Nurnberg A.G., hitherto known in the English gas engine trade as The Nuremberg Co., have, as a result of a friendly arrangement, terminated their agency agreement with Mr. James Halcrow, 8, Coleman-street, London, E.C., and have opened an office at 219, Caxton House, Westminster, S.W., where all future communications should be addressed. Telegraphic address: Klettillo London. Telephone, 3775 Victoria.

Electrical Engineering Business for Sale.—Messrs. Josolyne, Miles & Co., 28, King-street, Cheapside, E.C., advertise for sale the business of a well-known firm of electrical engineers.

Patents Development.—The proprietors of the following patents are desirous of entering into arrangements by way of licence or otherwise for exploiting same and ensuring their full development in this country :—

No. 10,495/1904, for "Improved Method of finding the Direction of Sound"; No. 10,477/1904, for "Improvements in Apparatus for Receiving Submarine Signals"; No. 10,463/1904, for "Improved Means for producing Sound Vibrations in Water applicable to Marine Signalling", No. 3,266/1903, for "Improvements in Apparatus for producing Sound Vibrations in Water"; No. 13,288/1902 for "Improvements relating to the Transmission of Sound for Submarine purposes and to Apparatus therefor"; No. 13,287/1902, for "Improvements relating to Apparatus for the Transmission of Sound for Submarine purposes"; No. 18,570/1906, for "Improvements in Devices for producing Sound Signals in Water"; and No. 18,909/1905, for "Improved Method of Electric We'ding Sheet Metal." Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

No. 16,729/1906, relating to "Dynamo Electric Generators." Applications to Messrs. Herbert Haddan & Co., 31 and 32, Bedford-street, Strand, London, W.C.

Storage Batteries in Hot Climates.—Exception is sometimes taken to the use of storage batteries in hot climates, but there is proof that the D.P. Battery Co., of Bakewell, Derbyshire, have succeeded in producing plates that will work satisfactorily under these conditions. Cells supplied to the Indian Government some six years ago by the company are (we are informed) still working well and giving no trouble. No renewals of either positive or negative plates have been required, nor are there signs, it is stated, of deterioration, according to the latest accounts received by the company.

CATALOGUES, &c.

Electro-Therapeutics.—*Correction*—In a note under this head in our last issue we referred to the receipt from "the Sanitas Co." of "The Book of the Multostat." The makers of the electro-medical apparatus referred to should have been given as "The Sanitas Electrical Co.," 61, New Cavendish-street, London, W., as there is otherwise possibility of confusion with the Sanitas Co., the well-known disinfectant specialists, of Bethnal Green, E.

Electrical Bleaching Apparatus.—We have received from Messrs. Siemens Bros. & Co., of Caxton House, Westminster, S.W., a pamphlet on electrical bleaching apparatus, which gives details of the Siemens process, and the advantages of electrical bleaching compared with other bleaching processes are fully set out. Some of the bleaching installations carried out on the Siemens system are illustrated, and a description given.

Street Lighting Fittings.—The Reason Mfg. Co., Lewes-road, Brighton, have ready a comprehensive brochure dealing with various types of fittings for street lighting. Several novelties, both in design and switching arrangements, are shown and full advantage of the latest developments in incandescent lamps is taken in the introduction of new features.

Insulated Lamp Holders.—In order to comply with the new Home Office Regulations regarding switch lamp holders, the British Central Electrical Co. are placing on the market a contrivance by means of which existing holders can be made to come within the regulations. A well-made hard wood case, shaped to receive a switch lamp holder, can be placed in position by simply passing the flex through the hole at the top and a cap, which is screwed on when the holder is in place, insulates the whole thing.

Potentiometers.—The Reason Mfg. Co. have also issued an interesting booklet on the Clark Fisher potentiometer, which describes very fully the various types of these instruments, with diagrams showing the different uses of the potentiometer. Complete instructions as to its use are also given.

Electric Cooking.—The new catalogue of the British Prometheus Co. deals with the various uses of Silundum in cooking utensils. It is claimed that the particular process of manufacture used permits the production of Silundum rods, which are specially applicable for electric cooking apparatus. This apparatus may be worked at incandescent temperatures without oxidization, and can be run at high temperatures without undergoing any material chemical or physical change. The various cookers made are illustrated and full particulars of their respective advantages are given.

Prescot Service Boxes.—The British Insulated & Helsby Cables (Ltd.), of Prescot, Lancs., are issuing a catalogue of the large service boxes made by them. Each type is amply illustrated, and full details of the size and price are given. The same firm are also sending out a list of their Monnot copper-clad steel wire for electrical purposes. In the manufacture of this wire the high tensile strength of steel is obtained in conjunction with the high electrical conductivity of copper. Tables showing the sizes, weights and resistance of the various classes of this wire are also given.

"Sucleen" Vacuum Cleaner.—With a title that will attract the curious, Messrs. Krupka & Jacoby have issued a booklet dealing with the "Sucleen" vacuum cleaner. This apparatus consists of a double acting positive suction pump driven by an electric motor, and it is also made for hand power.

The Brush Budget.—Contained in a tasty cover the latest Brush Budget has a well illustrated series of articles on "Brush" progress. Amongst the illustrations a 1,000 kw. alternator, suitable for coupling to an existing slow speed mill engine, driving a textile factory, is shown. The adaptation of the electric drive to other textile machinery by the use of individual motors is also illustrated.

Electricity Meters.—We have received from Simplex Conduits (Ltd.) several leaflets dealing with the various types of electricity meters which they supply. Each type is fully described, and curves and diagrams of connections are given.

"Eclipse" Fittings.—Mr. G. Braulik, 8, Lambeth-hill, E.C., has sent us a pamphlet describing a series of new "Eclipse" fittings for indirect lighting by means of metallic filament lamps. It is claimed that by the use of these fittings metallic lamps can be used in the most efficient way possible, while at the same time the light from them is neither injurious nor painful to the eyes.

BANKRUPTCIES, LIQUIDATIONS, &c.

A meeting to receive an account of the winding up of the International Telescriptor Synd. (Ltd.), will be held on July 28 at Norfolk House, Norfolk-street, London, W.C.

The Santoni Arc Lamp & Engineering Co. (Ltd.) is being wound up voluntarily. Mr. W. M. Whyte, 11, Queen Victoria-street, London, E.C., is liquidator.

Winding-up Petition.—A petition for the winding up of the North Western Electricity & Power Gas Co. has been presented by Messrs. Harper Bros. & Co., and will be heard in the High Court, London, by Mr. Justice Neville, on July 6.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

April 6, 1909.

8,202 Brown. Electric signals.
8,205 Taylor. Electric accumulator sub-stations.
8,212 Ford & Bonshor. Electrical cartridge fuse-holders.
8,231 Dorman, Smith & Baggs. Electrical switches and cut-outs.
8,263 Siemens Bros. Dynamo Works. (Siemens & Halske Akt.-Ges., Germany.) Electric fuse fittings.*
8,281 Freeman. Cut-outs.
8,283 Kruger. Regenerating blackened carbon filament lamps. (Date applied for, 6/4/08.)*†
8,293 Loebl. Electrically-wound clocks.
8,303 Holmes & McPherson. Electric indicators.
8,315 Waterman. Electrically-operated valves.*
8,345 Moser. Self-regulating alternating current additional machine or booster. (Date applied for, 11/7/1908.)*†
8,351 B.T.-H. Co. (G.E. Co., U.S.) Electric lamp-making machines.

April 7, 1909.

8,356 Howe & Irwin. Safety device for electrical apparatus.
8,383 Jopling. Improvements in electric arc lamps.
8,405 Poleschowsky. Anti-vibrator for electric incandescent lamps.
8,419 Gray. Electric conductors.
8,422 Trier. Electric ignition devices.
8,429 A. P. Lundberg, G. C. Lundberg & P. A. Lundberg. Electrical switches.*
8,456 Allgemeine Elektricitats-Ges. Electrically-operated cranes, lifts, and the like. (Addition to No. 17,622/08. Date applied for, 8/4/08.)*†

April 8, 1909.

8,489 Burks. Magneto-electric machines. (Date applied for, 5/3/09. Comprised in application No. 5,360, dated 5/3/09.)
8,521 Mahoney & McCurdy. Magnetic brakes. (Date applied for, 20/4/08.)*†
8,535 Schmahl & Henderson. Fuse and switch boards.*
8,570 Timar & Ziegler. Time relay for electric currents. (Date applied for, 12/12/08. Comprised in application No. 26,967, dated 12/12/08.)*
8,581 Marconi & Marconi's Wireless Telegraph Co. Wireless telegraphy. Addition to No. 17,505/08.)
8,582 Marconi & Marconi's Wireless Telegraph Co. Transmitters for wireless telegraphy. (Addition to No. 20,119/07.)

April 10, 1909.

8,601 [illegible] & [illegible]. [illegible] electrical and other purposes.*
8,619 [illegible]
8,649 [illegible] and the like.

April 13, 1909.

8,692 [illegible]
8,694 THOMSON. Electric coal-cutting machines.
[illegible] JENNINGS, jun. Electrical dynamometer.
8,721 SMITH, SMITH & GREEN. Cut-out for use with transformers and metal filament [illegible]
[illegible] B.T.-H. CO. (G.E. Co., U.S.) Rods or filaments of refractory metal.

April 14, 1909.

[illegible] WALTON. Matter intended particularly for electric insulating purposes.
[illegible] OKILL. Electric accumulators or storage batteries.

April 15, 1909.

8,912 LIDDLE. Low-voltage electric plug adaptors.
8,972 WEBB. Short-distance telegraphic apparatus.
[illegible] & 8,980 B.T.-H. CO., WEDMORE & WHITCHER. Electric distribution systems.
8,981 B.T.-H. CO. (G.E. Co., U.S.) Stems for incandescent electric lamps

April 16, 1909.

[illegible] LEGGE & SCOTT. Arc lamps. (Addition to No. 24,635/07.)
[illegible] SIEMENS BROS. DYNAMO WORKS & KLOSS. Starting and regulating of electric induction alternate-current motors.
9,035 [illegible] & [illegible] line systems for railways.*
[illegible]
9,048 SIEMENS SCHUCKERTWERKE G.m.b.H. Alternating-current dynamo-electric machines. (Date applied for, 25/6/08.)*†
[illegible] SIEMENS BROS. & CO. (Siemens & Halske A.-G., Germany.) Semi-automatic [illegible]*
[illegible] [illegible] & [illegible]. [illegible] batteries.
[illegible] LEWIS. Arc lamp electrodes.

April 17, 1909.

[illegible] MCGREGOR. Electric circuit closers.
9,133 MAV[illegible] & MAV[illegible] & [illegible]. Enclosed electrical machines
[illegible] SHEPHERD & LAGESEN. Heating by electricity.

April 19, 1909.

[illegible] TETLEY & STRACHAN. Securing a quick make and quick break in conjunction with electric switches.
9,194 COTTIER. Locking electric incandescent lamps to their holders.
9,201 KIRWAN & QUANEY. Switches for breaking electric circuits.
9,231 SUNDERLAND & PILLINGER. Electromagnets and solenoids.
9,265 BERGMANN-ELEKTRICITATS-WERKE AKT.-GES. Glow lamps with metallic filaments. (Date applied for, 18/2/09.)*†
[illegible] ELECTRIC PULLEY BLOCK CO. (Gese, Germany.) Starting and reversing devices.*

April 20, 1909.

9,304 GODDARD. Limit switch for electric lifts.
9,318 HORVATH. Electric incandescent metal or other filament lamps.
9,322 HOLLAND. Electric glow lamps.
9,339 FELTEN & GUILLEAUME-LAHMEYERWERKE ACT.-GES. Electric reversing gear. (Date applied for 30/11/08.)*†
[illegible] SILL. Electric controllers.*
[illegible] TETLOW. Trolley harps.*

April 21, 1909.

[illegible] SIMPSON. Electrically propelled vehicle brakes.
[illegible] MONASCH. Producing phase-displaced electromagnetic oscillations. (Date applied for, 21/4/08.)*†
[illegible] HAWKER. Electric switches.
[illegible] D[illegible]. Periodical interruption of alternating electric current. (Date applied for, 23/4/08.)*†
9,516 BLECKLY. Arc lamps.*

April 22, 1909.

9,550 DRAKE, WADDELL & D.P. BATTERY CO. Retaining charge in accumulator plates.
9,559 BURLEIGH & WARDLE. Dynamo-electric machines.*
9,592 SIEMENS BROS. & CO. (Siemens & Halske A.-G., Germany.) Switch plugs for telephone exchanges.*
9,623 ROBINSON. Train controlling means on electric railway systems. (Date applied for, 20/10/09. Comprised in Nos. 22,227, dated 20/10/03.)*

April 23, 1909.

[illegible] TAYLOR. Charging and discharging batteries.
[illegible] SHARMAN. Outgoing telegraph signal recorders.
9,693 JOEL. Portable electric lamps. (Addition to No. 11,106/08.)*
9,706 HIRST & KRAUSE. Electric fan motors.

April 24, 1909.

[illegible] MUIR & CHAMEN. Electric lamps or lanterns.
[illegible] BRADLEY & WILLIAMS. Electrolytic cells.

April 26, 1909.

9,807 LURRING, DYCHER & MORAN. Expansion plug for electrical switchboard 'bus bars
9,808 JERVIS-SMITH. Long-pull electromagnetic apparatus.
9,810 VERITYS LIMITED & ROGERS. Swinging joints for electric light and similar tubular fittings.
9,812 MACKAY. Incandescent electric lamp-holders and shade carriers.*
9,829 JACKSON & HURST. Electric controller contact finders.
9,831 AINSLEY, JOHNSON, PARKES & PORRITT. Circuit-breaker.

April 27, 1909.

9,980 SUCHOSTAWER. Electric traction on the induction system.
9,987 KRAUSE. Lightning arrester for overhead lines. (Date applied for, 29/7/08.)*†
9,999 BILTON. Sheet-metal telephone cases.*
10,003 HORN. Connections for electric tension measurement apparatus of dynamometric construction. (Date applied for, 27/4/08.)*†

April 28, 1909.

10,025 CAMPBELL. Trolley heads or collectors for electric tramcars and the like.
10,047 ALEXANDER & APPLEBYS, LIMITED. Trolley hoists.*
10,052 DYSON. Joining the ends of submarine or telegraphic cables.
10,067 SIEMENS BROS. DYNAMO WORKS & O'HAGAN. (Siemens Schuckertwerke G.m.b.H. Germany.) Arrangements for cooling commutators of dynamo-electric machines.
[illegible] B.T.-H. CO. (G.E. Co., U.S.) Production of high vacua.
[illegible] SIMMS & SIMMS MFG. CO. Magneto-electric machines.

April 29, 1909.

10,175 UGRIMOFF. Cooling device for electrical sliding contacts.*
10,198 NEWSTETTES. Electric generating systems.*
10,203 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Service registers in telephone installations.*
[illegible] WENTWORTH. Switch for use with transformers.

April 30, 1909.

10,225 MACDONALD. Electric current generators and electric motors.
10,255 CONNER. Telephonic party-line systems.
10,288 RAWLINGS. Fittings for electric candle lamps.
10,312 WOLTERS. Electric safety lamps. (Date applied for, 2/5/08.)*†

SPECIFICATIONS PUBLISHED.

1908 SPECIFICATIONS.

4,137 BOSCH. Starting internal combustion engines by electrical ignition. (Date applied for, 28/10/07.)
4,339 WARDELL. Magnetos for ignition purposes in explosion engines.
4,597 HOPE. Switches and fuses for starting three-phase electric motors and the like.
4,922 STEARN, TOPHAM, HANDCOCK & DYKES. Electric incandescent lamps. (Post-dated 3/9/08.)
4,950 PROTT. Regulating electric motors.
5,719 SCOTT. Swing-out electric lamp carriers.
6,959 B.T.-H. CO. (G.E. Co., U.S.) Alternating-current motors of the commutator type.
6,973 FENNELL & PERRY. Electric accumulators.
7,028 SCHIESSLER. Alternative wireless telegraphy and telephony. (Request under Section 19 not granted.)
7,335 JACKSON. Electric-motor control systems.
7,398 EVERSHED & VIGNOLES & EVERSHED. Electric meters of the moving coil type.
7,409 RORKE & RORKE. Switches for electrical purposes.
7,507 OERTLY & DUDLEY. Electrically-heated tools. (Date applied for, 6/4/07.)
7,644 FENNELL & PERRY. Restricting the maximum current passing in electric circuits.
7,645 FENNELL & PERRY. Electric meters.
8,093 MARKS. (Roberts.) Electrical heating.
8,253 APPLEBEE. Arc lamp lens and screen for theatrical stage effects.
8,308 DAVY. Arc lamps. (Cognate application, 9,862/08.)
8,543 BERGTHEIL. Mounting electrically-driven punkahs.
8,748 MCNALLY. Controlling electric circuits.
8,752 LILLICRAP. Electric Switches.
8,794 Electrical storage batteries.
8,863 GUNNING. Rotary interrupters or switches for electric circuits.
8,930 KNIGHT. Electrically-driven percussive tools, specially applicable for rock-drilling or stoping.
8,972 BALSILLIE. Generators for high-frequency electric currents.
9,099 WERMANN. Starlike trolley for electric railways and tramways
9,146 AKT.-GES. BROWN, BOVERI ET CIE. Electric transformers. (Date applied for, 26/4/07.)
9,156 WYNNE. Opening and closing an electric circuit.
9,195 MAJOR, STEVENS & STEVENS. Electric lifts.
9,222 CARPENTER & BANKS. Arc lamps.
9,229 GILES. Electrically-controlled clocks.
9,241 JONES. Arc lamps. (Request under sec. 19 not granted.)
9,2[illegible]1 K[illegible]. Electromagnets.
9,537 VAUGHAN & BIRCH. Metallic fittings for electric continuity system.
9,654 JUSTICE. (Deutsche Gasgluhlicht Akt.-Ges. Auergesselschaft.) Miners' lamps.
9,756 HILLIARD & PARSONS. Switches for electrical circuits.
9,844 FELTEN & GUILLEAUME-LAHMEYERWERKE AKT.-GES. Cut-out apparatus for electrical circuits. (Date applied for, 6/5/07.)
10,037 BOULT. (Schlesische Akkumulatoren-Werke Akt.-Ges.) Accumulators or secondary batteries.
10,378 CORNELIUS. Electric furnaces.
10,577 DONATI. Alternating-current regulators. (Date applied for, 15/5/07.)
10,712 COLLIS, EXLEY & LEITNER. Electric light fittings.
10,838 BEST. Electrically igniting miners' safety lamps in mines.
11,344 B.T.-H. CO. & DAWSON. Power transmission systems.
11,347 MERZ & REDMAN. Conductor rails for electric railways and the like.
11,586 HEINRICHDORFF. Carriage lamps by means of current.
11,634 B.T.-H. CO. & WEDMORE. Electric distributing systems.
11,986 WOOD. Electric circuit controllers.
12,250 ISARIA-ZAHLER-WERKE GES. Electricity meters. (Date applied for, 11/5/08.)
12,258 HUGOT. Electric furnaces for the manufacture of steel.
12,515 B.T.-H. CO. (G.E. Co., U.S.) Compressors of the centrifugal type.
12,923 TIERNEY & MALONE. Point-shifting arrangements for electric tramways and the like.
13,230 FENNELL & PERRY. Electric lamp-holders.
13,518 FLEMING. Detecting electric oscillations. (Cognate application, 26,832/08.)
13,654 W. T. HENLEY'S TELEGRAPH WORKS CO. & BISHOP. Suspension devices for electric cables.
14,312 VIDAL & VIDAL. Electrically transmitting and controlling motive power.
14,431 LOHAY. Electrically controlling mechanism at a distance.
14,655 EVANS. Earthing or metallic continuity of slip socket conduits for electric wires.
14,657 SIEMENS BROS. DYNAMO WORKS & GRIMSTON. Searchlights or projectors.
14,867 B.T.-H. CO. (G.E. Co., U.S.) Lamp filaments.
14,942 WESTINGHOUSE METAL FILAMENT LAMP CO. (Westinghouse Metallfaden Gluhlampen Fabrik Ges.) Production of tungsten filaments for electric incandescent lamps.
14,967 B.T.-H. CO. (G.E. Co., U.S.) Electro-magnetically controlled switches.
15,013 FRICKER. Electric motor starters.
15,089 CODY. Vapour lamps.
15,118 SIEMENS & HALSKE AKT.-GES. Electrical signalling installations. (Date applied for, 16/7/07.)
15,346 MOUNT & BECK FLAME LAMP. Mounting and feeding carbons in electric arc lamps.
15,571 SIR W. G. ARMSTRONG, WHITWORTH & CO. & WRIGHT. Electric capstans.
15,660 MARKS. (Soc. Anon. Italiana & Ansaldo, Armstrong & Co.) Electric control for elevating and training operations in ordnance mountings.
15,816 HELD. Electrical heating apparatus.
15,979 VAN RADEN & CO. & METZ. Electric battery lamps.
16,151 JANDUS ARC LAMP & ELECTRIC CO. & JONES. Arc lamps.
16,446 SIEMENS & HALSKE AKT.-GES. Electric telegraphs particularly applicable to fire-alarms. (Date applied for, 5/8/07.)
17,137 DUPONT & HARLE & CIE. Regulating the speed of continuous-current electric motors.
17,142 SNOWDON. Electric switches.
17,308 WATSON & ASHWORTH. Supplying and measuring electric current.
17,311 FERGUSON. Dynamo-electric machines.
17,348 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges.) Electric relay apparatus.
17,533 TRIN. Electrical accumulators. (Date applied for, 29/8/07.)
17,750 BOULT. (Allgemeine Akkumulatoren-Fabrik.) Cylindrical positive electrodes.
17,797 NOLAN. Water current motors. (Date applied for, 24/7/08.)
17,835 GOLDSCHMIDT. High-frequency currents and apparatus.
18,106 GUENET. Magneto-electric machines.
18,278 KREMENEZKY. Sealing the filament carrier into bulb of electric incandescent lamps
18,330 COOPER. Equalising device for alternating-current circuits. (Date applied for, 3/9/07.)
18,359 ROOS. Electric circuit tester.
18,619 B.T.-H. CO. (G.E. Co., U.S.) Electric protective devices.
18,721 DOE. Dry battery cells.
18,822 TIERNEY & MALONE. Point-shifting arrangements for electric tramways and the like. (Addition to No. 12,923/08.)
18,832 LISKE & ZOLLER. Arc lamps.
18,855 ALCOCK & SIMPSON. Magnetic separators.
19,049 BISHOP. Testing fluids by measurements of electric conductivity.
19,109 KIETH & TUSON. Electrically-operated valve-controlling devices.
19,286 REINHARDT, REINHARDT & WEIL. T-pieces for conduits.
19,309 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges.) Selectors for automatic telephone exchanges.
19,574 FELTEN & GUILLEAUME LAHMEYERWERKE AKT.-GES. Electric insulating tubes (Date applied for, 18/9/07.)
19,906 DICKSON. Thermally-actuated electric switches.
20,206 DE FOREST. Wireless communication.
20,715 SEFTON-JONES. (Kuzel.) Repairing electric metal filament incandescence lamps.
21,263 FESSENDEN. High-frequency electric oscillations. (Date applied for, 31/10/07.)
21,385 SIEMENS & HALSKE AKT.-GES. Vacuous electric incandescence lamps having metallic filaments. (Date applied for, 2/11/07.)
21,396 MARKS. (Dr. Cassirer & Co. Kabel-und-Gummi-Werke.) Drying chamber for electric cables.
21,482 MILLER. Electrically-governed automatically-operable train-controlling systems. (Date applied for, 10/10/07.)
21,602 PIERCE. Electric light stand.
21,659 JACOBSEN'S ELEKTRISKE VAERKSTED. Electrical signalling system. (Date applied for, 14/10/07.)
21,913 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke Ges.) Electrical potential regulators or speed-controlling devices. Addition to No. 14,725/07.)

COMPANIES' MEETINGS AND REPORTS.

Globe Telegraph & Trust Co. (Ltd.)

The thirty-sixth ordinary general meeting was held on Thursday last week under the presidency of the Marquess of TWEEDDALE, K.T.

The SECRETARY (Mr. Sidney Collett) read the notice convening the meeting and the auditors' report.

The CHAIRMAN then said: Our accounts show a slight falling off compared with last year, when they were exceedingly good—the best, in fact, we had ever presented. The receipts for the year under review, after deducting expenses, were £207,347 against £210,295 last year. We have already paid the usual three quarterly interim dividends at the fixed rate of 6 per cent., less tax, on the preference shares, absorbing in all £131,769, and we now recommend a final dividend on the ordinary shares of 5s. 6d. per share net, making 5¾ per cent. for the year against 5¾ per cent. last year. This, together with the final 3s. per share on the preference, absorbs £75,479, and leaves £27,305 to be carried forward. In view of the commercial depression which has prevailed, the shareholders will, I think, consider the results satisfactory. There is one item in the accounts that I may say a few words upon—the grant of £250 to the widow of our late registrar who died in April last after a long and painful illness and after serving first in one of the Associated Companies and afterwards in the Globe Company for nearly 40 years. Owing to his long illness it was found at his death that his widow would be penniless, and having regard to this and looking to her late husband's long and faithful service, and to the fact that the Globe, being a Trust Company, is precluded from creating a pension fund for the benefit of its employees, your Directors granted a compassionate allowance of £250, a grant which I believe will meet with the approval of the shareholders (hear, hear). I may conclude by saying that the present value of our investments shows an increase over their original cost of £230,000. I now move the adoption of the report and accounts and the declaration of the dividends set out therein.

Sir JAMES PENDER, Bart., seconded the motion, which was carried unanimously.

The retiring director (Sir John Denison-Pender, K.C.M.G.) and the retiring auditors (Messrs. Deloitte, Plender, Griffiths & Co., and Mr. John Newton) were then re-elected.

A cordial vote of thanks to the chairman and directors brought the proceedings to a close.

Marconi's Wireless Telegraph Co. (Ltd.)

At the meeting on Monday, the CHAIRMAN and MANAGING DIRECTOR (Mr. G. Marconi) said that he was occupying the position of chairman in consequence of the resignation of Sir Charles Euan Smith owing to ill-health. He had not very much to add to what had already been put before the shareholders in the directors' report, except that since the report was issued the position of the company had continued to rapidly improve. Important new orders for stations and plant had been received from the Portuguese and Greek Governments, and he was glad to say that the value of orders in hand amounted to over £100,000, with every prospect of a very substantial increase in the immediate future. The trans-Atlantic station at Clifden had been completed. The directors regretted that the completion of that station was seriously delayed by the failure of certain manufacturers to deliver the necessary plant at the dates promised, the delivery of certain essential machines having been retarded for nearly six months. The plant had in every way come up to his expectations in regard to efficiency. In regard to the corresponding station at Glace Bay, the machinery had already been completed and was now nearly all delivered. He did not expect that more than a month would be required for its efficient erection. If his colleagues had not considered it necessary for him to remain in England so as to be present at that meeting he would have been in Canada attending to the final completion of the station on that side. The limited service across the Atlantic, which had been established for over 18 months, had continued to give satisfaction to its principal users, but that service, although exceedingly useful to the company, had been very difficult to efficiently maintain whilst additions and alterations were being constantly carried out at the terminal stations. He had no doubt that a very great extension of the trans-Atlantic service might be anticipated as soon as the complete duplication of the station in Canada had taken place, which would enable the company to accept from 15,000 to 20,000 words per day for transmission across the Atlantic between the stations at Clifden and Glace Bay. The board expected about the end of August to be in a position to invite the Post Office to give effect to their agreement relative to the acceptance and delivery of the company's trans-Atlantic messages at Government telegraph offices throughout the United Kingdom. A thorough reorganisation of the administration of the company and of some of the associated companies was not only desirable but imperative. That, in his opinion, had been as far as possible carried out. The fear once entertained by the Board of the ratification of the Berlin Convention by the British Government being detrimental to the maritime business controlled by the company had not been realised, and a considerable addition had been made to the number of ships carrying the Marconi system. That was an eloquent proof that even under what certain foreign Governments called conditions of open competition, the system controlled by the company had proved able to more than hold its own against all other systems, even although these were powerfully assisted by Governments which considered their development a question of national and political importance. The assistance rendered by the company's organisation of wireless telegraphy to the steamships "Slavonia" and the "Republic" was still fresh in their memory. The stations of his system erected by the Italian Government on the Somaliland coast of Africa had been completed and were working satisfactorily. The location of those stations, being within a few degrees of the equator, was proof that no serious difficulty existed, as had sometimes been suggested, in regard to the efficient working of wireless telegraphy in the tropics. Arrangements had been made on satisfactory terms with the Meteorological Office in London and Hamburg for supply of weather reports from vessels crossing the Atlantic. The Meteorological Office had written to the company stating that they were agreeably surprised at the accuracy of the reports which they received by means of wireless telegraphy.

Their relations with H.M. Government were on a most satisfactory basis, and the directors expected every support would be given by the Government to the development of the company's affairs. The complete financial success of the company was dependent on the full and efficient working of the trans-Atlantic stations, yet it was also undoubtedly true that a large measure of success could now be obtained by the execution of orders in hand, which were coming in from all parts of the world. When it was realised that many foreign countries and colonial possessions were now inclined, for economical reasons, to utilise wireless telegraphy in place of the ordinary wire communication it was easy to understand what an enormous field existed for the manufacturing branch of the company. The Italian Government had already tried the experiment of installing wireless telegraphic stations in Africa, and was well satisfied with the result. That example might be followed in British colonies, where the scope was still greater. Since the issue of the report three influential gentlemen had consented to join the board—Messrs. Hammersley Heenan (Heenan & Froude), F. Whowell and Capt. H. R. Sankey, late R.E. The board wished to put on record their appreciation of the work carried out by all the company's staff, both here and abroad, and he himself wished to acknowledge the assistance he had received in endeavouring to carry out his duties as managing director from Mr. H. Jameson Davis and Major S. Flood-Page, and from Mr. H. W. Allen and Mr. W. W. Bradfield. He then moved the adoption of the report and accounts, which was carried.

J. G. White & Co. (Ltd.)

At the meeting on Monday Lord ARTHUR BUTLER expressed regret that the chairman (Mr. J. G. White) had been detained in New York and could not arrive until next month. The generally adverse business conditions and the very severe competition existing in the construction business had made the company's work difficult, but the figures in the balance-sheet indicated that those difficulties had been satisfactorily met, the profits for the year showing an increase over those at Feb. 28, 1908. The directors felt, therefore, that the shareholders were to be congratulated upon the results of the year's trading. The chairman dealt with the various items in the balance-sheet. The cash assets were practically equivalent to the whole preference capital. That was well, in so far as it proved that the assets were liquid, but unsatisfactory in so far as it indicated a reduced turnover. The company's resources and credit were being employed in a manner which earned satisfactory returns, though not quite what they should do with better general business conditions. The actual cash and call loans were equal to twice the whole indebtedness. The investments now standing at £109,429. 15s. 5d. were considerably lower than the corresponding amount last year. The securities sold realised more than the amount at which they were taken in last year's accounts, and the directors believe that the present valuation of securities is equally conservative. The valuation of plant, material in hand, &c., was nominal, having been taken at practically a scrap value basis, and not at its value to the company in carrying on its ordinary business. Regarding future prospects, the business in hand ensured satisfactory profits for the current year, and negotiations were progressing favourably for securing a considerable amount of new work. After deducting the dividends recommended, amounting to 8 per cent. on all classes of shares for the year, the company's reserve fund would stand at £100,000, and the profits carried forward amount to £15,460. 6s., making a total accumulated profit now in the business of £115,460.

The report was then adopted and the dividends therein declared were approved.

BRITISH ELECTRIC TRACTION CO. (LTD.)—The report for the year ended March 31 states that the subscribed share and debenture capital is £4,949,969, and the amount standing at credit of reserve is £602,420. 7s. 11d. In addition, reserves amounting to £59,162. 2s. 5d. have been made out of profits against loss or depreciation of specific assets. The various associated companies have created depreciation and reserve funds of their own which amounted at Dec. 31, 1908 (including balances carried forward) to £1,015,340. Creditors represent £65,227. 11s. 6d., of which £46,623 was in respect of debenture interest. Investments and undertakings stand at £5,037,095. 3s. 1d., and consist of shares and debentures in associated tramway, electricity supply, manufacturing and other companies, Consols and sundry securities. Investments standing in the books at £2,883,086 were revenue earning during the past year, and produced an average return of 4·18 per cent. Investments standing in the books at £2,012,441 did not earn any revenue during the year. The amount of sundry debtors and debit balances stands at £473,680. 5s. 11d.

The expenditure in connection with the new office building which has been erected for the British Electrical Federation was £36,188. 8s., and there is a further sum of £3,274. 1s. 1d. in respect of other buildings and land. Expenditure on acts of Parliament, &c., stands at £19,640. 11s. 6d.

The amount is being written down annually by 20 per cent. Stock stands at £9,876. 9s. 2d., and represents the stock of cars on hire to associated companies, electrical equipments, paving setts and general stores. Provision has been made for depreciation. Goodwill stands at £1,000, and is the balance of a larger amount.

The net profit for the year, after reserving £12,500 against depreciation of undertakings worked by the company, buildings and freehold land, stock, doubtful debts and expenditure on undertakings not proceeded with, is £130,725. 15s. 6d., to which is added £35,393. 12s. 8d. brought forward, making £166,119. 8s. 2d. After deducting debenture interest for the year (£97,484. 15s. 4d.) there remains £68,634. 12s. 10d., out of which a dividend has been paid on the preference shares of 3 per cent. for the year, amounting to £48,431. 2s., leaving £20,203. 10s. 10d. to be carried forward. The full dividend on the 6 per cent. cumulative preference shares has been paid to March 31, 1908.

The directors regret that the dividends and interest received from the associated companies during the past year show a diminution of £33,331. 15s. 4d. The decline in profits has been general throughout the country, and is attributed by many of the companies to the severe depression in trade which has prevailed. A few of the undertakings in England and those at Bombay and Auckland, however, show increased takings per route-mile which are sufficient to increase the average over the whole of the systems. The total number of passengers carried shows a small incrase, the route mileage of lines worked having slightly increased during the year, but the number of passengers carried per route-mile of line has fallen from 662,726 to 654,770. The effect of this decline in the number of passengers per route-mile has been somewhat counteracted by a small increase in the average fare per passenger, which was 1·23d. against 1·21d.

The general charges and expenses of administration again show a material reduction, being £16,868, compared with £24,186, the reduction on this occasion being mainly the outcome of the formation of the British Electrical Federation. In the last report it was stated that the directors were giving consideration to proposals for electrical enterprise submitted to them from countries where the conditions for the investment of capital are more favourable than in this country, and they are glad to say that the prospects of securing such business are encouraging. The company has secured a substantial participation in a powerful syndicate, which has been formed in association with German and other Continental banks, for negotiating with the St. Petersburg Municipality for a tramway concession in that city. Other negotiations are pending in regard to various enterprises abroad.

ELECTRIC & GENERAL INVESTMENT CO. (LTD.)—The gross profit on the transactions of the year ended May 31 was £11,565. 17s. 11d. After deducting general charges and interim preference dividend, and providing proportion of final preference dividend to May 31, there remained a balance of £4,095. 8s. 7d. As a further reserve to meet depreciation in the company's investment and loan securities, the directors have carried this amount to the contingencies fund, raising this to £71,651. 17s. 8d. The trustee for the ordinary shares reserve fund proposes to distribute 6d. per share out of the dividends received on the trust investments, and the trustee for the founders' shares reserve fund proposes to distribute £8 per share out of the dividends received on the trust investments.

GREENWOOD & BATLEY (LTD.)—The directors' report for the 12 months ended March 31 states that, after providing for debenture interest and expenses of management, and making due provision for doubtful debts, the profit was £7,642. 15s. 7d., which, with £5,451. 10s. 1d. brought forward, gave an available balance of £13,094. 5s. 8d. Of this sum £4,000 has been written off for depreciation. The preference dividend for the year absorbs £7,027. 17s. 3d., leaving £2,066. 8s. 5d. to be carried forward. The directors have transferred £15,000 from reserve in reduction of the book value of investments in subsidiary and connected companies.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.).—The directors' report states a provisional contract for the supply of current to Johannesburg municipality was completed in June, 1908, and the plant thus released was at once employed for the power requirements of various mines. Rapid progress in the construction of the 16,000 H.P. station at Simmer Pan has been maintained, and half the plant has already been put into commercial use. Applications for the supply of power continue to be received in a satisfactory manner and will provide work for the whole of the Simmer Pan station, and also necessitate an immediate extension of the plant. The statement of revenue and expenditure shows a surplus for the year of £48,117 compared with £36,685 in 1907.

"Z" ELECTRIC LAMP MFG. CO. (LTD.)—At the meeting on Monday the chairman (Mr. J. G. B. Stone) said the capital assets included certain works and their equipment, but consisted mainly of a number of patents in this country and a number of others which they had acquired as to the manufacture of "Z" Lamps in 17 British colonies and dependencies. He said that no doubt many of them were disappointed that substantial results had not already accrued from the manufacture and sale of their lamps. They had had many difficulties to overcome. Experience had shown that there were difficulties which arose when they manufactured in quantities. The directors had always felt that that business should be developed on a large scale, and they had always aimed at a considerable output. He thought that there was no firm in this country manufacturing so many metallic filament lamps or working with so small a percentage of breakage. When they started manufacturing the 100 volt lamp the lowest candle-power they could make for that voltage was 30 to 40; now they had on the market lamps of 16 c.p. for 100 volts, and of 30 c.p. for 200 volts. Throughout the year the candle-power had been steadily brought down. First, 30 c.p. lamps were standardised, then 25 c.p., then 20 c.p., and now 16 c.p. Each of those steps had entailed an immense amount of work in training the hands to manufacture and handle the finer filaments. The size of the bulb had also been reduced, and the form of support modified to suit the finer filaments. That took time, as the results had to be tested at each stage, and when they remembered that a life test of a lamp took 1,000 hours, which meant six weeks' continuous burning, they would understand why progress had not been more rapid. They had reached the stage when they could put a thoroughly satisfactory metal filament lamp on the market at reasonable prices, they had mastered the difficulties connected with the manufacture, and they must now increase their output to meet an increasing demand. Last month they sold the whole of their stock to the trade for forward dates at satisfactory prices. The efficiency of the factories was steadily improving, the output of lamps increasing, and the cost of manufacture steadily decreasing. They had made important improvements in the filaments, and in the finished lamps. It was a matter of importance and congratulation that both filament and lamp were made entirely in this country. On the basis of what they were doing they were earning a good profit and the board would be very disappointed if the results of the current year did not produce a return satisfactory to the shareholders.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES, CHARGES, &c.

NEW COMPANIES.

DREWS, HARRIS & SHELDON (LTD.) (103, 713.)—Reg. June 26, captal £5,000 in £1 shares, to carry on in South Africa, the United Kingdom or elsewhere the business of brassfounders, metal workers, manufacturers of electrical apparatus, &c. Private company. First directors, J. E. Sheldon and R. G. Richards.

ELECTRIC ORDNANCE CO. (LTD.) (103,690.)—Reg. June 24, capita £10,000 in 8,000 cumulative participating 10 per cent. preference shares of £1 each and 40,000 ordinary shares of 1s. each, with objects as indicated by the title. First directors, H. F. Spencer, A. Blackman and Dr. Woltereck. Reg. office, Ingram-court, Fenchurch-street, London, E.C.

STATUTORY RETURN.

KESWICK ELECTRIC LIGHT CO. (LTD.)—In return to April 10 capital is £20,000 in £1 shares (15,000 preference and 5,000 ordinary), of which 3,420 ordinary have been taken up. £3,420 has been received. Mortgages and charges, £10,100.

MORTGAGES AND CHARGES.

RHYMNEY VALLEY & GENERAL ELECTRIC SUPPLY CO. (LTD.)—Particulars of £1,250 debentures, created Jan. 1, 1909, have been filed, the amount of present issue being £1,100. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

RECEIVERS.

KINETIC SWANTON CO. (LTD.)—Two notices of the appointment of J. H. Moritz, C.A., 8, Queen-street, E.C., as receiver and manager on June 5, 1909, under powers contained in debenture dated March 13, 1908, and on June 10 under powers contained in debenture dated Dec. 31, 1908, have been filed.

CITY NOTES.

MEMORANDA (July 1).—Bank rate 2½ per cent. (since April 1, 1909). Price of silver, 24d. per oz. Consols 84⅛—84¼ for money and 84¼—84⅜ for account. Consols Pay Day, Aug. 5; Stock and Shares Continuation Days, July 12 and 27; Ticket Days, July 13 and 28; Pay Days, July 14 and 29; Mining Shares Carry Over Days, July 9 and 26.

PRICES OF METALS (London).—*Copper*, cash, 59$\frac{1}{16}$; three months 59⅞. *Lead*, English, 13½—13⅝; foreign, cash, 12¾—12$\frac{13}{16}$; three months, 13$\frac{3}{16}$—13¼. *Spelter*, cash, 22—22⅛. *Tin*, English, 132—134; foreign, cash, 131⅞; three months, 132½—133⅝. *Iron*, Cleveland, cash, 48/3 and three months, 48/11. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

GREAT NORTHERN TELEGRAPH CO. (LTD.)—The dividend payable by this company on account, on July 1, is at the rate of 2½ per cent. (being interim dividend for six months at the rate of 5 per cent. per annum).

HOBART ELECTRIC TRAMWAY CO. (LTD.)—A dividend of 1s. per share, tax free, has been declared.

SOCIETE ANONYME WESTINGHOUSE—The report for 1908 states that the gross trading profit was 1,686,000f., making with revenue from investments in subsidiary companies, &c., 1,780,000f. Deducting working expenses and fixed charges the balance is 806,900f. A dividend of 5 per cent. on the privileged shares is proposed, 86,000f. being carried forward.

STOCK EXCHANGE NOTICES.—An official quotation has been granted to a further issue of 900,000 £1 partly-paid 6 per cent. cumulative preference shares of the *Victoria Falls and Transvaal Power Co. (Ltd.)*. The committee have been asked to appoint special settling days in and grant quotations to £150,000 5 per cent. second mortgage debentures of the *Bombay Electric Supply & Tramways Co. (Ltd.)* and £100,000 5 per cent. first mortgage debentures of the *Southern Electric Tramways of Buenos Aires* (Cia de Tramways Electricos del Sud).

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 23	1,422	− 16	3	4,787	− 43
Airdrie	" 18	222	+ 3	24	5 202	− 87
Anglo-Argentine	" 24	37,872	+ 2,397	25	982,802	+ 56,595
Ayr Corporation	" 23	335	− 27	6	1,785	− 123
Baker St. & Waterloo Ry.	" 26	3,435	+ 420	25	83,650	+ 7,470
Barnsley	" 18	155	− 4	24	3,993	− 143
Barrow	" 18	212	− 21	24	5,151	− 350
Bath Electric Trams, Ltd.	" 23	772	− 37	25	17,203	+ 550
Birmingham Corporation	" 26	6 480	+ 214	13	81,865	+ 468
Birmingham & Mid.	" 11	757	− 300	23	15,812	− 3
Blackburn Corporation	" 23	1,049	− 169	13	14,910	− 261
Blackpool and Fleetwood	" 26	692	− 85	...	...	...
Bolton Corporation	" 27	2,266	− 250	13	30 20)	− 553
Bombay	May 27	R35,655	+ R1,129	20	R605,555	+ R51,593
Bournemouth Corporation	June 23	1,583	+ 4	12	20,132	+ 238
Bradford Corporation	" 19	5,020	+ 483	11	57,003	+ 1,353
Brighton Corporation	" 27	905	− 10	13	11,855	− 657
Bristol Trams & Carriage	" 25	5,318	+ 112	5	28,771	+ 890
Burnley Corporation	" 25	1,229	− 41	13	16,667	+ 267
Burton Corporation	" 27	297	+ 7	13	3,366	− 66
Bury Corporation	" 27	1,0.9	− 165	‡13	15,205	− 448
Calcutta Tramways Co.	" 26	R50,110	+ R9,518	25	R1,239,420	+ R118,[illegible]
Camborne-Redruth	" 26	109	− 50	26	3,121	− 110
Cardiff Corporation	" 26	2,098	− 118	13	27,199	− 557
Cavehill	" 18	117	+ 21	24	1,815	− 151
Central London Railway	" 26	5,661	− 1,834	25	139,113	− 17,196
Charing C., Euston & H'stead	" 25	3,980	+ 530	25	97,210	+ 15,950
Chatham & Dist. Lt. Rys.	" 24	782	− 69	25	19,118	+ 1,158
City & South London Rly.	" 27	3,325	+ 199	25	81,345	+ 1,359
City of Birmingham	" 18	2,713	− 179	24	65,432	− 983
Colchester Corporation	" 23	287	+ 86	...	...	...
Cork Electric Trams Co.	" 24	535	− 11	25	9,967	− 937
Croydon Corporation	" 25	1,122	− 126	‖12	18,633	+ 78
Devonport & Dist. Trams	" 18	353	− 88	24	8,828	− 1,725
Dover Corporation	...	...	...	...	...	...
Dublin & Lucan Railway	" 25	144	− 9	25	3,165	+ 253
Dublin United	" 25	5,689	− 576	25	128,641	+ 395
Dudley-Stourbridge	" 18	784	− 86	24	18,529	− 482
Dundee Corporation	" 23	1,184	− 51	†6	6,644	− 276
East Ham Council	" 25	991	+ 98	§12	12,758	+ 1,955
Exeter Corporation	" 25	318	− 15	13	4,604	+ 583
Gateshead & Dist. Trams	" 18	953	+ 1	24	23,578	− 48
Glasgow Corporation	" 26	17,386	− 1,717	14	66,783	+ 319
Glossop Trams	" 26	116	− 7	26	3,078	− 121
Gravesend—Northfleet	" 18	203	− 13	24	4,617	− 167
Great Northern & City Rly.	" 26	1,372	− 123	25	37,365	− 4,159
Gt. Northern, Piccadilly, &c.	" 26	6,025	+ 275	25	145,115	+ 9,375
Greenock & Port Glasgow	" 18	616	+ 103	24	12,180	+ 235
Hartlepool Tramways	" 18	238	+ 11	24	5,140	− 116
Hastings Elec. Trams Co.	" 24	898	− 106	25	21,619	− 634
Hong Kong	" 23	$8,022	+ $630	...	...	...
Huddersfield Corpn.	" 26	1,565	− 103	12	20,956	+ 466
Hull Corporation	" 26	2,497	+ 122	12	30,843	+ 162
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	" 23	139	+ 3	12	1,591	− 137
Ipswich Corporation	" 23	401	− 8	13	4,811	+ 15
Isle of Thanet Co.	" 26	718	− 76	§30	13,655	+ 209
Jarrow	" 18	119	+ 20	24	2,613	+ 272
Keighley Corporation	" 24	155	− 9	12	2,101	+ 59
Kidderminster & District	" 13	109	− 21	21	2,242	− 137
Kilmarnock Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	" 24	1,339	− 93	25	30,3.0	− 1,855
Lancashire United	" 23	1 235	− 53	25	31,677	− 194
Leamington	" 13	185	+ 21	23	3,769	+ 154
Leeds Corporation	" 26	6,800	− 119	13	85,001	+ 2,903
Leicester Corporation	" 26	2,320	− 63	...	...	...
Leith Corporation	" 19	596	+ 59	5	3,116	+ 324
Lincoln Corporation	" 26	125	− 1	13	1,618	+ 71
Liverpool Corporation	" 19	10,813	− 220	‡24	255,311	− 2,909
Liverpool Overhead Rly.	" 27	1,419	− 91	26	34,287	− 2,354
Llandudno & Colwyn Bay Ry	" 25	315	− 38	30	5,171	+ 1,573
London County Council	" 12	31,632	− 4,686	§10	376,659	+ 13,392
London United	" 26	6,342	− 1,601	‡28	141,559	− 13,025
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	" 26	171	− 31	12	2,289	− 183
Manchester Corporation	" 26	14,662	− 1,313	13	184,934	− 862
Mersey Railway	" 23	1,903	+ 113	25	49,260	+ 1,454
Merthyr	" 18	214	+ 15	24	5,024	+ 19
Metropolitan Dist. Railway	" 26	10,911	+ 1,153	25	248,235	+ 23,911
Metropolitan Elec. Trams	" 18	6,525	+ 513	24	140 596	+ 12,632
Middleton	" 13	362	− 103	24	7,860	− 446
Nelson Corporation	...	...	...	...	...	...
Newcastle-on-Tyne Corp.	" 26	6,052	− 225	12	50,538	+ 274
Newport (Mon.)	" 26	675	− 52	13	8,559	− 197
Northampton Corporation	" 25	452	− 22	§13	6,006	+ 125
Oldham, Ashton & Hyde	" 18	553	− 47	24	14 210	− 895
Oldham Corporation	" 27	1,788	− 250	†14	25,792	− 1,676
Perth (N.B.) Corporation	" 23	152	− 10	5	863	− 25
Perth (W.A.) Elec. Trams	" 25	1,310	+ 11	25	36,037	+ 204
Peterborough	" 13	115	− 7	24	2,577	− 198
Portsmouth Corporation	...	...	...	...	...	...
Potteries	" 13	1 681	+ 27	24	42,168	− 1,241
Preston Corporation	" 23	716	− 47	12	8,737	− 28
Rotherham Corporation	" 14	666	+ 46	12	7,159	− 170
Rothesay	" 13	300	+ 118	24	2,585	+ 82
Salford Corporation	" 28	4,378	− 759	‡13	58,919	− 2,239
Sheerness	" 18	62	− 12	24	1,110	− 152
Sheffield Corporation	" 27	5,697	− 31	§13	75,818	− 1,250
Singapore Trams	" 26	$3,986	+ $581	25	$334,771	+ $3,231
South Metropolitan	" 18	821	− 26	24	17,879	− 74
South Staffs	" 13	801	+ 26	24	19,720	− 1,183
Southend Corporation	" 24	525	+ 69	12	5,624	+ 888
Southport Tramways	" 13	377	− 33	24	6,239	+ 126
Stalybr'dge, Hyde, &c., Jt. Bd.	" 25	705	− 110	§12	9,748	− 337
Sunderland Corporation	" 27	1,128	− 239	13	14,371	− 636
Sunderland District	" 23	420	− 61	24	15,177	− 537
Swansea Trams	" 18	933	+ 55	24	21,891	+ 546
Swindon Corporation	...	...	...	...	...	...
Taunton	" 15	30	+ 1	24	863	− 75
Tynemouth and District	" 18	236	+ 42	24	4,171	+ 38
Tyneside Trams Co.	" 23	1,358	+ 76	25	11 073	+ 843
Wallasey District Council	" 26	920	+ 37	§12	11,681	+ 373
Walsall Corpn.	" 26	434	− 23	25	12,203	− 999
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	" 17	2,277	+ 131	11	26,593	+ 1,766
Weston-super-Mare	" 18	181	+ 20	24	1,363	+ 224
Wolverhampton Co.	" 18	403	+ 1	24	9,803	− 1,008
Wolverhampton Corpn.	" 24	785	+ 2	25	18,372	− 1,762
Worcester	" 18	283	− 5	24	6,157	− 56
Wrexham	" 18	98	+ 5	23	2,264	− 90
Yorkshire W.R. Trams	" 27	1,036	− 131	26	30,036	...
Yorkshire Woollen District	" 18	949	+ 137	24	21,085	− 424

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed June 30	Rate % Yield-ed. £ s d.	Dividend Due.	Business Week to June 30: Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½ −10	6 [illegible] 0	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝ −10½	4 9 0	Feb, Aug	[illegible]	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼ −10¾	5 11 6	Feb, Aug		..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	[illegible] −103	4 7 6	Jan, July	..	..
5	3 6	Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8¼ −8¾	5 11 0	March....	8¼	8⅝
5	3/6	Do. 7 per Cent. Pref.	8 −8½	4 2 [illegible]	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97 −100	4 [illegible] [illegible]	June, Dec	..	—
5	2 6	Charing Cross (W. End & City) El. Sup. Co.	3⅞ −4⅛	[illegible]	Feb, Aug	4¼	4
5	2/3	Do. 4½ per Cent. Pref.	4½ −4¾	4 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 −99	4 1 0	Jan, July	..	—
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 −102	4 5 0	..	..	..
5	2/8	†Do. City Undertaking 4½% Cm. Pref.	3⅞ −4⅛	5 [illegible] 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅞ −4⅛	4 [illegible] 3	March ..	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	101 −103	4 7 0	June, Dec	[illegible]	..
10	7/0	City of London Electric Lighting Ord.	10½ −11	5 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅞ −12⅜	4 15 0	Jan, July	12[illegible]	..
St.	5%	†Do. 5 per Cent. Deb. Stock (red.)	120 −123	4 1 6	June, Dec	..	..
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 −102	4 5 [illegible]	Jan, July	101	—
5	..	County of Durham Elec. P.D. Ord.	1¾ −2¼	..	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3⅜ −3⅞	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅜ −8⅞	5 15 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞ −11⅛	5 8 0	Mar, Sept	11	11[illegible]
St.	4½%	†Do. 4½% Deb. Stock (red.)	104 −107	4 8 6	Jan, July	[illegible]	..
St.	4½%	Do. Second Deb. Stock	100 −103	4 7 6	May, Nov	[illegible]	10[illegible]
5	3 6	Folkestone Electricity Supply Co. Ord.	4½ −5	5 10 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 −5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	98 −101	4 9 0	Feb, Aug	..	..
5	4 6	Hove Electric Lighting Ord.	7½ −7⅞	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord.	6½ −7⅛	5 2 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ −6⅞	4 14 6	Jan, July	..	—
t.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 −100	4 0 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	86 −89	5 1 0	Jan, July	..	..
8	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛ −5¼	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	89 −94	4 5 0	Jan, July	—	..
5	3 0	Metropolitan Electric Sup. Ord.	4⅞ −4¼	5 16 0	April, Oct	4[illegible]	4[illegible]
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4⅞ −5	4 10 0	Jan, July	..	—
St.	4½%	†Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4 2 6	June, Dec	—	..
St.	3½%	†Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ −86½	4 1 0	Jan, July	..	—
100	4½%	†Midland Elec. Corp. for P.D. 1st Mort. Db.	92 −95	4 13 6	June, Dec	..	—
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4⅞ −5	4 2 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	84 −85	5 5 11	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅝ −4¾	2 13 1	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞ −5¼	5 0 0	Feb, Aug	..	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 −101	4 0 0	Jan, July	—	.
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 19 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	91 −93	4 17 10	Jan, July	..	..
10	8/0	Notting Hill Electric Ord.	11½ −12½	5 12 0	March ..	—	..
5	4 6	Oxford Electric Ord.	6 −6½	5 8 0	March ..	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	94 −97	4 2 6	Jan, July	..	..
5	5 0	St. James' & Pall Mall Elec. Ord.	8¾ −9¼	5 8 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 6	Feb, Aug	..	—
St.	3½%	†Do. 3½ per Cent. Deb. Stock (red.)	81 −83	3 19 6	Jan, July	87	83⅞
5	..	Smithfield Markets Electric Sup. Ord.	[illegible] −1[illegible]	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¾ −3½	6 8 0	April	—	..
St.	5 %	†Do. 5% 1st Mort. Stk. Red.	100½ −102½	4 17 6	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	—	—
1	0 8¾	Do. 7 per Cent. Cum. Pref.	1¹⁄₁₆ −1³⁄₁₆	5 7 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −103	4 7 6	April, Oct	102	101½
5	2/6	Urban Electric Supply Ord.	⅞ −1	—	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	1⅞ −2⅜	11 15 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 −84	5 7 3	April, Oct	81	—
5	5/0	Westminster Elec. Sup. Ord.	8¾ −9⅜	5 7 0	Mar, Sept	..	..
5	2/8	Do. 4½ per Cent. Cum. Pref.	5⅛ −5½	4 11 0	Jan, July	5[illegible]	5⅛
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	93 −100	4 0 0	Jan, July	99¾	99½
1	..	Bath Elec. Trams Pref. Ord.	¼ −⅜	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 13 9	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 −91	4 19 0	April, Oct	.	..
St.	4½%	†B'ham & Midland Trams 4½ 1st Db. Stk.	87 −90	5 0 0	Jan, July	[illegible]	..
10	6%	Bristol Tramways & Carriage Ord.	7¾ −8¼	7 9 8	Feb, Aug	..	—
10	4%	†Do. Cum. Pref. (fully paid)	8 −8¼	4 14 1	..	..	—
St.	4%	†Do. 4 per Cent. Debs.	98 −99	4 0 10	Feb, Aug	.	—
10	..	British Electric Traction Ord.	⅞ −1	..	June, Dec	[illegible]	[illegible]
10	3/0	Do. 6 per Cent. Cum. Pref.	2½ −3	10 0 0	Feb, Aug	2½	2[illegible]
St.	5%	Do. 5 per Cent. Perpetual Debs.	89 −93	5 7 6	April, Oct	92½	90
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 −72	6 5 0	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	63 −65	5 0 0	Feb, Aug	64	63
St.	4%	Do. 4 per Cent. Pref. Stock	84 −86	4 13 0	Feb, Aug	—	..
St.	2½%	Do. Deferred Stock	47 −49	4 18 0	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	101 −103	4 17 6	Jan, July	10[illegible]	..
St.	4%	†Charing X, Euston & Hmpstd Per. Db. Stk.	91 −93	4 6 0	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ −5¼	4 15 [illegible]	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31 −32	4 1[illegible] 6	Feb, Aug	3[illegible]	31
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 −112	4 9 0	Feb, Aug	1[illegible]	..
St.	5%	Do. (1896)	105 −109	4 11 [illegible]	Feb, Aug	..	..
St.	5%	Do. (1901)	103 −105	4 15 3	Feb, Aug	104	—
St.	5%	Do. (1903)	93 −96	5 4 0	Feb, Aug	9[illegible]	93
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 −101	3 19 0	May, Nov	..	—
10	6/0	Dublin United Trams. Ord	—	4 15 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.	13 −14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ −1	..	Feb, Aug	[illegible]	[illegible]
10	..	G. Northern, Picc. & Brompton 4% G.P.	8 −8½	—	Feb, Aug	.	..
St.	4%	†Do. 4 per Cent. Deb. Stock	93 −95	4 4 0	Jan, July	9[illegible]	94½
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1⅞ −2⅛	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	87 −89	5 6 0	April, Oct	..	—
10	6%	Imperial Tramways Ord.	4½ −5	12 0 0	Mar, Sept	..	..
10	6%	†‡Do. 6 per Cent. Pref.	6⅞ −7½	7 13 0	Mar, Sept	..	..
St.	4½%	†‡Do. 4½ per Cent. Debs.	85 −87	5 3 5	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅛	..	Mar, Sept	..	—
St.	4%	†Do. 4 per Cent. Deb. Stock	55 −60	6 13 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9⅞ −10⅛	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ −90½	5 10 6	Jan, July	8[illegible]	.
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	[illegible] −5	5 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	.	..
10	2/6	London United Trams. 5% Cum. Pref.	1¾ −2½	..	Jan, July	2[illegible]	1[illegible]
St.	4%	†Do. 4 per Cent. 1st Mort. Deb. Stock	61 −65	5 18 0	Jan, July	..	..
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	—	..
1	10⅘	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April.. .	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	.	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	96½ −98½	5 1 6	Jan, July	[illegible]	93
St.	1%	Metropolitan Railway Consolidated	35 −38½	1 5 9	Feb, Aug	[illegible]	38½
St.	3%	Do. Surplus Lands Stocks	67 −69	4 6 9	Feb, Aug	69½	67¼
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3 17 0	Feb, Aug	9[illegible]	90
St	3½%	Do. 3½ per Cent. "A" Preference	82 −84	4 3 6	Feb, Aug	6[illegible]	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	83 −84	4 3 6	Feb, Aug	8[illegible]	—
St.	3½%	Do. 3½ per Cent. Debenture Stock	93 −95	3 13 3	Jan, July	94½	93½

In calculating the yield allowance has been made for accrued interest but *not* for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., June 30.	Rate % Yielded.	Dividend Due.	Business Week to June 30 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*		£ s. d.			
St.	3½%	Met. Elv. 3½ per Cent. "A" Deb. Stock	92–94	3 14 6	Jan, July	94	..
St.	..	Metropolitan District Railway Ord.	16½–17½	—	Feb, Aug	17 3/16	17⅛
St.	..	Do. Extension Pref. (5 per Cent.)	43–45	..	Feb, Aug	43	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	67–69	5 1 0	Feb, Aug		
St.	3%	*Do. 3 per Cent. Consoltd. Rent-charge	76–78	3 17 0	Jan, July	77½	76½
St.	4%	*Do. 4 per Cent. Midland Rent-charge	101–104	3 16 0	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	89–92	4 7 0	Mar, Sept	91	..
St.	6%	†Do. 6 per Cent. Perp. Deb. Stock	139–141	4 5 0	Jan, July	139½	..
St.	4%	Do. 4 per Cent. Ditto	93–95	4 4 0	Jan, July	97	93½
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½–¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	1/16–3/16	..	April, Oct	...	—
1	0/6	Do. 5 per Cent. Cum. Pref.	½–¾	6 0 0	Feb, Aug	...	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86–89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝–⅞	9 12 0	Feb, Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	70–74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db.	84–86	5 14 0	Jan, July	..	..
..	..	UndergdE.Rys.Lon.6 In.bds.with coup.8	37–39	..	June, Dec	..	..
..	..	Do. 5% Prior Lien Bonds	101½–102½	4 17 6	..	102½	102
..	4½	Do. 4½% Bonds with coup. 8	89–91	4 19 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½–1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2½–2¾	..	..	..	..
St.	4½	†Do. 4½ per Cent. 1st Debs.	84–86	5 2 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	11/16–13/16	..	..	—	..
1	0/3	Do. 6% Cum. Pf.	⅝–¾	7 3 2	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.	4⅝–4 11/16	4 13 0	April, Oct	4⅝	..
1	0/7½	Do. Pref.	1⅛–1¼	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅝–7⅞	6 9 0	July, Feb	7⅞	7½
5	3/0	Do. 6 per Cent. Pref.	6⅛–6⅜	4 9 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)	103–106	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91–96	4 13 8	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	1/16–3/16	—	Feb, Aug	1/16	..
100	6	Do. 6 per Cent. Prior Lien Dbs (rd.)	97–99	6 1 0	..	97½	98
St.	4%	*Do. 4 per Cent. Mort. Deb. Stock	38–42	9 10 0	Jan, July	..	..
St.	4½%	BrushE.Eng Co.4½ Perp. 1st Deb.Stock	43–48	9 8 0	Mar, Sept	..	..
St.	4½%	†Do. Perpetual 2nd Deb. Stock	27–31	14 10 0	Jan, July	..	—
5	10/0	Callender's Cable Con.Ord.	9⅜–10½	7 4 0	Jan, July	10¼	..
5	2/6	*Do. 5 per Cent. Cum. Pref.	5⅜–5½	4 11 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort Debs. (red.)	103–106	4 15 0	Nov, May	105	..
1	1/0	Castner-Kellner Alkali Co.	1⅞–2	6 5 0	May, Nov	—	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102–106	4 4 0	Feb, Aug	..	..
1	0/..	Chadburn's (Ship) Telegraph Ord.	15/16–1 1/16	6 11 9	March ..	..	..
1	..	Do. 6 per Cent. Cum. Pref.	1½–1⅝	5 14 0	April, Oct	..	..
1	0/8¾	Consolidated Electrical Co.	9/16–11/16	5 4 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1 5/16–1 7/16	7 16 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞–1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	1–1¼	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	94–97	5 2 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞–1⅛	..	Mar, Sept	..	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16–1¼	8 0 0	Sept	1 3/16	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅝–1⅞	4 16 9	Sept	—	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock	99–102	4 8 0	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	½–¾	..	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1½–2½	5 0 0	Feb, Aug	..	—
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock (rd.)	69–73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84–87	5 15 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	3/16–5/16	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅝–⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60–63	7 3 0	Jan, July	..	..
2	..	Electric Construction Co.	9/16–11/16	..	Jan, July	—	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1 7/16–1 9/16	8 ..	July	...	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59–63	6 7 0	Jan, July	..	..
St.	5%	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71–77	6 10 0	..	..	—
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛–7⅜	6 13 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85–88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11⅝–12⅛	6 2 6	Feb, Aug	12⅛	11⅞
5	2/8	Do. 4½ per Cent. Pref.	5⅝–6⅛	4 3 6	Feb, Aug	5⅞	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	104½–106½	4 4 6	Mar, Sept	106	104¼
10	15/0	†India Rubber, Gut. Per., &c., Wrks.	14⅝–15½	6 10 0	Feb, Aug	14⅞	..
10	..	Do. 5 per Cent. Cum. Pref.	10⅛–10¼	..	..	10⅛	..
100	4%	Do. 4 per Cent. Debs. (red.)	99–101	3 19 0	April, Oct	..	..
1	..	National Elec. Construction Co.	½–¾	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜–½	..	Nov	⅜	..
1	..	Do. 6 per Cent. Cum. Pref.	⅜–⅝	..	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. Perp. Deb. Stock	81–84	5 7 0	Jan, July	83½	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5–5½	..	..	—	—
12	24/0	Telegraph Construction & Maintenance	33–34½	5 4 6	Mar, July	33¾	—
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101½–103½	3 17 0	Jan, July	—	..
1	1/0	Vickers, Sons & Maxim, Ltd. Ord.	2 1/16–2⅛	5 9 3	—	2⅛	2 1/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛–1 3/16	4 0 6	—	1 3/16	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109–112	4 9 3	..	109½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	101½–103½	3 17 0	June, Dec	103	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103–105	4 5 6	June, Dec	104½	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105–107	4 18 0	..	105⅝	105½
10	6/0	J. G. White & Co. 6% Cm. Pref.	9¾–10¼	5 14 0	..	..	..
5	1/0	Willans & Robinson Ord.	⅝–⅞	3 15 0	Apr, Oct	—	..
5	3/0	Do. 6 per Cent. Cum. Pref.	3⅛–3½	9 4 0	Apr, Oct	—	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76–80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅝–3⅛	—	June, Dec	..	—
100	5%	†Do. 5 per Cent. Debs. (red.)	92–95	5 5 6	June, Dec	..	..
St.	15/0	Anglo-American	56–58	5 13 3	F,My,Ag,N	—	—
St.	30/0	Do. Preferred	99–100	6 0 0	F,My,Ag,N	99⅞	99
St.	8/0	Do. Deferred	16½–16⅝	2 11 3	F,My,Ag,N	16 7/16	16⅜
St.	4%	*Commercial Cable 4 per Cent. Deb. Stk.	89–91	4 8 0	Jn,Ap,Jy,O	[illegible]	89
10	6/0	Cuba Submarine Ord.	8⅝–8⅞	6 15 0	Feb, Aug	..	—
10	10/0	Do. Preference 10 per Cent.	17–18	5 11 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	2⅞–3⅛	5 18 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅛–8⅜	5 12 9	April, Oct	8⅛	..
St.	4½%	Do. 4½ per Cent. Deb.	100½–107½	4 7 6	Jan, July	..	..
20	4/0	Direct United States Cable	12¾–13⅛	6 5 9	Ja,Ap,Jy,O	12¾	..
100	4½%	*Direct West India Cable 4½% Rg. Db. (rd.)	99–101	4 9 0	June, Dec	..	..
St.	15/0	Eastern Ordinary	132–137	6 4 6	Ja,My,Jy,O	132	130
St.	17/6	Do. 3½ per Cent. Pref. Stock	85½–87	4 0 6	Ja,My,Jy,O	86⅞	85½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103–106	3 16 0	May, Nov	106¼	..
St.	6/6	Eastern Extension	11⅛–11⅜	6 16 0	Ja,Ap,Jy,O	11 5/16	11⅛
St.	4%	Do. 4 per Cent. Deb. Stock	102–104	3 18 0	Feb, Aug	..	..
St.	4%	Eastern & S.Afr. 4% Mauritius Sub.Debs.	100–102	3 18 0	May, Nov	—	..
10	..	G. N. (of Copenhagen), with Coupon 76	26¾–27¼	6 1 6	Jan, July	27⅛	..
..	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99–101	4 9 0	June, Dec	..	..
25	12/6	Indo-European ex all	61½–62½	5 16 9	May, Nov	..	..
..	$1	Mackay Companies Common	80–84	4 16 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	74–79	5 1 0	Ja,Ap,Jy,O	—	..
1	..	Marconi's Wireless Teleg. Co.	1 5/16–1⅜	..	April	¾	..
100	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	99–101	3 19 0	June, Dec	—	..
1	1/3	West Coast of America	1⅛–1⅜	4 12 0	May	—	..
100	4%	Do. 4 per Cent. Debs.	100–102	3 17 6	Jan, July	..	..
10	..	West India & Panama	1/16–1⅛	..	May, Nov	1⅛	..
10	6/0	Do. 6 per Cent. 1st Pref	8⅞–9⅛	6 17 0	May, Nov	..	..
10	6/6	Do. 6% 2nd Pref.	8–9	6 13 6	May, Nov	—	..
100	5%	Do. 5 per Cent. Debs.	100–102	4 18 0	Jan, July	..	..
10	..	Western Telegraph	13⅝–13⅞	5 2 6	Mr,Jn,O,D	13⅝	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	100–102	3 18 0	June, Dec	100½	100
..	4%	Western Union Teleg. $1 000 4% Bonds	93–96	4 6 0	..	..	..

Share	Last Dividend	Name	Price Wed., June 30	Rate % Yielded.	Dividend Due.	Business Week to June 30 Highest	Lowest
		TELEPHONES.		£ s. d.			
100	2$	†Amer. Telephn. & Telegh. Cap. St.	143½–144½	5 13 9	..	..	
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	98⅝–100½	3 19 6	Jan, July	..	
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	102–104	4 16 0	Mar, Sept	..	
5	3/0	Chili Telephone	8–8⅜	4 16 0	August ..	..	
1	0/7½	Monte Video Telephone Ord.	⅞–1	6 0 0	Nov	..	
1	0/6	Do. 5 per Cent. Pref.	13/16–15/16	5 7 0	May, Nov	..	
St.	6%	National Co. Pref. Stock	107–108½	5 10 6	Feb, Aug	108	1
St.	6%	Do. Def. Stock	119½–121½	4 19 0	Feb, Aug	120½	1
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½–11	5 9 0	Feb, Aug	..	
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10–10¾	5 11 6	Feb, Aug	10⅛	
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 7/16–5 11/16	4 8 3	Feb, Aug	5 7/16	
St.	3½%	†Do. Deb. Stock 3½ per Cent. (red.)	97–99	3 11 0	June, Dec	97½	
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	99–101	4 19 0	Jan, July	102	
1	1/0	Oriental	1 6/16–1 7/16	5 7 8	April, Oct	1⅜	
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16–1 3/16	4 17 6	April, Oct	.	
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86–88	4 11 0	Jan, July	..	
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98½–100½	4 9 6	Jan, July	..	
5	3/0	United River Plate	6 11/16–7 1/16	5 13 3	July	6 11/16	
5	2/6	†Do. 5 per Cent. Cum. Pref.	5⅛–5¼	4 15 0	June, Dec	5 3/16	
St.	4½%	†Do. 4½ Deb. St. Red.	102–103½	4 7 0	Jan, July	—	
		FINANCIAL INVESTMENT, &c.					
5	3/0	†Elec. & Gen. Investment 6% Cum. Pref.	3–3½	8 11 6	Jan, July	..	
10	5/6	Globe Telegraph & Trust	10¼–10¾	6 7 0	SpDcMrJu	10¼	1
10	3/0	†Do. 6 per Cent. Pref.	12⅞–13⅜	4 11 0	SpDcMrJu	13 1/16	1
10	6%	Submarine Cables Trust (Cert.)	128–131	4 11 6	April, Oct	..	
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	†Anglo-Argentine 6% Cum. 1st Pref.	6–6½	4 18 0	April, Oct	6 1/16	
5	5/0	†Do. 10% Non-cum. 2nd Pref.	9¼–9½	5 5 0	Jan, July	9¼	
St.	4%	†Do. 4% Deb. Stock	91¼–91¾	4 7 0	June, Dec	91½	
St.	5%	†Auckland Elec. Trams. 5% Deb. (red.)	100–102	4 18 0	Jan, July	102	1
5	3/6	Brisbane Electric Trams. Invest. Ord.	6⅜–6⅝	4 19 0	May	6 7/16	
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5¼	4 15 0	May, Nov	5 3/16	
St.	4½%	†Do. 4½ per Cent. Db. Prov. Certs.	100½–104½	4 4 0	Jan, July	..	
St.	8%	British Columbia El.Ry.Df. Ord.	145–147	5	Mar, Sept	146½	1
St.	6%	Do. Pref. Ord. Stock	121–124	4 .. 0	May, Nov	123	1
St.	5%	Do. 5% Cum. Perp. Pref. Stock	110–113	4 8 6	Jan, July	110½	
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102–104	4 6 6	April, Oct	..	
100	4½%	Do. Vancouver Power Debs.	102–105	4 5 6	Jan, July	..	
St.	4½%	Do. 4½% Perp. Con. Deb. St.	99–101	4 19 0	—	100½	
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99–101	4 19 0	Mar, Sept	100½	1
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96–100	6 0 0	Feb, Aug	..	
5	2/0	Calcutta Tramways (1 to 137,610)	4⅝–4¾	4 14 9	Mar, Sept	..	
100	2/6	†Do. 5 per Cent. Cum. Pref.	4½–5	5 0 0	Jan, July	..	
1	4½%	†Do. 4½% 1st Deb. Stock (red.)	97½–100½	4 9 6	Jan, July	..	
St.	..	Cape Electric Tram Shares	⅛–⅜	..	..	..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅝–5⅞	4 5 6	F,My,A,N	5 3/4	
St.	4%	†Do. 4 per Cent. Deb. Stock	98¾–101	3 19 0	June, Dec	..	
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95–98	5 2 0	May, Nov	96½	
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80–83	6 0 9	June, Dec	..	
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93–96	5 4 0	Feb, Aug	..	
1	..	Kalgoorlie Elec. Trams Sh.	1/32–3/32	..	..	..	
..	—	Do. 5 per Cent. "A" Deb. Stock	87–90	5 11 0	Jan, July	..	
100	5%	Do. 6 per Cent. "B" Ditto	63–67	9 0 0	Jan, July	..	
5	6%	Lisbon Elec. Trams. Ord.	1 5/16–1 7/16	4 14 0	July	..	
5	1/0	Do. 6 per Cent. Cum. Pref.	13/16–1 1/16	6 1 0	Jan, July	..	
100	0/7½	Do. 5 per Cent. Reg. Mort. Debs	93–97	5 2 6	Jan, July	93½	91
St.	5%	†Madras Elec. Trams. 5% Deb. Stk.	90½–93½	5 7 0	Jan, July	..	
St.	5%	Manila Elec. Ry. $1,000 Gold Bonds	94–96	5 4 0	Feb, Aug	..	
..	5%	Mexico Trams Co. Com. St.	124–127	3 18 9	..	129	12
100	$1½	Do. Gen. Con. 1st Mort. 5% Gold Bds.	91½–93½	5 7 0	..	92	91
..	5%	Montreal St. Ry. Sterling 4½ per Cent.					
St.	4½%	Debs. (1922) (Nos. 601 to 2,000)	103–105	4 6 0	Feb, Aug	..	
		Do. do. (Nos. 1 to 4,600)	102–104	4 6 6	..	..	
St.	4½%	Perth Elec. Trams Ord.	⅝–⅞	8 0 0	May	11/32	
1	0/6	†Do. 1st Mt. Db. Stock	100½–103½	4 16 6	Jan, July	—	
St.	5%	†Rangoon Elec. Trams & Supply Co. 6%					
5	3/0	Cum. Pf.	5⅝–5¾	5 4 8	..	..	
		†Do. 4½% 1st Mort. Deb. Stk.	98–100	4 10 0	..	..	
St.	4½%	Rio Janeiro Tram, Lt. & P. Co.	85–87	..	..	90½	82
100	..	Do. 30 yr. Gold Bnds.	95–96	5 3 6	..	96	95
..	5%	Do. 10 yr. Mt. Bnds	83–85	..	..	84½	83
100	5%	†Sao Paulo Tramway, Light & Power Co.					
—	$2½	$100 Stock	145–148	6 8 3	..	148⅜	..
		Do. 5 per Cent. 1st Mt. $500 Db.	95½–97½	5 2 6	June, Dec	97½	97
..	5%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	99–101	4 11 0	Feb, Aug	..	..
100	4½%						
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛–5⅜	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½–10	6 0 0	..	—	..
St.	4½%	†Do. 4½ per Cent. Deb. Stk. (red.)	93–95	4 14 0	Jan, July	..	—
5	4/9	Calcutta Elec. Supply Ord.	5¾–6¼	6 8 0	April, Oct	..	..
100	$1½	Canadian Gen. Elec. Co. Com. St.	120–123	5 14 0	..	121¾	120
100	$3½	Do. 7% Cm. Pf. Stock	121½–123½	5 13 6	..	123	121
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	97–101	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	87–89	5 12 0	—	88½	88
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	..	..	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Deb Stock	...	5 8 0	Jan, July	—	..
St.	5%	†Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	83½–83½	5 13 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½–2	—	..	—	..
10s	4	†Kalgoorlie Elec. Power & Ltg. Ord.	¼–¼	..	..	..	—
1	0/7½	Do. 6 per Cent. Cum. Pref.	25/32–⅞	6 17 0	April, Oct	13/16	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76–80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83–85½	5 17 6	..	84½	83½
St.	$1	Mexican Lt. & Power Co. Com. St.	67–70	5 13 6	—	69	67
500	5%	Do. 5% 1st Mort. Gold Bnds.	86–88	5 13 6	..	87½	85
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	121–125	4 16 6	F,My,A,N	123¾	122
1	1/7½	River Plate Electricity Co. Ord.	1⅜–1½	5 6 8	April	..	..
1	1 2⅝	Do. 6 per Cent. non-Cum. Pref	1 1/32–1 5/32	5 4 0	May	1 1/32	..
St.	5%	†Do. 5 per Cent. Deb. Stock	102–105	4 15 0	Jan, July	103½	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 3/16–5 5/16	5 7 6	April, Oct	..	—
100	$1	Shawinigan Water & Power Co. Ca	92–95	4 5 0	—	94	93
..	5%	Do. 5 per Cent. Bds.	106–108	4 12 6	Jan, July	107½	106½
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	96–98	4 12 0	..	97½	97
..	6d.	Victoria Falls Power Co. Pref.	21/32–23/32	5 18 0	Jan, July	21/32	..

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NOTES.

The C.M.B. Auto-Converter.

It is an interesting coincidence that whereas last week we had to chronicle the arrival of a 200 volt 16 c.p. metal filament lamp, we are able this week to describe a simple machine which promises to do for the consumers connected to continuous-current supply mains what the auto-transformer has already done for the alternating-current consumer. An important difference, however, between the two cases is that the new auto-converter for continuous currents, which is being placed on the market by Messrs. Crompton & Co., is only intended for use by large consumers, say, those whose load is 1 kw. or above. Nevertheless, the C.M.B. auto-converter, as it is called, is almost certain to arouse much interest in the electricity supply world, where it will probably be regarded as a strong competitor of the motor-generator; and as its efficiency is appreciably higher than that of the latter machine for a similar output, the additional advantages of reduced floor space required, smaller weight and cheaper cost are likely to appeal largely to central station engineers. It would appear, moreover, that the capabilities of the machine are likely to lead to extensive applications, for it has already been adapted experimentally to the control of electrical vehicles, and other possibilities are indicated in the descriptive articles elsewhere in this issue.

Electricity in Coal Mines.

On another page we publish an abstract of an interesting Paper on "Electricity in Coal Mines," read by Mr. Robert Nelson at the last general meeting of the Institution of Mining Engineers. Some of the remarks contained therein are exceedingly pertinent in view of the regrettable calamity which occurred at a Nottingham colliery only a few days ago. The difficulty of securing an efficient earth at the coal face is no new one, but is, none the less, of extreme gravity. It is obvious that a coal cutter cannot well be connected directly to earth at the point where it is working, simply because it is always on the move. There are two possible solutions, both of which are discussed by Mr. Nelson; one is to employ a continuous uninsulated return securely fastened to the frame of the cutter, and the other is to make use of an insulated conductor connected to the cutter frame and carried back to the gate-end switch, where it is made fast to a substantial earth. The author describes a special type of gate-end switch designed to deal with this problem, in which the earthing conductor consists of two wires connected to separate parts of the cutter frame. These wires constitute two cores of the trailing cable, and are carried to the gate-end switch through a five-way plug, in the case of a three-phase system. An excellent feature of the device is that the switch cannot be closed unless there is a complete circuit through these earthing conductors, while the connecting plug cannot be withdrawn so long as the switch is closed. It thus appears to be impossible for any person to get a shock from the cutter frame.

In dealing with problems of this nature it must be remembered that the conditions of working at the coal face are exceptional. The temperature is unusually high, there is often a considerable amount of moisture on the ground and the coal dust is extremely dense. Add to these facts the further one that the work and workers are generally very rough, and the wonder is that many more accidents do not occur. Nevertheless, no pains should be spared to render miners free from the risks of electric shock, and the matter is one that should, and undoubtedly does, receive due attention from manufacturers of electric coal-cutting machinery.

Portable Lamps.

In our Correspondence columns this week Mr. F. Johnston raises an interesting point in connection with the new Home Office Regulations for the use of Electricity in Factories and Workshops. In Regulation 13 it is stated that a lamp-holder shall not be in metallic connection with the guard or other metal work of a portable lamp. Our correspondent considers that if the metal work of the fitting is earthed it would also be advisable to earth the holder, and he thinks the word "not" has accidentally crept into the Regulation; his supposition is, however, erroneous. It will be seen, by regarding the Regulation as a whole, that the requirement of earthing the metal work of a portable lamp depends upon whether the person handling the lamp is liable to get a shock if the metal becomes charged. If the circumstances necessitate the earthing of the frame, it is evident that the lampholder must then be efficiently insulated, since it cannot be earthed by the same wire or to the same earth-plate without being placed in metallic connection with the guard. By insulating the lampholder, however, there is less chance of the guard becoming alive, and therefore less reliance is placed on the efficiency of the earth connection.

That the regulation is very generally understood and applied is proved by the numerous portable lamps of recent manufacture we have seen, in which the lampholder is well protected by an ebonite or wooden sleeve so that it is practically impossible for an accident to occur owing to a lampholder becoming alive. Switch lampholders are especially inadvisable on portable fittings, and as regards replacing a lamp, this can be easily carried out without the slightest danger in the new hand lamps to which we have referred. As doubts are almost certain to arise in connection with the interpretation of some of the Regulations, further information may in some cases be necessary, and we believe a Memorandum is in preparation, and will shortly be published, dealing with a number of points which have arisen.

Exhaust Turbine Operation.—The "Zeitschrift des Vereins Deutscher Ingenieure" recently contained an article on this subject in which the operation of a 3,200 kw. exhaust turbine installed at the Gutehoffe mines was described. This turbine is supplied with exhaust steam from the winding machines, compressors, steam-driven ventilators and coal-washing apparatus. The steam is collected in three pipes, at a pressure of 0·2 atmosphere, and is thence supplied to Rateau exhaust turbines, each 1,600 kw. in capacity and driving Brown-Boveri generators supplying current at 3,000 volts with a frequency of 50. These machines exhaust into a surface condenser in connection with which cooling towers are also provided. Tests showed that with a load of 2,400 kw. the costs of operation were as follows: Wages and lubrication 0·014d., interest and depreciation 0·067d., steam 0·037d., total 0·118d. Taking the cost of generating a kilowatt-hour by means of a live steam turbine at 0·35d., the saving with the exhaust steam arrangement, supposing the yearly output to be 17,280,000 units, would be £20,000.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Dakar—Conakry	May 13, 1909	—
Tangier—Cadiz	May 19, 1909	—
Tourane—Amoy	June 17, 1909	—
Trinidad—Demerara	June 21, 1909	—
Fort de France—Paramaribo	June 28, 1909	July 2, 1909

New Cable to Argentina.—The important project submitted by the Western Telegraph Co. to the Argentine Government, in the terms of which the company would lay a cable to Buenos Ayres, via Ascension, giving Argentina direct telegraphic connection with Europe, has passed the Argentine Senate.

Royal Society of Arts.—On Wednesday last the council of this Society attended at Marlborough House, when H.R.H. the Prince of Wales, president of the Society, presented the Albert Medal to Sir Andrew Noble, F.R.S., "in recognition of his long continued and valuable researches into the nature and action of explosives, which have resulted in the great development and improvement of modern ordnance."

Electric Purification of Steel.—A patent recently issued to the Bismarckhütte describes a method of improving steel produced in electric furnaces. The steel, previously refined in a basic electric furnace, is passed into a crucible with an acid lining and allowed to settle. A mechanical readjustment takes place, the steel taking up silicon, which, it is claimed, has a favourable influence on the internal structure of the steel. In addition, the production of iron alloys or the addition of modifying agents can be easily controlled. The latter is accomplished by passing the unalloyed steel into the crucible before adding the modifying constituents.

Marseilles International Congress of Applied Electricity, 1908.—The results of the deliberations of this Congress, which, it will be remembered, was held at Marseilles in September of last year, have just been issued. They make up three large volumes, the first two of which are taken up with "Rapports Preliminaires," consisting practically of Papers by various authorities on which the discussions at the sectional meetings were based. The range covered is extremely large, as the Congress was divided into a number of sections covering practically every branch of electrical engineering. From the first the organising committee recognised the necessity of providing a basis of discussion at the various meetings, and for this reason a number of preliminary reports were prepared on certain questions. These reports, which, as mentioned above, are contained in the first two volumes of the "Proceedings," represent the individual work of a number of authors, while the third volume contains the discussions which took place at the various meetings of the Congress. There are also a certain number of written communications on the Papers, and these, in fact, form by far the larger part of the third volume. As regards official representation from the various Governments, a number of countries, including Great Britain and Germany, were not represented, though a total of about 1,400 members attended in all. It is impossible to give any adequate idea of the information contained in these volumes, but they should form an excellent work of reference in future, showing, as they do, the state of the electrical industry in 1908.

New Locomotives for the New York, New Haven & Hartford Railroad.—According to the "Electric Railway Review," the New York, New Haven & Hartford Railroad has recently placed an order for two freight locomotives to be employed on its main line. One of these locomotives is to be equipped with side rods and the other is to be of the geared type. It is understood that tests will be made with these locomotives to determine (1) the relative performance of electric and steam locomotives for freight service and (2) the relative advantages of the two types of locomotives which are to be employed. So many conflicting reports have appeared in the technical and public press in regard to the proposed extension of the New Haven electrification that it may be well to give the facts. The performance of the present electrical system is very satisfactory, and the number of engine-miles per failure is far larger than with steam operation. During the month of May it amounted to 7,345. The engineers of the company have made a very careful investigation as to the cost of electrifying the company's six-track Harlem River branch and the four tracks of the main line from Stamford to New Haven, inclusive of the necessary power houses, looking to the handling of passenger and freight trains. The investigation also covers the trackage incident to the electrification of freight and passenger yards. These estimates have been filed with the directors of the company, but no definite action has been taken by them looking to immediate extension of the system. It is proposed, however, during the next few months, to extend the present

electrification from Stamford for the distance of 1 mile for experimental purposes. The overhead construction will differ somewhat in regard to the form of steel bents and arrangement of overhead wires from those previously used, but these changes are incident only to the improvements in forms of construction and reductions in cost. The main features of the present form of construction, including a steel contact wire suspended every 10 ft. by clips of the present design from an overhead copper conductor, will be retained.

Aluminium Lightning Arresters.—A recent issue of "Engineering News" contains a description of a modern installation of aluminium lightning arresters to protect the transmission system of the Schenectady Power Co.'s 40 cycle three-phase generating station on the Hoosick River, N.Y. From this station, electrical energy to the amount of 12,000 kw. is transmitted at 32,000 volts to the works of the General Electric Co. at Schenectady, a distance of 21 miles. The main overhead lines enter the sub-station through six roof-entrance bushings, and horn gaps are placed between the lines and the arresters inside the station. Besides serving as spark gaps to prevent full voltage from being continuously impressed on the arresters, the horn gaps can be used as short-circuiting switches, by virtue of their adjustability, and are used in this way to connect the arrester momentarily with the line for the purpose of renewing the electrodes of the aluminium cells. The gaps are arranged so that one horn of each pair may be revolved about its support through 90 deg., to serve as disconnecting switches for isolating the arrester from the line when desired. At the power station end of the line the arresters are installed in fireproof compartments in the rear of the switchboard, while the horn gaps are placed on the roof. Each arrester unit consists of a series of aluminium plates dished to a conical shape and placed in a stack, points down, one above another, with a vertical spacing of about 0·3 in. between surfaces, the spaces between cones being partially filled with an electrolyte. The supporting rods are of wood and the cones are separated by washers of non-conducting material, so that the only electrical connection between any two cones is through the electrolyte. The stack of cones with the electrolyte in place is immersed in oil in a cylindrical steel tank with welded seams. The electrolyte has a greater specific gravity than the oil and therefore is not displaced on immersion. The oil not only improves the insulation between the conical plates, but prevents evaporation of the solution, and, due to its heat absorbing capacity, enables the arrester to discharge continuously for long periods without overheating. On both surfaces of each conical plate a thin film of aluminium hydroxide is deposited by an electro-chemical process. This film has the property of offering a very high resistance to the flow of current up to a definite critical voltage. The renewing of the films on the plates is effected by allowing daily a small current to pass through the stacks for an instant by closing the horn gaps. The presence of the gaps normally prevents the flow of current through the arrester from the line unless the operating voltage is exceeded.

The Iffland System of Electric Winding.—A recent number of "Gluckauf" describes an installation which has been put down at the Kaliwerke Friedrichwerke. The generating station at this place contains two tandem steam engines, one of which has an output of 900 H.P. to 1,200 H.P., and the other from 450 H.P. to 600 H.P., when running at 107 revs. per min. Both these are coupled to three-phase generators, which supply current at 2,200 volts for lighting and other purposes. Another small steam engine having an output of 150 H.P. is also coupled to a three-phase generator. For excitation purposes three three-phase-continuous-current motor-generators are used, and are connected to an exciter battery. When the station is shut down the battery can supply power to the network through these machines. The depth of the shaft at these mines is 900 ft., and 75 tons have to be drawn up per hour. The winding motor is coupled to a Koepe pulley, 20 ft. in diameter, and is supplied with current from a controlling dynamo, whose pressure varies between +500 and −500 volts. This dynamo is permanently connected to a booster which can supply 1,030 amperes at 500 volts in connection with a battery of 236 cells. The whole of these sets, consisting of the controlling dynamo and the booster, can be connected with either of the steam engines. When the load comes on suddenly the booster begins operating, being driven by the battery as a motor, and assists the steam engine in driving the controlling dynamo. When the brakes are put on, the booster works as a generator, and supplies current to the battery, so that the steam engine works at a constant load. A special transforming arrangement, as used in the Ilgner system, is, therefore, unnecessary. In order that the booster may work in the way stated above, its voltage must be dependent on the load on the winding motor. This is effected by using a second dynamo, which is connected to the field of the booster, and supplies current against the excitation of the battery. This dynamo is excited in proportion to the load on the winding motor, and runs at the same speed as the latter. For bringing the winding motor to rest a compressed air brake with two cylinders is used. The necessary compressed air is supplied by a small compressor worked by a 500 volt direct-current motor.

Electric Refrigerating Plant at Philadelphia.—The following information on this subject is taken from the report by H.M. Consul at Philadelphia (Mr. W. Powell) on the trade of that district in 1908. A refrigerating plant, worked by electricity, has recently been established in Philadelphia, and although it can hardly claim to be a pioneer establishment, it is an installation representing the most recent progress in the direction of cooling without ice. The apparatus occupies two stories in the building where it is installed. On the ground floor there is situated one large cooling room, on the second floor there are three separate rooms used as freezers. The pickling room is situated in the rear of the second floor; a portion of this room is partitioned off for the brine tank, which is situated here as being the best available space. The machinery installed includes two 25-ton refrigerating machines, each driven by a 50 H.P. electric motor through chain gearing, one triplex plunger brine pump driven by a 5 H.P. electric motor, and one pump for condensing water worked by a $3\frac{3}{4}$ H.P. motor. The system employs a brine circulation exclusively, all the expansion coils being placed in the brine tank. This contains over 5,000 gallons of brine, which is cooled to a temperature of 5°F. to 8°F.; there is also a 6 H.P. electric motor for the lift. The object in putting in two refrigerating machines was to permit one machine to rest during heavy duty in summer, and also to allow for the growth of the business. The two machines have never yet been needed at the same time, six hours' operation in 24 hours for one machine in ordinary warm weather having been found ample. In winter weather, one hour's operation of one machine and about $1\frac{1}{2}$ hours' operation of the brine pump are all that is required to produce the desired temperature. The cooler usually holds about 20,000 lb. of meat, and is maintained at a temperature of 35°F. This room is well insulated with three layers of cork laid in asphalt pitch. There are three doorways, and the interior is lighted with incandescent electric lamps. In the shop the wall cases and the counter cases are also cooled by the brine pipe, which is placed above in the wall cases and at the bottom of the counter cases. These cases are made of glass, and being thus cooled permit the display of choice cuts of meat without fear of deterioration. The freezer room is divided into three sections, which can be used independently of one another, in order to get better results and to allow of considerable differences in temperature, as at certain seasons it is necessary to take care of various descriptions of food, some of which require a very low temperature. A temperature can be maintained as low as zero Fahrenheit in any one of the rooms if necessary, but a temperature of 15 deg. is found, as a rule, to be sufficient. The pickling room is found to be cold enough at 35°F., but on account of the presence of the brine tank in it the temperature is usually 30°F., with scarcely any circulation in the coils. It is difficult to compare the cost of working this equipment and the cost of ice as used in the older plants. With ice, the freezing rooms would not be possible, and the low temperature of the other parts of the plant could not be maintained with the same regularity. Outside storage charges would be incurred. Calculations indicate that not less than 150 tons of ice per month would have been necessary, and at the prevailing prices this would have cost $375 (about £78). The average bill for electric power has proved to be about $190 (about £39. 10s.).

ELECTRICITY IN COAL MINES.*

BY ROBERT NELSON.

Summary.—The author describes the difficulties experienced in employing electrical apparatus in coal mines and makes suggestions for meeting them. For this purpose he considers separately (1) cables and transmission system, (2) switch gear, (3) motors and transformers, and (4) lighting.

No system of power transmission is altogether free from danger; care in design, maintenance, and operation is therefore essential, whatever system may be adopted. Even under the severe conditions which obtain underground, however, mine-owners may confidently avail themselves over a very wide field of the advantages which electricity offers as a power agent, given due care, firstly in the choice and secondly in the installation of the apparatus. The dangers of electricity in its application to coal-mining work underground (and all subsequent remarks have application only to plant underground, not to plant on the surface) are two in number, namely:—(*a*) Danger of shock to persons, owing to contact with "live" metal. (*b*) Danger to persons and property, through the ignition of explosive gas or coal-dust by an electric spark.

As technical considerations practically necessitate that all colliery motors of any size must work at a higher voltage than 150, the limit of dangerous pressure from a shock point of view, the possibility of a fatal accident from shock is present in all colliery power installations, and must therefore be guarded against. Again, the current of modern opinion seems to be setting in in favour of the view that danger from sparking is largely independent of voltage; that is to say, it is not obviated even if the pressure be kept below the 150 volts referred to. To avoid this sparking danger, it is necessary to isolate or limit the volume of explosive mixture which might be ignited under normal conditions of working, preferably by arranging for circuits to be made and broken under oil; or if this be impracticable, as it is if the current be continuous, in properly designed explosion-proof chambers.

The practical requirements for safety in operation may accordingly be stated to be:—(1) Strong metallic coverings wherever accidental contact with current-carrying parts would otherwise be possible. (2) A good earth connection for metallic coverings of apparatus. (3) Provision for cutting off current automatically as soon as leakage begins to occur.

The author proceeds to consider the difficulties experienced in meeting these requirements underground, and suggests means of meeting them.

The Cable System.—The opinion was frequently expressed during the Departmental Committee proceedings on the use of electricity in mines that the chief danger to be apprehended in working would arise from the cables in a mine rather than from the motors and apparatus, that is to say, from the transmission of electricity rather than from its application; and there is much to be said in support of this view. The question of the relative merits of the three-phase system of distribution as against the continuous-current system occurs at the outset, and the writer is tempted to reply at once and without qualification in favour of the first-named system. The sole merit of the continuous-current system appears to him to rest upon the possibility of using the concentric system of working with a continuous uninsulated return in pits where safety-lamps are not required, and where the limit of medium pressure is sufficient for economical distribution. The concentric system has special advantages also where coal-cutters are extensively used, for no doubt can then exist as to the frame of each machine being effectively earthed. The system is, however, inherently one of limited range, and three-phase systems are here only considered.

Wherever chemical investigation shows that the water in the pit will not attack lead, a lead-sheathed and armoured cable is recommended. The alternative is fibre insulation with a sheathing of vulcanised bitumen. Cables of this kind have some advantage from the point of view of keeping supply going in the event of damage from a fall, but the inherent disadvantages of an unarmoured cable system appear overwhelming, namely:—(1) Increased possibility of an arc appearing external to the cable; (2) difficulty in securing a good "earth" for in-bye apparatus; and (3) danger of shock from bare parts of damaged cable. One of the chief uses of the lead sheathing is to provide a continuous metallic covering (in addition to the armouring) which may be earthed, and thus provide a "dead" earth inside the cable itself in case the insulation should be destroyed and one of the copper cores become displaced by mechanical damage. For this reason if an armoured cable with vulcanised bitumen insulation is decided upon, a continuous copper sheath may be used instead of a lead sheath. A cable of this kind has one advantage in being more flexible than a lead-sheathed cable. But whatever type of cable be installed, both metallic sheathings, the armouring and the lead (or copper), should be connected to two earth-plates—one at the bank and the other underground—both placed in carefully chosen surroundings. The obtaining of a good earth is considered in an appendix. Where disconnecting boxes and joint-boxes are inserted the cable armouring should be securely fastened in metal outlet boxes so as to secure good mechanical and electrical connection, and the lead sheathing should be bonded inside the box. The point to be observed is that metallic sheathings should be continuous from dividing box to dividing box—that is to say, from the point where the three cores are separated for convenience in joining to the control switch at the generating station, to the point where they are again separated for connection to the transformer or motor switch.

Next, as to the risk of a spark appearing external to an electric transmission cable underground. Electrical circuits are ordinarily protected in two ways:—(1) by fuses, and (2) by maximum cut-outs. The first method is the cheapest, but it is uncertain in action, and in any event is not always admissible. The second method is that generally adopted in the case of main transmission lines in collieries. The provision of merely a fuse or a maximum cut-out does not, in the writer's opinion, afford complete protection for a transmission line in any place where General Rule No. 8 of the Coal-mines Regulation Act may be said to apply—that is to say, anywhere where safety-lamps are compulsory. There is, however, already on the market a method of protection which it is suggested may offer a solution of the difficulty. The action of this new protective system depends upon the physical fact that the current leaving a length of cable is exactly equal in amount to the current entering that length of cable, if the conditions be normal. But in the event of leakage there is no waiting for the leakage current to reach a certain value and thereafter to establish its bona fides by maintaining this or a higher value; the cut-out is put into action immediately and the circuit itself is broken as soon as the switch has had time to open. This is the outstanding feature of the new protective system,* and it cannot be claimed for any other system of cable protection.

The above method of applying the system requires a pilot wire to be run the whole length of the transmission main to be protected. It is possible, however, in the case of colliery cables (where, in general the various circuits to be protected radiate from a common point, and are not inter-connected) to apply the balanced principle without pilot-wires, and indeed to existing cables at comparatively little expense, in cases where the neutral point of the transmission system is permanently connected to earth—an arrangement recommended on other grounds. Instead of making use of the fact that the electrical conditions are similar in normal circumstances at the points of entry and exit, it is possible to base the action of the cut-out on the physical fact that the amount of current entering and leaving the main at the supply end thereof (through the several cores of the main) must at every instant be equal unless there is a leakage. Apparatus working on this principle would not operate when ordinary working overloads occur. It is, however, extremely easy to adapt such apparatus so that it combines all the features of an ordinary maximum cut-out with its own particular characteristic as regards leakage. If a cut-out of this type were placed above-ground, and through it power were fed to a distribution point in the pit below, a leakage on any one of the individual motor circuits fed from such distribution point, or a leakage on the main cable down the shaft, would operate the cut-out gear instantaneously, whilst ordinary overloads—unless greater than a pre-determined value and maintained for an appreciable period—would not operate it. A better plan perhaps would be to instal cut-out gear on each individual motor circuit at the main distribution centre below ground, and to provide pilot wires in the main shaft cable feeding such centre. If balanced protective gear of the type first described were then installed on the shaft-cable, the cut-out above ground would not operate unless a leakage actually occurred in that cable. Thus, although a leakage on a motor circuit underground would at once operate the cut-out controlling that circuit, the main cut-out above ground would remain closed, and all the motors except that on the faulty circuit would continue to run. The makers of the new protective gear might consider the advisability of demonstrating by experiment its effectiveness under varying conditions, as if it will in all circumstances prevent a spark from penetrating the armoured covering of a cable to the outer air, the problem of the safe transmission of electricity in collieries would seem to be very near solution.

Although hard and fast rules cannot be laid down, it should be accepted that the use of unarmoured cable should be limited to cable

* Abstract of a Paper read at the General Meeting of the Institution of Mining Engineers.

* The Merz-Price Patent Protective System. *See* THE ELECTRICIAN, June 12, 1908, p. 331.

for portable apparatus and to end-connections where there exists no danger from falls or of firing timber work; that junction and other boxes should not be opened with current on; and that inflammable or explosive material should not be stored in the neighbourhood of electric mains. One other point on which there may be unanimity is the use of well-protected but unarmoured trailing cables for coal-cutters. Such cables should, however, be provided with an extra wire, or pair of wires, for the purpose of ensuring a good earth connection for the machine frame. A gate-end switch of special design, hereafter described, seems to secure this result in practice most effectively. Additional protection over and above heavy braiding is required by trailing cables, and the most successful forms of protection seem to be plaited leather and a hard light rope covering, the latter wound round the cable spirally. Rope protection has some advantage in cheapness and in the ease with which it can be repaired. Well-designed plug connections for both ends of a trailing cable are essential, and the leads, from starting or controlling switch on machine frame to motor, should be completely protected from end to end, and not left exposed as is so frequently the case.

In connection with the use of unarmoured cable, it must be remembered that ordinary rubber insulations ignite easily and burn freely. Certain precautions are therefore necessary; the wires should be carried on porcelain insulators, giving at least 1 in. separation from the surface wired over; they should be supported at fairly short intervals, and separated from each other and from contact with side walls, roof, floor, and roof supports, by a few inches of air space. It would be well to specify for underground work insulation the interstices of which have been filled with fire-proof compound, and it is particularly recommended that slow-burning cable of this kind be used where wires are brought together at the back of switchboards or large distribution boxes.

Switchgear.—The general principles of design may be briefly summarised as follows:—(1) Accidental contact with any live metal should be rendered impossible by an earthed metal outer covering. (2) The make and break in the case of three-phase circuits should be under oil. (3) The design should be such as to preclude the possibility of coal-dust, dirt, or moisture diminishing the insulation. (4) There should be a minimum amount of cleaning necessary to maintain the gear in good condition. (5) Ready means should be provided for making the whole or part of the apparatus dead, so that inspection and cleaning may be done in safety. (6) The construction should be mechanically strong, so as to resist rough usage. (7) The switch must be of ample capacity. (8) There should be automatic protection for each circuit.

Switchgear to fulfil the above conditions can be obtained from well-known makers; one or two special pieces of apparatus are, however, considered in detail. A great deal of the switchgear in present use errs, in the writer's opinion, on the side of too little clearance. Greater generosity in this respect, combined with closer attention than is frequently given to the construction of gas-tight joints, would be of advantage. The usual method of making a gas-tight joint is to use a rubber-joint ring. It is commonly said, however, that although this may be perfectly satisfactory above-ground, conditions are different underground, and sooner or later a poor joint will be made, or a cover will be left off altogether. In the case of boxes often opened, a plain "metal to metal" joint is probably the best solution, either a flange joint, or a turned and fitted V and groove. No difficulty should be experienced in securing a gas-tight joint of this kind; failure can only arise through carelessness or incompetence. The modern tendency is, however, to construct "explosion proof" rather than gas-tight joints. The writer has recommended a metal to metal joint, and the flanges should not be less than 1¼ in. wide. The principle underlying this construction is that of the Davy safety lamp.

One feature common to many switch and fuse boxes in present use appears to the writer to merit emphatic condemnation, namely, the combination of a narrow rubber joint ring with a hinged box cover. A safety joint should be made by dropping the cover flat in its final position, and it should be secured by a number of bolts in the same way as is a steam joint. But despite the comparative simplicity of the problem, there will hardly be two opinions on one point—namely, the fewer the boxes that require bolted joints in an installation the better.

At the present moment there is difficulty in obtaining oil-break switches with overload trip coils which will operate on circuits carrying less than 100 amperes. It seems to the writer that a reliable oil-break switch with an overload attachment for use on motor circuits of 10 H.P. and upwards would, practically speaking, do away with the necessity for fuse boxes on motive-power circuits, besides other advantages in greater rapidity and certainty of action in opening circuit. Where fuses are unavoidable, it should not be forgotten that totally enclosed fuses of the "cartridge" type can now be readily obtained in all sizes. The protection afforded can, however, be but partial, as in the behaviour of a fuse a great deal depends upon the capacity of the supply system. The writer has also heard a suggestion which may be of practical value—namely, that fuse boxes might be packed tightly with slag wool where it is thought that danger exists of igniting gas.

There is one special use of electricity underground which really deserves much more than passing consideration, and that is its use in driving coal-cutting machinery, which the writer believes experiences the worst treatment. Attention is called to a gate-end switch for coal-cutters, designed by Mr. H. S. Fisher of the Lambton collieries, County Durham, which has, it is claimed, the following important features:—(*a*) The switch is totally enclosed in a cast-iron box, so that no live parts are accessible to an unauthorised person. (*b*) Attached to the switch box at one end is a dividing box with glands and clamp to secure the armour of the incoming cable, and to earth the box efficiently. At the opposite end is a socket for the plug attachment of trailing cable. The latter plug when in place is interlocked with the switch, so that it cannot be withdrawn when the switch is closed; that is to say, it cannot be withdrawn when carrying current. (*c*) An adjustable overload release with "time" lag operates on each pole, removing the necessity for fuses. There is also a "no voltage" release. (*d*) The switch must have a special trailing cable with an additional pair of small cores, making a five-core plug and cable for a three-phase machine. This additional pair of cores (which does not appreciably increase the cost of a trailing cable, as the cores are small) is connected to two points on the coal-cutter frame; and the arrangements are such that unless this pilot circuit from switch to frame and back again to switch is complete, the gate-end switch cannot be closed. The effect is that unless the frame of the coal-cutter be properly earthed the gate-end switch will not operate; and if at any time during the working of the coal-cutter the pilot circuit in the trailing cable is broken by mechanical damage, the gate-end switch at once opens circuit. (*e*) A small switch on the plug at the coal-cutter, connected so as to break the above-mentioned pilot circuit, enables the man operating the machine to cut off supply instantly at a critical moment. If then this switch be left open, it prevents anyone switching on supply at the gate-end switch while inspection or repair is under way. Anyone who has had experience of coal-cutters in practical operation will appreciate that from the point of view of safety this switch represents a very considerable advance on older methods. The above method of protection is applicable either to a three-phase or to a direct-current system.

It has been said that the three-phase system is in general favoured for colliery work. In connection with switchgear this system enables oil-immersed switches, controllers, and even resistances, to be used when otherwise the circuit would require to be broken in air—an advantage almost sufficient, if none other existed, to justify the preference. The use of wire with "slow-burning" insulation and asbestos covered is recommended for resistance and controller connections.

Motors and Transformers.—In the recent interesting Paper by Mr. Simon,* read before the Glasgow Local Section of the Institution of Electrical Engineers, dealing almost exclusively with the protection of electric motors, the conclusion reached is that "plate" protection affords sound mechanical protection together with what is lacking in the case of totally enclosed motors, namely, ventilation. But Mr. Simon rightly recommends the grouping of the motors whenever possible in the neighbourhood of main air-ways, in separate rooms, separately ventilated with intake air, so as to avoid altogether the necessity for any special protective device. The Home Office rules require all motors located in places where General Rule 8 applies, and which are not separately ventilated with intake air, to be totally enclosed. The plate protection referred to cannot therefore be adopted at present in this country in lieu of total enclosure, but there can be no doubt as to the value of the idea from the ventilation standpoint, if it is demonstrably as safe as, or safer than, the latter.

Apart from any special conditions under which it may be set to operate, there is no safer apparatus for its purpose than an electric motor. Squirrel-cage motors can be used for almost every service, and should undoubtedly be utilised wherever possible. The terminals, if any, should be mounted on incombustible insulating material, covered and hermetically sealed; or, in the alternative, short lengths of cable should be brought out through suitably bushed openings in the motor-case, for the purpose of jointing to the incoming service leads, the joints to be made by connectors or otherwise. Motor rooms should, wherever possible, be separately ventilated by intake air. They are, however, often made too small, and they sometimes have an even worse feature in being constructed largely of inflammable material.

Transformers for use underground are almost universally oil-cooled. A difference of opinion, however, exists as to the earthing

* "Notes on Safety of Working Electrical Plants in Coal Mines," THE ELECTRICIAN, April 9, 1909, p. 1,014.

of the neutral point of each transformer secondary. In the writer's view it is better to earth these neutral points, as immediate warning is then given at the transformer station of an earth on any one of the outers by the automatic opening of the faulty circuit. The strongest argument against the earthed neutral is a "safety-from-shock" argument; but it is surely better to provide fully against accidental contact as far as it is possible to do so, rather than depend upon an arrangement which has some fairly obvious disadvantages against a single advantage, and one which may in practice prove illusory. In America the insulated neutral is common practice, but on the other hand Continental engineers incline to earthed neutral points. In England either arrangement seems to have been adopted indifferently.

It is unnecessary to emphasise the importance of permanently and effectively earthing both motor frames and transformer cases by stout wires. In connecting such an earth wire to the (already earthed) armouring or lead or copper sheathing of a cable, the earth wire should be sweated into a lug attached to a clamp, and the latter firmly bolted to the armouring or sheathing after all rust and scale has been removed.

Lighting.—Reference is made to the set of rules of the Institution of Electrical Engineers. Electric lighting underground is practically confined to places near the shaft-bottom and to motor rooms separately ventilated by intake air, and there can be no doubt that it should be so confined. A lighting circuit is as likely, or even more likely, to be the cause of a spark than is a motor circuit, and the greater difficulty of effectively controlling the current in lighting circuits is obvious. Wherever electric lighting is installed, only such switches and fuses as have been specially designed to meet the severe conditions underground should be used.

The widest latitude is given by the Home Office Rules on the subject of wiring for lighting circuits, but in the writer's opinion two systems only are possible:—(*a*) Open-type wiring, the wires being supported on porcelain insulators, and (*b*) a stout steel smooth-bored pipe (which may be protected from corrosion externally and have an insulating internal casing) to contain the wires. In dry places where there is no likelihood of a fall of roof there is a great deal to be said in favour of open wiring. On the other hand, in damp places or where mechanical damage is likely to occur, as in crossing haulage roadways or where the roof is low, protected wiring is necessary.

Reference is made to the new Home Office rule for safeguarding the use of portable hand-lamps, and the writer believes that this rule should also be observed in mines. When the system of distribution is three-phase, the use of small lighting transformers giving a secondary pressure below the danger point for shock, say of 100 volts or less, is recommended. With a voltage of this kind, portable apparatus in particular can be handled with much greater freedom and safety.

In conclusion emphasis is laid on the importance of using well-designed apparatus, of efficiently earthing all protective coverings and casings, and of drawing the attention of workmen to the danger of touching current-carrying apparatus, such as cables and motors.

In one appendix to the Paper are given the rules relating to high-tension apparatus at the Lambton Collieries, and in a second the author describes the arrangement for efficient earthing. Unless the conditions are altogether abnormal, a copper plate of 16 S.W.G., about 3 ft. by 6 ft. in area, buried in a damp place or below permanent moisture level, with 2 ft. of crushed coke both under and over it, should make a sufficient earth for an ordinary colliery installation. Two such earth-plates are recommended to make sure that one at least is fulfilling its duty. Should the ground be everywhere dry, the neighbourhood of an earth-plate should be frequently and freely watered. Main earth connections should be of copper and have a section of not less than 0·25 sq. in.

THE COMPOSITION AND DURABILITY OF CABLE PAPERS.

BY C. BEAVER.

(Of Messrs. W. T. Glover & Co.)

Introduction.—This subject was recently dealt with in these columns from the chemist's point of view in a series of articles by Messrs. Clayton Beadle and Henry P. Stevens (*see* THE ELECTRICIAN dated April 16, 23 and 30, 1909). The authors prefaced these articles by the statement that they were not electricians; but as the electrical engineer's point of view on this subject is too closely allied to that of the chemist's to be ignored, it appeared to the writer desirable to supplement what has already been written by a short statement of facts from the cable manufacturer's standpoint.

Maker and User.—In the following remarks the sequence of Messrs. Beadle and Stevens' statements will be followed as closely as possible for the sake of easy comparison of the two points of view.

The opinions the authors gave on the mutual ignorance of the paper maker and the cable manufacturer, as to the arts of the one and the requirements of the other, may be passed over with the remark that the matter is of such importance to both that the present degree of electrical excellence and physical durability of the best makes of paper insulated cables could never have been arrived at without close co-operation between them.

The requirements of the cable manufacturer, after long experience and research, may be regarded as having been reduced to

(*a*) Composition or constituents of the paper, and

(*b*) Mechanical constants (*i.e.*, tensile strength, elongation, and other points affecting the structure of the paper).

When these are fixed, and the paper is subjected to uniform treatment in the cable works, the electrical and physical properties follow. The relation between the composition and structure—the latter determining the mechanical constants—and the electrical and physical properties, is an extremely delicate one. So delicate indeed as to be almost incredible to any but those in close touch with all features of the production of paper insulated cables. This will be referred to later on, but it may be said, in passing, that an immense amount of experimental work has been carried out during the past 12 or 13 years by the writer, for the purpose of clearing up the large number of electrical and physical problems which have attended the development of such cables into their present state of excellence. The requisite accuracy for this experimental work could only be attained by careful adjustment of all conditions, from the selection of the raw materials for the paper to the final tests on finished lengths of cable.

Composition, &c.—To return to the parallel statement of the matter from the electrical and chemical points of view, the writer is in substantial agreement with Messrs. Beadle & Stevens as to the difficulty attending the identification of hemp fibres in a well-beaten fully-bleached paper in which both hemp and manila are present; but insulating paper pulp does not require bleaching, nor is it desirable to beat it more than is necessary to make a uniform sheet of paper. Further, with the keen co-operation of the paper maker, and the usual routine chemical and microscopic examination of the paper by the cable manufacturer, it is found quite possible to ensure that undesirable fibres do not enter into its composition to any great extent. Certain fibres, such as sisal, for instance, would be avoided by the paper maker for his own sake, because they do not felt well with manila and break up the structure, causing irregular mechanical tests to be obtained. With regard to the distinction between accidental admixture of other fibres with manila and deliberate adulteration, there certainly is no difficulty, because the fact that a small weight of paper makes a large area of sheet renders it very unlikely that an appreciable proportion of foreign fibre would be found in several places if its presence were accidental. In other words, average sampling of paper is easier than the average sampling of most other materials.

The difficulty of distinguishing foreign fibres in a manila paper fortunately relates chiefly to those of the harmless hemp or flax class. Those of ligneous character which may be regarded as detrimental to the durability and other desirable properties have characteristics by which they are easily distinguished.*

The authors' statements generally with regard to the composition of cable papers, are liable to give one the impression that a pure manila paper is a rarity. If their results are based on papers "offered," or "stated to be supplied" to cable manufacturers, the writer can understand them, because the paper maker who has not been educated by the cable manufacturer as to his particular requirements imagines that any grade of what his trade calls manila paper is suitable for insulating purposes. The result is that the cable manufac-

* "Some Points on the Selection of Electric Cables," Atkinson and Beaver, THE ELECTRICIAN, Vol. LIV., p. 784.

turer is flooded week after week with samples of alleged insulating paper which have not the remotest chance of ever being used for that purpose.

These come largely from America and Germany, and it is a curious fact that, while few samples from America contain anything but ligneous fibres of one kind or another, the best and most largely-used American paper cables are insulated with pure manila paper. On the other hand, German cables are mostly insulated with paper either containing wood pulp in large proportions or made exclusively from it. In fact, some German firms state openly that wood pulp papers are better than manila papers, though justification for such statement from electrical or physical (durability) points of view has neither been offered in support of the statement nor demonstrated in practice.

So far as the best cable makers' practice in this country is concerned, it is hardly the fact that "there appears to be a general recognition that paper need not consist entirely of manila," as stated by the authors. The writer's opinion is that paper made of pure manila, hemp or flax, or even mixtures of them, will always be superior as regards durability and electrical and physical properties to those made from ligneous fibres.

With reference to the mineral matter in cable paper, this is a point where the electrician's point of view is certainly the predominating one. The writer has proved that in papers containing only the natural amount of mineral matter, which for manila paper is usually between 1·3 per cent. and 3·2 per cent., a considerable variation in insulation resistance and capacity occur for ½ per cent. variation in mineral matter. Again, insulation and capacity are affected when the character of the mineral matter varies, but the writer has not definitely determined whether this is directly due to the difference in the mineral matter itself, or whether some change in the character or development of the fibre—due to the same cause which brings about the change in the normal mineral matter—accompanies the variation in the mineral matter and is chiefly responsible.

The type of variation in the mineral matter which may frequently be found in manila fibre, is from one which consists chiefly of silica, alumina and oxide of iron with traces of lime and magnesia, to one consisting chiefly of carbonate of lime with traces only of oxide of iron, alumina and magnesia.

It will, therefore, be seen that it is far more important, from the electrical point of view, to prohibit the addition of mineral matter, than from the standpoint of strength or durability, and the cable manufacturer would be aghast at the 10 to 20 per cent. of added mineral matter referred to by the authors.

Mechanical Constants.—We now come to the matter of mechanical constants, under which heading Messrs. Beadle and Stevens' remarks on tensile strength, elongation and proportion of air space fall. From the cable manufacturer's point of view the acquisition of an exceedingly high tensile strength is unnecessary so long as there is a substantial factor of safety to enable the paper when used on the cable to withstand all the mechanical strains that are likely to come upon it. It is certain that a manila paper which will comply with all other requirements has an ample margin in this respect, so that any plea for the use of chemical wood paper on this ground is superfluous.

The relation between longitudinal and traverse strength is important, because it has a direct bearing on the structure of the paper—*i.e.*, the felting of the fibres. The average ratio over several hundred tons of satisfactory insulating paper recorded by the writer has been 2·02.

As a further check on the structure of the paper the writer has found that the percentage elongation in both directions gives a useful indication. The average figures are 2·2 per cent. for the longitudinal direction and 4·4 per cent. for the transverse direction, giving a ratio of 0·5. The writer was surprised to notice that elongation figures were not recorded by Messrs. Beadle and Stevens.

The air-space volume measurement described by the authors is an admirable analytical method of determining a feature which is of great importance from an electrical point of view, and supplements the mechanical tests in their bearing on the structure of the paper.

The whole matter of constant average structure has an important bearing on the uniformity of electrical properties, and affects dielectric strength, insulation resistance and capacity, especially the two latter properties, which vary very considerably with structure. In this connection the writer certainly cannot agree with the authors that the paper in a cable should be regarded as the medium which holds the insulator.

Manufacture.—With regard to the process of manufacturing paper outlined by the authors, no mention was made of the magnetic arrangements which are used to extract iron and magnetic oxide particles from the pulp of which insulating, photographic and other important papers are made.

Another important point in the purification of the "half stuff" is the elimination of oily particles where the pulp is prepared from manila and hemp ropes. These particles turn up in the finished paper as carbon spots, which may easily be detached, leaving holes right through the thickness of the paper. In the early days of paper-insulated cables, it was difficult to find a square foot of the raw paper—certainly not a square yard—free from carbon spots, so that this source of weakness in a cable dielectric was not an imaginary one. Now-a-days they have to be hunted for.

As to the matter of resin sizing, while this is permissible to the extent the paper maker requires to assist him, if used in excess it has a detrimental effect on the capacity of dry core paper insulation, which the writer presumes is what the authors referred to as Post Office insulation.

Impregnating Paper.—The writer is in cordial agreement with the authors' views as to the uselessness of bestowing great care on the composition and structure of insulating paper without due regard to the chemical stability of the impregnating medium under all working conditions to which the cable may be submitted. In the early days of paper cable manufacture, some trouble in this direction was experienced in this country, but during the past 13 years the writer has not encountered an instance of conductor corrosion in British cables traceable to this cause.

On the other hand, in German cables it is comparatively common to find traces of it at the present time. This statement is made by the writer with reluctance and absolutely without prejudice, and would in all probability be supported by the experience of Messrs. Beadle and Stevens, and many other impartial authorities. The whole matter of the chemical stability of all constituents of a complete dielectric is one of the elementary features of the cable maker's art, and has duly received attention as such on the part of the best firms.

The development of rancidity referred to by the authors does not occur with pure mineral or resin oil, but is chiefly due to the use of fatty oils of vegetable origin. The best British practice avoids the risk of this, as fatty oils are hardly used at all in most impregnating compounds used in this country. Further, there is not the slightest difficulty in procuring the oils which are used in British practice perfectly free from either organic or inorganic acids.

With regard to this point, the authors make reference to two analyses of impregnating material in which they found 44 per cent. and 47 per cent. respectively of resinous acids, and state that with resin oil they would expect to find about 40 per cent.

Some mistake evidently exists in this statement, because commercial bright resin oil (not prepared specially for cable work) is easily obtainable which contains no resinous acid whatever, or, at most, not exceeding 0·02 per cent.

The reference to resinous acids may give rise to some false impression in the mind of the reader who is not *au fait* with the chemistry of organic substances which are used in cable dielectrics, and it may be advisable to mention that these acids —chiefly abietic acid—have no detrimental or corrosive effect on the conductor or other component parts of a paper cable.

Deterioration under Heat.—Finally, the authors referred to the matter of the deterioration of paper dielectrics under the influence of heat, and their remarks give the impression that the liability for such deterioration to occur under conditions of use to which cables may be subjected has received no atten-

tion either from cable manufacturers, or from independent investigators. They also state that they can find no publication whatever on the subject. The writer several years ago made a large number of careful experiments on this subject, which not only covered the ground as regards deterioration of the paper then in use on the cables produced by his firm, in air and insulating oil under various elevated temperatures, but also compared the relative deterioration of papers of different fibrous composition. This research was briefly referred to, and a typical diagram showing the general order of the results obtained was given in a Paper on "Some Points on the Selection of Electric Cables," by Ll. B. Atkinson and C. J. Beaver, reproduced in THE ELECTRICIAN dated March 3, 1905, Vol. LIV., p. 784.

The results therein touched upon were obtained by taking tensile tests on strips cut from the main samples after various periods of exposure to various temperatures. Briefly, it may be said, that it was shown that deterioration was generally more marked in samples heated in contact with air than in those heated in insulating media out of contact with air, and, further, that the rate of deterioration under both sets of conditions was very much greater in papers containing woody fibres than in pure manila paper.

"C.M.B." PATENT AUTO-CONVERTER.

BY J. C. MACFARLANE, WH.SCH., M.I.E.E., AND H. BURGE, A.M.INST.C.E.

In the following Paper the construction is described, and several applications discussed, of a new type of rotary electric transforming machine developed by the authors, for reducing supply voltages for the economical working of metal filament and arc lamps, for battery charging, gun-fire, and navy-phone circuits, and also for balancing three-wire circuits.

sub-divide the poles into two parts, to correspond with the position of the short-circuited brushes. This step is shown in Fig. 2, where the poles are shown divided unequally, as would be required for an unequal division of the voltage. It will be noted that when the E.M.F. applied to brushes *a a* is to be split unequally, the field should be divided unequally, and the short-circuited brushes should divide the armature in a corresponding manner, as this will lead to greater efficiency and economy in material. In reducing from a constant potential of 220 to a constant potential of 50, say, the part pole ratios should be approximately 2 : 1 for maximum economy.

If the supply voltage is constant, and the speed of rotation is to remain unchanged, any increase of flux on one side of the short-circuited brushes must necessarily take place at the expense of the flux on the other side. In order to regulate the secondary voltage, therefore, or compensate for voltage drop in the converter, the authors provide the machine with a ring wound armature, and entirely isolate the two magnetic circuits from one another. It should be noted that it is quite impossible to get any regulation of the secondary voltage without absolutely isolating the one magnetic circuit from the other, and also impossible to prevent wasteful circulating currents in the short-circuited brushes. It is obvious that the machine in Fig. 2 would be unsatisfactory for two reasons; firstly, because any reduction in the M.M.F. on poles n_1 and s_1, say, and a corresponding increase in n_2, s_2, would have no effect on the relative amounts of flux through the two parts of the armature, thus preventing any alteration to the division of voltage; secondly, the armature reaction flux has still a low resistance path as indicated by the dotted lines in Fig. 2. As mentioned above, a variation of the voltage on either side of the short-circuited brushes cannot take place unless a ring armature is used, due to the fact that the armature conductor of a drum armature spans across the pole pitch.

The construction adopted for completely isolating the magnetic circuits, shown diagrammatically in Fig. 3, consists primarily in placing the pole parts n_1, s_1, n_2, s_2, in a vertical position with relation to the plane passing through the short-circuited brushes. It will be seen from the diagram that the length of the mean resistance path for the flux, due to the armature M.M.F., is considerably increased, and that as the yoke length is shortened the weight and cost must be considerably reduced. Although all the above precautions were taken in the

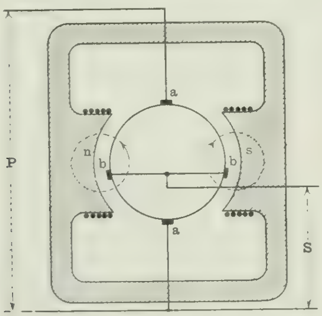


FIG. 1.

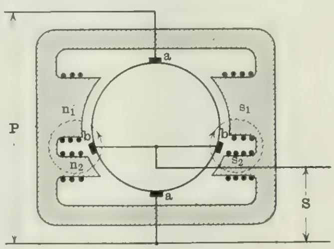


FIG. 2.

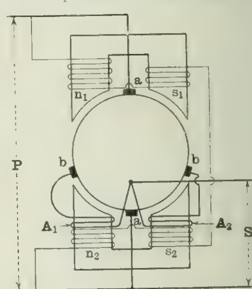


FIG. 3.

The lines along which this machine has been developed are easily followed by reference to the accompanying diagrams. Fig. 1 shows an ordinary two-pole dynamo-electric machine in which *n* and *s* represent the field poles, and *a a* the main brushes. If cross brushes *b b* are placed on the commutator and short-circuited, and if the primary supply voltage is represented by P, then this may be reduced to any desired secondary value represented by S, depending chiefly on the position of the short-circuited brushes *b b* on the commutator in relation to the main brushes *a a*.

The machine as shown in Fig. 1 would have several serious defects, viz:—(1) The presence of poles *n s* immediately over the short circuited brushes *b b* would not permit of sparkless commutation at these brushes. (2) It would not be possible to regulate the secondary voltage S, either automatically or by hand. (3) The M.M.F. of armature reaction would cause a large cross flux to pass through the armature between the short-circuited brushes across the pole faces, as shown by dotted lines in Fig. 1. The armature revolving in this flux would create a large circulating current in the short-circuited brushes—either causing the machine to race dangerously or lose speed. Such a circulating current would also be very wasteful, and would tend to make one of the short-circuited brushes spark more that the other. (4) The weight of the field magnets and space occupied would be excessive.

The method adopted to get over the sparking difficulty has been to earlier designs, these machines still gave considerable trouble, due to the short-circuit current flowing through the armature across the short-circuited brushes. As already stated, this short-circuit current, if not properly controlled, makes the operation of such a machine practically impossible, and it was found in the earlier machines referred to above that there was a very great liability for the machines to race dangerously, especially when the secondary voltage was varied between wide limits. This is, of course, due to the fact that the armature reaction, caused by circulating current in this case, may be in direct opposition to the M.M.F. on the main field poles, resulting in a de-magnetisation of these poles, and raising the speed.

To get over this difficulty in the most effective and simple manner possible, the poles are provided with series windings in addition to the ordinary shunt coils, and connected as shown in Fig. 3, where A_1 and A_2 represent the series coils. These coils are each connected to one of the short-circuited brushes, and their other ends connected together at one of the secondary terminals of the machine. Under normal circumstances when there is no circulating current flowing through the armature across the short-circuited brushes, each brush and each main coil will be carrying half the secondary load current; if, however, a circulating current arises, it will flow in opposition to the load current in one coil A_1, say, and in conjunction with the load current in the other coil A_2: in effect, therefore, the current in coil A_1 will be less than in A_2, and if these coils are suitably coupled up will

have the effect of correcting or preventing the short-circuit current from rising to any considerable value. In other words, as the current in the coil A_1 is less than the current in the coil A_2, the M.M.F. on the pole n_2 is less than the M.M.F. on the pole s_2, and this tends to cause a greater voltage to be generated under the pole s_2 than under the pole n_2, thus opposing the voltage which is creating the circulating current.

A little consideration will show that these balancing series coils can be placed on all the poles, and can be wound, not only to effect the governing of the circulating current, but also at the same time to create either a compounding or differential effect on the secondary circuit. When these series coils are used, there is no tendency for the machine to race, and the currents coming from each of the short-circuited brushes are always within 10 per cent. of each other, even when the magnet poles are entirely unsaturated, which would be impossible without these windings.

These converters may be divided into three classes, depending on the use to which they are to be put—(*a*) For giving a constant secondary voltage for any value of the secondary current. (*b*) For giving a secondary current which is to remain approximately constant for a given range of secondary voltage. (*c*) Machines which are to be used for converting from alternating to direct current, the direct-current voltage being capable of variation without affecting the power factor of the alternating side.

As a general rule the coupling diagram shown in Fig. 3 is suitable for machines giving constant voltage. Such machines would be the direct current equivalent of an alternating-current auto-transformer, but would have the advantage that the secondary voltage could be easily altered at will, independently of the primary voltage, or compounded for voltage drop. As machines of this class, having a capacity of between 2 kw. and 3 kw., will have an efficiency of from 75 to 80 per cent., it is obvious that their application to transforming the voltage for metallic filament lamps has led to very good results in many cases. For instance—in large shops, hotels and theatres, when the full load can be switched on at once, and kept on for a considerable time, the saving will be something like 70 per cent. in power, as compared with the most efficient carbon lamps. The secondary voltage can be made to vary up or down, either automatically or by hand regulation, to suit the various conditions to which the machines may be applied.

In all the above cases it is desirable to arrange the values of the ampere-turns on the poles on both sides of the short-circuited brushes, so that both poles and yokes are unsaturated magnetically. This permits of good regulation and perfect governing for short-circuit current. With the poles on the primary side of the short-circuited brushes—viz. n_1, s_1—absolutely unsaturated magnetically, and the poles on the secondary side highly saturated, it is possible to use this machine by applying a flywheel to its shaft, for reducing the voltage from a tramway circuit to, say, 220 or 110 volts, and at the same time to smooth out the variations in voltage on the secondary side, so that the machine can be used for supplying incandescent lighting successfully from its secondary terminals. With the usual variation of pressure of a tramway circuit, a practically constant voltage can be obtained at the secondary terminals of the machine.

The machines have also been applied to balancing three-wire circuits with great success, the largest as yet made being two machines for the Calcutta Electric Supply Corporation, dealing with an out-of-balance load of 60 kw. on either side of the middle wire, the voltage of the outers varying from 460 to 580 volts. These machines were required to balance the voltage within 1 per cent. of the mean value on either side of the middle wire at all voltages between 460 and 580. Their efficiency was 94 per cent. on test, which is 4 per cent. or 5 per cent. higher than that obtained with double machines.

The advantages of using such machines as balancers are the small weight and space taken up, absolute reliability, small wear and tear on the brushes, and high efficiency. When used as a balancer the armature is divided into two equal parts by the short-circuited brushes; also the polar limbs are all equal in dimensions, the series compounding coils are arranged on all the poles, not only for the purpose of voltage regulation, but also to balance the circulating current across the short-circuited brushes.

From the foregoing it will be seen that there is an unlimited field for the use of this converter, owing to the high efficiency and small space required. Passing on now to the construction of the machine used for the purposes set forth under heading (*b*), *i.e.*, a constant secondary current over a given range of secondary voltage. The characteristic of the secondary is shown by the curve in Fig. 5, and is suitable for supplying a single arc lamp, or two or more arc lamps in series, without the use of steadying resistances.

Fig. 4 shows the winding diagram of the machine arranged to give automatically a practically constant secondary current. On examining this diagram it will be noticed that the shunt winding on the poles n_1, s_1, is connected between the positive supply main and the short-circuited brushes, whereas the shunt coil marked B is connected right across the supply mains. The shunt coil C is connected between the short-circuited brushes, and the negative supply main. The series coils A_1, A_2, on the poles n_2, s_2, are each connected to a short-circuited brush, in the same way as described with reference to Fig. 3, but in this case the series coils A_1, A_2, are so connected that their M.M.F.'s oppose the M.M.F.'s of the shunt coils B and C. The action of the machine is as follows:—If the secondary current tends to increase, the opposition M.M.F.'s of the series windings A_1, A_2, are increased, which reduces the secondary voltage S, the persence of the separately excited coil B preventing the flux in the poles n_2, s_2, being wiped out altogether. The secondary voltage having dropped, the voltage between the short-circuited brushes and the positive main brushes must rise, causing the shunt coils D to increase the flux through the part poles n_1, s_1, thereby replacing the flux withdrawn from the part poles n_2, s_2, and so keeping the speed constant.

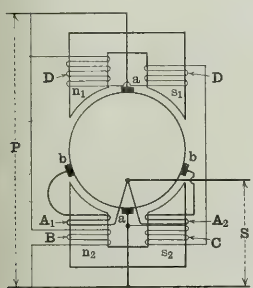


FIG. 4.

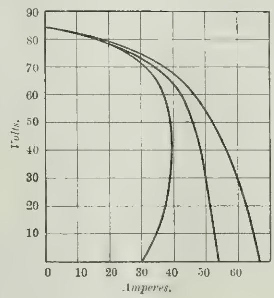


FIG. 5.

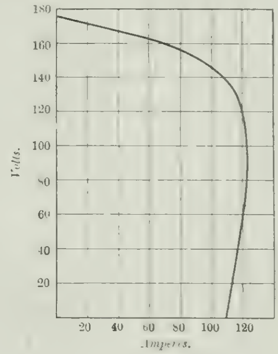


FIG. 6.

When under load the armature is divided into a motor portion and a generator portion by the short-circuited brushes, and the M.M.F. of the motor part will be in opposition to that of the generator part. With a certain transformation ratio these M.M.F.'s are equal and opposite, but in the case of the arc lamp converter just described, on approaching the short-circuit condition the M.M.F. of the generator portion is much greater than the motor part, and a cross flux already referred to passes between the short-circuited brushes, following the path shown by the dotted lines in Fig. 1, causing a large parasitic current to flow between the short-circuited brushes. This cross flux can be neutralised by strengthening the M.M.F. in the pole n_2 and weakening s_2, and the parasitic current traversing the coils A_1, A_2, performs this function to a great extent; but to neutralise the cross flux entirely the authors place the shunt coil B, which maintains its strength throughout, on pole n_2, and the coil C—which becomes gradually weaker towards short-circuit—on the pole s_2.

These machines are absolutely automatic in their action, and will run for any length of time on open circuit, full load, or with the secondary terminals of the machine short-circuited. They can be worked with perfect safety to the operator, and no damage can be done to the lamp, as the current can never exceed the full load working current. In cases where the lamp has to strike automatically, this is insured by the fact that when the carbons are brought together

there is an instantaneous rush of current equal to about twice the full load value, which makes the lamp strike. This current settles down to the full load value in less than a second, and if the lamp does not strike, the machine merely allows normal current to pass through the short-circuited carbons. A variation in the secondary characteristic can be produced by inserting a shunt regulator. Similarly, a constant current of practically any value can be obtained for a given range of voltage by merely fixing the position of the shunt regulator handle.

Fig. 5 shows some actual curves taken from a test on a machine. Curve 1 is vertical, and one might suppose there would be instability when working on the vertical part of the curve. This is not the case, as it is quite possible to arrange these machines to work two arc lamps in series. When one lamp only is working, the other being short-circuited, the machine is quite stable, and supplies the remaining lamp satisfactorily with the same current, but at a lower voltage. As far as the authors are aware, this is the first time such a result has been obtained.

The various characteristic curves as shown in Fig. 5 are produced by altering the resistance in circuit with the shunt coil B, and this being an extremely simple thing to do, such a machine is specially adapted for working a cinematograph, and in fact any kind of projector lamp, because of the ease with which the light intensity can be altered, by adjusting the amount of current passing through the arc, 50 per cent. above or below the normal. It is possible with such a machine to place it at a long distance from the operator and merely bring two small wires to the shunt regulator at the operator's hand; any alteration to the intensity of the light can be obtained by adjusting the shunt regulator handle. A cinematograph machine capable of giving a supply of 50 amperes to a 50 volt arc is 22 in. high by 21 in. wide by 14 in. long, and weighs 5 cwt. The efficiency of such a machine works out at from 75 to 80 per cent. on full load, and it will therefore save, when replacing a steadying resistance worked off a 440 volt circuit, about £13 per week; when replacing a steadying resistance worked off a 220 volt supply some £5 per week; and when replacing a steadying resistance worked off a 110 volt supply, the saving will be about £1. 10s. per week. These figures are based on the assumption that the price of current is 3d. per unit, and that the lamps are used for 50 hours per week. The price paid for such an installation, working on these assumptions, will be saved—in the first case in four weeks, in the second case in about 10 weeks, and in the third case in about 35 weeks.

In electric welding any of the characteristics in Fig. 5 will be suitable. The primary supply voltage should be low, for the machine can be made rather lighter, more efficient, and of better proportions, the lower the primary supply voltage. A very good portable welding set could be made by supplying in conjunction with such a machine an 80 or 90 volt battery capable of giving high discharges for short periods.

Fig. 6 shows the relationship between the secondary amperes and voltage of a 220 volt machine made for the purpose of supplying two 120-ampere 60-volt arc lamps in series. The efficiency of this machine, when supplying the two lamps in series, was over 92 per cent. The dimensions of the machine are 24 in. high by 22 in. by 24 in. long, and it weighs 8 cwt. The weight of the set, and the space taken up, have probably never been reached before within 50 per cent., and are remarkably small, when it is considered that each part of the armature, and each part of the field system has to be capable of dealing with the full primary voltage and the full secondary current at the same time.

Under heading (3) are machines which are used for converting alternating currents to direct currents; these are really the machines which come under headings (1) and (2), supplied with a suitable number of collector rings to suit the number of the phases of the supply. The advantages to be obtained by using such machines for this purpose are as follows:—The direct-current voltage taken from the secondary is more or less independent of the alternating supply voltage, and can be varied either automatically or by hand without altering the power factor of the alternating-current supply to any appreciable extent. It is evident, therefore, that machines of this kind can be used for all the purposes set forth under headings (1) and (2) by applying similar windings to the part poles n_1, s_1, and n_2, s_2, and when supplied with collector rings and a belt pulley this machine is extremely valuable for teaching purposes in technical colleges.

With the cross brushes up, such a machine can be used as a direct-current dynamo, a direct-current motor, an alternating-current dynamo, an alternating-current motor, a combined direct- and alternating-current dynamo, a split pole rotary converter. With the cross brushes down, it can be used as a direct-current auto-transformer, converting if desired from constant potential to constant current, and again as a rotary converter, converting from alternating to direct current of practically any voltage between given limits.

THE ABRAHAM DOUBLE PROJECTION RHEOGRAPH.

At the exhibition of scientific instruments held by the Physical Society of London, in December last, a new form of rheograph or oscillograph, lately brought out by Prof. Abraham, of Paris, was exhibited by the Cambridge Scientific Instrument Co., Ltd., and its simplicity of working caused very general interest.

The apparatus, which we described briefly in our issue of Jan. 1, 1909 (p. 469), consists of two parts (*see* Fig. 1), a double galvanometer, G_1 and G_2, and a synchronous motor, S. In the standard instrument the two galvanometers are identical and entirely independent of each other. The moving part of the galvanometer consists of a small rectangular frame of aluminium (A in Fig. 2), closed upon itself, about 38 mm. long, 6 mm. wide and 0·9 mm. thick, carrying upon it the comparatively large mirror B of area 18 sq. mm. The aluminium frame is suspended by means of a very thin silver wire, W, in the field of a permanent magnet, C, the wire being so thin as to exert practically no torsional control. The frame forms the secondary of a small transformer, the primary D consisting of several turns of wire, whilst a laminated core of soft iron, E, carries the flux through the secondary. The two ends of the fixed or primary winding are brought out to the terminals on the front of the instrument.

To study the wave-form of a given current or P.D. it is necessary to arrange that a current in quadrature with it should be passing through the primary winding of the oscillograph. If the wave-form of a P.D. is being studied, then a condenser is placed in series with the oscillograph, or if a current curve, then a small series current transformer is used, the current under investigation being passed through the primary, the secondary being closed through the oscillograph. The resistance of the secondary of this current transformer is purposely made high so that the induced current will be in quadrature with the main current, and not in opposite phase, as is usually the case with such transformers, owing to the secondary resistance being kept very low.

As already explained, the current in the suspended aluminium frame is produced entirely by induction from what is practically a small transformer in the oscillograph itself. This has been so designed that the flux is proportional to the ampere-turns without the hysteresis of the iron exerting any material influence. As the frame consists only of a single turn, the induced E.M.F. depends almost absolutely on the rate of change of the primary current. The time constant L/R of the secondary being extremely small (some hundred thousandths of a second) the current is at any moment proportional to the induced E.M.F. It may be stated, therefore, that the current produced in the moving system is proportional to the rate of change of the current in the primary of the rheograph.

Now the current in the primary produced by the condenser, if a P.D., or a transformer if a current curve is being studied, is of the form de/dt or dC/dt. The current induced in the frame is, therefore, of the form d^2e/dt^2 or d^2C/dt^2, and therefore the force acting on the frame is equal to $G\frac{d^2C}{dt^2}$, where G is a constant.

The equation of movement of the frame in the case of a current observation is

$$A\frac{d^2\theta}{dt^2}+B\frac{d\theta}{dt}+C\theta=G\frac{d^2C}{dt^2},$$

where θ is the deflection and A, B, C, G are constants. In the instrument the inertia term $A\frac{d^2\theta}{dt^2}$ has been given a preponderating value, the damping forces $\left(B\frac{d\theta}{dt}\right)$, and controlling forces $C\theta$, being rendered negligible by the employment of a weak permanent magnet and a slender suspension respectively.

The equation may thus be reduced to

$$A\frac{d^2\theta}{dt^2}=G\frac{d^2C}{dt^2},$$

from which it will be seen that the deflection varies directly as the current.

It may, perhaps, be helpful to regard the moving system of the rheograph as similar to the moving coil of a ballistic galvanometer. Considering, for example, the investigation of a P.D. wave by the rheograph: the moving system is deflected by a charge of electricity proportional to the initial variation E of the voltage, a charge, CE, passing from the condenser to the rheograph. The charge is not instantaneous (owing to the circuit resistance), so that during the small interval over which the charge lasts the current, at first zero, rises rapidly and then falls to zero again. The magnetic flux, increasing and then diminishing, develops successively two induced currents in opposite directions in the moving system. These induced currents, under the influence of the magnetic field, both move and stop the movements of the moving system.

The synchronoscope is an extremely simple and efficient form of synchronous motor used to project vertically upon the screen, and proportionately to the time, the horizontal movements of the beam of light from the mirrors of the two galvanometers. It consists of an equilateral total reflecting prism (*see* Fig. 3) mounted on a horizontal axis, a simple toothed iron wheel, I (Fig. 1), forming the rotor of a synchronous motor being mounted on the same axle. The motor will be found to operate on circuits of from 10 to 90 frequency

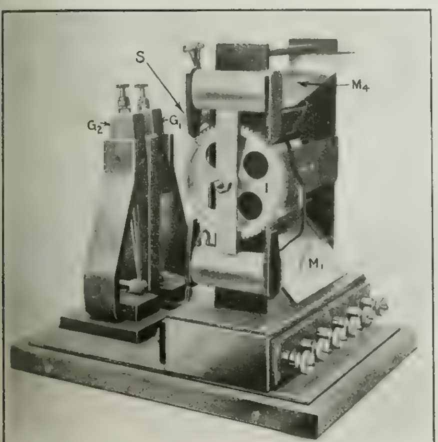


Fig. 1. The Abraham Rheograph.

without difficulty, making one rotation per second when the frequency is 36. If the prism alone were used only three reflections per second would be given, and these would not be sufficient to give an appearance of continuity on the screen. Prof. Abraham has, therefore, introduced four mirrors in a most ingenious manner to increase the number of reflections to 12, this number being sufficient to give an appearance of almost perfect continuity. Two of the mirrors are clearly shown in Fig. 1—M_1 and M_2.

The beam of light from the arc lamp A (Fig. 3) is thrown by the small mirror B on to the galvanometer mirror C, is reflected from that on to the prism G, is again reflected on to one of the fixed mirrors M, and from that on to the screen at a point P. If the prism is rotating in the direction of the hands of a watch, then the beam of light will be reflected from the mirrors M_1, M_2, M_3, M_4 respectively. The diagram shows the beam reflected from the mirror M_3.

It will have been seen that the rheograph can be used for the study of either a P.D. or current curve, or even for the changes of flux in a magnetic circuit.

(*a*) *The Study of a Curve of E.M.F.*—Connect one of the terminals of one of the vibrators to a condenser, one terminal of which is connected to the circuit to be studied. Then the current passing through the rheograph is the charging current of the condenser, and it is proportional to the rate of change of the P.D. under examination. The amplitude of the curve obtained can be varied by altering the capacity of the condenser. The normal sensibility at a distance of 3 metres is 1 metre for a root mean square voltage of 100, the condenser employed having a capacity of about 1 mfd., the current taken being about 25 milliamperes.

(*b*) *The Study of a Current Curve.* There is no difficulty in studying the current through a resistance, inductive or otherwise, the current through an arc or rectifier, the harmonics due to resonance, &c. To obtain a current curve the terminals

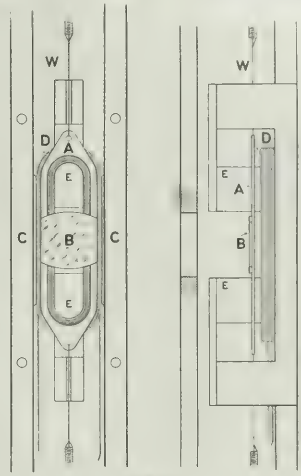


Fig. 2.

of the rheograph are connected to the secondary of a small transformer, the primary being connected to the circuit under observation. This transformer is divided into two identical parts mounted with their opposite poles opposite one another in order to neutralise the effect of varying stray fields. The two parts of this transformer can be placed either in series or in parallel as desired. Two standard types of transformers are supplied, one suitable for currents of the order of 1 ampere, the other for currents of about 10 amperes. The secondaries are constructed so as to satisfy the conditions of maximum sensibility, the self-induction being equal to the fixed or primary

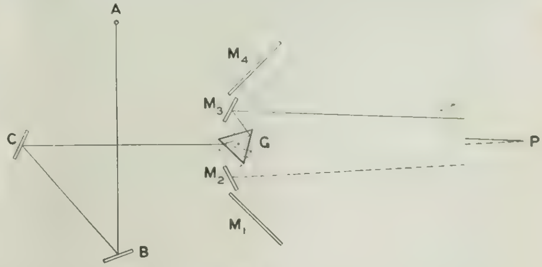


Fig. 3.

circuit of the rheograph. In the case of the 10-ampere transformer, in which the full current is passing, and in which the primary circuit has a resistance of several hundredths of an ohm, the self-induction being about 0·0001 henry, the deflection on the screen at a distance of about 3 metres will be 0·5 metre. If the deflections on the screen are too large for a given current they can easily be reduced by the insertion of a resistance between the rheograph and the transformer.

(*c*) *The Study of Variation in the Flux in a Magnetic Field.*—The rheograph is connected to a coil placed in the magnetic

field, this coil having approximately the same self-induction as the rheograph in order to give maximum sensibility. A coil of 100 turns with a mean area of 10 sq. cms., cutting a field of 100 gauss, gives a deflection of 0·5 metre at a distance of 3 metres.

(*d*) *Employment as a Ballistic Galvanometer.* The sensibility as a ballistic galvanometer is not great. With an instrument of about 15 ohms resistance the scale deflection at 3 metres is 3 mm. per micro-coulomb. Ballistic measurements can, of course, be made, following one another at very short intervals.

Accuracy.—It is obvious that the results given by the rheograph are only correct so far as the various assumptions made are permissible. The self-induction of the instrument itself is neglected. In the majority of experiments in which the apparatus will be used the self-induction does not introduce an error of any importance. For instance, when determining a current curve, the self-induction of the rheograph and transformer of the secondary may each amount to 0·004 henry. Assuming that a resistance of about 100 ohms is also in circuit, then the effect of self-induction does not make itself felt until a frequency of 2,000 has been obtained; this limit can be still further extended by increasing the resistance, which would only have the effect of diminishing the sensibility.

In the case of a voltage curve the self-induction causes no error, except with frequencies of the same order. The precision could also be increased by diminishing the capacity of the condenser in series if a decrease in sensibility can be accepted. Even if the frequency is such that the self-induction becomes of importance the shape of the curves remains unaltered, although a retardation may have been introduced.

From an investigation of the records obtained with a rheograph and the Duddell and Blondel oscillographs, it has been shown that the records obtained from the rheograph are remarkably accurate, provided the phenomenon under observation is perpetually varying. It can readily be seen that the whole action being that of a transformer, it cannot reproduce satisfactorily a voltage or current remaining stationary for a comparatively long period.

ELECTRIC TRACTION ON RAILWAYS.*

XVI.—COLLECTORS FOR OVERHEAD CONDUCTORS.

BY PHILIP DAWSON.

(*Continued from page 381.*)

Summary. Two forms of collector have been developed—the trolley wheel and the sliding bow. For railway work the choice and design of the collector depend on the line voltage (which, in a given case, determines the current to be collected) and the speed. The author considers that for main-line railway working with high-pressure currents some form of bow collector, preferably operated by compressed air, is indispensable. He then describes the types so far employed, viz., (1) the pantograph or scissors type, (2) the ordinary bow type, and (3) the rod collector of the Oerlikon type.

In this section we shall deal briefly with the apparatus generally used for collecting the current from overhead conductors and bringing it to the motors on the car or locomotive. The shuttle arrangement used in collecting the 500 volt continuous current from the overhead conductors originally erected in the case of the Baltimore & Ohio Railway has already been mentioned in a previous section.

Reference has also already been made to the fact that the majority of tramways and light railways to-day utilise the overhead conductor, and there are in this connection two forms of collectors which have so far found practically universal adoption.

Besides the trolley and trolley wheel the other form of collector, which has been very largely developed and used on the Continent of Europe, is generally known under the name of the sliding bow collector. It is claimed by some that for tramway work advantages have been derived from it, but these are not of very great importance, as long as they are only applied to tramways, but when the question of railway electrification crops up the case is entirely different and has given an importance to the bow collector which it never possessed before.

It has been claimed that the use of the sliding contact bow must of necessity produce a much greater wear of the trolley or contact wire than the use of the trolley wheel, but experience on the Continent seems to show that this is not the case; indeed, some German authorities go as far as to say that the wear on the overhead wire is less with the bow than with the trolley wheel.

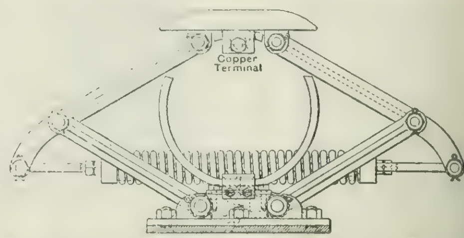
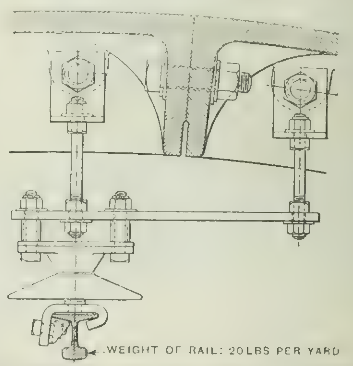
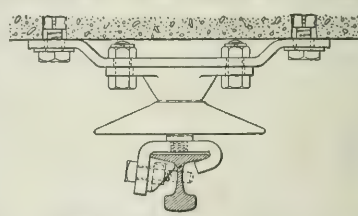


Fig. 1.—Current Collector for Cars running in East River Tunnels, Long Island Railroad, New York. (For Continuous Current.)

In railway work, as distinct from tramways, two sets of conditions have to be specially considered, one being the line voltage, on which for a given motor equipment the current to be collected depends, and the second point being the speed at which it is intended to operate. On these two conditions the choice and design of the collector depend, and each case must be carefully considered on its own merits.



Adjustable Bracket for Overhead Contact Rail in cast-iron section.



Construction in tunnels in concrete section under East River. Distance between supports 9 ft.

Fig. 2. Arrangement of Overhead Contact Rail for Continuous Current in Tunnels of Long Island Railroad, New York.

Thus, for railways using the low pressures such as are at present met with in continuous current traction, very large overhead conductors are required in order to secure a large contact surface in the current collector. Such an arrangement, as adopted by the Long Island Railway Co. in its tunnels under the river between New York and Long Island, is shown in Fig. 1, and Fig. 2 shows the type of overhead collector and conductor used for this construction. The overhead conductor in this case consists of a steel T rail weighing 20 lb. per yard and supported every 9 ft. A similar shoe has been adopted in the case of the New York Central Railway for those portions where, owing to the intricacy of the tracks, the protected third rail was found impossible, and where overhead construction had to be adopted as mentioned in a previous section.

When dealing with cases, such as those mentioned above, great difficulties are encountered where heavy currents ranging from 1,500 to 3,500 amperes, may have to be dealt with per locomotive, and hence the general use for continuous current railways of the third rail and contact shoes already referred to. When we come to deal with high-pressure work, in consequence of the possibility of very considerably reducing the current required to be dealt with for each train or locomotive, we are at once led to consider minimum working pressures of 6,000 volts and upwards, in many cases pressures of 11,000 and even 15,000 and 22,000 volts being dealt with. In other words, the minimum pressures worth considering with overhead conductors are 10 times greater than the pressures at present used with continuous current motors and six times greater than the maximum pressure which it would seem (with our present knowledge) ever advisable to use with continuous current traction plant.

The maximum current to be dealt with, therefore, varies from 100 to 350 amperes per train, according to the pressure on the overhead conductor and the type of train to be dealt with. By this means the current to be collected is at once reduced to the magnitude approaching that with which one has had to deal in tramway and light or ordinary interurban light railway working.

It is at once evident that for main-line railway working with high-pressure currents two features are indispensable for a satisfactory trolley or current collector :—

1. The collector must be such that there is no possibility of it coming off the conductor wire or getting entangled at points and crossings, and it must always and under all circumstances, remain in contact with the trolley wire as long as it is in the running position.

2. In view of the high pressure used, it must be possible to raise the collector up against the wire and to pull it down mechanically from the driver's compartment without any possible risk to himself and with absolute certainty that the collector will move either up or down as the case may be, and will also immediately come into proper contact with the collector wires, no matter where the train may be located, either on the straight or a curve under points and crossings.

These conditions, so far as the writer is aware, can only be met by the use of some form of bow collector, preferably operated by compressed air. This conclusion is justified by all existing experience on high-tension electric railway work. Having come to this conclusion, we may examine the types so far employed. Collectors may be classified as follows :—

(1) Collector bows operating equally well in either direction.

(2) Collector bows operating only in one direction.

Or they can, alternatively, be classified by their external appearance as well as by the methods used to accommodate them to run at varying heights, and in that case we can distinguish three classes—

(*a*) The pantograph or scissors type of collector, which would come under category (1) as mentioned above.

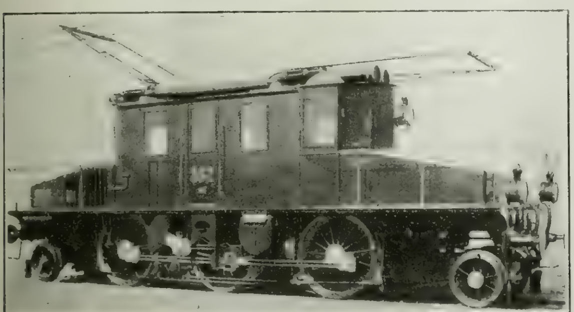


Fig. 3.—View of Ganz Three-phase Locomotive showing Overhead Collectors.

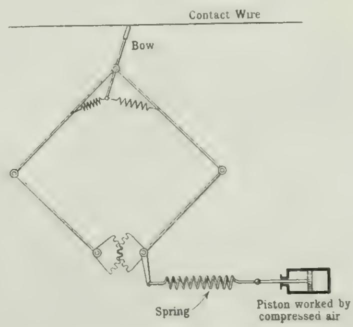


Fig. 4.—Diagram of modified form of Pantograph, as adopted by the A.E.G., of Berlin.

(*b*) The ordinary bow type, either plain or composite, which can or cannot, according as it is plain or composite, operate equally well in both directions.

(*c*) The rod collector of the Oerlikon type.

Considering first the collectors used in connection with three-phase main-line electrification, there are two principal examples to be considered, the first being the Burgdorf-Thun line equipped by Brown-Boveri, and which has now been running for a considerable number of years. In this case the separated sliding bows located side by side are used, and at such a height that by slightly lifting the wire when the train movement is reversed they can operate in either direction.

In the next three-phase line considered (the Ganz installation on the Valtellina line, Fig. 3), the collector is of an entirely different construction and is not reversible. In this case the collecting device or the trolley consists of two cylindrical rollers terminating in two small conical surfaces, designed to work without difficulty at the switching points. The rollers are of phosphor bronze, 3 mm. thick, and are fitted on a shaft upon which they turn, being supported by ball bearings.

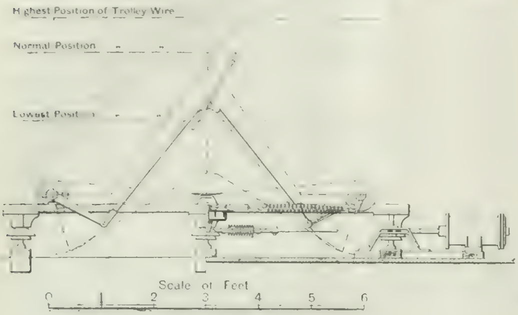
For this type of apparatus one collector is required for operating in each direction, it being, of course, possible to

run against the normal direction at very slow speeds if this is found necessary in case of emergency.

We will next consider the scissors type of bow now very commonly used both in America and in Europe. In America this type has been specially developed by the Westinghouse Company. Contrary to the general practice in Europe of using a soft metal, such as aluminium, to make contact with the wire, and which normally should take most if not all the wear, the Westinghouse Company use a galvanised iron bar for their contact piece, fitted with one or more semicircular longitudinal grooves, which are filled with grease. The width of this contact strip in the case of the Midland Railway is 6 in. The contact piece itself is $\frac{1}{16}$ in. thick and weighs 8 lb. The bow frame is built out of light steel tubing, which also serves to conduct the current.

A modification of this bow has been suggested by the Allgemeine Elektricitäts Gesellschaft, of Berlin, and has been adopted for the large and powerful single-phase locomotive constructed by that company for the Prussian State Railways. The modification consists of fitting a small reversible bow collector operated by separate springs to the top of the pantograph, as shown diagrammatically in Fig. 4.

Having thus considered this type of pantograph we will proceed to consider another reversible type such as has been extensively used by Messrs. Siemens-Schuckertwerke. This is generally known as the inverted pantograph type, and it is fitted with a separate collector member worked by separate springs. This type gives satisfaction wherever the total difference in height to be negotiated is not too great, and the general idea of the form of construction is illustrated in Figs. 5 and 6, and shows this form fitted on the roof of an electric locomotive.



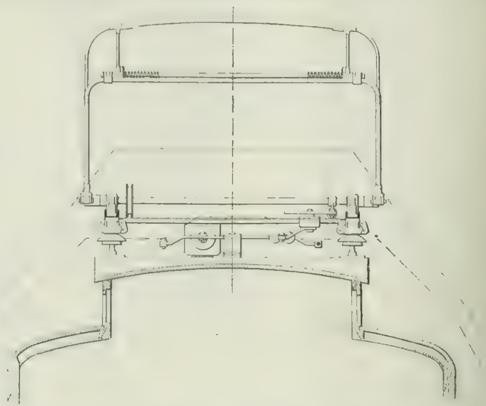


Fig. 5.—Standard Siemens inverted Pantograph Collector, as used on several Continental Railways.

Fig. 6.—Siemens-Schuckertwerke Bow Collector for Single-phase High-tension Railways, proposed for high speeds up to 80 miles an hour. L Lightning Arrester.

(*To be continued.*)

RESEARCHES IN RADIOTELEGRAPHY.*

BY PROF. J. A. FLEMING, D.SC., F.R.S.

(*Concluded from page 467.*)

I may, then, bring to your notice some recent work on another form of radio-telegraphic detector, which I first described to the Royal Society about five years ago under the name of oscillation valve. It consists of an electric glow lamp, in the bulb of which is placed a cylinder of metal which surrounds the filament but does not touch it. This cylinder is connected to a wire sealed through the glass. Instead of a cylinder, one or more metal plates are sometimes used. The filament may be carbon or a metallic filament, and I found some year or more ago that tungsten in various forms has special advantages. The bulb is exhausted to a high vacuum, but, of course, this means it includes highly rarefied gas of some kind. When the filament is rendered incandescent it emits electrons, and these electrons or negative ions give to the residual gas a unilateral conductivity, as shown by me in a Friday evening lecture given here 19 years ago. Moreover, the ionised gas not only possesses unilateral conductivity, but its conductivity, like that of the crystals just mentioned, is a function of the voltage applied to it. Hence, if we apply an E.M.F. between the hot filament and the cool metal plate, we find that negative electricity can pass from the filament to the plate through the ionised gas, and that the relation between the current and voltage is not linear, but is represented by a characteristic curve bending upwards which has changes of curvature in it (*see* Fig. 18). The sharp bend upwards at one place implies a large increase in the current corresponding to a certain voltage, which means that, corresponding to a certain potential gradient, and therefore velocity,

* Lecture (slightly abbreviated) delivered on June 4th before the Royal Institution

of the electrons, considerable ionisation of the residual gas is beginning to take place. The current, however, would not increase indefinitely with the voltage, but would before long become constant or saturated. It will be seen, therefore, that at points on the curve where there is a bend or change of curvature the second differential coefficient of the curve may have a large value. Hence, if we consider the current and voltage corresponding to this point, it will be seen that any small increase in the voltage increases the current more than an equal small decrease in voltage diminishes it. If, then, we superimpose on a steady voltage corresponding to a point of inflection of the curve an alternating voltage, the average value of the current will be increased. This, then, points out two ways in which this oscillation valve or glow lamp can be used as a radio-telegraphic detector. First, we may make use of the unilateral conductivity of the ionised gas in the bulb and employ the glow lamp with cylinder around the incandescent filament as a rectifier of trains of oscillations

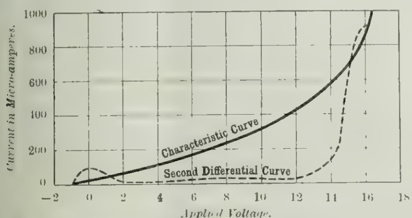


Fig. 18.—Characteristic Curve of Rarefied Gas ionised by Hot Negative Electrode.

to make them affect a galvanometer or telephone. This method was described by me in Papers and specifications in 1904 and 1905. In that case the valve is arranged in connection with a receiving antenna, as shown in Fig. 19, and used with a galvanometer or telephone. Mr. Marconi subsequently added an induction coil and condenser, and employed in 1907 the arrangements shown in Fig. 20. In this case the trains of oscillations set up in the antenna could not by themselves affect a galvanometer or a telephone, but when rectified by the valve they become equivalent to an intermittent unidirectional current, and can then affect the telephone or a galvanometer, or any instrument for detecting a direct current.

On the other hand, we may take advantage, as I have more recently shown, of the non-linear form of the characteristic curve; in other words, of the fact that the conductivity of the ionised gas is a function of the voltage applied to it, and in this second method the valve and receiving circuits are arranged as shown in Fig. 21. In

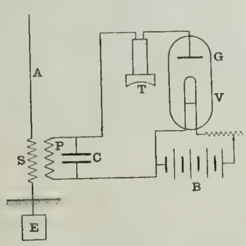


Fig. 19.—Connections for Oscillation Valve used as Radio-telegraphic Detector.

this case we have to apply to the ionised gas a unidirectional E.M.F. which corresponds to a point of inflection on the characteristic curve, and then to add to this voltage the alternating voltage of the oscillations set up by the incident electric waves in the receiving circuit. The result is to cause a change in the average value of the current through the telephone, and therefore to produce a sound in it, long or short according to the number of trains of waves falling on the antenna. This last method, then, requires the application in the telephone circuit of an accurately adjusted steady E.M.F., not any E.M.F., but just that value which corresponds to a point on the characteristic curve at which there is a sudden change of curvature.

At this point we may notice a broad generalisation which has already been made by H. Brandes—viz., that any materials, such as the crystals mentioned, or ionised gases, which do not obey Ohm's law as regards the independence of conductivity on impressed voltage, can be used as radio-telegraphic receivers. It is necessary to be able to test the relative sensibility of detectors to know whether any new form is an improvement. It is not always possible for an inventor to get these tests made at real wireless telegraph stations. Moreover, it is no use to test over short distances, because then all detectors appear to be equally good. I have found, however, that we can make these comparative tests very easily within quite moderate distances by employing closed sending and receiving circuits which are poor radiators. All the devices called wave detectors are really only oscillation detectors, and we can, therefore, test their value simply by ascertaining how feeble an alternating current or alternating voltage they will detect. If we then set up in one place a square circuit of wire a few feet inside, and complete the circuit by a condenser and a spark-gap, we can set up oscillations in it by means of an induction coil. I find that it is necessary to enclose the spark-gap in a

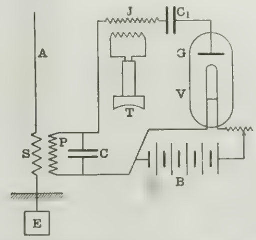


Fig. 20.—Connections for Oscillation Valve used as Radio-telegraphic Detector.

cast-iron box, and to blow upon the spark with a jet of air to secure silence, absence of emission of electromagnetic waves direct from the spark balls, and constancy in the oscillatory circuit. I then set up, a few score or few hundred feet away, a similar tuned closed oscillatory circuit, and I connect the oscillation detector to be tested either in this circuit or as a shunt across the condenser. The closed receiving circuit is so constructed that it may be rotated round either of three axes. It is then generally possible to find some position of the receiving circuit such that no sounds are heard in a telephone connected to a highly sensitive detector associated with the circuit. This position is called the zero position. If the receiving circuit is rotated round some axis it begins at a certain displacement to receive signals, and the angle through which it has to be turned is a measure of the insensibility of the particular oscillation detector being used. I find, for instance, that it is quite easy to take one of my oscillation valves, a magnetic detector, an electrolytic detector

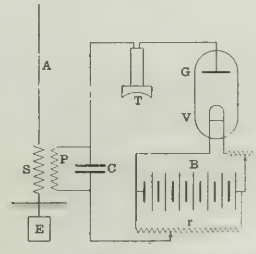


Fig. 21.—Connections for Oscillation Valve used as Radio-telegraphic Detector.

a crystal detector, or any other type, and arrange these in order of their sensibility by means of the device described. Sensibility is not, however, the only virtue which a wave detector should possess. It is important that it should be simple, easily adjusted and not injured by the chance passage through it of any unusually large oscillatory currents. Another quality which is desirable is that it should be quantitative in its action, and that any change in the amplitude of the wave received should be accompanied by an equal change in the current which the detector allows to pass through the telephone. A quantitative oscillation detector then enables not merely signals, but audible speech, to be transmitted. In other words, it can effect wireless telephony. The difficulties, however, in connection with the achievement of wireless telephony are not so much in the receiver as in the transmitter. We have to obtain, first, the uniform production of persistent electromagnetic waves radiated from an antenna; and, next, we have to vary the amplitude of these electric waves pro-

portionately to, and by means of, the aerial vibrations created by the voice speaking to some form of microphone. We cannot employ an intermittent spark generator, because each spark would give rise to a sound in the telephone, and these sounds, if occurring at regular intervals, would produce a musical note in the telephone. If, however, we make the sparks run together into what is practically a high voltage arc taking a small current, then, in an oscillatory circuit shunted across this arc, we have set up persistent high frequency oscillations, as first achieved by Mr. Duddell. We can greatly

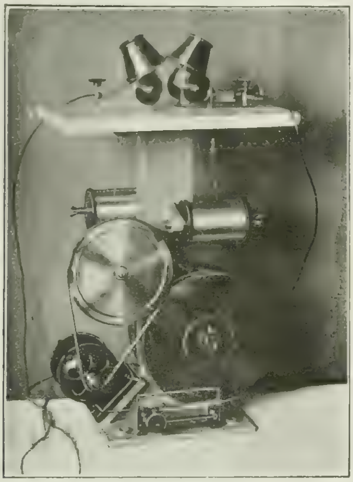


FIG. 22.—ERNST RUHMER'S HIGH-TENSION ALUMINIUM ARC FOR PRODUCING PERSISTENT OSCILLATIONS FOR RADIO-TELEGRAPHY.

increase the energy of the oscillations by immersing the arc in a strong transverse magnetic field and also in a hydro-carbon gas, as shown by Poulsen, or we may employ a number of arcs in series. E. Ruhmer has lately also employed a high-tension arc between aluminium electrodes (*see* Fig. 22), shunted by a condenser and inductance as a means of generating persistent oscillations. As an alternative, it is possible to create them by a mechanical method—viz., by a high-frequency alternator—subject, however, to certain limitations as to frequency. Both these types of generator have

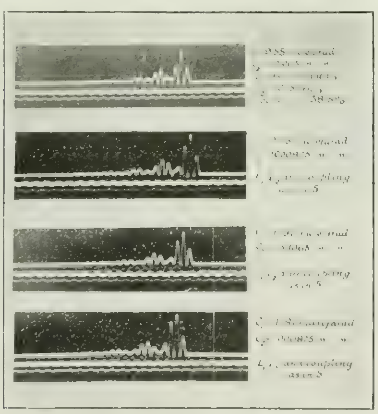


FIG. 23.—RESULTS OBTAINED BY PROF. E. TAYLOR JONES referred to on p. 391 of our issue of June 18th

their advantages and practical objections. There is good evidence that radio-telephony has been accomplished over distances of 100 miles or more by each of these methods in the hands of experts, but what is now required is the reduction of the apparatus to such simple manageable and practical form that it can be applied in regular work. The wave generating apparatus must be capable of producing uniform persistent oscillations of high voltage and frequency, not less than 30,000 or 40,000 per second, or at least above the limits of audition, and the amplitude of these oscillations must be capable of being varied by some form of speaking microphone placed in the oscillation circuit or in the radiating antenna, or in a secondary circuit coupled to it. No ordinary simple carbon microphone will safely pass sufficient current for this purpose. A type of multiple microphone has been used successfully and also a duplex microphone, the invention of Ernst Ruhmer.

It is not, however, possible to speak of radio-telephony at the present time as having reached the same level of practical perfection as radio-telegraphy. But the possibilities of it are of such a nature that it will continue to attract the serious attention of inventors. This is not the place to enter into a full discussion of the causes which limit submarine telephony through cables, but there are well-known reasons in the nature of submarine cables as at present made which impose very definite limits upon it, owing to what is called distortion of the wave form. Electric wave telephony is free at least from this disadvantage, and if (as has been asserted) arc generators can be made self-regulating and capable of being worked for hours automatically, or even for 10 minutes without being touched, then the remaining difficulties with the microphone are not insuperable.

Time does not permit of the discussion of the many other points in connection with radio-telegraphy and telephony which have been the subject of recent work. Much attention has been paid lately to methods of cutting out atmospheric signals due to natural electrcial discharges in the atmosphere, which are troublesome disturbers of the ætherial calm necessary for radio-telegraphy. Considerable thought and expenditure have been necessary to discover means for overcoming the difficulties of long-distance transmission by daylight, and also those arising from the cross talk of other stations. Much also has been done in training skilled wireless operators both in the Navy and for the mercantile marine work. Radio-telegraphy, like aviation, is an art as well as a science, hence personal skill is a factor of importance in turning the flank of the difficulties of the moment. Nevertheless, the art and the science of radio-telegraphy are both progressing, and the splendid services already rendered by it in saving life at sea are at once a proof of present perfection and an evidence that the arduous labours of investigators and inventors have borne fruit in yet larger power to command the forces of Nature for the use and benefit of mankind.

THE C.M.B. AUTO-CONVERTER AND ITS APPLICATIONS.

On Friday last we paid a visit to the works of Messrs. Crompton & Co., at Chelmsford, to inspect what is undoubtedly one of the most interesting electrical machines of recent years, namely, an auto-converter for continuous currents.

Although the machine contains only one armature, one commutator and one set of brush-gear, it performs the functions of a motor-generator, and can even be adopted as a balancer for three-wire circuits. Being provided with ball bearings, it runs for lengthy periods without any special attention, whilst a considerable saving of space is obtained, as compared with a motor-generator. Also the machine is free from vibration and runs practically silently and sparklessly, so that it can easily be installed on consumers' premises. The field magnet system consists of a mild steel casting having four poles, on which are mounted the exciting coils, and it will be seen from Fig. 1 that the yoke is in two parts, separated by dividing pieces, whilst the arrangement of the winding will be seen from Fig. 2. From this it will be noticed that the machine really contains two independent magnetic circuits, the voltage reduction being controlled by the arrangement of these circuits and also by the position of the secondary pair of brushes relatively to the armature winding. The latter it may be remarked is of the ring type. The single commutator is of large diameter and the positions of the carbon brushes are fixed by the pressure transformation required, no further adjustment then being necessary.

Perhaps the feature of the machine which will appeal most to central station engineers, in addition to the advantages of low cost, simplicity of construction, small weight and small floor space required, is the high efficiency obtainable. With a 30 kw. machine an efficiency of 92 per cent. is guaranteed

at full load and 88 per cent. at half load, whilst with a 50 kw. machine an efficiency of no less than 94 per cent. has been obtained. A 10 kw. machine gives an efficiency of 86 per cent. at full load and 80 per cent. at half load, whilst a 1 kw. set, which is intended mainly for use with metal filament lamps, shows an efficiency of 75 per cent. at full load and 65 per cent. at half load. These efficiencies, of course, compare very favourably with those of motor generator sets. The curve in Fig. 4, which relates to a special machine, will give some idea of the efficiency obtained at the various loads.

The C.M.B. auto converter possesses a wide range of applications, amongst which may be mentioned the possibility of using low voltage metal filament lamps, no necessity for resistances in connection with cinematograph arc lamps, searchlights, &c., the control of electrical vehicles (referred to below), winding machinery in collieries, rolling mills, electric welding, the driving of printing machinery and the balancing of three-wire circuits (*see* Fig. 3). It will be seen, therefore, how extensive is the field likely to be affected by the introduction of this new converter.

We do not propose to enter into any technical details of the construction or theory of the machine, as these are dealt with elsewhere in this issue (p. 498) by the inventors of the C.M.B. auto-converter, Messrs. J. C. Macfarlane and H. Burge. We

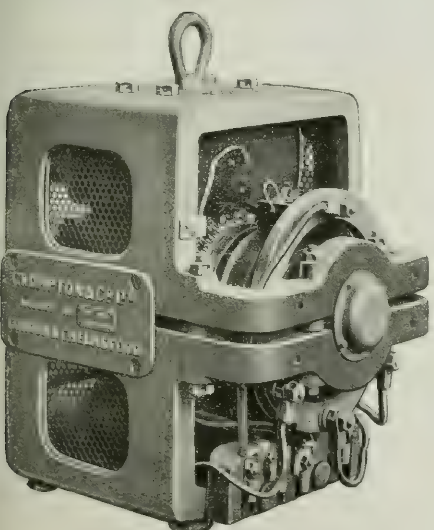


Fig. 1. C.M.B. Auto-Converter.

would like to mention, however, that although at first sight the machine would appear to be somewhat opposed to existing theories of design, there is no doubt as to the results which are obtained, both as regards sparkless and quiet running and efficiency. We should also point out, however, that the auto converter is not intended for use by small consumers with metal filament lamps, but rather for shops where a large number of lamps are required and these practically for the same length of time. In such cases the auto-converter would be run only at times of considerable load, and any lamps required to be used throughout the day would be connected direct to the supply mains.

Whilst visiting Messrs. Crompton's works last week our attention was drawn to an auto converter which had been designed for electric welding. The feature of this machine was that it withstood repeated short circuits lasting several seconds, the ammeter merely showing an increase of 10 per cent. in the current, and the voltmeter reading falling to zero.

We have mentioned above the extensive field of operations open to the C.M.B. auto-converter, and among these the one likely to lead to the most important developments is, perhaps, the application of the auto-converter to the control of electrical vehicles, particularly omnibuses and tramcars. An omnibus in which electric accumulators are employed has been designed and constructed by Messrs. Crompton & Co., and from trial runs with this vehicle which we witnessed last week it may be inferred that the supersession of the petrol omnibus has received a distinct impetus.

The system of control for electric vehicles patented by Messrs. Crompton & Co. in connection with Messrs. Macfarlane and Burge is similar to the Ward-Leonard system, but possesses some important additional features. A motor-generator, or auto converter, adds to or reduces the supply pressure, thus

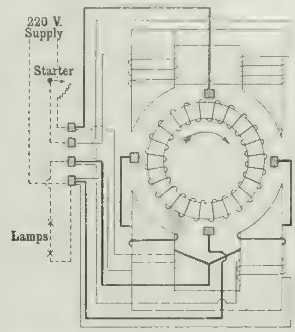


Fig. 2.—Diagram of Connections of Auto Converter.

giving a range of voltage on the motor terminals varying from double the supply voltage down to zero. This variation is obtained entirely without the use of starting resistances or main circuit controllers, and it naturally gives enormous variation in the torque of the motors, especially as it is accompanied by suitable variations in the field strength.

Fig. 5 shows the connections employed, a motor-generator being indicated to simplify the diagram. The whole of the control of the train, tramcar or omnibus is managed by the reversing field regulator attached to the high-resistance coil on the generator field (*see* Fig. 5). This exciting coil is by itself capable of completely controlling the pressure of the generator within the limits already given. Its effect is, how-

Fig. 3.—Diagram of Connections of Auto-Converter used as a Balancer.

ever, modified by a limiting winding in series with the motors, the effect of this winding being to prevent the current under any circumstances rising above a certain predetermined figure, sufficient to accelerate the vehicle under all conditions, or to produce the requisite amount of braking.

Owing to the presence of this limiting coil, the amount of skill required by the driver is enormously reduced. The driver may throw his regulator full over into the starting position ; the current then rises to the proper starting current and no higher, and remains at this amount as the car accele-

rates, falling to the normal running current when full speed is attained. This method would always be used when the maximum rate of acceleration is required. If, however, through any reason the driver should wish to accelerate more slowly, he will then move his regulator slowly, and we noticed last week that by means of this regulator it was possible to control the rate of acceleration so that the vehicle merely crawled from rest. It will be obvious that the limiting coil results in a reduction of speed on up-gradients, since an excessive current cannot flow. Objection may be raised to such reduced speed on hills, but this is not by any means a disadvantage from the efficiency point of view.

It will also be noticed that the system is regenerative. When it is required to stop the car the motor-generator field regulator is thrown to the stop position; this at once reduces the pressure supplied to the motors; the latter, then becoming dynamos, return power to the supply circuit. Again, the braking current is limited in exactly the same way as the accelerating current, and provides for the greatest advisable retardation of the vehicle; a slower movement may, however, be used if a slower rate of retardation is required.

The circuit between the source of supply, the motor-generator and the two car motors is never broken, but a reversing switch is provided for reversing the direction of rotation of

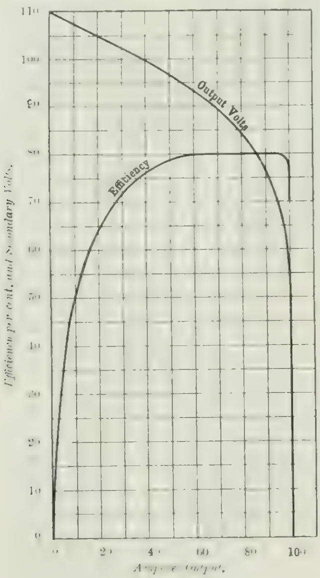


FIG. 4.

the motors. The motor field excitation consists of two coils for each motor, one coil being separately excited from the main supply and exciting the fields to a sufficient extent to enable the train to run at its full speed on the level. Under these conditions the fields are, comparatively speaking, weak, and the extra field strength required during accelerating and retardation is provided by the second winding, which is connected from a point between the two motors to a point between the motor-generator and the source of supply (*see* Fig. 5). An examination of the diagram of connections, Fig. 5, will show that when the two motors have full pressure on their armatures the difference of potential across the second winding is zero, but at starting-up, when the voltage across the motors is practically zero, there is then a difference of potential across the coil equal to the supply voltage, and the motor fields, therefore, are at their full strength.

We have already mentioned the simplicity of the system of control; in fact, a foot pedal (which varies and reverses the field of the motor-generator or auto converter) suffices, and as this is fitted with a spring return to the top position, the car is immediately brought to a standstill if the driver leaves his position. When one considers the strain imposed upon the drivers of existing motor omnibuses, due to changing the gear, braking, &c., the advantages provided by this new system of control are fully appreciated.

As to its advantages, it is claimed that much greater efficiency is obtained, due to the absence of resistances, series-parallel control, and braking by mechanical means; it is said that about 50 per cent. greater mileage can be obtained with such regenerative control when electric accumulators are employed for traction purposes. Also, repairs are considerably reduced, as compared with existing motor vehicles, owing to the non-use of mechanical brakes and the graduated variations in torque.

The system lends itself readily to multiple unit control. In a train consisting of a number of motor-driven cars it is merely necessary to provide self-starting switches for the motor-generators, solenoid control switches for the field regulators, and solenoid control reversing switches for the motors. Each of these will require only one or two wires run throughout the length of the train, thereby greatly simplifying the flexible connections between cars. As the motor-generator field regulators return to the stop position of their own accord, all parts of the train will naturally be brought to rest if through any cause the train is broken and the circuit operating these regulators is opened.

We may mention that the omnibus which we inspected at Messrs. Crompton's works last week has been under trial for

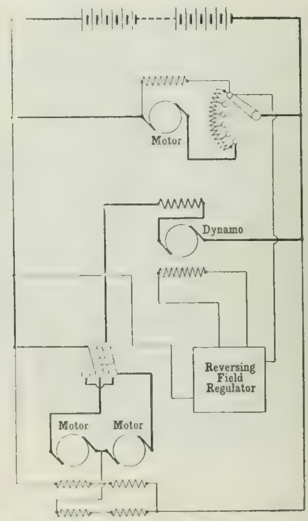


FIG. 5. NEW SYSTEM OF CONTROL FOR ELECTRICAL VEHICLES.

some time past, and its control, both for forward and backward running, uphill and downhill, should certainly prove interesting to most engineers who are acquained with existing vehicles. We hope on a future occasion to give a more detailed description of this omnibus and also of the application of the C.M.B. auto-converter to electric welding and electrical winding, since in the limits of this article we have only been able to touch upon some of the possibilities latent in this most interesting converter.

Electric Traction in British Columbia.—A hydro-electric railway, 100 miles in length, is to be put in hand forthwith through the Okanagan Lake district in British Columbia. Starting from Vernon, the main line will follow the west side of the lake to Summerland, and there will be a branch, 40 miles long, on the east side of the lake to Kelowna. Electrical energy will be generated from waterfalls in the neighbourhood. This scheme has the financial support of the Earl of Aberdeen, who is a large property owner in the locality of the line, and it is stated that the construction will be completed by the end of next year.

THE CHARGE FOR POWER AT WEST HAM.

Mr. H. Ross Hooper continued, on Monday last, the inquiry into the application made last year by West Ham Corporation for permission to borrow £51,000 for their electricity department and also their recent application for sanction to a further loan of £23,000.

Mr. Hugh Seabrook, in reply to Mr. Elvy Robb, said he had not with him the details of the 0·37d., the price charged for a large supply of current at Silvertown. He had not had sufficient time. The normal evaporative capacity of their boilers was 15,000 lb. each, the total was 17 times that. They could put in half as much capacity again without increasing the size of the boiler house. They could also put in engines for another 15,000 kw. without increasing the size of the engine room. That would be on the turbine system. The 0·37d. included net profit and reserve. He was anxious to get more consumers with the same load factor on the same terms. He regarded that class as almost the ideal consumer. He did not say that profits would be largely increased if all their customers were of that class. With regard to public lighting, the charge was 1·53d. per unit, which included capital expenditure (£7,355), but not maintenance. The £7,355 was the capital expenditure at 1906. Additional lamps had since been provided out of revenue. The public lighting load factor was 30 per cent. He did not agree that, on the Corporation's scale, the price earned on public lighting was 0·98d.

Mr. Robb calculated on a hypothetical total output of 53 million units that deducting from last year's total expenditure of £33,837, the amount of £16,140 for coal would leave £17,733 for wages, repairs, stores, &c., which, he said, gave a cost for the latter item of 0·0797d. Capital charges calculated in the same way was 0·1325d. and coal was 0·2d. This was on a 100 per cent. load factor. This, Mr. Robb said, would mean a loss of £9,395, if the consumers were all 0·37d. consumers.

Mr. Seabrook said if the whole of their customers were 24-hour customers they would not have had such a large capital expenditure, as a smaller plant would give a larger supply spread over 24 hours. Therefore Mr. Robb's calculation as to cost did not apply. The new long-hour consumers could not reduce the present capital cost but they reduced the additional capital. He did not think they supplied anyone at less than 0·37d. Deducting the other classes of consumption the quantity of current supplied by contract (according to the published accounts for 1905) would be 1,301,471 units. The price for contracts was therefore 0·336d. per unit. That was not the price charged, but it was the price obtained as special circumstances arose, into which he did not think it necessary to enter. The price charged was 0·4d. A consumer to whom they supplied transformed current would have to pay an amount for transformation, &c., varying with the size of the transforming plant. 0·25d. would be a ridiculously high figure. He said in evidence on the L.C.C. power bill of 1906 that if they took a bulk supply it would cost 0·25d. to transform it, but that was on a different load factor to that of the large power consumers they were now supplying. The question whether he was to give the details of the costs included in the 0·37d. was one about which he would have to take further instructions.

In reply to Mr. Morten, Mr. Seabrook said the L.C.C. in their offer under their 1906 Bill wanted to leave to West Ham customers whom they did not want themselves. The offer was £3. 17s. per year per kilowatt, plus a flat rate per unit. The new contracts were supplied without loss to the other consumers. They would have had to increase lighting charges if these power contracts had not been obtained. A railway company would not be expected to charge fares on a new branch which would cover the proportion of capital charges on the whole of their undertaking. The cheap supply had led manfacturers to come into the borough. (A list of such manufacturers was handed to the inspector.) That increased the ratable value and employment in the borough. In his view the capital charge to be debited to a particular supply was the capital expenditure on that particular supply.

By the Inspector: The capital expenditure was £438,000 and £93,600 had been repaid. In five years' time he thought a mere nominal reserve would be necessary in view of the fact that the undertaking was now only 10 years old and 21 per cent. of the capital had been repaid. The same as to the amount of reserve would apply in 15 years' time. They had much shorter periods for repayment than other local authorities. He meant shorter than the periods allowed by the L.C.C. £2,000 or £3,000 a year would be sufficient to place to reserve at West Ham. The present reserve fund was £5,871. If that were put against the loss incurred on the undertaking in the first 10 years it would leave a deficit of £19,000, which might be called a debit against the depreciation, reserve or obsolescence account.

Mr. Elvy Robb said his clients (the India Rubber, Gutta Percha & Telegraph Works Co.) considered that there was a serious error in the Corporation's calculation as to the power supplies at Silvertown. They would not press for an unconditional refusal of the loan, but they asked for an undertaking that no further contracts should be entered into at similar prices, that the present contracts should not be renewed at the present prices and that there should be a sliding scale as to price of coal, &c. In some cases they were bound (according to Mr. Seabrook) for 14 years. He asked that in future contracts at low prices there should be a limitation of the Corporation's liability for failure of supply. This undertaking, with nearly £500,000 capital, had been at the mercy of two young men, both very able and very sanguine—Ald. Littler and Mr. Seabrook. It was not right that the ratepayers should be bled to provide a hobby for Mr. Littler or a reputation for Mr. Seabrook. Mr. Seabrook had told the Inspector there was an estimate of the cost of the 0·37d. supply which was prepared at the time the contract was entered into but he (Mr. Robb) was afraid they were obliged to conclude that there was no estimate, and that the price was arrived at in a hap-hazard manner. He thought there was no doubt Mr. Seabrook had said, in effect, to his committee that they could supply at 0·37d., only taking into account the cost of the additional plant and mains required. He (Mr. Robb) said there was an overcharge for public lighting, and Mr. Seabrook had stated that for depreciation of arc lamps and meters only 6·6 per cent. had been provided, whereas the Inspector was of opinion that 12 per cent. should be put by if 10 years was the period of repayment. They would also have to pay at least from £4,000 to £5,000 a year rates on the undertaking. All these items would do away with the surplus shown in last year's accounts and leave a considerable loss. It was also admitted that there should be a reserve fund. The rates had contributed £25,000 directly to the support of the undertaking and had paid indirectly at least £1,000 a year overcharge for public lighting, and the addition to the rates which the department should have paid made at least £50,000 in all that the undertaking had cost the ratepayers. The suspicious and discreditable way in which the undertaking had been managed brought municipal trading into contempt. His clients did not oppose municipal trading generally, but they complained of this concrete example. In reports of committees submitted to the Council in October, 1908, a deficit was shown on the electricity department of £52,340.10s.8d. but it was stated to have been reduced to a much smaller sum. If Mr. Morten objected to that subject being brought in, on the ground that it was a matter in dispute in the lawsuit which was pending, the only course for the Inspector would be to postpone the inquiry until after the action.

Mr. Stuart Russell, engineer to the India Rubber Company, said his company asked him to look into the matter of the power contracts of the Corporation to ascertain whether they were remunerative, and the result of his investigations was that the company opposed the application, not because they wished to hinder the development of the undertaking but to get some assurance that contracts would not be made at unremunerative rates in future. He was of opinion that each consumer should pay his proportion of standing and running charges. If a consumer's demand on the peak were a twentieth part of the maximum demand of the station he should pay a twentieth of the capital and running charges. He did not agree that a new consumer should only have to pay the capital charges on the extension and not on the original capital cost of the undertaking. That would be unfair to the old consumers. His estimate of the average cost per unit was 0·980d., of which coal was 0·249d. per unit. He had assumed for 100 per cent. load factor no increase in wages, oil, waste, repairs, rents, rates, &c., working and general costs would be 0·412d. on the 53 million units and the loss, at 0·37d., would be over £9,000 per annum. He had increased the wages in his estimate for 8,000 kw. maximum demand by 15 per cent., repairs was also slightly increased, coal, oil and stores might be covered by 0·2d. He would fix the charge to a new consumer so as to provide for profit and for contingencies and for alteration in price of coal. He did not think a price of 0·37d. could be remunerative from a consumer with less than 100 per cent. load factor. 2 to 2½ per cent. would be a very moderate figure for depreciation. He did not admit the accuracy of the surplus in the accounts, because there should be £5,800 paid for rates on the present assessment, £1,300 had been overpaid for public lighting, and £8,000 or £9,000 should be placed to reserve. These items would change the surplus of £3,800 to a deficiency of about £12,000. He would look for a large reduction in the cost of coal per unit for an increased demand of 4 million units but not a reduction in the total amount spent on coal. Mr. Seabrook said there would be a profit of £8,500 on the 4 million units, but at 0·37d. those 4 million units would only produce £6,000. He considered that the old consumers suffered an injury if the new consumers only bore the capital cost of the extensions. He would accept Mr. Morten's definition "a loss of prospective benefit" instead of an "injury," but the old consumers would have a grievance even if the benefit could only be obtained by quoting the low charge for current. The old consumer should benefit by reduced capital charges as well as reduced working charges. There might be a profit on the 0·37d. if the charges of the whole undertaking were not spread over the whole undertaking, including the new consumers. His estimate of the cost of additional plant was £21 or £22 per kilowatt. That covered the whole undertaking. His figure of 0·412d. was for generation and distribution only, and there were other items included in the 0·37d. charged to certain consumers, apart from the question of capital charges. His figure of £21 per kilowatt for additional plant was based on the additions that had been made in the last few years.

Mr. W. H. Patchell said he was in general agreement with Mr. Stuart Russell. He had tried very hard to substantiate the charge of 0·37d. and he had failed to do so. Even assuming 100 per cent. load factor, that price could not be profitable at West Ham because of their present commitments. There was a danger in filling up the spare plant at very low rates, because one might have to go later and get additional plant to supply other consumers, thereby increasing capital charges. He did not see any other way of working out the capital charge than that adopted by Mr. Robb, which resulted in a capital charge of 0·133d. on 100 per cent. load factor. It seemed to him absurd to claim that the 0·37d. supply produced a profit. No consumer ought to pay less than 0·404d. per unit, even with a 8,000 kw. maximum demand. The costs would, he estimated, be for capital 0·133d., establishment 0·028d., wages 0·014d. coal 0·2d., oil and stores 0·045d. total 0·390d. Even 0·404d. was not likely to be profitable in practice. The Charing Cross Co. would be paying some £4,000 a year to the West Ham rates under their new assessment. He thought 2 per cent. was little enough for depreciation, and there should be some provision for contingencies. He also agreed that there was an overcharge for public lighting.

By Mr. MORTEN: He did not know that the Charing Cross Co. were supplying at 0·33d. per unit, or 0·275d. without the standing charges.

Mr. MORTEN said that was so in the case of a consumer with an 80 per cent. load factor and three miles from the station. At Bristol the Corporation gave a consumer a supply at 0·365d.

Mr. PATCHELL further said it would not be fair to charge a new consumer only with the capital expenditure on his own supply.

Mr. ROBB asked that any loan which might be sanctioned before the hearing of the action between the India Rubber Company. and the Corporation should be so ear-marked that it could not get out of its proper channel. The Corporation were acting in defiance of the regulations of the L.G. Board and he asked the Board to visit it with the gravest consequences.

On Tuesday Mr. J. S. HUDDLESTON, manager of the cable department of Siemens Bros. & Co., put in the order received by his firm in October, 1907, from West Ham for cable. In reply to Mr. Drucker (who appeared for local electrical contractors), Mr. Huddleston said his firm cut off samples from the cable they supplied. The cable which the Corporation supplied to Troup, Curtis & Co. was not Siemens'. There was nothing on the West Ham Corporation's list of prices to show whether these were Association or non-Association cables.

Mr. DRUCKER said it was obvious that the sales and wiring department of the Corporation had been working at a loss.

Mr. PATTERSON, borough accountant, handed in an account showing a net surplus of £228. 19s. 2d. on the sales department for the year to March last. The present amount of expenditure outstanding on purchase of motors was £14,067.

The INSPECTOR said a reasonable amount of capital charges on the motor account for the year 1909 would be £1,758, and asked where the equivalent of that amount was shown in the accounts? There was a statutory requirement that money for such purposes should be borrowed, but apparently £10,715 of it was not to be borrowed at all, and he did not think the L.G. Board would accept that. If the amount spent on motors for hire were charged with capital charges the result of the trading would be different.

Mr. PATTERSON said £700 had been allowed for depreciation on that department, and he had charged it with what he thought a reasonable interest.

The INSPECTOR said if the money for motors for hiring were borrowed and provided for by a sinking fund at 12½ per cent. per annum there would be a further charge of £760 a year. Deducting £480 left £280 loss on hiring of motors, and that added to the wiring loss made a total loss of £543. That would be the position if the money had been borrowed and repaid in respect of motors.

Mr. DRUCKER said the electrical contractors whom he represented were being ruined by the policy the Corporation pursued. The intention seemed to be to show a profit, and that a profit on one branch should be used to set off a loss on another. In most cases that class of department had been worked at a loss The association for which he appeared had successfully appealed against a clause allowing similar trading being included in any fresh bills before Parliament. Sir Alexander Kennedy advised Woolwich to give up their wiring and sales department. £20 as rent, rates and taxes was not a sufficient amount to charge to the sales department. No provision for bad debts had been made in the present account. The only part of the scheme which paid was the hire-purchase wiring, in which there was no competition, because a condition of the consumers coming into the scheme was that the Corporation got the work. But there was a considerable loss on the competitive part of the work, which was the part that was ruining his clients.

Mr. H. H. HOLMES (until recently manager of the sales department) said the quotation they gave Messrs. Troup, Curtis & Co. was only for indiarubber covered wires. They got an order from the firm for black v.i.r. There was no stipulation or promise that the cable should be made by members of the Cable Makers' Association. The cable produced by Mr. Troup was not Siemens'. The profit on the cable supplied was at least 15 per cent. The prices in the West Ham list were for German make of cable. The statement that Siemens cable had been supplied to Troup, Curtis & Co. was due to a mistake.

Mr. SEABROOK said they had a sample of the cable sent to Troup, Curtis & Co. tested. The indiarubber was analysed and found satisfactory, and the cable was submitted to several insurance companies and they accepted it.

Mr. FINER complained that the ratepayers had not had a proper account of the electricity department, and he and Mr. HUGHES (ratepayer) asked that a L.G. Board auditor should go through the accounts before loans were granted. Mr. BISHOP (another ratepayer) said he was one of the assessment overseers, and he had appealed some three years ago to have the undertaking properly assessed. He wished to clear the overseers from the suggestion that they had been responsible for the fact that the undertaking had not hitherto been rated.

[Mr. Stuart Russell here handed in a telegram from Mr. Patchell relating to the low price for current stated by Mr. Morten to be charged by the Charing Cross Co. to any of its power consumers, but the Inspector ruled that it could not be taken as evidence. We gathered, however, that Mr. Patchell had found, upon inquiry, that the price mentioned was plus a standing charge.]

Mr. MORTEN, in his address on behalf of the Corporation, said Mr. Robb had asked that the moneys to be borrowed should not be allowed to be applied to revenue account, but it seemed rather an idle suggestion that the Board should put upon them that condition, because they always lent the amounts for specific capital purposes. Mr. Robb had also asked that the loans should not be sanctioned prior to the hearing of the action that was pending by the India Rubber Co.; but the Court had to deal with the merits of cases as they stood when the writs were issued, and not according to conditions that arose afterwards. Mr. Robb's object was to delay the sanction of the Board and to prevent the Corporation getting the money they urgently required. Mr. Robb also asked for conditions that no renewals of contracts or new contracts should be entered into at unremunerative prices, and that a sliding scale to provide for variations in price of coal should be inserted in contracts. The former begged the whole question by assuming that the prices of contracts already entered into were unremunerative. Mr. Russell and Mr. Patchell had brought out the costs at 0·412d. and 0·401d., and they suggested that there must be a loss in selling at 0·37d. Mr. Patchell took 0·2d. for coal and stores, but Mr. Seabrook did not give that figure for 100 per cent. load factor. The capital charges estimated by Mr. Patchell and Mr. Russell were 0·123d. and 0·111d., and Mr. Robb spread the whole of the capital charges over the whole undertaking, and that was where they came to their main contest. Distribution costs in the case of the large consumers were infinitely smaller than those of the average consumer, and although that supply had been given there was no increase in total distribution expenses. His clients were satisfied that their contracts did show a profit. The suggestion that the price of current should vary with the price of coal would not be practicable. The electricity supply was an inducement to manufacturers to settle in the borough, and, even if the undertaking were making a loss, the benefit of bringing in those manufacturers would exceed any loss that might occur. The progress of the borough depended to some extent upon the low prices at which they could now supply electricity for power purposes. None of the opponents had asked that a loan should not be granted, but only that conditions should be imposed. The case for a load had been fully made out, and there was no ground for any condition.

The INSPECTOR then announced that the inquiry was at an end.

THE FARADAY SOCIETY.

At the meeting held on Tuesday, June 29th, at the Institution of Electrical Engineers, Dr. N. T. M. WILSMORE in the chair, Dr. H. J. S. SAND read a Paper entitled

"Apparatus for the Rapid Electro-analytical Separation of Metals."

The Paper contains a description of some developments made in the apparatus, first described by the author about two years ago, for the rapid electro-analytical deposition and separation of metals (Chem. Soc. "Trans." 91, 373, 1907; also "Trans." 93, 1,572, 1908). This apparatus for the first time combined in a practical manner the use of an auxiliary electrode and very rapid stirring of the electrolyte, and made it possible, as has been shown so far, to deposit and separate from each other for purposes of chemical analysis the metals silver, mercury, copper, bismuth, lead, cadmium, zinc, antimony and tin. The time required for these depositions varied in the majority of cases between five and fifteen minutes. Apart from the very high stirring efficiency of the electrodes the apparatus is believed to be superior to others of similar type in the exceedingly great simplicity of the method of making and undoing the electrical connections on a single stand, in the fact that the electrodes may be used with ordinary beakers, and in the simple manner in which the electrodes may be washed and dried. No alterations in principle have therefore been made to the apparatus, but the following additions and simplifications are described. As hitherto, a mercury contact has been employed in the electrolytic stand to make the connection between the stationary and the moving parts; a special screw cap has, however, now been provided, which may be screwed down when the apparatus is not in use, making it possible to transport it without taking out the mercury. A clutch arrangement has been added which enables the operator to start or stop the rotation of the anode without stopping the motor. Such an arrangement will be found of advantage if it is desired to actuate several sets of apparatus from one shaft driven by a single motor; or if the current is obtained from a small motor-generator which is also employed for rotating the electrode, the clutch making it possible to stop or start the stirrer without stopping the current; or lastly, if a hot air or water motor is employed which cannot be stopped instantly during the washing of the electrodes. A very considerable simplification has been obtained by fitting all the apparatus required for the measurement of the potential of the electrode in a single box. The arrangement has been designed so that by depressing a key it will also allow the P.D. between the anode and the cathode to be read directly. It was thought very desirable to retain the capillary electrometer as a zero instrument, but it became necessary to design a new portable form suitable for the purpose in view. It may be described as a closed evacuated form developed from the Ostwald horizontal capillary electrometer. It is provided with an enclosed scale, and if observed by a lens of small magnification it will readily indicate 1 millivolt.

A Paper entitled "RESEARCHES ON THE RELATIVE RATES OF MI-

GRATION OF IONS IN AQUEOUS SOLUTION" was communicated by Dr. B. Beckett Denison, and Mr. S. FIELD then read in abstract a Paper on

"The Conditions which Determine the Composition of Electro-deposited Alloys. Part I: Copper-Zinc Alloys."

As the result of a large number of experiments on the electrolytic deposition of brass, the author has, by the analysis of the deposits, shown the regular manner in which the composition changes with such varying conditions as (1) proportion of copper and zinc compounds in the solution; (2) strength of the solution; (3) temperature; (4) current density; and (5) the presence of free cyanide. It is thus shown that the proportion of zinc is increased (*a*) at lower temperatures; (*b*) with more dilute solutions; (*c*) with increased current density; and (*d*) by the absence of free cyanide. With a large proportion of zinc compound copper is still freely deposited. The author incidentally draws attention to a number of important conditions which primarily affect the composition of the solution and ultimately the character and composition of the deposit. The work is being continued on other binary alloys.

NOTE ON WIRELESS TELEPHONY.*

BY M. COLIN AND R. JEANCE.

Various transmitting apparatus were considered by the authors in order that undamped simple oscillations of constant energy might be obtained when the microphonic apparatus was not in operation. Several arcs in series were supplied with current at a voltage of 600, which could be varied at the will of the operator, and burnt either in air, coal gas, methane, acetylene, petrol, alcohol or heavy oils. A rheostat and several choking coils were connected in series with the arc, the former of which allowed the potential drop to be regulated and a certain degree of stability to be obtained. The latter were for the purpose of opposing the passage of the oscillations. The first oscillating circuit contained the arcs in series, a capacity that could be regulated, a choking coil which could also be regulated and which formed the primary of a Tesla coil, and an interrupter. A voltmeter was connected across the terminals of the arc. If the phenomena which occurred in this circuit were studied by means of a wave measurer, it was found that it was the seat of a large number of undamped oscillations which did not follow a harmonic law; and that each variation, however slight, in the length of the arcs, gave rise to a corresponding variation in the length and intensity of the oscillations generated.

It results from this that an antenna connected to a choking coil, forming the secondary of a Tesla coil whose primary is the coil in the arc circuit, will vibrate under the action of numerous oscillations created in this circuit, and will not transmit in consequence either a simple oscillation or one of constant energy. The needle of the milliampere meter on the wave measurer indicated these conditions as being present by its rapid variations from a mean position.

The authors, therefore, endeavoured to obtain arcs as stable as possible, and to produce a simple and invariable oscillation in the antennæ. To satisfy the first condition they used several arcs in series whose positive electrodes were made up of large copper cylinders with flat ends. These were cooled by the circulation through their interiors of cold insulating liquid. The negative electrodes were made up of a very thin pencil of carbon carried in a support with a large radiating surface. Under these conditions, when the circuits had been regulated, the arc was constant; the positive electrodes were not worn away, and the negative electrodes increased slowly and very regularly in length (unless the arcs were burning in an atmosphere containing oxygen) on account of the deposited carbon which forms at either end and arises from the decomposition of the methane under the action of the arcs.

When the arcs burn in air, or in an atmosphere containing oxygen, the number in series must be considerably increased and the active part of the negative electrode must have a large surface of purified carbon. To satisfy the second condition, the authors employed a second oscillating circuit, whose electrical characteristics were invariable and which was made up of an adjustable choking coil forming the secondary of a Tesla transformer whose primary was the choking coil in the arc circuit, one or more condensers which could be regulated, and a choking coil forming the primary of the second Tesla coil. This intermediate circuit was tuned to the oscillations produced by the arc current. Lastly, a fourth choking coil, which could be regulated, was connected by a convenient point to the antennæ and to earth.

Under these conditions, tuning being realised, the oscillations transmitted were simple and constant both in length and energy. This could be verified by means of a wave measurer. The microphone arrangement was placed in a circuit, which contained a regulating resistance connected at one end to earth and at the other to a point on the secondary of the second Tesla coil. In this way, variations in the weak current flowing through the microphone could be made to give any desired alteration in the fairly large current which passed through the antennæ. To suppress the troubles due to variation in the resistance of the microphone when not working to diminish the sparks and to increase the sensibility and purity of the transmission, the authors used a large number of microphones connected in series. These microphones, which were specially designed, contained no combustible material, the carbon grains being placed in circular holes sunk in a plate of marble or slate. The diaphragm was maintained at a convenient distance from the grains by a metal ring.

To sum up, the points to which particular attention is called in this apparatus are the arrangement of the negative electrodes so that their stability is assured; the utilisation of an intermediate current, which allows a simple oscillation to be obtained; and the arrangement and general make up of the microphonic apparatus.

* Translated from the "Comptes Rendus." Slightly abbreviated.

THE FIRE ON THE METROPOLITAN DISTRICT RAILWAY.

The report of Mr. A. P. Trotter to the Board of Trade, in connection with the fire which took place at Charing Cross station of the Metropolitan District Railway, London, on May 24th has been issued. We give an abstract of the report below:—

It appears that the fire was not of an electrical character, but was due to a spark from a brake block, or from a lighted match or cigarette end, which ignited dust and dirt in a concrete chamber flush with the ballast immediately under the edge of the north platform. The low-pressure mains from the sub-station come out from below the platform into this chamber. The cover of this concrete chamber was made of ordinary plank. It was intended that Jarrah wood should be used, and if that material had been employed, it is probable that the fire would soon have burned itself out, as Jarrah wood is nearly non-inflammable. An iron cover, or indeed a heavy cover, would not be suitable, as it is close to the positive conductor rail, and the space between that and the platform is very limited. These concrete chambers are periodically examined and cleaned.

The passage between the concrete chamber and the sub-station through which the cables are laid, forms one of the intakes of air into the sub-station, which is powerfully ventilated. The first notice of trouble was given by smoke entering the sub station through the low-pressure cable ducts. The strong draught appears to have fanned the fire and accounts for the fierceness of it. It was seen that the fire would soon reach and damage the low-pressure cables, and orders were given to cut off the electrical supply. The proper course would have been then to have disconnected the low-pressure cables from the junction pillars at the ends of the east and west sections, and to disconnect the station section altogether, and to "jump" the station section, or to work the traffic on the south line by the cross-overs.

Unfortunately a train running eastward entered the station and stopped with a motor car immediately over the feeder supplying the station section, so that the feeder cable was sawed through only under great difficulties. If the train had not been allowed to come up to this point, it is probable that traffic might have been resumed after a few minutes. At the time when the current was cut off no electric damage had been done, but the fire was fierce enough to melt the lead sheathing of the low-pressure cables, and when the oil-impregnated paper insulation caught fire there was considerable smoke. An inspection of a similar chamber at Victoria showed that there was no appreciable accumulation of dust or dirt. A further precaution is to be taken by bricking in the entrance of the passageway leading to the sub-station, except so far as is necessary to allow the cables themselves to pass.

BOOKS RECEIVED.

Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Congrès International des Applications de l'Electricité, Marseille, 1908." Parts I. and II. Rapports Préliminaires. (Paris: Gauthier-Villars.) Fr.24 each.

"Congrès International des Applications de l'Electricité, Marseille, 1908." Part III. "Organisation du Congrès." (Paris: Gauthier-Villars.) Fr. 20.

"The Design and Construction of Induction Coils." By A. F. Collins. (New York: Munn & Co.) $3 nett.

"Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Baldwin, Kansas, 1901–1904; at Vieques, Porto Rico, 1903–1904; and at Sitka, Alaska, 1902–1904. Three vols. By Daniel L. Hazard. (Washington: Government Printing Office.)

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THE COMPOSITION AND DURABILITY OF CABLE PAPERS.

In THE ELECTRICIAN for April 16th, 23rd and 30th we published an article by Messrs. CLAYTON BEADLE and H. P. STEVENS on the "Composition and Durability of Cable Papers," and in the present issue there appears an article by Mr. BEAVER on the same subject. The first article is written from the point of view of the chemist, and the second from that of the cable maker; and, as these points of view are by no means identical, we think we may be able to assist our readers by briefly reviewing and commenting on the articles in question.

One of the first statements made by Messrs. BEADLE and STEVENS was to the effect that there is a want of co-operation between the paper manufacturer and the cable maker. This view, we think, is somewhat incorrect. Undoubtedly there are to-day many manufacturers whose "cable papers" are never, or scarcely ever, used by recognised British cable makers, chiefly because there is available more suitable material; these unfortunates may, of course, lay claim to a want of co-operation. But when it is remembered that practically all the leading cable makers in this country employ a factory chemist, who, while he may not possess a detailed knowledge of paper manufacture, is sufficiently informed in the different pro-

cesses involved to guide him in his chemical, physical and general examination of cable paper, it is almost ridiculous to expect that the cable maker will withhold any data likely to assist his paper manufacturer in improving an already good material.

Although there is not much published data regarding this subject, as mentioned in the summary of Messrs. BEADLE and STEVENS' article, it seems to us more than likely that cable manufacturers possess much information on the point, especially when we reflect that not only are they in a position to obtain full details as to composition, quality and mechanical properties of the paper by laboratory tests, but are also able to follow up its behaviour during the various cabling operations, and obtain the electrical values of paper as an insulating material in finished cables—surely a comparative study of these accumulative records will permit a suitable selection of material.

As regards fibre composition, we are inclined to agree with Messrs. BEADLE and STEVENS that admixtures of manila and hemp, and, perhaps, even a little flax, frequently constitute the composition of cable paper supplied as "manila," or even as "pure manila." There is undoubtedly much scope in using the term manila in a generic sense, and while cable manufacturers might knowingly use a mixed paper as "manila," perhaps because of its greater suitability for the particular work required of the cable, yet we agree with Mr. BEAVER that pure manila paper can be obtained if desired. Regarding the presence of the fibres of grass, straw, chemical and mechanical wood in cable paper, we take it that these have sufficient individuality to render their identification easy; consequently no cable maker need unknowingly use a paper composed of them wholly or in part.

Coming now to mineral matter in cable paper, we agree with Messrs. BEADLE and STEVENS that (as loading) it should be avoided; not, however, so much from the point of view taken by them that it may reduce the strength of the paper as well as its lasting qualities, but rather do we share Mr. BEAVER's opinion that it should be avoided because of the degrading influence it would exert on the electrical insulation and capacity properties of the paper. We would further add that it is highly improbable that the regular makers and suppliers of cable paper ever load their material. The mineral matter, as obtained after complete incineration of the paper, should consist entirely of the natural ash of the paper's component fibres, and we agree that the maximum should be between 2 and 3 per cent.

Regarding the mechanical constants of paper, Messrs. BEADLE and STEVENS mention that "one has to take into consideration the stresses and strains to which the strips of paper are subjected at the moment they are lapped round conductors." We would emphasise the importance of this from the cable maker's standpoint, and would supplement Mr. BEAVER's statement by remarking that, generally speaking, if the paper is mechanically strong enough to withstand satisfactorily all the different strains and stresses, twistings and turnings to which it is subjected during cable operations, it is highly probable that it is mechanically strong enough to withstand any subsequent average degree of rough treatment it may meet after lead sheathing.

There is no doubt that the structure of cable paper, as indicated by figures representing specific gravity or density and air space, &c., mentioned by the authors of both articles, is a matter of great importance to cable makers, and while we agree with Messrs. BEADLE and STEVENS that the air space value may be used to indicate to what extent the paper possesses the desirable absorptive properties necessary for power cable paper, we also support Mr. BEAVER in his view that it provides other valuable indications, notably those as to its electrical insulation and capacity, especially for air space cable work (telephone cables), where absorptive properties in respect of compound are not necessary, and where the paper is certainly something more than a medium for holding the insulator.

Mr. BEAVER mentions that cable paper manufacturers employ magnetic arrangements for extracting particles of iron and magnetic oxide. While this is a fact, and accounts for the general absence of these bodies in good paper, it is equally a fact that particles of metallic copper, and, less frequently, copper alloys, are sometimes found in the paper as delivered from the mills. The presence of these particles of copper is usually attributed by the paper manufacturer to small pieces of copper wire returned from the cable makers in waste cable paper, of which a certain amount has been re-pulped and incorporated in a fresh batch. We understand, however, that the paper manufacturers are now discontinuing the practice of using cable makers' paper scrap for this purpose.

Regarding insulating compounds used for impregnating, obviously it would be useless to employ a satisfactory paper should it be subsequently impregnated with substances which possess, or could develop, properties causing corrosive action on the copper conductor. In this connection we agree with Mr. BEAVER that mineral and resin oils have no corrosive action on copper, but that oils such as castor oil and other fatty seed oils sometimes have pronounced corrosive action. Messrs. BEADLE and STEVENS give the results of analysis of two impregnating materials: "The so-called acidity in terms of resinous acid we found to be in the case of No. 1 44 per cent., and in No. 2 47 per cent; with resin oil we should expect to find about 40 per cent." While we agree with Mr. BEAVER that there is no difficulty in procuring the oils which are used in British practice perfectly free from either organic or inorganic acids, we would say that, so far as obtaining resin oil practically free from organic acids—such as may be understood by the expression of resinous acid mentioned by Messrs. BEADLE and STEVENS—it is unnecessary to provide for its absence, at least, so far as copper corrosion or deleterious effect on any of the components of the insulation is concerned. At the same time we would say that 40 per cent. resinous acids (indicated by titration with caustic potash) is very much higher than is usually found in good commercial resin oil.

Further, Messrs. BEADLE and STEVENS state: "We have noticed traces of both copper and lead in such papers when impregnated with resin oil." Here, again, they seem to imply that the presence of these traces is a function of the resin oil; but, in our opinion, it is more likely to be due to friction, and would probably be found restricted to the two surfaces of the particular layers of paper immediately next

the conductor and lead sheathing respectively. Lead being a soft metal could easily impart faint local spots, streaks or films of metal to the compounded paper when the cable is bent, and, as is well known by those who have handled copper wire, its surface frequently contains traces of very finely divided copper dust; assuming the absence of particles of metallic copper in the paper, as referred to above, this may easily account for the traces found by Messrs. BEADLE and STEVENS. However this may be, provided the traces are restricted to the layers of paper mentioned, and that they are in the metallic state, and not salts, which would be more likely to penetrate, we endorse their opinion that the amount is too small to affect the dielectric properties. We cannot, however, agree to pass over lightly the statement made by Messrs. BEADLE and STEVENS regarding traces of metallic salts in paper; we are of opinion that all traces of metallic salts, other than those found in the fibre's natural ash, should be most rigidly excluded from the paper, especially those readily soluble in water and which may impart an acid reaction to the paper, such as alum, &c. Electrical cable manufacturing engineers, of any experience at all, know that the presence even of a faint trace of mineral acid salts in the insulator will seriously degrade the dielectric strength and insulation resistance, &c., of the material, and, generally speaking, there is nothing in the composition of impregnating compounds used in British practice which would tend to arrest the weakening effect of such traces of mineral acid salts on the insulating properties of the compounded paper.

Regarding the deterioration of paper under heat tests we are inclined to support Mr. BEAVER's views that, in most cases, paper containing woody fibres—*i.e.*, in larger quantities than accidental traces—deteriorate at much greater rate than pure manila or manila and hemp papers. Certain it is that papers containing or consisting wholly of chemical wood pulp, possessing even perhaps only a faint acid reaction due to insufficient washing or neutralisation, will deteriorate in strength under the influence of heat, at a very pronounced rate.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Elementary Dynamo Design. By W. BENISON HIRD. (London: Cassell & Co.) Pp. ix. 276. 7s. 6d. net.

As the author explains in his preface, "the aim of this volume is to explain by means of numerical examples the methods and calculations necessary for the design of dynamo electric machinery. Controversial points as to nicety of design are avoided, as belonging to a more advanced study than is here intended." With this object in view, the author gives the calculations necessary for the design of a continuous current generator and motor, and of a three phase alternator and a three phase induction motor.

In the introductory chapters a short *résumé* is given of the electrical and magnetic properties of the materials used in electric machinery, as well as a description of the various types of continuous current machines; the description of armature and field windings is very simple and clear. The design of continuous-current machinery is dealt with in the usual way, but we think it would have been better if, instead of merely stating the fact, the author had proved how the output in watts per revolution per minute depended on the d^2l dimensions of the armature, and how the various constants, which affect the result, may be taken into account. This is the chief fault of the book: Formulæ and statements are given which the author seems to have assumed the reader could elucidate for himself. Whatever merits such an assumption may possess, it is certainly too much to expect of one just commencing the study of dynamo design. The problem of commutation is dealt with in Mr. Hobart's empirical method, and is very clearly expressed: The author mentions Mr. Mavor's formula for reactance voltage, but leaves it for the reader to work out for his satisfaction.

The heating of the armature and field coils is treated in the orthodox method.

Reference is made to special machines, such as generators for coupling to steam turbines, variable speed motors and the use of commutating poles and compensating windings by means of which are overcome the commutation troubles, which come into great prominence with such machinery.

After dealing with the principles of alternating currents, the author goes through the calculations for a three-phase alternator, but we cannot commend the manner in which he starts his design. He objects to taking the leading dimensions of the stator from the curve showing watts (in this case kilovolt-amperes) per revolutions per minute proportional to d^2l, since these, he maintains, must largely depend on the regulation required of the machine. We cannot agree with this, for in all, except small diameter machines, the output is determined by the stator dimensions, whilst the rotor and gap can be left to look after the regulation. By the suitable choice of constants which make up the "kilovolt-amperes per revolutions per minute" expression, the linear dimensions can easily be predetermined. We note no attempt is made to calculate the magnetic leakage of the alternator, which is surely a serious omission, even for an elementary book.

The three-phase induction motor is very clearly worked out and special prominence is given to Heyland's circle diagram.

The last chapter deals with special alternating-current machinery, such as synchronous motors and single-phase induction and commutator motors; but we are surprised to see no mention of the rotary converter or the cascade motor converter. We hardly need say the subject has been treated in a very brief manner, considering that there are only 276 pages; but, with the exception of the points already noted, the author has treated his subject very well, and has clearly indicated the lines by which machines are designed. To the conscientious reader it should be of great assistance. It is a pleasure to find a book so well arranged and provided with such excellent diagrams.

Die "Elektrische" Taschenbuch. By PAUL SCHARLOTT. (Leipzig: Carl Scholtze.) Pp. 266. M.1.75.

In this small pocket-book the features of electric tramways are dealt with in an elementary manner. The object of the book, namely, to give the ordinary tramway personnel a rudimentary knowledge of the electrical phenomena and mechanical actions which are met with in electric tramway work, has been satisfactorily attained. By carefully studying the subject-matter contained in the volume the reader will be able to obtain a very good grasp of the apparatus and machinery he is to handle; and his task is rendered all the easier by the large number of excellent drawings and illustrations of the details of tramway material with which the book is furnished. The descriptions, if somewhat brief, in consequence of the extensiveness of the subject and the necessarily confined space available, are, however, clear and to the point.

There are 11 chapters. The first gives the elementary principles of magnetism, electricity, electromagnetism, current, voltage, resistance, the production of heat, light and electrical energy and electric lighting. Chapter II. explains the applications of electrical phenomena. Chapter III. is a short one on electric tramway systems. Chapter IV. is descriptive of the power-house, boilers, dynamos, switchboards, accessories, batteries, pumps, condensers, &c. Chapter V. briefly explains the more important points of the cable network. Chapter VI. is on the overhead line equipment, including poles, and is one of the

best in the book. Chapter VII. contains information on the track with its attendant constructional work. Chapter VIII. goes carefully into the details of the parts and the manipulation of tramway rolling stock. It contains good illustrations of the parts of car bodies, trucks, trolley standards, controllers, motors, and so on. Chapter IX. deals with the various car types—single and double-deck cars, trailers, two and four-axle bogies. Tramway brakes are then explained in Chapter X.—hand, electric and pneumatic brakes, with their modes of action, manipulation and arrangement. Chapter XI. is a very short one on the departures necessary for inter-urban and long-distance lines. Chapters XII. and XIII. give operating rules and disturbances which occur in working, faults on the overhead line, mains, &c. And the final chapter is an appendix containing extracts of German rules with some hints on first aid.

AUTOMATICALLY CIRCULATING FURNACES OF THE GIN TYPE FOR THE ELECTRICAL PRODUCTION OF STEEL.*

BY GUSTAVE GIN.

Summary.—A description is given of induction furnaces in which the molten material is in continual circulation. An electrode furnace is also described in which the same principle is applied, and finally a combined induction and electrode furnace.

Gin Induction Furnace.—In induction furnaces with an open connecting channel it is difficult, on account of the small heat conductivity and of the slowness with which the molten bodies diffuse, to obtain a uniform distribution of either the heat or the purifying

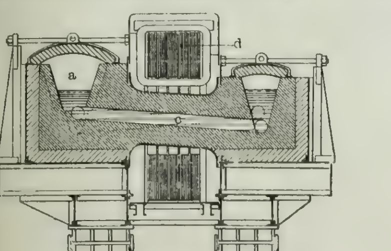

FIG. 1.—INDUCTION FURNACE.

reactions. A much better result is obtained from the technical point of view by keeping the molten material in continual circulation, as this causes a mixture of all the parts and brings fresh surfaces of the reacting bodies into contact. Such a circulation has been obtained by Schneider, and also by the author, the latter furnaces being characterised by a converter which is composed of two crucibles, both partly filled with the molten material, and of communicating inclined channels, wholly filled with this material. The whole arrangement forms a closed circuit, through which the heat generated causes a general circulation. This continues owing to an ascending movement which occurs in the connecting channels, and is transmitted through the whole molten mass.

Fig. 1 shows a model furnace which the author designed with the assistance of MM. Schneider et Cie. for construction at the Krupp works in Essen. This furnace consists of two crucibles, *a* and *b*, connected by the heating channel, *c*. The larger of these crucibles, *a*, is known as the working crucible, and is fitted with a draw-off door for the slag, and a pouring funnel for the steel. The inducing circuits surround the two heating channels and are cooled by forced ventilation. To facilitate pouring and the withdrawal of the slag, the whole furnace can be turned about an axis by means of an electrically driven worm. It is easy to understand why such a furnace should be better from a technical point of view than one with an open connecting channel. The heating is uniform throughout the furnace, and a very high temperature can be obtained without any fear of introducing the "pinch phenomenon" in the heating channels. Every portion of the molten mass comes successively, and at a rapid rate, into contact with the oxidising slag, thus permitting a much more rapid and complete purification than can be obtained in ordinary furnaces. The speed reached in the channels varies according to their gradient and diameter, but the arrangements are so designed that a minimum velocity of 0·10 metres per second is obtained.

* Abstract of a Paper read before the Faraday Society.

In induction furnaces with an annular channel the coefficients of self- and mutual induction increase with the dimensions of the secondary circuit and, therefore, with the capacity of the furnace. This makes a reduction in the frequency of the primary current necessary, and leads to the employment of generators and transforming apparatus, abnormal in dimensions, weight, and size. With the automatically circulating furnace the ohmic resistance of the circuit can be increased without correspondingly altering its self- or mutual induction, thus allowing furnaces with a satisfactory power

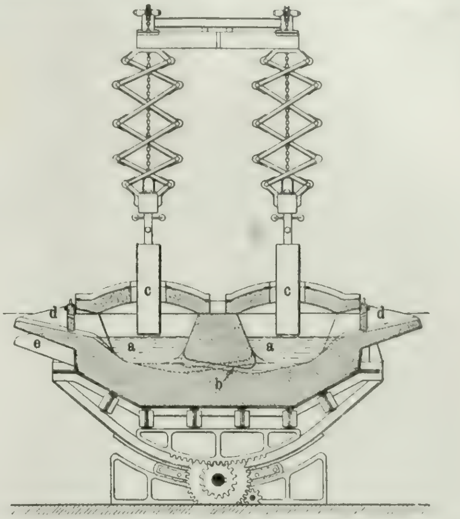

FIG. 2.—ELECTRODE FURNACE.

factor to be obtained, and generators and transformers of normal frequency, weight, and price to be employed. The furnace illustrated is constructed for a power of 420 kw. The primary current is supplied at an average pressure of 4,800 volts, and its frequency is reduced to 5 per second. Its capacity is 5 tons.

Gin Electrode and Automatically Circulating Furnace.—In some electric furnaces which are applied to the production of steel, the arc plays between one or more electrodes and the bath it is desired to heat. If the current pass from one electrode to the bath and thence to a second electrode which is movable like the first, a purely superficial heating is obtained by means of two arcs in series. This is favourable to a high temperature of the slag, but produces an in-

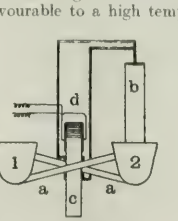

FIG. 3.

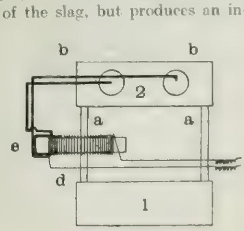

FIG. 4.

complete and non-homogeneous heating of the molten metal in the bath. If the current from a single electrode pass through the bath to leave by a conducting hearth, an amount of heat is set free in the mass traversed, which is proportional to the electrical resistance of this mass. But if a metal like iron, whose resistance is comparatively low, is being worked with, this quantity of heat is practically negligible, and the useful effect is reduced to the superficial heating produced by the arc between the electrode and the surface of the bath. In both cases the thermal efficiency is low, for the heat conductivity of liquids is small, and the ascending and descending currents which are produced when the source of energy acts on the lower part of the bath cannot be used for the transmission of heat. This disadvantage

is remedied by causing the molten mass to be artificially circulated. To obtain this circulation the author has designed an induction furnace made up of a series of crucibles, partly filled with the molten material, and connected by communicating inclined channels which are completely filled with the molten mass. The same principle can be employed in electrode furnaces. The simplest application is shown in Fig. 2, which illustrates a furnace made up of two crucibles, *a*, connected by inclined channels, *b*, sloping in opposite directions. In the two crucibles are placed the electrodes, *c*, which are connected to an electricity supply. The current passes from the electrode into the bath in the first crucible, and from there into the other bath through the channels, *b*, which serve as conductors both of electricity and heat. Lastly, the current passes from the bath in the second crucible to the corresponding electrode. On account of the heating which is produced in the communicating tubes and the difference of

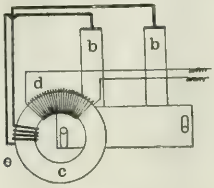

FIG. 5.

level which exists between their two ends, the molten mass rises in them and passes from the first furnace to the second by one of the tubes and in the opposite direction by the other, so that a continuous circulation and even heating is obtained.

A three-phase furnace can be similarly arranged by connecting three crucibles by inclined tubes, which serve as both electrical conductors and transmitters of heat. The author has designed furnaces on this system for powers of 750 kw., 1,500 kw., and 2,500 kw., from which 8 tons, 14 tons, and 20 tons of metal can be respectively obtained.

Combined Induction and Electrode Furnace with Automatic Circulation.—By combining the methods of heating by electrodes and induction, when materials containing large quantities of impurities are being used in steel production, refining produces a large quantity of slag whose electrical resistance is very great compared with that of the metal it covers. If the heating is effected simply by induction the transformation of the electrical into thermal energy takes place

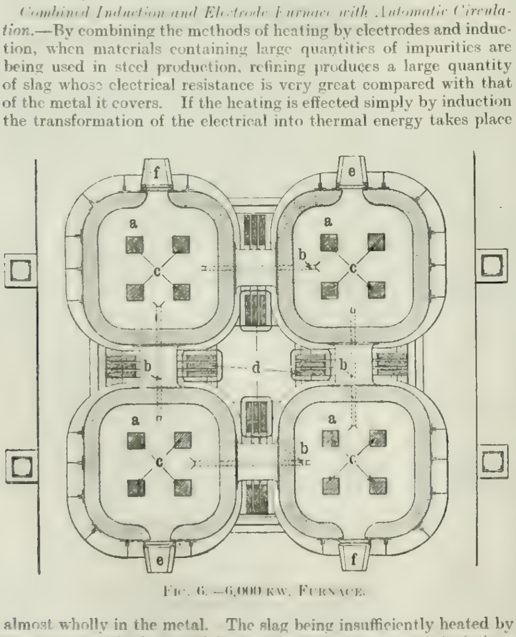

FIG. 6.—6,000 KW. FURNACE.

almost wholly in the metal. The slag being insufficiently heated by its contact with the metal bath, it is difficult to maintain it in a conveniently fluid state or at a temperature suitable for the purifying reactions. To remedy this disadvantage the employment of a second source of heat, electrical or otherwise, which allows the slag to be specially heated has been proposed by Schneider et Cie., and the Rochlingsche Eisen und Stahlwerke and Rodenhauser.

A mixed furnace which gives better technical results is obtained by employing the arrangements shown in Figs. 3, 4 and 5, which represent diagrammatically two crucibles, 1 and 2, connected by channels, *a*, which slope in opposite directions. Round one of these channels is an inductive system, *c*, fitted with a primary winding, *d*, and a secondary winding, *e*. The ends of the latter are connected to two electrodes, *b*, by which current is brought to the surface of the bath in one of the crucibles. As in the ordinary induction furnace, however, the bath made up of crucibles 1 and 2, and the channels, *a*, forms a secondary winding in which is induced a secondary current that is transformed into heat. An internal heating in the channels and a superficial heating in crucible 2 is thus simultaneously obtained. The electrodes being movable, the resistance of the circuit in which they are connected can be varied at will, and thus the total power distributed in the most convenient manner according to the working conditions.

The furnace shown in Fig. 6 has been designed for a power of 6,000 kw., and can furnish 50 tons of metal at a pouring.

In a note submitted in 1907 to the American Electrochemical Society, the author stated some theoretical data for the design of induction furnaces; the remainder of the present Paper is devoted to practical applications of such data. In order to emphasise the possibility of obtaining a powerful furnace with this arrangement, while still utilising generators of standard frequencies two furnaces of 420 kw. and 790 kw. are compared, the supply current to the first furnace being at a frequency of 5 and that to the second at a frequency of 25. The first of these furnaces was erected at the Krupp works in Essen, while the second is to be used in the factory now under construction at Ste. Marie de Cunies (Savoie). The details of the first furnace are:—power 420 kw., supply voltage 3,500-4,000, frequency 5, area of iron in transformer 8,950 sq. cm., estimated flux 9,000 gauss, diameter of channels 17 cms. And of the second furnace: power at the primary terminals 790 kw., supply voltage 500 to 550, frequency 25, area of iron in the transformer 4,200 sq. cm., estimated flux 9,000 gauss., diameter of channels 12 cm. The resistance of the molten metal may vary between 140×10^3 and 200×10^3 electromagnetic units.

The author calculates the dimensions and constants of the two transformers, the efficiencies being shown to be 95·5 and 95·2 per cent., respectively.

CORRESPONDENCE.

DIFFERENTIAL BALLISTIC METHODS OF MEASURING HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must thank Dr. Beattie for his reply to my letter explaining more fully than in his article the measurement of **H** in his specific-loss method of testing straight bundles of iron for hysteresis. Granting that $\mathbf{H}_a$ is proportional to **B**, I can find no fault in Dr. Beattie's reasoning. Nevertheless, I am still doubtful whether the hysteresis loss in the centre of a straight bundle can be materially different from the hysteresis loss in a closed ring.

Dr. Beattie claims that identical results being obtained by his total loss and specific loss methods is in a measure a proof of their correctness. It appears to me just the opposite. I should expect to find a normal hysteresis loss in the centre of the bundle, but a greatly reduced hysteresis loss over the bulk of the iron, especially near the ends. I feel, however, rather out of my depth when discussing non-uniform magnetic circuits, so may be quite wrong.

I note that Dr. Beattie found the same loss at the centre of a straight bundle as in a ring when a wattmeter was substituted for a ballistic galvanometer, the loss being then 1·6 times the loss found ballistically. This appears to prove my contention that the hysteresis loss in the centre of a straight bundle is quite normal, and that, therefore, there is something wrong about the ballistic test. What this is I cannot at present say.

That an air-gap in a magnetic circuit does decrease the total hysteresis loss can be proved by making a wattmeter test on a closed ring and then sawing through the ring, but I have always felt that the decrease in hysteresis must necessarily be confined to that part of the iron in the immediate neighbourhood of the air-gap.

I am obliged to Dr. Beattie for his explanations and for his references. I have not yet been able to look up the latter, being away from home, but will have great pleasure in doing so on my return.—I am, &c., LANCELOT W. WILD.

Westminster Electrical Testing Laboratory, July 3.

THE NEW HOME OFFICE REGULATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with the new Home Office regulations for the generation, transformation, distribution and use of electrical energy in premises under the Factory and Workshop Acts of 1901 and 1907, which come into force to-day and on January 1, 1910, there is a sentence in regulation No. 13 which seems to require a little explanation. This regulation reads as follows:—

"13. Every flexible wire for portable apparatus, for alternating current or for pressure above 150 volts direct current, shall be connected to the system either by efficient permanent joints or connections, or by a properly constructed connector. In all cases where the person handling portable apparatus or pendant lamps with switches, for alternating current or pressures above 150 volts direct current, would be liable to get a shock through a conducting floor or conducting work or otherwise, if the metal work of the portable apparatus became charged, the metal work must be efficiently earthed; and any flexible metallic covering of the conductors shall be itself efficiently earthed, and shall not itself be the only earth connection for the metal of the apparatus. *And a lamp-holder shall not be in metallic connection with the guard or other metal work of a portable lamp.* In such places, and in any place where the pressure exceeds low pressure, the portable apparatus and its flexible wire shall be controlled by efficient means suitably located, and capable of cutting off the pressure, and the metal work shall be efficiently earthed independently of any flexible metallic cover of the conductors, and any such flexible covering shall itself be independently earthed."

It is the sentence, the words of which I have put in italics, that seems to me to call for comment. If the remainder of the metal work of the fitting is earthed, it would also seem to be advisable to earth the holder. If the holder is insulated, it is liable to become charged, and anyone turning the switch on or off, if the holder is of the switch type, or putting in a new lamp or tightening up the barrel while holding the metal stem of the fitting, or while making contact in some other way with earth, would be liable to get a shock. I can only conclude that a printer's error must have occurred here, and that the word "not" should be deleted. It seems a little late in the day to be writing in reference to this matter, seeing that we have all had so much time in which to give these excellent regulations our consideration, and it is possible that I have not interpreted the sentence correctly in its relation to the rest of regulation. If so, I should like to be put right.—I am, &c.,

Strathleven, Holywood, Co. Down, July 1. F. JOHNSTON.

[We refer to this letter in our "Notes" columns.—ED. *E.*]

CHEAP UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There are one or two points in connection with your leading article on the above subject to which I should like to refer. You state your preference for the more exact method of a fixed charge per annum per kilowatt of maximum demand coupled with a low price per unit, and you add that the diversity factor should be taken into account in making the fixed charge. In the above I am quite with you, and the only point I want to see cleared up is the question of the application of the diversity factor in the reduction of the fixed charge. The effect of the diversity factor may be taken account of in two ways; (1) it may be expressed as the ratio of the sum of the maximum demands of the various consumers (including the new consumer under consideration) to the new maximum demand at the station; or (2) it may be expressed as the ratio of the *increment* of the sum of the maximum demands of the various consumers to the *increment* of the maximum demand at the station. The corresponding analogy in the matter of load factor would be that (1) a consumer would only get the benefit due to the percentage improvement that he conferred upon the load factor of the whole station, or (2) he would get the whole benefit due to *his own* load factor. I contend that in the matter of diversity factor the consumer ought to be treated under the second method.

If this principle be granted, and I cannot help feeling that it is the right one, then the allocation of the fixed charges becomes an easy matter, and it is only necessary to add a percentage of profit on to the true running cost to cover all cases. My point is, that a consumer coming on in the dead of night is just as profitable, or even more so, to the station if he is charged in the above manner as the ordinary consumer would be who comes on at peak load. In the latter case the station incurs a very big expenditure for the sake of getting the consumer, and the real issue comes in the question of *what is the net profit*, after all the other expenses have been met. I do not, therefore, agree with your statement that a consumer with a maximum demand occurring between midnight and 6 a.m. should contribute something towards *capital* charges; but that he should contribute merely to "net profit" charges.

It also appears to me that in the desire to be scrupulously fair towards the old consumers, some of our friends are overshooting the mark and are grossly unjust towards the (would be) new consumers. I am not at all sure that if the restricted-hour system could be applied in the way I suggest and carried until reasonably late in the afternoon, much business might not be done in heating and cooking, as well as in power. Surely there can be no harm in offering the terms, if the station is properly protected against spurious peaks. There is at least the *chance* of capturing some new consumers—and that is worth something.—I am, &c.,

King's Heath, July 6. A. M. TAYLOR.

THE PURIFICATION OF WATER BY OZONE.*

BY S. RIDEAL, D.SC., F.I.C.

Particulars are first given of the early experiments with ozone for purifying water. In September and October, 1908, the author examined in detail the working of De Frise's installation for the sterilisation of water by ozone at the St. Maur municipal waterworks of the city of Paris. These municipal waterworks draw water from the river Marne, a stream which receives a considerable amount of sewage pollution above the intake. The water is pumped into sedimentation reservoirs, then drawn off and filtered through gravel and sand. The filtrate had no odour, was clear, and in small quantities was practically colourless; in bulk it had a varying tint of greenish-brown. On the surface of the water in the reservoirs, and in the channels, gelatinous green masses containing water algæ were frequent. The straining beds of gravel and sand did not completely remove these organisms, and the water which passed through them, although generally clear, was by no means pure or safe. Sterilisation, as far as it can be practically effected, is evidently an urgent need. For this purpose ozone has always seemed a most suitable and natural agent for two chief reasons:—(1) It is only a more active form of ordinary oxygen, already existing normally in small quantities in the atmosphere, and continually assisting in natural oxidations. (2) It adds no residue of any chemical to the water, and in doing its work of purification it is simply resolved into ordinary oxygen, which dissolves in the water and adds slightly to its aeration.

Experience and researches have proved that it is more economical and practical to supply the ozone in a state of large dilution with air, avoiding contamination with nitrous compounds or other impurities, and a series of careful tests showed that the Siemens-De Frise ozonisers now in use at these works yield the gaseous mixture in a very pure state.

The plant consists of an efficient arrangement for the production of ozonised air and for its intimate admixture with the water. The current was generated by means of a 45 H.P. steam engine and a Mordey alternator of 110 volts, and changed by a transformer to 4,000 volts. The ozonisers were of the Siemens-Halske type, placed in a dark cool room. In my experiments there were six of these ozonisers running. The electrical energy required for the production of the ozone averaged 1·31 kw.-hours per 100 cubic metres of water sterilised, equal to 57 units per million gallons. In addition, the energy required for compression, 1·675 units per 100 cubic metres, must be added to the cost, giving a total of 133 units per million gallons. M. Colmet Daage, the chief engineer to the Paris municipality, taking 0·11 fr. as the price per unit (being that charged by the Société de l'Est Parisien), estimates the average cost of treat-

* Abstract of a Paper read before the Royal Sanitary Institute.

F

ment at 0·0184 fr. per cubic metre. He further estimates that for treatment of 300 cubic metres at an electrical cost of 0·055 fr. per unit, the expense would only be 0·0072 fr. per cubic metre, say, one-third of a penny per 1,000 gallons, excluding interest, amortisation, and repairs.

The ozonised air was introduced laterally into the stream of filtered water in a proportion which was kept constant throughout the run, the volume of filtered water being 104 cubic metres per hour, equal to 22,880 gallons, and that of the ozonised air 42 cubic metres per hour (1,483 cubic feet), so that the volume of ozonised air supplied averaged 40·1 per cent. of the volume of filtered water treated. The water and air are drawn together, by means of an injector, into the bottom of a sterilising tower. This is a vertical cylinder of enamelled cast iron constructed in sections, and divided at regular intervals by horizontal diaphragms consisting of carefully levelled and finely perforated trays made of celluloid, with holes 0·7 mm. (0·026 in.) diameter, whereby the ascending current of gas and water is intimately mixed. In addition, the height of the column is sufficient to make the air and water meet under an extra pressure of from 10 lb. to 15 lb. per square inch, which facilitates the absorption of the ozone. The columns are provided at intervals with small glass windows for inspection, and with cocks for collecting samples. I noticed that the process of solution of the air was indicated by the bubbles becoming smaller and less numerous as the tower was ascended, and my chemical results show that the oxygen dissolved in the filtered water entering is usually about 3 to 4 cubic cm. per litre, whereas the escaping treated water is practically saturated with oxygen at the temperature, containing constantly about 6½ cubic cm. per litre.

The aerated and ozonised water flows from the top of the cylinders into an open collecting tank of white enamelled cast iron. During its passage through the columns it parts with a considerable portion of its ozone in oxidising the organic matter of the water, but it still retains a small excess of ozone dissolved, and in order to utilise this as much as possible in the purification the tank is divided into three chambers, so that the water flows through submerged orifices from the first compartment to the second, and then over the top of another partition into the third. In the discharge pipe just before entering into this reservoir a small exit, always running, and carefully protected by a glass bell jar, is placed for the periodical collection of samples. A feature of the method is that in order to economise the fraction of ozone that passes away with the residual air from the top of the cylinders the process is worked in a cycle, and the escaping gases are strained, dried, cooled, re-ozonised, and used over again. To replace the gas absorbed, an automatic valve just above the top of the cylinder opens at very frequent intervals to admit fresh air.

The results show that: (1) The water under treatment is cooled to a slight extent and issues at a constant temperature independent of that of the filtered water, or of atmospheric conditions during the time. (2) As to corrosion of the apparatus by ozone with metallic contamination of the water, my tests were entirely negative. (3) Oxides of nitrogen, chlorine compounds, or peroxide of hydrogen are not formed in the process. (4) The physical characters are greatly improved, and the organic matter, as shown by the oxygen-consumed figure, is considerably reduced. The average of 14 determinations showed a reduction from 0·125 parts per 100,000 to 0·072 parts, corresponding to a removal of 43 per cent. of the organic matter as judged by the oxygen-consumed standard. (5) When the ozonised air is kept regularly at 40·4 per cent. of the volume of filtered water treated, the ozone divides itself into three portions: (*a*) oxidising the organic matter in the water, 73 per cent.; (*b*) dissolving in the water and passing out with it into the collecting tank, 7 per cent.; (*c*) escaping with the air current at the top of the tower to be used again in the cycle, 20 per cent. This proves that the De Frise cycle, in which the residual ozone is used again, is essential for economy. (6) A further quantity of organic matter was oxidised in the first hour or two; also the small quantity of ozone dissolved in the treated water does not remain as a permanent constituent, consequently as ozone is absent from the water when it reaches the consumer no physiological effects can be attributed to it.

The results of a bacteriological examination prove, as a general conclusion, that the ozone treatment destroys all but the more resistant spore forms of bacteria present in the filtered water: coli and allied intestinal organisms are entirely eliminated, and subsequent contamination being excluded, there is no recrudescence of this class of organism. The ozonised water during the period of the tests showed a uniformly constant degree of sterility as against a very variable bacterial content of the unozonised filtered water.

The author finally compares the relative circumstances existing in Paris and in London. If the conclusions of Dr. Houston are correct as to storage and filtration, existing storage reservoirs for London will not only require rearrangement, but additional works will be necessary. An inquiry would seem to be necessary as to whether the outlay on the additional works will secure the same quality as an ozone treatment of the existing water as it leaves the filters.

The Paris municipality have decided to ozonise the whole of their Marne supply at St. Maur, equal to 90,000 cubic metres per day. The water to be treated will pass through the existing filters at twice the present rate, 16 ft. instead of 8 ft. per 24 hours. An ozone installation capable of treating 10 million gallons a day (half the above quantity) by the system described in this Paper will be erected at St. Maur, involving no further outlay for storage or filters. The whole of the water passing through the filters, whatever its coli content, will be ozonised at an expenditure of 315 units per million gallons. All towns with a river-water supply have at present conditions similar to those of Paris and London, and the reasons for an ozone treatment therefore seem applicable. Many other places whose conditions of supply involve drawing on wells which may be subject to occasional or periodic pollution could by this treatment ensure a guaranteed purity.

The author's general conclusions are that (1) the ozone treatment of filtered river water as carried out at St. Maur, Paris, by the De Frise process is a satisfactory method of ensuring a standard of purification for a municipal water supply equal to modern requirements. (2) The De Frise process differs from all previous attempts at water sterilisation by means of ozone in combining the De Frise steriliser and ozone recuperation system with the Siemens-De Frise ozoniser, which combination avoids the difficulties attending the use of the emulsifiers and sprayers which have been hitherto used for this purpose, and is attended with a low cost for renewals owing to breakages in the dielectric.

BRITISH MADE METAL FILAMENT LAMPS.

The Edison & Swan United Electric Light Co. have recently placed on the market a very complete and extensive range of new British-made metal filament lamps, under the name of the "Royal

Royal Ediswan "Metfil" Olive Lamp.

Ediswan Metfil." Lamps of this make were exhibited by the company at the Franco-British Exhibition last summer, where they obtained the highest award possible for lamps, while at the Manchester Exhibition "Metfil" lamps were also on view, and earned a high opinion. Since then the Ediswan Company have been steadily making and selling lamps of this type, whilst at the

same time they have been constantly experimenting with the rare metals in order to ensure that the Royal Ediswan Metfil lamps shall be turned out with the same care and accuracy that has always characterised the Ediswan carbon filament lamps; the intention of the company being to make certain that the new metal filament lamps turned out from the Ediswan works at Ponder's End should occupy the same pre-eminent position in the lamp world as is occupied by their older type.

As original inventors and patentees of the incandescent lamp the firm were in an enviable position as regards working with the rare metals in filament manufacture, as they had the lamp-making experience of over a quarter of a century behind them. As a matter of fact, the firm have been endeavouring for many years to produce a high-efficiency, long-life lamp, and whilst the efficiency of the Royal Ediswan Metfil may be taken as being as high as that of any other metallic filament lamp on the market, the useful life is not less than 1,000 hours.

A noticeable feature is that the lamps do not blacken with use; many lamps having burned for three or four times the normal life without showing any traces of discolouration. In addition, it is claimed, the filaments are not fragile, and will withstand ordinary usage, a point which is of considerable importance. The filaments are so arranged that they are supported throughout their entire length, thus enabling the lamp to be used in any position without fear of the filament sagging or fracturing.

The firm have been successful in producing what was considered to be an impossibility a few months ago, namely, a metal filament lamp suitable for use in single parallel on circuits of from 200 to 250 volts. A further point in connection with the ordinary Royal Ediswan Metfil lamps is that they can be used in the same sized shades as are generally used in connection with the carbon filament lamps of the same size and candle-power, thus rendering it unnecessary to provide shades of special shape or size. This is an important feature.

A number of varieties of flame and candle lamps are also listed in the new catalogue issued by the company, and which contains a most comprehensive range of lamps. The lamp is made for practically every required candle-power and voltage, ranging from small miniature lamps for use with batteries to the somewhat larger lamps used in connection with the Ediswan auto-transformers, and so on through the 100 and 200-volt ranges.

LEGAL INTELLIGENCE.

Williams v. Beckenham Local Council.

In the City of London Court on Wednesday, before Judge Lumley Smith, K.C., and a jury, Messrs. J. T. Williams & Sons, of Bermondsey, London, sought to recover from defendants £74. 15s. 2d. for work done in repairing a burnt-out armature and supplying a new governor valve and spindle in respect of certain electrical machinery.

Mr. Warren, for plaintiffs, said a contract was made between the parties for the Council to hire a Siemens generating set on Oct. 16, 1906, at £60 a month for six months certain, and if defendants wanted to purchase the price was fixed at £1,430. If defendants decided not to purchase, the hire was to be increased to £125 a month. At the expiration of the hire, defendants were to return the machinery in the same good condition as they received it, fair wear and tear excepted. Defendants, it was alleged, did not return the machinery as they received it; an armature became burnt out in the course of running it. As to the governor valve, when the machinery left defendants' hands it was discovered that there was a flange that had been cracked or broken. All the repairs were due to the machinery firing.

Mr. Richards for defendants, said the Council only ran the generating set for 109 hours during the six months. They refused to pay because they did not get what was bargained for. Legal proceedings were brought by plaintiffs, and any possible claim that could now be made was, he urged, settled in a previous action, when plaintiffs received £500. The case would never have been settled if it had not included everything in dispute between the parties.

Mr. Warren contended that there was no settlement of the present cause of action. The defects were only discovered after the £500 was paid.

Judge Lumley Smith, K.C., held that plaintiffs could not recover after the previous action, and he found for defendants, with costs.

Johnson & Phillips v. Palmer.

The Lord Chief Justice, on Tuesday, had an action to recover from defendant £300 paid to defendant by plaintiffs on conditions which, it was alleged, had not been fulfilled.

Mr. Norman Craig, K.C., for plaintiffs, said the defence raised was that the payment of the £300 was an out and out payment; secondly, that even if the money was repayable by the contract defendant was entitled to detain it in consequence of the acts of plaintiffs; and, thirdly, because plaintiffs were indebted to defendant in respect of another matter. The transaction arose out of the promotion of the Woking and Bagshot Light Railway Order by the West Surrey Light Railway Co., to whom defendant was solicitor. Plaintiffs were approached with the view to their being the contractors for the light railways, and also to help in financing the undertaking. Plaintiffs were prepared to apply 27½ per cent. of the contract price of the Guildford and the Woking and Bagshot contracts in subscribing for ordinary shares of the company formed by the West Surrey Co. Plaintiffs were also to pay the necessary deposits to the Board of Trade (£1,000 and £4,000) and also £4,000, the expenses of the promoters in framing the Woking and Bagshot orders, and finally plaintiffs were to pay £500 to defendant towards his expenses of negotiation, and that was the basis of the claim in the present case. That £500 was divided into £200 for the expenses of the Guildford order and £300 for the Woking and Bagshot order. The £500 was to be paid on plaintiffs' obtaining the contract. But defendant made application for the money before it was payable, and plaintiffs paid it on the express condition that if the plaintiffs did not get the contract defendant would repay it. That was in writing, and the real issue was whether plaintiffs were entitled to get the £300 back having regard to the terms of the letters.

After hearing the evidence his Lordship reserved judgment.

On Wednesday the Lord Chief Justice, in delivering judgment, said that though the facts were peculiar the case did not raise any question of real difficulty. It was clear that a great deal of money had been spent in obtaining the orders and that plaintiffs were approached for financial assistance in carrying out the scheme. Plaintiffs' only interest in the matter was in obtaining the contract, and they were not liable for preliminary expenses. Plaintiffs sent the cheque on the clear understanding that if the contract was not given to them the money would be returned. As the contract was not given to them through no fault of their own, the money was repayable. The result was that the £300 must be paid to plaintiffs, and there must be judgment for them for that amount, with costs.

Stay of execution was granted on the money being paid into Court within a fortnight.

Postmaster-General v. Great Southern & Western Railway Co.

At Dublin, Mr. Justice Dodd delivered judgment in this case, which raised a point as to the scope of certain covenants which the company had made with the Post Office Department to carry certain telegraph materials and men and stores free of charge for the Postmaster-General.

On behalf of the Post Office it was contended that the covenants were applicable to all forms of telegraphic communication, including telephonic communication; but for the company it was argued that the covenants did not extend to telephonic apparatus.

Mr. Justice Dodd now held that telephone instruments or appliances intended to be used for the carrying on of telephonic business by the Post Office were not within the purview of the covenants. He also held that men other than telegraphists could not be carried free. He could not give the declaration sought by the Postmaster-General, and, therefore, dismissed the action.

W. F. Jackson v. F. Bailey and F. H. Jackson.

Last week the Lord Chief Justice heard an action brought by Mr. Wm. F. Jackson, of Weybridge, against Messrs. Frank Bailey and F. H. Jackson, electrical engineers, for breach of contract.

Mr. Rufus Isaacs, K.C., for plaintiff, said an agreement was entered into between the parties in September, 1906, by which defendants agreed to grant to plaintiff the full and exclusive licence and authority to construct and vend a clutch which, it was contended, would be of considerable value for use in machinery for the transmission of power. Defendants agreed to let plaintiff have this privilege for £1,000, and supply a specimen clutch for use in a 25 H.P. motor. The trial was not a success, and plaintiff claimed the return of his £1,000, and asked for other damages. Defendants denied any breach of warranty.

Mr. Haviland, an expert, exhibited a model of the clutch and explained that the principal portion of the invention was an oil cushion constructed inside the flywheel. Owing to a leakage of oil the clutch would not work, but he thought upon reconstruction it could be improved and made useful.

Mr. Simon, K.C. (for defendants) contended that he had no case to answer. There was no breach of warranty because the clutch was constructed according to a workable invention.

Mr. Isaacs said it was not a defect in an invention which plaintiff complained about; it was because the particular sample which was provided was of no use and was unworkable because of a defect which the defendants would not or could not remedy.

Mr. Simon said he would call no witnesses, and his lordship reserved judgment.

On Monday, his Lordship said the action must fail. The proceedings were based on the ground that defendants did not supply a workable sample of their patent, for, after the clutch had been fixed to the motor, it broke down. Plaintiff paid the £1,000 before the invention was tried, to obtain certain rights. The patent was an ingenious device which failed through one defect which the inventor could not foresee but which, it was said, could be remedied.

His lordship entered judgment for defendants, with costs.

The Johannesburg Contracts.

On Tuesday the House of Lords (the Lord Chancellor and Lords James, Atkinson, Gorell and Shaw) allowed an interlocutory appeal by the Municipal Council of Johannesburg against a decision of the First Division of the Court of Session. The respondents were D. Stewart & Co. (1902), Ltd., Glasgow; William Beardmore and Mrs. Joseph Beardmore, (sued as the executrix of her late husband).

The action arose out of certain contracts under which respondent Company contracted to supply appellants with gas producer and electric generating plant. (The matter has been reported in THE ELECTRICIAN for Feb. 5, and March 26, 1909.) The Town Council of Johannesburg in Sept., 1903, resolved to instal plant for the production and supply of electrical energy for municipal purposes, and issued tenders. The specifications were divided into sections and the tenders made by Messrs. D. Stewart & Co. (1902), Ltd., Glasgow, for sections B, C, D and E (the last three being electrical generating machinery) were accepted. The plaintiffs in the action claimed that as defendants had committed a breach of their contracts they were liable to repay to the Council the payments already made on account of the contract price, and to pay them damages for breach of contract.

The present appeal, so far as this part of the action was concerned, related entirely to the determination of the tribunal and procedure, by which this question between the parties was to be settled, the appellants contending that the question fell to be decided by the Courts, being outside the scope of the arbitration clauses contained in the contracts. The Court of Session were of opinion that defendants' contention was sound. Further they dismissed the claim against the sureties as being premature and they directed that the action should go to arbitration in England.

The Municipal Council appealed, and in the course of the arguments it was stated that the sums claimed against the Scotch Company were in all £418,694, and against the sureties (Mr. William Beardmore and the executrix of Mr. Joseph Beardmore) £115,131.

At the close of the arguments, the Lord Chancellor expressed the opinion that the arbitration clauses were to be construed according to English law, and that so construed the Court had power to enforce the contract. He was further of opinion that the suit against the sureties had been wrongly dismissed.

The other noble and learned Lords concurred, and the appeal was allowed with costs, and the action directed to be tried in the Scotch courts.

Re Amalgamated Radio-Telegraph Co. (Ltd.).—On Tuesday Mr. Justice Neville heard a summons in the matter of the liquidation of this company, by which Mr. Ashby claimed remuneration and costs in respect of the sale of the compans's assets. Mr. Ashby was a shareholder in and creditor of the company, and was its managing director before it went into liquidation. At his suggestion the liquidator suspended the sale of the company's assets, as he thought he would be able to obtain a better price than that at which they were first offered. A better price was ultimately obtained, and in respect of the sale Mr. Ashby claimed remuneration and also his costs of attending the proceedings in Court for carrying the sale through.

His LORDSHIP, after consulting with the Master, said he was told that Mr. Ashby was not authorised to act on behalf of the Court, and, therefore, he could not give him any remuneration. Mr. Ashby's attendance, however, no doubt facilitated the carrying through of the sale, and he would, therefore, allow him the costs of such attendance.

North-Western Electricity & Power Gas Co. (Ltd.)—On Tuesday petitions for the compulsory winding up of this company were before Mr. Justice Neville, but they were directed to stand over until Tuesday next.

Re Platinum Corpn. (Ltd.)—On Tuesday Mr. Justice Neville, on the petition of H. B. Gill and others, made an order for the compulsory winding-up of this company.

PARLIAMENTARY INTELLIGENCE.

Miscellaneous Bills.—In the House of Commons on Monday the Bristol University Bill, the Liverpool Corporation Bill (authorising construction of additional tramways), the Wakefield Corporation Bill (for further powers relating to electricity supply), and the Southport and Lytham Tramroad (Abandonment) Bill were read a third time.

In the House of Commons on Tuesday the Gateshead and District Tramways Bill was read a second time.

In the House of Lords on Wednesday the Edgware and Hampstead Railway Bill was read a second time.

Telegraph (Arbitration) Bill.—On Friday this bill was read a second time in the House of Commons.

Electric Lighting Acts (Amendment) Bill.—In the House of Commons on Friday this bill was read a second time.

Mexico.—The "Mexican Herald" states that arrangements are being made for the transfer to the Mexican Northern Light & Power Co., of Montreal, of a large tract of land on the Rio Conchas, 30 miles from Santa Rosalia (Chihuahua State), on which the company will erect water driven electric power plant.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

York Corporation require two clerks of works for permanent way construction of light railways. Wages £3 per week. Forms of application from the City Engineer. Applications by July 15.

A pupil is wanted for a low-tension three wire station in the South London area. See advertisement.

A science master and principal is wanted for the Loughborough Technical Institute. Particulars from Mr. W. A. Brockington, Leicestershire Education Committee, 33, Bowling Green-street, Leicester. Applications by July 14.

Dudley Education committee require a principal of the Technical School, and organiser of evening school work. Salary £200 to £250 per annum. Applications on forms of tender to be obtained from the Director of Education (Mr. J. M. Wynne), to be sent in by July 12.

There is a vacancy for an improver at Watford Council's electricity works. Applications to the chief engineer, Mr. F. W. Purser.

The Shanghai Electric Construction Co., Basildon House, London, E.C., require a superintendent for track and equipment (to look after permanent overhead equipment and cables).

Mr. G. D. Laing has been appointed resident engineer of the Hexham & District Electric Supply Co.

Mr. J. Southall has been appointed chief tramway inspector at Ilkeston.

Croydon Education committee have appointed Mr. A. Blok chief lecturer in electrical engineering at the Central Polytechnic at £110 per session.

EDUCATIONAL NOTICES.

Borough Polytechnic.—The Education committee of London County Council propose to appoint a head of the chemistry department, in succession to Dr. F. Mollwo Perkin, at a salary of £300, rising to £400 a year by increments of £15 a year for four years and of £20 a year for the two following years; and the proposal of the governors to increase the salary of the head of the electrotechnics department (Dr. J. Henderson) to £340 a year, rising to £400 a year, has also been approved, provided that the increases be at the rate of £15 a year for two years, £20 in the following year and £10 in the succeeding year.

University of Liverpool.—The session 1909-1910 commences on Tuesday, October 9. The courses of study in the faculty of engineering, leading to the ordinary degree of B.Eng., extend over at least three years, and are so arranged as to afford a general scientific training for those who intend to become engineers or naval architects, or to enter any allied profession. The honours course enables students to specialise in some branch of the profession, and opportunities are afforded for post-graduate work and research. Prospectuses may be obtained from the registrar, Mr. P. Hebblethwaite, M.A.

Heriot-Watt College, Edinburgh.—The training for engineers given at this College consists of three years in the College, and a three years' apprenticeship on the "sandwich" system in a local engineering works. The course in mining extends over two years, and is recognised by the Home Office as equivalent to two of the five years underground training required for the colliery manager's certificate. There are also complete courses of instruction (extending over four years) for students preparing for the fellowship of the Institute of Chemistry, and practical training for technical chemists in the laboratories of the Corporations' gas works. The classes are recognised by the University of Edinburgh as qualifying for science degrees. Particulars of fees, bursary, &c., from the principal, Mr. A. P. Laurie, M.A., D.Sc.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

American Street and Interurban Railway Association.—We have received some particulars of the objects, constitution, &c., of this Association, which was started in 1882, and has 300 active members

(electric railway companies, with a capital of $2,148,272,441 and 19,586 miles of single track), and over 700 associate members (consisting of electric railway officials, representatives of manufacturing interests, &c.). The organisation seems to be very complete. There are over 20 representative committees or sub-committees which deal with the various subjects affecting street railway working and organisation. There are committees for dealing with standards, equipment, way matters, power generation, power distribution, insurance, welfare of employes, municipal ownership and public relations, shop accounting, international standard form of report, standard classification of construction, and equipment accounts and form of report, employment, ways and means, interurban rules, city rules, passenger traffic, express and freight traffic, transfers and transfer information, training of transportation employes, &c.

Ashford.—Mr. M. Parker will apply for a provisional electric lighting order for this district.

Asleep on Duty.—At Longton on Monday, Herbert Williams, electrician in the employ of the Florence Coal & Iron Co., was charged with an offence under the Mines Regulation Act by sleeping while on duty at the colliery.

Mr. G. C. Kent, who prosecuted, said defendant was in charge of a large electrical installation in the mine, and had examinations to make and records to take, but on the 23rd ult. he was discovered asleep while the machinery was working.

Defendant was fined 40s. and costs.

Assessment Appeal.—On appeal the assessment of the Rhondda Tramway Co.'s undertaking has been reduced from £24,866 gross and £5,680 net to £13,000 and £5,500 respectively.

Bath.—The adjourned inquiry into the Council's application for sanction to borrow £9,470 for the electricity undertaking was held on Friday.

The town clerk (Mr. F. D. Wardle) said the original application had been amended and they now asked for a loan of £9,500 instead of £11,700.

The Inspector (Mr. H. Ross Hooper) then examined the details of various amounts included in the aggregate, and said he could always rely upon receiving anything he asked for in Bath in great detail.

In regard to an item of £350 for water-softening plant, Mr. Teague (the city electrical engineer) said that was a sum which, in view of the inspector's remarks in reference to water-softening treatment, they might not spend.

Mr. Hooper said if, later, they found it necessary to proceed with this work, the £350 could be subsequently applied for, and there would be no need for a separate inquiry.

A new item (£350) in respect of machine tools, Mr. Teague explained, was included with an eye to economy. At present repairs were done by local firms and delay resulted. No part of the £500 asked for in respect of an automatic stoker had been spent, and the amounts of £4,000 for mains, £1,500 for house services and £500 for transformers, were almost entirely for future requirements.

The Inspector said he did not know if they had ever worked the matter out, but he thought it would be well worth doing. They had a capital of something like £164,000, and now that they knew the undertaking was going to remain in their own hands, he thought it was desirable that they should go carefully through the whole of the assets of the undertaking, with their value, and see how far the present value balanced with the capital expenditure and with the sinking fund which they had in hand, so that when they came to the end of a financial year they might see the real proportion of revenue-earning capital as against what might be called "dead" capital. In that way they would be able to compare their undertaking with undertakings that started later and under more favourable circumstances, and they would, he thought, have a better knowledge all round of the true position of the undertaking.

Mr. Teague said he quite agreed that that would be well worth doing.

Blackburn.—The Council have decided to take up a further loan o £18,000 for extensions to the electricity undertaking.

Cardiff.—Mr. W. Howard-Smith, who was recently called in to report upon the condition of the tramway track, &c., has presented his report.

Mr. Howard Smith pronounces against the use of hard wood for paving, and concludes his report with a number of recommendations as to the elimination of rail corrugation, &c.

Cowdenbeath (N.B.)—Mr. Geo. Balfour has intimated that he will apply for a provisional electric lighting order for this district.

Customs Duties in South Africa.—A Parliamentary Paper has been issued containing the draft South Africa Constitution Bill, one section of which provides that there shall be Free Trade throughout the Union, but until Parliament otherwise provides the duties of Customs and Excise leviable under the laws existing in any of the Colonies at the establishment of the Union shall remain in force.

Darlington.—The Electricity committee have applied for sanction to a loan of £700 for new meters, and have asked the L.G. Board to grant a longer period than five years for repayment, as the average life of meters used by the department appears to be more than ten evis.

Derby.—On Wednesday the Council adopted a recommendation of the Electricity committee to apply for a provisional order to extend the electricity supply area to the parishes of Littleover, Markeaton, Darley Abbey, Breadsall, Chaddesden, Alvaston and Boulton, Normanton and Sintin Moor.

Devonport.—A loan of £6,329 for mains extensions has been applied for.

Dover.—The charge for electric current for public and private lighting has been increased ½d. per unit. The L.G. Board have declined to sanction a loan for laying mains to St. Margaret's-at-Cliff, on the ground that the proposed expenditure would not be sufficiently remunerative.

Dudley.—Generator field coils are to be rewound at a cost of £80 and a mechanical stoker is to be fitted to a boiler at a cost of £190.

Eccles.—The Municipal houses in Corporation-road are to be wired.

Electricity in Mining.—At the meeting of the Rand Collieries (Ltd.) last week the chairman (Mr. Albu) said that the proposed mechanical improvements would make it quite within the limits of practical working to reduce milling costs to 1s. per ton, and cyaniding to 1s. 6d. per ton. The company was making arrangements with the Victoria Falls Transvaal Power Co. for electrical power.

Electricity in Printing Works.—In the extensive machine room of the Sydney (N.S.W.) "Evening News" there have recently been installed three fine double-deck Hoe presses capable of producing 150,000 copies of the "Evening News" per hour. In the issue of that journal for May 15 an account of the installation is given, accompanied by an illustration showing the range of Hoe and other presses, which, in addition to the "Evening News," produce the "Town and Country Journal" and the "Woman's Budget." All three publications have large circulations. The Hoe presses, each of which weighs about 60 tons, and a new type of Phœnix press, are operated and controlled electrically, each Hoe machine being driven by a 50 H.P. motor. The Phœnix two-revolution press was built at Leipzic, and is a fine-art machine of the latest type, "a combination of mechanics, pneumatics and electric power machinery." The electro-mechanical outfit of the Sydney journals is causing great interest locally, as, besides the electrically-driven printing machines, the Linotype composing machines, hoist for handling paper, and, in fact, everything that can be operated and controlled electrically, is "connected to the mains." Current is generated on the establishment, gas-engine plant being installed for the purpose.

Epsom.—The electrical engineer (Mr. H. F. Foster) recently tendered his resignation, but the Council have decided to retain his services for 12 months as consulting engineer at a salary of £100.

Greystones (co. Wicklow).—Rathdown No. 2 Rural Council passed a resolution on Friday last to grant permission to Greystones Electric Lighting Co. to lay their cables in Greystones for the electric lighting of the district.

Handsworth.—Mr. H. Ross Hooper held an inquiry last week into the application of the Council for permission to borrow £4,400 for their electricity department.

The clerk (Mr. E. Ward) stated that the total capital of the undertaking would be £74,750, with the amount they now proposed to borrow. This application was one of the subjects that came before an inquiry in November, but it was held over on the question of "free" wiring

The Inspector said they could not regard free wiring as an asset, as landlords might require it to be removed, and to take it out would cost more than to put it in, and they would have to repair the walls and any damage done. A successful system was to require 25 per cent. of the cost before the work commenced and the remaining 75 per cent. in two or three years. Such a scheme had been found to work successfully.

The electrical engineer (Mr. Nixon) said that consumers would be required to pay 25 per cent. before the work commenced and the balance in three or five years in quarterly instalments.

Hanley.—Electric current is to be supplied to places of amusement at 3d. per unit for the first 400 units per week, and 1½d. after.

Hastings.—The Council last week adopted the recommendation of the Electricity committee that a new 37/11 electric supply main, to transmit current at 1,000 amperes per square inch section, be laid in connection with the extension of the supply in the St. Leonards district.

Hospital Lighting.—At the last weekly meeting of the Metropolitan Asylums Board the Works committee reported that the Engineer-in-Chief had reported the results of three months' tests of low voltage metal filament lamps at the South Western Hospital, and he suggested that at certain of their institutions these lamps should be installed in place of carbon filament lamps.

The estimated cost of the change over would be: North-Western Hospital, £250; Western, £360; South-Western, £280; South Eastern, £280 (£200 only at present); Children's Infirmary, £480; Downs School, £180; Western Ambulance station, £30; South Western, £26; Mead, £15; South-Eastern, £40; Central Stores, £60.

Italy.—Mr. S. J. A. Churchill, British Consul at Naples, states that further consideration has induced the civic authorities of Naples to entertain a scheme for two electricity generating stations on the Volturno river (instead of one as originally proposed), one at the meeting of the Rochetta and Vandra and the second 9½ km. further down stream. The works are expected to produce 25,000 H.P. at high and 21,500 H.P. at low water.

The Ministry of Public Works and the communal authorities of Civitanova Marche have entered into a contract for the construction of an electric tramway from Civitanova Marche to the docks. The contract carries a Government subsidy of 1,415 lire (£57) per kilometre per annum for 50 years.

Keighley (Yorks.)—The L.G. Board have sanctioned a loan of £2,950 for prospective expenditure on mains, services and motors; and have assented to the allocation of the unexpended balance (about £1,200) of loans previously sanctioned.

With regard to the loan for the installation of high tension alternating-current generating plant, the board intimate that they would be prepared to entertain an application for a loan provided evidence be furnished of a sufficient demand from prospective consumers to justify the expenditure.

Larne (Ireland).—The Council on Monday sealed an agreement with the Larne Electric Light Works (Ltd.) for the electric lighting of the streets by the company, for three years, from August 1 next, at £180 per annum.

Leek.—The salary of the borough electrical engineer (Mr. R. M. Carr) has been increased by £25 per annum.

Leith.—An additional line of tramway was opened for traffic on Saturday. The maximum speed allowed is 15 miles, and the speed on the other portions of the tramways has been increased.

Leyton.—The electrical engineer (Mr. F. Harman Lewis) recently obtained particulars from 13 makers of arc lamps as to the annual cost per lamp for carbons and capital charges (assuming 10 years life and interest at 4 per cent.), and it has been decided to obtain lamps for a three months' trial from the first four of the following firms:—

Johnson & Phillips, (*a*) hours of burning for one trimming, 80 to 90; (*b*) annual cost per lamp, £1. 17s. 1d. Jandus Arc Lamp & Electric Co., (*a*) 60 to 80; (*b*) £2. 0s. 8d. Crompton & Co., (*a*) 37; (*b*) £2. 11s. 6d. Oliver Arc Lamp (Ltd.), (*a*) 37; (*b*) £2. 13s. 4d. Gilbert Arc Lamp Co., (*a*) 55 to 60; (*b*) £3. 4s. 9d. Arc Lamps (Ltd.), (*a*) 35 to 37; (*b*) £3.4s.9d. General Electric Co., (*a*) 45 to 50; (*b*) £3. 5s. 11d. British Westinghouse Co., (*a*) 50 to 60; (*b*) £3. 11s. 1d. G. Braulik, (*a*) 34 to 36; (*b*) £3.15s.4d. Maxim Electrical Co., (*a*) 37 to 40; (*b*) £4. 5s. 2d. Abbey Electrical Co., (*a*) 20; (*b*) £4. 8s. 2d. Electrical Co., (*a*) 30 to 32; (*b*) £4. 8s. 2d. Union Electric Co., (*a*) 34; (*b*) £4. 17s. 10d. Beck Flame Lamp (Ltd.), (*a*) 32 to 36; (*b*) £4. 18s. 2d. Westminster Engineering Co., (*a*) 22; (*b*) £5. 19s. 1d.

London County Council.—On Tuesday a loan of £7,000 for electric lighting for Stepney was approved.

Invention by an Official.—The General Purposes committee recommended that Mr. T. R. Ireland be permitted to take out a patent for an improvement invented by him in the ordinary tramway controller, subject to the condition that the Council use the patent should it so desire without payment. The invention has for its object the prevention of accidents such as have occurred recently on the tramways of other municipalities and consists of an electrically connected device for interlocking one controller with another, or alternatively arranged to indicate to the motorman any incorrect position and relationship of the reverse cylinders of the controllers, whereby the proper operation of the electric brakes would be affected.—Agreed to.

Central Car Repairing Depot.—The Highways committee recommended that £47,500 be expended in the erection of the second section of the central car repair depot, and £11,500 in respect of the provision of tools, machinery, cables, &c.—*Postponed.*

L.C.C. Tramways.—St. Pancras Council are recommended by their Works committee to approve the plans of London County Council for continuing the Caledonian-road tramways at Pentonville-road to Gray's Inn-road, by means of a bridge to be erected over the Metropolitan Railway at King's-cross station.

L.C.C. Tramways Employes and Conciliation.—The ballot of the tramway employes of London County Council has resulted in a large majority (4,734 votes against 759) in favour of the principle of Conciliation Boards, and steps will be taken by the Board of Trade to conduct the elections of the employés' representatives for the four sectional boards.

Lytham.—The directors of the Lytham Electric Light & Power Co. have decided to proceed with the work of establishing electricity supply in the district.

Manchester.—At the Council meeting on Wednesday, the Chairman of the Electricity committee (Mr. Howarth) said the tender of Siemens Bros. & Co. at £1,998. 10s. 10d. for supply of service cables during 12 months, had been accepted, because it was the lowest received, being £34. 7s. 6d. less than that of Connolly Bros.

Mr. Howarth said it was not fair to firms who tendered in answer to an advertisement if the committee afterwards started negotiations to get one firm or another to reduce its tender.

Mr. Fox moved that the matter be referred back, as he was in favour of work being given to local firms.

Mr. White and Mr. Cook supported this view. Other members supported the committee's recommendation, which was ultimately carried.

The Council approved the report of the special committee appointed to consider the question at issue between the Mutual Telephone Synd. and the Corporation, which read as follows:—"Having heard the statements of Mr. Thomson, Mr. Bradley, and Mr. Scott, this committee do not consider that any equitable liability attaches to the Corporation to reimburse out of the City Fund the expenses which were incurred by the gentlemen who constituted the New Mutual Telephone Synd. (Ltd.)"

Manufacturers and Contractors.—It is announced that at a largely-attended meeting of electrical manufacturers of the United Kingdom, held on 1st inst., at the Hotel Cecil, London, it was unanimously resolved that the action of the National Electrical Manufacturers' Association in their negotiations with the Electrical Contractors' Association, regarding the proposed agreement to give special terms to members of that association, be endorsed, and that the terms set out in the official journal of the Electrical Contractors' Association of April, 1909, could not be entertained. The meeting was not confined to members of the Manufacturers' Association, all manufacturers being invited whether members or not.

Municipal Officials' Expenses.—At a meeting of Belfast Tramways and Electricity committee on Monday a letter from Sir Hy. A. Robinson, President of the Local Government Board (Ireland), in reply to a letter from Mr. Nance (manager of the tramways department), was read. The letter reads: "The auditor is bound to surcharge all payments for which no statutory authority can be shown, and unless you can refer him to statutory authority warranting the payment of expenses of the Belfast tramway officials in attending a conference, the only way in which the expense can be legalised is by a clause in the next local act empowering such expenses to be charged." It was decided to request the Law committee to carry this suggestion into effect.

Museum Lighting.—The contract for the wiring and fitting up of the new Victoria and Albert Museum, which was recently opened by the King, was carried out by Messrs. T. Clarke & Co.

Newfoundland Cables.—A statement has appeared in a number of journals to the effect that the Commercial Cable Co. was seeking an undue advantage in an agreement regarding landing rights for a cable to Newfoundland. This statement has been answered by the company as follows:—

Referring to an item dated St. John's, Newfoundland, June 27, wherein the impression is conveyed that the Morris Ministry decline to ratify the agreement between the Commercial Cable Co. and the Bond Ministry, on the ground that the Commercial Co. received under that agreement a special concession equivalent to the free landing of a new cable, whereas other cable companies were called upon to pay a cable tax of £800 per annum, I am directed by my board of directors to state that this allegation is incorrect. The agreement in question requires the Commercial Company to pay an annual cable tax of £800, and the company expects to pay that amount accordingly.

Fred. Ward, Manager in England.

Nottingham.—On Monday the City Council adopted a report of the General Purposes and Tramways Committees, recommending that powers be obtained for constructing tramways to Sneinton.

Obituary.—On July 4 Mr. Edwin Trenam, I.S.O., late Chief Controller of Telegraphs, passed away after a short illness at Upper Norwood, London. Mr. Trenam was born on April 17, 1843, and was connected with the old Electric & International Telegraph Co. in 1857, and with the Magnetic Telegraph Co. in 1862. On the taking over of the telegraphs by the State in 1870 he became superintendent of telegraphs at Leeds, and 20 years later occupied a similar position at Manchester. In 1900 he was appointed traffic manager of telegraphs at St. Martins le Grand, and later became deputy controller and controller at the Central Telegraph Office. He retired in 1906.

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer. We would add that the portrait is mounted so as to be conformable as to size with "The Electrician" series of steel plate portraits, and is suited for framing with the series.

Palestine.—It is reported that a scheme is being prepared for the erection of electricity works in Jerusalem, and for the construction of an electric tramway between that city and Jaffa.

Presentation.—A pleasing ceremony, evidencing the esteem in which Mr. Seabrook was held by his staff at West Ham, was performed on 2nd inst., when the resident engineer (Mr. Lloyd-Jones) presented to Mr. Seabrook, on behalf of the staff of the generating department, a gold watchchain on the occasion of his leaving to take up the position of general manager to the Marylebone undertaking.

In making the presentation, Mr. Lloyd-Jones referred to the rapid progress of the West Ham electricity department under Mr. Seabrook's zealous administration, and the vigorous advertising campaign which kept West Ham electricity supply constantly before manufacturers and others. He referred to the low works costs for the year ended March, which, he said, constituted a record for any municipal undertaking in or around London, and that result had been largely due to the able direction of the engineering policy by Mr. Seabrook.

Mr. A. Hugh Seabrook, in reply, expressed his appreciation of the valuable present. He regretted having to part company with the staff, who had served him so loyally whilst at West Ham, and he hoped that their good services would be continued under his successor, Mr. Couzens.

Rugby.—Application has been made for sanction to a loan of £5,500 for a 150 kw. steam alternator, switchboard, mains, meters, &c.

School Lighting.—At a meeting of Brighton Education committee last week Mr. Lethbridge opposed a recommendation that tenders be obtained for the installation of the electric light (at an estimated cost of £225) at Ditchling-road school and cookery centre, on the ground that the capital expenditure would be equal to the cost of 10 years' consumption of gas. Mr. J. Carden explained that they had always had complaints about the lighting of this school, and the hall could not be let for public meetings in consequence. In the schools that had been wired for electric light they saved in the last quarter of 1908 £53 compared with the charge for gas; and when metal filament lamps came to be used they would save £200 a year. Electric light was healthier, and they ought to support the Corporation's undertaking. It was ultimately decided to adopt the recommendation in favour of electric lighting.

Southwark.—Newington Town Hall is to be re-wired at a cost of £41 and superheaters are to be obtained for four boilers at £570.

Street Lighting in the City of London.—The Streets committee will issue in a few days the report of the sub-committee who recently visited the Continent for inspecting the lighting arrangements of the principal cities of France and Germany.

The "City Press" states that the sub-committee will report that the lighting of the City is capable of great improvement, and that in many respects the arrangements adopted abroad are far superior to those in the City of London. In particular, it is urged that there is no uniformity of lighting in the City, and that the advantages of some of the schemes in operation are very considerably minimised through faulty placement.

Switzerland.—An 80 years' concession for the construction and working of a single track metre gauge electric tramway from Massagno to Ostarietta, via Cadempino, has been granted to M. Medardo Polar (of Massagno) and M. Elvezio Crivelli (of Lugano), representing a preliminary syndicate.

Tewkesbury.—The local Electric Light Co. commenced supply of electricity for public and private lighting on June 28.

Torquay.—The Council have voted an honorarium of 100 guineas to the borough electrical engineer (Mr. P. Storey) in recognition of the valuable services rendered by him in connection with the extensions of plant for the tramway supply at the electricity station.

Transvaal Mining Industry.—The Board of Trade Commissioner (Mr. R. S. Holland), who has been investigating the conditions of the Witwatersrand mining industry, is reported to have said that he considered the Rand offered the greatest scope for the development of British trade if the opportunity were fully seized, particularly in respect of electrical machinery, which was rapidly displacing steam plant.

German manufacturers were represented by very keen men of business and were greatly assisted by the financial support of their commercial banks. Mr. Holland considers it advisable for the principals of British manufacturing firms to visit Johannesburg in person. The contracts which are being placed as a result of the extensive development of mining operations give an opportunity for business in all classes of mining machinery. Manufacturers should give their local representatives bottom prices and a freer hand. Mr. Holland will present his report to the Board of Trade in due course.

Travel, Sports and Pastimes Exhibition.—The latest exhibition at Olympia has been given the above title, and was opened on Tuesday last by Lieut. E. H. Shackleton, the hero of the South Pole. It will remain open until Aug. 4. Its purpose is to supply visitors with information they may require before undertaking a journey to any part of the world. The needs of those who travel in style and those who rough it are equally considered.

A glance round the exhibition shows that purely electrical features are practically absent. The hall is, of course, lighted electrically, and this work has been carried out by Messrs. Brookes, of Hammersmith. An exhibit which is attracting much interest is that of Marconi's Wireless Telegraph Co. This consists of two stations, one at each end of the hall, between which communication is established for the benefit of visitors. These stations are fitted up with standard apparatus, having a range of about 500 miles, energy being supplied from the alternating-current system of Hammersmith Corporation. One of these stations is fitted up in a model ship's cabin, and illustrates the way wireless apparatus is arranged on a Cunard liner. For the benefit of visitors messages will be sent from these stations to any ships at sea on the payment of the usual rates. This company is the only electrical one exhibiting. We must call attention to the excellent exhibit of our contemporary the "Sporting Life," which contains interesting relics pertaining to all kinds of sport.

Walsall.—The General Purposes committee recommend extensions of, and alterations to, the electricity works, at an estimated cost of £35,000. The Council will discuss the proposal at their meeting on Monday next.

Walton-on-the-Naze.—The Board of Trade have issued a special report on the application of the Coast Development Corpn. for a provisional order for this district.

The company has established electricity works with the concurrence of the Urban Council. An agreement between the Council and the company provided that the Council should support the company's application for a provisional order. This agreement contained a provision that the company should supply "at a price not exceeding 6d. per unit to private consumers by means of overhead or underground wires, or both, as the company may think fit." The Council refused their consent and opposed the grant of the order on the grounds: (1) That the maximum price proposed to be charged by the company should be 6d. per unit instead of 8d., as specified in the draft order; (2) that underground mains should be substituted for the existing overhead wires within five years; and (3) that the order should contain a provision giving the Council a special power to purchase the undertaking. The company agreed to these conditions except that relating to price. They represented that their agreement with the Council under which the price was fixed at 6d. provided for the use of underground or overhead wires, or both, as the company might think fit, and that if they were required to substitute underground mains for overhead wires the expense involved might render the supply at a maximum price of 6d. unremunerative. They had, however, given to the Council an undertaking that they will not charge a higher price than 6d. per unit so long as they are not required to place any of their electric lines underground. The Council, however, still refused their consent, and the Board of Trade, after hearing the parties and considering all the circumstances of the case, decided to dispense with the consent of the Council and to grant the order, allowing a maximum price of 8d. per unit and inserting provisions (*a*) requiring the removal of overhead wires within five years, and (*b*) giving the Council a special power to purchase the undertaking.

Wednesbury.—The salary of the borough electrical engineer (Mr. Wm. Fennell) has been increased by £25 per annum.

West Bromwich.—The Council have decided to allow a discount of 2½ per cent. on accounts for electric current for lighting and power, excepting traction.

Willesden.—The Council have renewed for seven years their agreement with the North Metropolitan Electric Power Supply Co. for the supply of electricity in bulk for lighting and power, and there is provision for a further reduction in price.

Wood Green.—At a meeting of the Council last week it was decided to adopt a scheme for electricity supply prepared by the consulting engineers (Messrs. May & Hawes), subject to the terms of an agreement with the North Metropolitan Electric Power Supply Co. being arranged to the satisfaction of the Council.

In their report Messrs. May and Hawes start by dealing with the position of Wood Green in regard to electricity supply, and, after pointing out the advantages of being able to obtain electricity in bulk from a power company at favourable rates, they recommend the adoption of the three-phase alternating-current system of distribution, the e.h.t. bulk supply being transformed at the distributing station from 10,000 to 3,000 volts and thence transmitted at high pressure to sub-stations or transformer pillars. From sub-stations distributing mains would be laid for a three-phase a.c. supply at a pressure not exceeding 240 volts for lighting and 415 volts for power, the frequency being 50 periods per second. A site adjacent to the free library (between station and River Park roads) is recommended for a distributing station, and at the outset

this would be equipped with transforming plant of a capacity of 500 kw., and the necessary switchgear, &c. There would be three transformer sub-stations, and a list of streets is given in which mains should be laid. In the estimates provision is made for connecting up 450 consumers, including meters, and it is also proposed to supply small house transformers for use with metal filament lamps. It is also suggested that the Council should adopt a scheme for wiring consumers' premises. In regard to public lighting, it is recommended that 51 arc lamps should be erected in five thoroughfares. The estimates prepared by Messrs. May and Hawes are based on the current price of copper wire bars at £65 per ton and lead at £15 per ton.

Estimate of Capital Expenditure.

Buildings, including distributing station, with transformer and switch rooms, test and store room, engineer's office, &c., £1,500; three transformer sub-stations, £450; total £1,950.

Equipment of distributing station, including 500 kw. of transformers, e.h.t. and high and low-pressure switchboards, pressure regulators, public lighting switchboard, cable connections, meter and general testing apparatus and instruments, wattmeters to measure bulk supply and maximum demand, telephones, &c., £3,100; equipment of three transformer substations, including two 50 kw. three-phase transformers for each substation, high and low-pressure switchboards, &c., £1,300.

Mains.—High-tension feeders, comprising 6,300 yds. 0·05 three-core armoured cable laid direct in the ground, together with four-core 7/20 armoured cable for pilot and telephone wires, £2,030; low-tension distributors, comprising 21,310 yds. of four-core armoured cable of various sizes laid direct in the ground, £7,040; public lighting cable, comprising 8,050 yds. of 7/18 armoured twin cable laid direct in the ground in six separate circuits, £1,030; disconnecting boxes, bricks, brick pits, sectioning pillars and terminal end boxes, £370; trenching and reinstatement, £3,850; house services, comprising cable, house service boxes, house fuse boxes, trenching and reinstatement, jointers' kit, &c., for 450 services, £2,530.

Meters.—440 single-phase and 10 three-phase meters of various sizes, £1,800; 300 small house transformers for metallic filament and other high-efficiency low-voltage glow lamps, £500.

Provision for general expenses and contingencies comes to £1,500. For plain wiring of residential houses (exclusive of moveable fittings, lamps and consuming apparatus) provision is made for an expenditure of £2,500, and for 51 public arc lamps £1,750, making a total of £31,250.

The estimated revenue is put at £6,092 (including £5,180 from private lighting and power, £612 from public lighting, and £300 from rental of meters, &c.), and working expenses at £3,722, leaving £2,370 to meet interest and sinking fund, which, it is calculated, would come to £1,870 per annum, or a net profit of about £500 a year.

Workhouse Lighting.—Haslingden Guardians have accepted the offer of Rawtenstall Corporation to supply electricity for lighting at 3d. per unit, and for power at 1d. per unit, on a five years' contract.

York.—The Corporation have decided to weld the whole of the rails used in connection with the electrification of the municipal tramways by the "Thermit" process.

Application has been made for sanction to a loan of £2,510 for mains extensions.

Annual Outing.—On Saturday last the employés of the British Electric Calibrated Fuse Co. (Harpenden) went for their fourth annual outing to Brighton. After dinner the general manager (Mr. Weekes) stated that the progress of the firm during the last year had been entirely satisfactory. Although trade was supposed to be bad in the electrical profession, the firm had kept up their record of beating by a big margin the turnover of the year before. That had been the case every year since the start of the firm.

On 26th ult. the mains and public lighting staff of St. Pancras electricity undertaking had their 15th annual staff outing and dinner at Bournemouth. About 60 sat down to dinner.

Among those present were the Mayor of St. Pancras, Councillor E. T. Heron, J.P. (who presided), Ald. D. McGregor, Mr. C. H. F. Barrett, the town clerk, Mr. S. W. Baynes, chief electrical engineer, and Messrs. Boot, Brown, Ashton, Jennings, &c.

Mr. W. A. Brown proposed the toast of "The Visitors," and in reply the Mayor said he was pleased to note the good fellowship and co-operation. Mr. Barrett also responded.

Mr. Boot proposed "The Chief Engineer," and said that although that was the first time for 14 years he had been present they hoped he would endeavour to come every succeeding year.

Mr. Baynes suitably responded.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Barnsley.—The accounts of the electricity department for the year ended March 31 show total revenue £12,345. 11s. 8d.

The total expenditure was £5,675. 16s. 1d., leaving £6,669. 15s. 7d. to meet interest on loans, &c. (£2,558. 5s. 1d.), instalment of principal on money borrowed (£692. 3s. 10d.) and sinking fund (£1,190), giving a net profit of £1,429. 6s. 8d., of which £1,000 has been allocated in relief of rates and the balance placed to reserve. 1,702,682 units were generated. 835,442 units were supplied to private consumers, 322,360 to the tramways, and 274,592 to public lamps. The total maximum supply demanded was 849 kw. Capital expenditure is £75,370. 11s. 6d., an increase of £708. 18s. 5d. on the year.

Croydon.—The accounts of the tramways department for the year ended March 31 were recently approved by the Corporation.

Traffic revenue from Corporation lines was £69,496. 16s. 11d., receipts under the agreement with the South Metropolitan Tramways Co. for running powers amounted to £2,565. 18s. 7d., and sundry revenue realised £1,753. 13s. 1d.—total £73,816. 8s. 7d. Working expenses were £54,726. 7s. 3d. (6·75d. per car-mile) and gross profit £19,090. 1s. 4d. (2·354d. per car-mile). After paying interest (£8,355) and income tax (£646. 4s.) there was a balance of £10,692. 5s. 11d., and after providing for contributions to sinking fund and repayment of loans the net balance was £3,294. 10s. 2d., which has been transferred to reserve and renewal fund. Capital expenditure amounts to £280,603. 2s. 6d. 16,266,475 passengers were carried and 1,945,645 car-miles run; average traffic revenue per car-mile was 8·889d.; 2,429,291 units of current were used for traction, lighting and rail grinding (an average of 1·25 units per car-mile); the average cost of energy per car-mile was 2·218d.; and the percentage of working expenses to total revenue was 73·54.

Hove.—The accounts of the Aldrington electricity supply department show a deficiency of £452 for the year ended March 31, after paying all expenses, including interest and sinking fund.

Loughborough.—At the meeting of the Council on Monday the accounts of the electricity department for the year ended March were approved.

The total income was £3,284. 18s. 10d., including £2,328. 10s. 4d. from sale of current by meter, £100. 15s. 4d. from public lighting, and £660. 12s. 7d. from sale and repair of lamps, motors, &c. Total expenditure was £2,738. 5s. 0½d., leaving a balance of £546. 13s. 9½d. to meet interest (£1,477. 16s. 9d.) and sinking fund (£606. 17s. 8d.). A grant of £1,500 was made from the general district fund, and £44. 14s. 11d. has been provided as a reserve against free wiring account. 266,372 units were sold (against 258,646 in previous year), including 101,526 (105,316) for private lighting, 7,726 (12,164) for public lighting, and 157,120 (141,166) for power. The equivalent of 21,804 8 c.p. lamps is connected (against 18,310), and there are 68 motors, representing 382 B.H.P. Works costs were 1·852d. (2·254d.). The capital expended is £31,904. 7s. (increase £1,071. 13s. 3d.).

The chairman (Ald. Bumpus), in moving the adoption of the accounts, referred to the recent report of Mr. Snell on the working of the electricity undertaking. Broadly, they had adopted the recommendations of Mr. Snell, and with respect to the consumption of coal they had accepted his advice, and he was informed the consumption was now much lower. For the success of the undertaking the output would have to be doubled, and he was pleased to say it was increasing, especially for power.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Electric Lighting committee of Hull Corporation invite tenders for the supply and laying of electric mains, &c., during the period ending March, 1910. Forms of tender and specification may be obtained on depositing one guinea with the city treasurer (Mr. T. G. Milner). Tenders to the chairman of the Electric Lighting committee, Town Hall, Hull, by noon July 29. See also an advertisement.

Salford Electricity committee invite tenders by noon July 12 for re-wiring at the Royal Technical Institute. Specifications, &c., from the Borough Electrical Engineer.

Hornsey Council want tenders by 4 p.m., July 12, for wiring and other work at the Frobisher-road school, Harringay. Forms of tender from the Borough Electrical Engineer.

Luton Corporation require tenders by 10 a.m. July 19 for supply, fixing, &c., of 500 kw. steam-driven generator and of condensing plant. Specifications from the Borough Electrical Engineer.

Long Eaton Council want tenders and schemes by mid-day July 20 for the installation of water-softening plant at the electricity works. Particulars from the Engineer and Manager.

The Board of Control, Winnipeg, Canada, require tenders for the following contracts in connection with the Point du Bois hydro-electric development scheme. For contract A tenders are to be in by August 2, and for the remaining contracts by August 16. The numbers preceding the items are those of the specifications:—

A (5) five 5,200 H.P. turbines, and (6) two 450 H.P. turbines (deposit, $250); B (7) five 3,000 kw. generators, (8) two 250 kw. generators, (11) switching and accessory apparatus, (deposit, $250); C (10) six step-up transformers (deposit, $100); D (12) light, heat and power systems (deposit, $50); E (23) protective apparatus (deposit, $50); F (25) three electric travelling cranes (deposit, $50); and G (27) Auxiliary apparatus (deposit, $100). Specifications and plans may be seen at the

office of "Engineering," where also copies of the instructions to competitors, and of the plans and specifications and forms of tender may be obtained.

Tenders are invited for the supply of 13¼ miles of bare hard-drawn copper cable, and also for the supply of 6,410 yds. of single conductor lead-covered cables and 1,400 yds. of concentric lead-covered cables to the City Council of MELBOURNE. Specifications, tender forms and conditions from the Agents for the City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., with whom tenders must be lodged by Friday, July 23.

The TRANSVAAL Department of Posts and Telegraphs require tenders for supply of 2,500 tapered iron telegraph poles and 20 tons of g.i. wire. Tenders to the Agent-General, 72, Victoria-street, London, S.W., by noon July 23.

Tenders are invited by the Public Works Department, MADRID, for a 60 years' concession for the construction and working of an electric tramway between Monachil and the suburbs of Gabia Grande (Granada). Tenders (with deposit of 3,588 pesetas=£130) to the Direccion General de Obras Publicas, Madrid, before noon, August 26. The "Madrid Gazette" for June 21 containing further particulars, may be seen at 73, Basinghall-street, London, E.C.

Tenders are invited by the COPENHAGEN Lighting Corporation for 12 months' supply of d.c. cable, and for 800 a.c. electricity meters. Tenders to Directoren for Belysningsvaesenet, Raadhuset, Copenhagen, before noon of July 19 and July 17, respectively. Copies of specifications, &c., at the Board of Trade, 73, Basinghall-street, E.C.

The Italian State Railways department, ROME, require tenders by August 10 for supply of 100,000 linear metres (62 miles) of telegraph cable.

TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the following tenders:—

R. Bridger & Co., for wiring the "Oliver Goldsmith" School (Peckham), at £138. 8s.

For wiring the Great Marlborough-street fire station, five tenders (from £169 to £210) were received, and the lowest, that of G. E. Taylor & Co., has been accepted.

For constructing the authorised tramways along the Victoria Embankment, Blackfriars-road and Southwark-street, five tenders (varying from £11,420. 6s. to £14,707) were submitted, and the second lowest (that of Dick, Kerr & Co. at £12,055. 4s. 5d.) has been accepted (see THE ELECTRICIAN, July 2, p. 484, for full list of tenders). The following portions of the contract may be sub-let: (1) Anderston Foundry Co. or Wilsons, Pease & Co., yokes; Doulton & Co. or Bullers (Ltd.), insulators; Bayliss, Jones & Bayliss or Guest, Keen & Nettlefold, tie bars, bolts, &c; Associated Portland Cement Manufacturers, cement; to Harrison & Co. or Hadfield's Steel Foundry Co., plough boxes and drain boxes; and the Forest City Electric Co., bonds.

For steam piping, valves, water tanks, &c., for Greenwich station the following firms tendered: –

Staveley Coal & Iron Co. (ac.)...£7,566 7 2 &	£7,066	7	2	Foster Bros..........	£8,168	12	0
Edward Le Bas & Co.	8,495	2	5	J. Oakes & Co.........	8,002	19	0
Babcock & Wilcox...	8,400	0	0	S. Russell & Sons ..	7,954	9	6
John Spencer.........	8,291	7	11	Shelby Mfg. Co.......	7,733	13	3
Stewarts & Lloyds...	8,232	9	8	Railway & Gen. Eng. Co..................	7,342	13	1

For condenser water piping, valves, &c., at Greenwich station the following submitted tenders:—

Railway & Gen. Eng. Co. (accepted)	**£2,986**	**14**	**6**	J. Oakes & Co ...	£3,092	18	0
S. Russell & Sons ...	3,236	18	0	John Spencer ...	3,064	5	8
J. Wilson & Co.	3,183	18	2	Staveley Coal & Iron Co.	3,023	15	4
				Foster Bros........	2,617	0	0

The contract for the construction of junction line from Junction-road to Holloway car shed has been let to J. Mowlem & Co. as an extra on their existing contract.

For the supply of 362 moulded plough bases for electric cars and stores vehicles the tender of J. G. Ingram & Co. at £814. 10s. has been accepted; and for the supply of 150 outside stringers and 150 inside stringers and 1,200 galvanised risers the tender of G. A. Harvey (Ltd.) at £81. 1s. has been accepted.

Wigan Corporation have received the following tenders for extensions of the electricity works:—

Cables.			
W. T. Glover & Co. (*prov. accepted*)	£9,297	7	2
Siemens Bros. & Co. (brick pits not included)......	8,946	11	8
Electrical Co. (brick pits not included)...............	9,105	13	9
Lahmeyer Electrical Co. (brick pits not included)	9,193	16	7
British Insulated & Helsby Cables	9,415	13	8
Callender's Cable & Construction Co.	9,426	2	7
Johnson & Phillips	9,462	6	2
Western Electric Co.	9,493	13	6
W. T. Henley's Telegraph Works Co.	9,595	11	7
Aubert, Grenier & Co. (not to specification).........	3,918	13	4
Two Boilers.			
Babcock & Wilcox (*prov. accepted*)	£3,036	0	0
Water Tube Boiler Co.	2,525	0	0
Hawksley, Wild & Co. (Suckling boiler)	2,719	10	0
Stirling Boiler Co. (not to specification)	3,034	10	0
J. Thompson (Dürr)..	3,100	0	0
British Thomson-Houston Co. (Babcock)	3,219	6	0
Musgrave & Sons (Woodeson)	3,307	0	0
Clark, Chapman & Co. (Woodeson)	3,472	0	0
George Sinclair	3,668	14	0
Pipework and Condensers.			
Tickle Bros. (*prov. accepted*)	£1,689	0	0
Browett, Lindley & Co.	1,602	0	0
Worthington Pump Co.	1,645	0	0
British Thomson-Houston Co.	1,647	8	6
Crompton & Co.	1,711	0	0
Körting Bros.	1,725	0	0
Johnson Bros.	1,823	2	2
Willans & Robinson	1,825	0	0
Musgrave & Sons	1,993	0	0
C. A. Parsons & Co.	2,010	0	0
F. J. Mitchell (not to specification)	1,290	0	0
Tinsley & Sons (not to specification)..................	1,462	16	0

For the extension of the station buildings eight tenders (varying from £2,475 to £5,400) were received, and the lowest (that of D. A. Ablett & Sons) has been accepted. For the constructional steel works 12 tenders (from £694. 12s. 11d. to £1,010. 8s. 6d.) were received, and the contract has been let to Wm. Park & Co. at £720. 8s. 7d. Consideration of the tenders for pipework, economisers, coal conveying plant, engine, electric generator, and switchboard has been deferred until a sub-committee have visited works where turbo engines and modern coal conveying plants are in operation.

The Metropolitan Asylums Board have placed an order with W. J. Fryer & Co. for altering the electrical installations at certain of the hospitals and institutions of the Board for metal filament lamps. The lowest estimate was accepted for the work.

Woolwich (London) Council have accepted the tender of Babcock & Wilcox (at £70) for repairs to a boiler, and that of the British Insulated and Helsby Cables for 2 tons of compound, at £25. 13s. 4d. per ton, delivered in 7 lb. tins.

Dudley Council has accepted the tender of Dudley Electrical Co. for repairs to the telephone communications between Dudley, Netherton and Woodside, and to maintain same for three years for £30. 15s.

Leyton Council have placed an order with Venner & Co. for annual supply of meters, with the Reason Mfg. Co. for electrolytic type ordinary meters, and with Mordey, Fricker & Co. for electrolytic type slot meters.

Grimsby Corporation have placed contracts with J. Wilson & Co. for exhaust pipework at £145, with Hebb & Co. for renewal of the cooling stack at £140, and with McPhail & Simpson for two superheaters at £255.

The D.P. Battery Co., Bakewell, have received an order from the Midland Electric Light & Power Co. (Leamington) to instal and maintain for 10 years a storage battery of their LS 17 type in replacement of two batteries of another make.

Bury (Lancs.) Council have accepted the tender of Ferranti (Ltd.) for the supply and erection of a main high-tension switchboard.

Lewisham (London) Guardians have accepted the tender of T. L. Helsby & Son for a telephone installation at the workhouse and infirmary, &c., at £49. 6s.

Leyton Council have accepted the tender of Siemens Bros. & Co. for an electric motor for the baths, and that of H. Grimshaw & Son for wiring work.

W[illegible] Council have placed an order with Stuart & Moore for [illegible] fire alarms at £33 per annum for 12 years, and £17 per year for maintenance.

Spennymoor Council have accepted the tender of the Northern Counties Electricity Supply Co. for public lighting at 50s. per lamp per annum.

Derby Council have accepted the tender of the Chloride Electrical Storage Co. for the renewal of the traction battery, and 10 years' maintenance at £100 and £1,300 to be paid in yearly instalments.

Worcester Electricity committee have accepted the tender of Heenan & Froude for a steel storage bunker and coal elevator and conveyor at £656.

Durham Education committee have accepted the tender of Cox-Walkers (Ltd.) for wiring the Henry Smith schools, Hartlepool, at £192. 10s.

Salford Council have accepted the tender of the Tudor Accumulator Co. for supply and erection of a battery booster and switchgear, with fittings, cables, connections and accessories for £8,809.15s.

The tender of Plymouth Corporation electricity department has been accepted for wiring the new education offices.

Chester Council have accepted the tender of Crompton & Co. for a switchboard for the electricity works at £785.

Hornsey Council have accepted the tender of the Reason Mfg. Co. for the supply of electrolytic meters.

Burnley Guardians have accepted the tender of B. C. Smith for converting the infirmary lift into an electric one.

Rugby Council have accepted the tender of W. T. Henley's Telegraph Works Co. for cable.

Hackney (London) Council have accepted the tender of Sykes & Sugden for three-core service boxes at 9s. per box.

Longton Council have accepted the tender of Tompkinson & Bettelley for the extension of the electricity station at £452.

Warrington Guardians have accepted the tender of H. Bibby for electrical goods.

Darlington Council have accepted the tender of W. E. Dove & Co. for a motor generator set, switchboard, &c.

The Metropolitan Water Board have accepted the tender of the Key Engineering Co. for electrical fittings for the Hampton Works.

Manchester Corporation have accepted the tender of Siemens Bros. & Co. for 12 months' supply of service cable at £1,998. 10s. 10d.

The Rochdale Electric Co. have secured a contract for the electric lighting of St. Mary's Church, Rochdale.

BUSINESS NOTICES.

The Witton-Kramer Electric Tool & Hoist Co., Witton, Birmingham, announce that they have acquired the goodwill of the business of Kramos (Ltd.), including patterns, designs, patents, &c., The company are carrying on the manufacture of similar specialities to those of Kramos Limited, adding important improvements in the construction of mono-rail electric hoisting machinery, electro-lifting magnets, brake magnets and portable electric tools.

It is announced that the book departments of the McGraw Publishing Co. and the Hill Publishing Co., both of New York, have been consolidated under the corporate name of the McGraw-Hill Book Co., with offices at 239, West 39th Street, New York, where the "Electrical World," "Electric Railway Journal," the "Engineering Record," the "American Machinist," the "Engineering and Mining Journal" and "Power and The Engineer" are published.

The Cutler-Hammer Mfg. Co., of Milwaukee, U.S.A., announce that they have purchased the plant and business of the J. L. Schureman Co., of Chicago.

Electrical Engineering Business for Sale.—Messrs. Josolyne, Miles & Co., 28, King street, Cheapside, E.C., advertise for sale the business of a well-known firm of electrical engineers.

The Journal.—Part 195 of "The Journal of the Institution of Electrical Engineers" is now ready, price 5s. For particulars of contents see advertisement.

CATALOGUES, &c.

G.E.C. FANS. The General Electric Co. have issued a pamphlet entitled "A Good Breeze," which deals exhaustively with their latest patterns of "Freezor" fans. These include desk, bracket and ceiling fans, as well as those for more serious purposes which can be fitted in trunks or near portholes on board ship. The desk type combines in one unit the three styles known as desk, trunnion and bracket fans, and may be adjusted to propel the air in any direction. The same catalogue contains details of speed regulators for use with these fans, electric buffing machines and small motors for all kinds of work.

A subject somewhat similar to the above is dealt with in another pamphlet, in which is described the well-known "Bandy" electric punkah. By means of this apparatus it is claimed a periodically varying movement is given to the air, thus allowing much more efficient ventilation to be obtained than with the ordinary fan. By means of an ingenious arrangement the necessary "flick" is given to the punkah, and this "flick" is equal in strength in both directions, unlike the hand-pulled punkah, which only gives the "flick" in one direction.

TUDOR ACCUMULATORS.—Owing to the introduction of metal filament lamps, the number of small installations using pressures of 25 to 50 volts is rapidly increasing, and, as these installations in almost every case include a battery, the Tudor Accumulator Co. have issued a list giving prices and particulars of complete 25 and 50 volt batteries. This list deals with batteries whose working rates on a 10 hour basis vary from 3·5 to 65 ampere-hours. The cells, though of small size, are of the Tudor standard type, and of exactly the same design as are supplied for large central stations. A useful leaflet enclosed with this catologue shows the approximate rates for the carriage of acid to a number of important towns.

PARAFFIN ENGINES. As a prime mover for use in country houses, and other small places the paraffin and petrol engine is now in great vogue. In a recently-issued pamphlet Messrs. Fyfe, Wilson & Co., of Glasgow, give details of a set they are turning out for this purpose. The features of the electrical apparatus for use with this engine are also described.

AJAX IRON-CLAD SWITCHGEAR.—The present time—as regards switch arrangements, at any rate—may be considered as the age of the switch fuse. A useful piece of equipment of this kind is that made by Messrs. Parmiter, Hope & Sugden, and is known as the Hope "Spring-on" switch fuse. Details of this switch of the two and three-pole type, and for pressures up to 600 volts, are given in a pamphlet recently issued by this firm. "Ajax" time switches and fuse apparatus are also described.

"FACILE" MULTIPLE SWITCH.—An interesting switch with this title has recently been placed on the market by Messrs. D. H. Bonnella & Son. It consists essentially of two insulating discs on the upper of which are mounted four spring contacts and on the lower one a brass plate. One of the main wires is connected to one of these contacts, the other three being connected to the lamps. By a movement of the switch through a greater or lesser arc any number of lights can be switched on as required. This arrangement is adaptable to pendants, electroliers, floor standards and radiators.

SMALL ELECTRIC LIGHTING SETS. From Messrs. Nursey & Marr we have received a pamphlet dealing with their apparatus for the electric lighting of private residences and other places requiring small supplies of current. This pamphlet is fully illustrated, and full details of all the equipment are given.

ARTISTIC CALENDAR.—Mr. George Ellison, of Birmingham, has issued a calendar for July in which art and switchgear are well combined.

SAFE LOAD AND RADIUS INDICATORS FOR CRANES.—The Auto-Recorder Co., of Leicester, describe in a pamphlet recently sent out an arrangement whereby all cranes with movable jibs can be made quite safe.

"POPE" METAL FILAMENT LAMPS.—Turning to fresh fields, Pope's Electric Lamp Co. (Ltd.), of Willesden, N.W., have entered the metal filament lamp market. Their first catalogue on the subject, just issued, gives details of the various lamps made by them. The consumption of these lamps is 1·25 watts per British candle-power, and the life appears to be well over 1,000 hours.

BARWICK SPECIALITIES.—Messrs. Donovan & Co., of Birmingham, forward a number of pamphlets dealing with their specialities,

These include motor-starter panels and field regulators of various kinds, "Danco" single-enclosure arc lamps, and metal and carbon filament lamps.

B.C.E. Electric Fans and Motors.—The British Central Electric Co. deal in their latest catalogue with electric fans of all kinds, and details are given of small motors. Leaflets included with the catalogue describe the "Guardian" hand lamp and the "Efesca" metal filament lamp.

Trolley Hoists.—The Witton-Kramer Electric Tool & Hoist Co., of Birmingham, are in a position to supply a number of portable electric tools and other similar apparatus. These include an arrangement consisting of a motor and starter fixed on a truck. The motor drives a flexible shaft to which a grinding or drilling attachment can be fixed. Other specialities are electric brake magnets and Witton-Kramer magnetic drill posts. By means of the latter arrangement the drill can be brought up to the face of the work by simply fixing the post magnetically to, say, a boiler without any clamping being necessary.

The "Ready" Fire Extinction System.—A pamphlet recently issued by Messrs. Lund Bros. & Co. deals with the "Ready" fire extinction system, for which simplicity, efficiency and reliability are claimed.

Simplex Electrical Home.—Simplex Conduits (Ltd.) have recently prepared a description of their Electrical Home at the "White City," in which their well-known apparatus is used throughout for furnishing purposes. We shall describe the equipment of this house in detail later.

Cowans' Specialities.—We have received from Messrs. Cowans (Ltd.), of Manchester, a binder containing leaflets in which are illustrated and described a number of their specialities. These include regulating transformers on the Cowan-Still patent system, which are designed for obtaining variable pressures from a constant pressure supply for use in testing work. Extra high-pressure transformers, resistances and rheostats are also dealt with. Other sections in the catalogue describe various types of switches, including those for house service work and for use on circuits containing high inductances. These latter switches are supplied with a self-contained non-inductive resistance, which is inserted as the switch is opened. Relays, switch fuses and circuit-breakers of the type recently described by us in our Industrial Supplement are also included.

Igranic Control Apparatus.—The Adams Mfg. Co., of Bedford, have recently issued a catalogue dealing with their well-known Igranic starters and rheostats. A number of old friends are to be seen in these pages, and the firm is still keeping to its reputation for good engineering work.

BANKRUPTCIES, LIQUIDATIONS, &c.

Wm. Thos. Harris (trading as T. Harris & Sons, electrical engineers, 460 and 464, Commercial-road, and 47, Emanuel-street, Portsmouth) has been adjudicated bankrupt.

Claims against Jas. Hy. Mockridge and Arthur Pearce (trading as Jukes, Coulson, Stokes & Co. and as Moreton & Foster), engineers and telegraph buoy makers, London and Sheffield, are to be sent to Mr. H. Allen, 147, Leadenhall-street, London, E.C., by July 17.

Christian & Phillips, 1907 (Ltd.) is being wound up voluntarily, and Mr. W. A. Pearce, 16, Finsbury-circus, London, E.C., has been appointed liquidator. A meeting of creditors will be heard at 16, Finsbury-circus on July 19.

Rex Electric & General Supplies (Ltd.) is being wound up voluntarily. Mr. W. McI. White, 11, Queen Victoria-street, London, E.C., is liquidator. Claims by July 31.

A meeting to receive an account of the winding up of the Conduit & Insulation Co. (Ltd.) will be held on Aug. 4 at 23, Queen Victoria-street, London, E.C.

Winding-up Petition.—A petition for the winding-up of the British Aluminium Co. (Ltd.), presented by Messrs. Dick, Kerr & Co. will be heard in the High Court on July 13. (As reported in our last issue, Mr. Justice Warrington, on June 30 appointed Mr. A. W. Tait as receiver and manager of this company for a period not to extend beyond Oct. 31.)

Mountain & Gibson (Ltd.)—At a meeting on June 30 it was resolved that Mountain & Gibson (Ltd.) be wound up voluntarily, and that Mr. H. H. Bowden, 77, King-street, Manchester, be appointed liquidator. Notice is given that a meeting of the creditors of this company will be held at 60, Spring-gardens, Manchester, on July 19 at 11:30 a.m.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—The undermentioned [illegible] inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.

May 1, 1909.

10,348 Beamish & Osb[illegible]. [illegible] (Addition to No. 8,601/09.)
10,396 B.T.-H. Co. (G.E. Co., U.S.) Supports for incandescent electric lamp filaments.
10,409 Brush Electrical Engineering Co. & Bastian. Vapour electric apparatus and methods of operating the same.

May 3, 1909.

10,446 Favero. Terminal or context pieces and body of electric incandescent lamp-holders.
10,450 Pictet. Telegraphic receivers.*
10,497 B.T.-H. Co. (A.E.G., Germany.) Alternating-current dynamo-electric apparatus. (Addition to No. 786/09.)*

May 4, 1909.

10,539 Beaver, Stratton, Shaw & Claremont. Electric terminals.*
10,544 Nussbaum. Telephonic transmitters or microphones.
10,550 Siemens Bros. & Co., Lauckert & Nebel. (Siemens & Halske Akt.-Ges., Germany.) Varying the connections of electrical apparatus.*
10,555 Handcock, Dykes & Rawlings. Bending electrical conductors, rods, tubes and the like.
10,564 & 10,565 Mathieu. Electric batteries.
10,585 Newbery. Electric signalling apparatus.
10,586 Rymer-Jones. Wireless telegraphy and telephony.*
10,588 Parsons, Law & Stockbridge. Commutators on dynamo-electric machines.
10,594 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric distribution systems.
10,600 Martin. Construction of electrical resistance devices.
10,607 Key Engineering Co. & Andrews. Electric cables.
10,608 Hill. Boxes for use in electric wiring systems.

May 5, 1909.

10,655 Cowper-Coles. Electro-deposition of iron.
10,663 Brazil & Cooch. Protective devices for alternating-current systems.
10,665 Allgemeine Elektricitats-Ges. Alternating electric current commutator machines having two working and two exciter windings. (Date applied for, 6/5/08.)*†
10,680 Kilroy & Evershed & Vignoles. Starting of electric motors.
10,694 Rittman. (Charles L. Chisholm, Canada.) Telephone transmitters or the like.
10,698 Burge. Operation of electric switches, circuit-breakers, cut-outs and the like.
10,709 Stone. Electric distribution systems.

May 6, 1909.

10,729 Cochrane. Through-control magnetic switches for electric lighting installations on trains.
10,739 Pugh & Bull. Junction fittings of metallic conduits for electric conductors. (Date applied for, 4/12/08. Comprised in application No. 26,232, dated 4/12/08.)
10,757 Elieson. Switches.
10,791 Schauli. Electrolyte for primary or secondary galvanic batteries.*
10,793 Schwerin. Production of electric currents. (Date applied for, 7/5/08.)*†
10,796 Sheehy. Fuse-boxes.*
10,799 Smith. Dynamo-electric machines or electromagnetic power devices.

May 7, 1909.

10,834 Fahn. Depolarisators of galvanic batteries.
10,860 Martyn. Junction boxes for electric wires and cables.
10,869 Blenheim & Vaughan-Williams. Electric-current regulator.
10,876 Valoris. Utilisation of hertzian electric waves. (Date applied for 28/10/08.)*†

May 8, 1909.

10,911 Niblett. Electrolytic apparatus.
10,913 Taylor. Charging and discharging electric accumulators on traction or lighting and like circuits.
10,934 Hansford & Wright. Prepayment apparatus.
10,955 B.T.-H. Co. (G.E. Co., U.S.) Electric resistance conductors.

May 10, 1909.

10,974 Barber. Electric switches and combined switches and fuses.
10,995 Cowper-Coles. Extraction of iron from its ores.
10,996 [illegible] Terminals for electric wiring.
11,060 Johnson. (Chemische Fabrik Griesheim-Elektron, Germany.) Production and maintenance of long electric arcs.
11,061 Head. Rotary electric contact devices or current collectors.

May 11, 1909.

11,107 Dyhr. Portable current generators.
11,116 Traun. Protective coverings for ships' propeller shafts.*
11,135 British Insulated & Helsby Cables, Cole & S[illegible]
11,149 Soc. Française d'Incandescence par le Gaz (Systeme A[illegible]). S[illegible] electric lamp filaments. (Date applied for, 13/7/07. Comprised in No. 12,720, dated 13/6/08.)
11,154 Patterson. Batteries and battery holders. (Date applied for, 26/5/08.)*†
11,155 Patterson & H[illegible]. Batteries. (Date applied for, [illegible])
11,169 Isaacson. Magnetic ignition apparatus.
11,172 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.

May 12, 1909.

11,209 Russell & Lord. Splicing [illegible] conductors. (Date applied for, [illegible])
11,210 Russell & Lord. Section insulator for electric tramways. (Date applied for, 2/11/08.)*†
11,223 Hall. Electric ignition apparatus for internal-combustion engines.*
11,242 Sharman. Master switches for [illegible]
11,267 Brand. Connecting terminals for switchboards.*
11,282 Grote. Arc lamps.
11,285 B.T.-H. Co. & Wedmore. Electric distribution systems.
11,302 & 11,303 Zweigbergk. Electric controllers for railway service and the like.*

May 13, 1909.

11,317 R[illegible] & Belcher. Electric furnaces.
11,326 Eccles & Hatfield. Trolley retriever for electric cars.
11,339 Allgemeine Elektricitats Ges. Power transmission systems. (Date applied for, 13/5/1908.)*†
11,400 Allgemeine Elektricitats-Ges. Power transmission systems. (Date applied for, 13/5/08. Addition to No. 11,339/09.)*

May 14, 1909.

11,402 Goddard. Prepayment electricity meters.
11,417 Fifield & Morris. Secondary or storage battery or accumulator for electric current.
11,445 Dawson & Pyne. Control of electric motors.
11,460 Blackall & Jacobs. Electric [illegible]
11,480 Hirth & S[illegible]. Electric [illegible]
11,482 Davy. Arc lamps.
11,497 Peticky, Suchanek & Cizek. Automatically connecting up the subscribers of a telephone exchange. (Addition to No. 28,036/04.)*

May 15, 1909.

[illegible] B.T.-H. Co. (G.E. Co., U.S.) [illegible]
[illegible]
[illegible]
11,559 Postans. Electrical contacts.

May 17, 1909.

[illegible]
11,578 Duschnitz. Arc lamp with conducting supporting member. (Date applied for, [illegible])
[illegible]
[illegible]
11,634 Siemens-Schuckert Werke, G.m.b.H. Electric meters. (Date applied for, [illegible])
[illegible]

May 18, 1909.

[illegible]
[illegible]
11,741 Regnart & Huntalite. Holders for electric candle lamps. (Addition to No. 20,010/04.)*
11,760 New Ignition Synd. & Sandy. Electrolyte for use in electric batteries. (Addition to No. 10,520/08.)

May 19, 1909.

11,767 Donaldson. (James Donaldson, U.S.) Electrical switches.
11,773 Johnston. Ceiling roses, junction boxes, conduit boxes and like electric fittings.
11,799 McLaren. Recording mechanism for ships' telegraphs.
11,822 Parsons & Law. Dynamoelectric machinery. (Date applied for, 8/8/08. Comprised in application No. 16,704, dated 8/8/08.)
11,842 Cowper-Coles. Regenerators for use in the electro-zincing process.
[illegible]

May 20, 1909.

[illegible]
[illegible]
11,904 Siemens-Schuckert Werke, G.m.b.H. Commutators for dynamoelectric machines. Addition to No. 4,240/08). (Date applied for, 31/7/08.)*†
11,906 Szek. Boxes or jars for electric batteries.
11,925 Newlands & Parkinson. Electrolyte for primary batteries.
11,938 Simpson. Generation of electric energy and apparatus therefor.
11,945 Willing. Jumper stay Morse signalling apparatus.*
11,947 Munro & Railless Electric Traction Co. Current collectors for electric traction systems.
[illegible]

May 21, 1909.

11,958 Taylor. Charging and discharging secondary batteries or electric accumulators.
11,981 Pease. Flexible protection for electric cables and the like purposes.
[illegible] messages for telegraphic and other purposes.
12,016 Polkey. Charging electric accumulators.
12,047 B.T.-H. Co. & Kingwell. Control of electric motors.
12,048 B.T.-H. Co. & Wedmore. Electric distribution systems.
12,050 Turner. Controllers for electric motors.

May 22, 1909.

12,036 Swainson & Swainson. Electrical wiring.
12,139 Ireland. Controlling and indicating the condition of control of electrically propelled tramcars and other vehicles.
12,146 Vernier. Electrical conductors.

May 24, 1909.

12,156 Garnett. Arc lamp.
12,254 Bluhm. Third rails.*
12,253 Zuckerfabrik Frankenthal. Starting and cutting out electric motors. (Date applied for, 1/6/08.)*†

May 25, 1909.

12,235 Hall. Magneto-electric ignition apparatus for use in connection with the ignition systems of internal-combustion engines.
12,296 Dunkley. Fixing terminals or connections in carbon rods or blocks.
12,308 Curwen. Metal sheathing of electric conductors.
12,335 MacDiarmid & Bates. Electric switches.*
12,347 & 12,348 Zimmer & Needham. Incandescent electric lamp.

May 26, 1909.

12,395 Electric Control, Macmillan & Dryer. Electric switch operating mechanism.
12,396 Electric Control, Macmillan & Dryer. Carbon brush-holders for switches.
12,442 Hamilton. Combined section insulator and double-action quick-break switch.*
12,452 Fisher. Electric plugs.
12,473 Webb. Multiplex transmitter and circuit for same.*
12,474 Grote. Manufacture of filaments for incandescence electric lamps.
12,477 Bullers Limited & Dagnall. Electric insulators.
12,481 Dewhurst & Roscoe. Automatic cut-in and cut-out device for electric circuits.

May 27, 1909.

12,501 Westwood & Dawson. Electromagnets for lifting purposes and the like.
12,507 Ruthenburg. Electrodes for electric furnaces.
12,562 Cooper, Sharp & Stevens. Electrical heating device.*
[illegible]

May 28, 1909.

12,607 Smith & Watson, jun. Trolley heads for electrical tramcars.
12,677 Benko. Carbon electrodes for galvanic elements.*
12,685 Field & Ferranti Limited. Generation, transmission and distribution of electricity.
12,686 Bourdos. Filaments for electric lamps.

May 29, 1909.

12,689 B.T.-H. Co., Gray & Holden. Electric meters.
12,709 Electrolytic Alkali Co., Connor & Stubbs. Electrodes.
12,744 W. T. Henley's Telegraph Works Co. & Nichols. Electrical fuse carriers.
12,774 McLean. Brush-holders for dynamoelectric machines.
12,776 Graetz. Metallic filament lamps.*
12,782 Allmanna Svenska Elektriska Aktiebolaget. Electric polyphase commutator machines. (Addition to No. 24,591/08.)*

SPECIFICATIONS PUBLISHED.

1908 Specifications.

[illegible] by means of electromagnetic radiations. (Date applied for, 11/2/07.)
10,520 New Ignition Synd. & Sandy. Electrolyte for use in electric batteries.
10,521 Boult. (O. A. Miller Treeing Machine Co.) Electrically-heated tools.
10,535 Cohen, Cramer & Geifel. Electric cables and the like.
[illegible]
10,539 Berry. Electric power hammers.
10,760 British Prometheus Co., Cooper & Sharp. Luminous electric radiators.
[illegible] (Date applied for, 7/10/07.)
[illegible]
11,135 Brown. Telephony and telegraphy.
11,170 Brooks & Alston. Induction coils.
11,183 Thomas & Thomas. Electrical circuit-breakers.
[illegible]
11,345 B.T.-H. Co. (G.E. Co., U.S.) Control of electric circuits and apparatus.
11,608 Lironi. Trolley wheels for electric tramways, railways and the like.
11,871 Parsons & Law. Commutators for dynamoelectric machines.
11,[illegible] B.T.-H. Co. & Wedmore. Electrical distributing systems.
12,191 Abbott. Electric cooking and heating apparatus.
12,447 Massone. Electric motors for vehicles.
12,508 Barlow. Motor-controlled switches. (Post-dated 7/12/08.)
13,215 Hookham. Electrical contacts. (Cognate application, 26,973/08.)
14,049 Siemens Bros. Dynamo Works & Kloss. Dynamoelectric machines.
[illegible] Hazleton. Casings for electric interrupters.
14,701 B.T.-H. Co. (G.E. Co., U.S.) Electric regulating devices.
14,814 Vogel. Accumulator electrodes.
15,116 Shaw. Arc lamps.
15,487 Burleigh. Dynamoelectric machines.
15,424 Page. (Universal Electric Welding Co.) Electrical welding.
15,664 Allgemeine Elektricitats-Ges. Electromagnetic relay apparatus for polyphase circuits. (Date applied for, 24/7/07.)
15,791 B.T.-H. Co., Bacon & Tuppen. Motor-controlling switches and the like.
16,060 Rayner & Chillington Tool Co. Connection between electrical conductors.
16,772 [illegible]
17,170 White. Electric fuses.
17,380 B.T.-H. Co. (G.E. Co., U.S.) Current-collecting rings for dynamoelectric machines.
17,412 Siemens Bros. Dynamo Works & Nicholls. [illegible] switches and the like.
17,621 Coolidge. Manufacture of refractory electric conductors. (Date applied for, 24/8/07.)
18,233 Weissmann. Fitting incandescent electric lamps. (Date applied for, 10/1/08.)
18,715 Siemens Bros. Dynamo Works. (Siemens-Schuckert Werke Ges.) Regulation of alternating-current electric generators working in parallel.
19,365 Bayliss. Holders, sockets or like attachment fittings for electric lamps.
19,621 Scott. Suspension of trolley wires for electric tramways and railways.
19,679 Lightfoot. Safety device for portable electric hand lamps.
22,168 Kompe. Trolley heads or collectors for electric traction. (Date applied for, 22/10/07.)
22,210 Tiffany. Electrical circuit closer.
22,426 Peyrusson. Insulation of switches, current breakers, automatic switches and the like. (Date applied for, 23/10/07.)
22,450 Schanschieff. Construction of field magnets for electric generators or motors. (Post-dated, 24/12/08.)
22,562 Voigt & Haeffner Akt.-Ges. Electric distributing stations. (Date applied for, 1/11/07.)
22,915 Larsson & Svalling. Radiometers.
23,002 Curran & Kelly. Locking hook for trolleys or collectors of electric tramcars. (Addition to No. 13,299/08.)
23,069 B.T.-H. Co. (G.E. Co., U.S.) Supports for filaments of incandescent electric lamps. (Addition to No. 16,531/07.)
23,426 Popow. Signalling by electricity.
23,590 Baumer. Telephonic installations.
24,008 Heil. Primary electric cells or batteries.
24,058 Lundberg, Lundberg & Lundberg. Electric switches.
24,192 Conrad. Electric relays. (Date applied for, 15/11/07.)
24,224 Fiedler. Plates for secondary batteries.
24,702 Murray. Electric fusible cut-outs.
24,737 Soc. Anon. Montbarbon. Magneto ignition apparatus. (Date applied for, 19/12/07.)
25,851 Siemens & Halske Akt.-Ges. Electric incandescence filaments from tungsten or other difficultly fusible metal. (Date applied for, 11/12/07.)
26,120 Jackson. Electrical distribution. (Date applied for, 6/12/07.)
26,170 Pontois. Inductor magneto alternators. (Date applied for, 11/7/08.)
26,367 New Ignition Synd. & Foster. Closing electric battery cells and securing electrodes in the same.
26,507 Johnsen & Walleen. Conducting current to or from continuous-current electrical machines.
26,555 Conrad. Transformers for operating vapour electric devices. (Date applied for, [illegible])
26,583 Marconi's Wireless Telegraph Co. & Round. Measuring electromagnetic wave-lengths.
26,808 Meirowsky. Electrical condensers. (Date applied for, 18/5/08.)
27,[illegible] Siemens-Schuckert Werke Ges. Securing thin electric insulating covering to fine single wires. (Date applied for, 14/12/07.)
27,075 Schroter. Attaching electric wire conductors to insulators. (Date applied for, 12/12/07.)
27,138 Bonbright. Electric speedometers and odometers.
27,140 Drysdale. Potentiometer for measurements on alternate-current and direct-current circuits.
27,143 Timar & von Dreger. Arc lamp with pairs of carbon arranged tangentially to the axis of the lamp.
27,144 Kroll & Saklatwalla. Production of pure and thin filaments for illuminating purposes. (Date applied for, 13/12/07.)
27,477 Justice. (Essex Co.) Third-rail insulators.
27,536 Holman. Arc lamps.
27,830 Hartmann & Braun Akt.-Ges. Electric resonance apparatus. (Date applied for, 12/6/08.)
27,991 Highfield. Lamp supports and casings.
27,999 Thompson. (Ernst Eisemann & Co. Ges.) Magneto-electric sparking apparatus.
28,017 Soule. Electric motor control. (Date applied for, 10/1/08.)
28,102 Westcott & Gartside. Coupling for electric cables, wires, and rods.
28,192 Allgemeine Elektricitats-Ges. Starting devices for electric motors. (Date applied for, 28/12/07.)
28,276 Voelker. Electric furnaces.
28,442 Bosch. Insulation of the layers of windings of electromagnetic apparatus. (Date applied for, 12/12/08.)
28,525 Anspach. Electric transmission of visual images.

1909 Specifications.

331 Siemens Bros. Dynamo Works & Schupp. Starting switches for alternating-current electric motors.
355 Rawdon. Telegraphic repeaters.
404 Kunkel. Dynamo-electric machines. (Date applied for, 10/1/08.)
636 Zipplies. Electric motor meters. (Date applied for, 18/1/08.)
747 Bryan. Trolleys or collectors for electrically-driven vehicles.
1,070 Delon. Converting alternating potential differences into high continuous potential differences. (Date applied for, 17/1/08.)
1,316 Gebr. Siemens & Co. Electrode for searchlights. (Date applied for, 9/4/08. Addition to No. 13,071/07.)
1,332 Kuzel. Metal filaments for electric lamps. (Date applied for, 22/2/08.)
1,651 B.T.-H. Co. (G.E. Co., U.S.) Balancing end thrusts in dynamo-electric machines. (Date applied for, 18/8/08.)
2,004 Chaudoir. Electric fuse boxes, cutouts, switch fuses or the like.
2,076 Beaver & Claremont. Apparatus for use in connection with electric cables. (Date applied for, 23/3/08.)
2,106 Green. Holders for electric lamps.
2,216 Centralstelle fur Wissenschaftlich-Technische Untersuchungen Ges. Producing long voltaic arcs. (Date applied for, 1/2/08.)
2,353 Hatry. Electric fuses fitted with indicating devices.
2,851 Siemens Bros. & Co. (Siemens & Halske A.-G.) Telephone exchanges.
2,853 Siemens & Halske Akt.-Ges. Electric incandescence filaments from tungsten or other difficultly ductile metals. (Date applied for, 11/2/08. Addition to No. 4,814/07.)
3,199 Thompson. (Mea Fabrik Magnet-Elektrischer Apparate Ges.) Magneto-ignition apparatus for multi-cylinder internal combustion engines.
3,340 Bronee. Electrical printing telegraph. (Date applied for, 11/2/08.)
3,621 Peaucellier. Electric contact making and breaking device. (Date applied for, 4/3/08.)

COMPANIES' MEETINGS AND REPORTS.

British Electric Traction Co. (Ltd.)

The thirteenth ordinary general meeting was held yesterday (Thursday) at the offices of the company, Kingsway, London, W.C.

The SECRETARY (Mr. C. H. Dade) read the notice convening the meeting and the auditors' report.

The CHAIRMAN (Sir Charles Rivers Wilson, G.C.M.G., C.B.) said that particulars given in the report and accounts would convey a general idea of the magnitude of the work done by the companies, and a close study of the details would, he felt sure, show that this work was done efficiently and economically. Referring to the depression which prevails in all electrical branches, Sir Charles said that in such circumstances it was unavoidable that the traffic receipts of tramway companies should suffer, and that people should make special effort to keep down their lighting bills. The year had not only been one of many disappointments, but they had also suffered a great loss by the death of Mr. Arnold Forster. They had looked forward to his being present this year, and keenly felt his loss. He was glad to say there appeared to be a general awakening apparent. Referring to the decreased revenue from the associated companies, he was sorry to say that, while these undertakings were able to hold their own, on most of them there had been no marked improvement, and unless trade revived before the end of the year he was afraid the dividends for the current year would not show any material increase. In regard to the company being able to pay in the immediate future the 3 per cent. on the preference shares, their hope was to pay this as the minimum dividend. The profits of the past year were £15,000 short of the amount required; they had brought forward from the preceding year £35,393, and carried forward only £20,203, after paying the dividend. Unless the net profits increased, it would be obviously unwise to pay the same dividend for the current year, and it became a matter for serious consideration whether the interim dividend of $1\frac{1}{2}$ per cent., requiring £24,000, should be paid in August with the risk of not being able to pay the same dividend in February, or whether the question should be left over until the accounts of the year were made up. The directors were of opinion that unless the prospects materially improved it would be wiser to suspend the further payment of dividend on the preference shares until the accounts for the current year were made up. The still further reduction in management and general expenses from £24,100 to £16,800 was mainly the outcome of the formation of the British Electrical Federation. In regard to the all-important question of tramway fares, when he informed them that the infinitesimal increase in the average of only $\frac{1}{10}$th of a penny represented no less than £24,000 addition to the revenue, or a half-year's interest on the preference shares they would see how important this question was. In 1901 the average fare was 1·38d. If this had been the present average, they would have an increased revenue of no less than £200,000.

In regard to the Brush Company the falling off was in common with most other electrical companies. He felt that a very small measure of Tariff Reform would make an enormous difference to the electrical industry generally. They had taken steps to secure concessions for tramways in St. Petersburg. The conditions for doing business abroad were much more favourable than at home, and although exposed to powerful competition they had been able to join forces with German and Russian competitors, and a syndicate had been formed by means of which the chief competition was eliminated. There was one enterprise not specifically referred to in the report; the North-West London extension of the Baker-street and Waterloo Railway. The Brush Company obtained an Act for a tube railway from Cricklewood to Victoria, which at the time looked very promising. The results from tube railways in London was, however, so disappointing that the matter had to be reconsidered, and they came to the conclusion that with the prevailing low fares and other considerations the original scheme could not be proceeded with. They, therefore, felt that the best portion of the scheme would be utilised as an extension to the Baker-street Railway. After considerable trouble an arrangement was come to, but the House of Commons rejected the scheme, although the general consensus of opinion was that it was better than the original. He felt that a Committee of the House was a most unsatisfactory tribunal to deal with electrical matters, and hoped the time would come when some other tribunal would be established which would give the companies fair consideration. He then moved the adoption of the report and accounts.

Mr. EMILE GARCKE seconded the resolution, and said he would like to submit a word in regard to legislation affecting the electrical industry. Matters were becoming worse, and instead of legislation to ameliorate the present condition, the Board of Trade in the present session had introduced a bill entitled the Electric Lighting Acts (Amendment) Bill, which, while not doing anything to carry out the promises of the Board of Trade, contained clauses which were excessively harassing to the industry, without, he ventured to say, being of any benefit to the public. The bill had been referred to a standing committee, instead of to a select Committee, as they had hoped, so that there was no opportunity for them to protest and give evidence. Clause 6 empowered a local authority to go outside its area and compete with a company, but a company could only go outside its area and compete with a local authority if it obtained the consent of that local authority. There were also other obnoxious clauses in the bill. If the bill had only applied to future undertakings it would have been bad enough, but it also applied to existing undertakings. He regretted there was no organisation by which they could make their views felt.

Mr. H. B. BRAITHWAITE endorsed Mr. Garcke's remarks regarding the bill, which he hoped would not go through in its present form.

Mr. G. PARKER asked whether, seeing the loss that had occurred, some form of capital reorganisation was not necessary to put the company on a sound footing?

Several other shareholders having spoken,

The CHAIRMAN, in reply, said that there was no necessity to raise fresh capital for the enterprise at St. Petersburg. This was only a matter of finance. It would be unwise, in view of the present depression and reasonable expectations, to reconstruct their capital.

The report and accounts were adopted, the resolution authorising the dividend on the preference shares was passed, the retiring directors (Mr. J. S. Raworth and Mr. P. D. Tuckett) were re elected, as were the auditors, and a cordial vote of thanks to the chairman and directors brought the proceedings to a close.

Electric & General Investment Co. (Ltd.)

The twentieth ordinary general meeting of this company was held on Wednesday. Mr. J. B. BRAITHWAITE presided.

The SECRETARY (Mr. S. R. Shaw) read the notice convening the meeting and the report of the auditors.

The CHAIRMAN said: The past year has been one of comparative stagnation in the electrical business, and therefore we have not had the opportunities for profitably employing all of your capital that we have had in the years which are past. The year is certainly considerably better than the result which we showed last year. The most noticeable feature in the balance-sheet is the reduction of the amount of the liabilities, which, of course, is due to the stagnation which has been going on, and also to the gradual realisation of the various investments. The investments in the accounts stand at very much the same figure as they did last year—there is a difference of about £2,000—a decrease of that amount for, in these accounts, by investments in debentures and shares of other companies, &c., at cost we show £249,613. 8s. 2d., as compared with £251,793 last year. The loans against securities have been materially reduced. They stand in these accounts at £16,890. 19s. 2d., as compared with £28,992 last year. The cash balance this year is very much the same as it was last year—namely, £2,415 as compared with £2,487—and the item of sundry debtors also stands at very much the same sum as before, namely, £5,029. 12s. 3d. On the other hand, you will see that, on the debtor side of the balance-sheet the capital remains the same, and the provision for contingencies has been increased by the sum which was added to it last year, and it then stood at £67,556. 9s. 1d., and if you approve of the recommendation in this report, then the total will be increased by the surplus revenue of this year, which is transferred from profit and loss account, of £4,095, raising the total of the provision for contingencies to the satisfactory figure of £71,651. 17s. 8d. The loans from bankers and others now stand at £67,800, as compared with £73,500 for the corresponding year, so that there is a considerable decrease there. Sundry creditors on open accounts also show a decrease, the item having been reduced from £22,199 last year to £14,474 this year. Turning to profit and loss account, the total profits for the year have amounted to the sum of £11,565. 17s. 11d., as against only £7,889 last year, or nearly £4,000 more, and that is an increase of something like 40 per cent. That is due to the fact that although there has been during the past year, as I have already said, a period of continued stagnation, speaking generally, still there have been one or two little opportunities for doing good business of which we have been able to avail ourselves, with the result that we can show you this extra £4,000 of profit for the past year. The general charges you will see are much about the same as last year, and the preference dividend which we propose to pay to you is, of course, the same, with the final result that we have a balance of profit remaining after the payment of that preference dividend of £4,095, as against only £568 last year, so that there is a net improvement of about £3,500. That sum you will see represents about a return of 15 per cent. upon the amount of capital which is paid up upon the ordinary shares; but, gentlemen, in view of the continued depression in many of the electrical securities which this Company holds, the Directors feel confident that they will have your support in their proposal to transfer this amount to the contingencies fund. As you know, that fund is a reserve against depreciation, and, of course, if the market improves later on then the contingency fund might be drawn upon, if it were necessary for dividend purposes, provided of course that the value of the investments, which we hold, stood in the market at a sum which was equal to the cost at when they stand in the books of the Company at that moment, or were beyond it. At the present moment, however, I repeat that we do not think it would be desirable to divide this surplus, and we therefore ask you to approve of the proposal to place the sum to the contingency fund. I now move the adoption of the report and accounts.

Mr. EMILE GARCKE seconded the motion.

After a short discussion,

The CHAIRMAN, in reply, said that he was glad the balance of opinion was in favour of the conservative course which the Directors were adopting in placing the money to the reserve and contingency fund, and he would like to take that opportunity of reminding the ordinary shareholders of one fact, and that was that the ordinary shareholders had always recognised that that Company was a finance Company, and therefore everything must be dependent upon the prosperity of the Company from time to time. He further desired to remind the shareholders that they had very large dividends paid them in the past, and that altogether for each £1 which had been paid up upon the ordinary shares they had up to the present time received a return of £4. 16s. It was true that they had the power to distribute a dividend upon the present occasion out of the profits which they had made for the past year, and which surplus profits they were placing to the contingency fund.

The resolution was then carried unanimously.

Resolutions approving the payment of the preference dividend, and re-electing the retiring director (Mr. Gaucke) and the retiring auditor Mr. G. T. Kirtt were then carried, and a vote of thanks to the Chairman, directors and staff terminated the proceedings.

CHILI TELEPHONE CO. (LTD.)—The directors' report for the year ended March 31 states that the aggregate number of subscribers at all centres at the end of the year was 8,011 compared with 7,666 in 1908. Gross revenue in Chili from all sources was $1,720,716 against $1,469,611. Expenditure in Chili was $824,082 against $744,121. Net income in Chili from all sources was $896,633 against $725,489, an increase of $171,144. The average rate of exchange for the year was 10·09d., compared with 11·21d., a decrease of 1·12d. Converted into sterling at these rates, the figures given are £37,698, against £33,883, an increase of £3,815. The balance to credit of revenue account (including £2,777 brought forward) is £38,104, of which £17,683 has been carried to reserve. An interim dividend of 3s. per share (tax free) was paid on Jan. 15., and the directors now recommend a final dividend of 5s. per share (tax free), leaving £2,820 to be carried forward. The total mileage was 14,121 miles 584 yds., against 13,496 miles 275 yds., an increase of 625 miles 309 yds. on the year.

DELHI ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The report for the year to Oct. 31, 1908, states that, after providing £619 for debenture interest and debiting the balance of £446 to penalty suspense account, there is a debit balance of £347 to be carried forward.

EDMUNDSONS' ELECTRICITY CORPN. (LTD.—The net profit for the year ended March 31, after payment of interest on debenture and prior lien debenture stocks, was £597. 5s. 8d. Adding balance of £20,417. 5s. 9d. brought forward, less expenses of issue of prior lien debenture stock, £14,809. 7s. 11d. remains, and the directors recommend that this sum should be carried forward. The dividends and interest received have increased by £2,871. 7s. 6d., the loss on working the local authorities' undertakings is reduced by £997. 1s. 6d., and the Urban Co. guarantee is less by £386. 16s. In view of the conditions which have adversely affected almost all electric supply undertakings during the year, the directors consider that these results are not unsatisfactory. The reduced net profit is attributable to the diminution in the trading profits consequent upon a reduced capital outlay by the subsidiary companies, but it is the avowed policy of the board to restrict capital expenditure as far as is reasonably possible.

ELECTRIC CONSTRUCTION CO. (LTD.)—The net profit for the year ended May 31, after payment of £10,250 for debenture interest and crediting £5,000 as formerly to depreciation account, is £10,730. 12s. 7d., which with £1,746. 8s. 1d brought forward, makes £12,477. 0s. 8d. From this has to be deducted the dividend on the 7 per cent. cumulative preference shares for the year 1908 (£4,394. 12s.), leaving £8,082. 8s. 8d. The directors recommend payment of the 7 per cent. cumulative preference dividend for 1909 (payable July 31), absorbing £4,394. 12s., leaving £3,687. 16s. 8d. to be carried forward. The increase in the volume of business referred to in last report is reflected in the foregoing results, which show a considerable improvement on those of the past few years. The reduced demand for electrical plant caused by the introduction of metal filament lamps and the general depression in trade affected the volume of home orders received during the year, but this was counteracted to some extent by an increase in export business. The directors are very hopeful that the enhanced profits now reported will be fully maintained, notwithstanding that the industry is still in an unsatisfactory condition.

LONDON UNITED TRAMWAYS (1901) (LTD.)—A circular has been issued stating that although the earnings for the first six months of the year show a surplus sufficient to pay the dividend on the 5 per cent. cumulative preference shares at the reduced rate of 2½ per cent. per annum, the directors consider that until they can see their way to the resumption of the full dividend at the rate of 5 per cent. it will be better to postpone any distribution until the accounts for the whole year are before the board. The registered offices have been removed to High-road, Chiswick, London, W.

ROYCE LTD.—The report for the year ended March 31 states that there is a loss of £1,514. After meeting debenture charges there remains to be carried forward a net debit balance of £925.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES, CHARGES, &c.

NEW COMPANIES.

ADNIL ELECTRIC CO. (LTD.) (103,763.)—Reg. June 29, capital £10,000 in £1 shares, to carry on the business of electricians, electrical and general engineers, ironmongers, makers of and dealers in electric tramcars, motor cars and other vehicles, manufacturers of and dealers in dynamos, motors, telephones, electroliers, arc and other lamps, electric light fittings, &c. Private company. Reg. office, Adnil-building, Artillery-lane, London, E.C.

MILLS BROS. & CO. (LTD.) (103,776.)—Reg. June 29, capital £1,000 in £1 shares to carry on the business of general dealers and manufacturers, engineers, metal workers, machinists, electricians, &c. Private company. Reg. office, 305-6, Moorgate Station-chambers, London, E.C.

STATUTORY RETURNS.

EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)—In return to May 26 capital is £600,000 in £10 shares, all of which has been taken up and paid for in full. Mortgages and charges, £199,500.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—Return to May 25 gives capital as £132,520 in 53,008 shares of £2. 10s. each, of which 45,008 have been taken up. £20 has been paid on 8 and £112,500 is considered as paid on 45,000. Mortgages and charges, £170,000.

WESTERN TELEGRAPH CO. (LTD.)—According to return to May 26 capital is £2,500,000 in £10 shares, of which 207,930 have been taken up. £1,300,000 has been received, and £779,300 is considered as paid. Mortgages and charges, £800,000.

MORTGAGES AND CHARGES.

ELECTRIC BATTERIES & CARBONS (LTD.)—Debenture dated June 2, 1909, to secure £1,500, charged on company's undertaking and property, present and future, including uncalled capital. Holder, R. G. Orr.

F. HUTCHINS & CO. (LTD.)—Particulars of £5,000 debentures created June 21 has been filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

RECEIVERSHIP.

BOGOTA TELEPHONE CO. (LTD.)—A notice of the appointment of D. Gibson, C.A., 4, Kingsmead-road, South Oxton, Birkenhead, as receiver, on June 29, 1909, under powers contained in first mortgage debenture trust deed dated May 30, 1905, has been filed pursuant to sec. 94 of the Companies (Consolidation) Act, 1908.

CITY NOTES.

MEMORANDA (July 8).—Bank rate 2½ per cent. (since April 1, 1909). Price of silver, 23½d. per oz. Consols 84 9/16—84 11/16 for money and 84⅝—84¾ for account. Consols Pay Day, Aug. 5; Stock and Shares Continuation Days, July 12 and 27; Ticket Days, July 13 and 28; Pay Days, July 14 and 29; Mining Shares Carry Over Days, July 9 and 26.

PRICES OF METALS (London).—*Copper*, cash, 58¼; three months 59 1/16. *Lead*, English, 13–13⅜; foreign, cash, 12 7/16–12 11/16; three months, 13. *Spelter*, cash, 21⅞—22. *Tin*, English, 130—132; foreign, cash, 131¼; three months, 132—132⅝. *Iron*, Cleveland, cash, 48/- and three months, 48/8½. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CLONTARF & HILL OF HOWTH TRAMROAD CO.—The directors have declared a dividend of 3 per cent.

DUBLIN UNITED TRAMWAYS CO. (1896) (LTD).—The directors recommend dividends for the half-year ended June, at the rate of 6 per cent. per annum on the preference, and at the rate of 6 per cent. per annum (tax free) on the ordinary shares, and £7,502 is to be carried forward.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—The interest on the 4 per cent. mortgage debenture stock for the half-year ending 31st inst. will be paid by warrant on Aug. 3 next. The 4 per cent. mortgage debenture stock register will be closed from the 27th to 31st inst. inclusive.

NEW GENERAL TRACTION CO. (LTD.)—The revenue for the year ended March 31 was £18,703, and after paying interest and charges, the net profit was £427, which reduces the debit balance to £25,807.

NORTH METROPOLITAN ELECTRIC POWER CO.—At an extraordinary meeting on Friday a resolution increasing the capital of the company by £200,000, by the issue of preference stock at a rate not exceeding 6 per cent. per annum, was agreed to.

NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)—The directors have paid interim dividends of 3 per cent. and a bonus of 1 per cent. (together 8s. per share), less tax, on the ordinary preference shares and 3 per cent. (6s. per share), less tax, on the ordinary shares for the past half-year.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to 60,000 £1 fully-paid 6 per cent. cumulative preference shares and £70,000 4½ per cent. mortgage debenture stock of the *Mansfield & District Tramways (Ltd.)*, a further issue of £200,000 5 per cent 50-year mortgage bonds of the *Rio de Janeiro Tramway, Light & Power Co.*, a further issue of 1,000 £10 fully-paid shares of the *South African Lighting Association (Ltd.)* and £63,200 additional first mortgage 6 per cent. 35-year sinking fund gold bonds of the *West Kootenay Power & Light Co. (Ltd.)* The committee have been asked to allow a further issue of 12,800 £5 fully-paid ordinary and 2,777 £5 fully-paid 6 per cent. cumulative preference shares of the *United Electric Tramways of Monte Video (Ltd.)* to be quoted.

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—The directors have declared an interim dividend of 12s. per share.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The directors recommend a final dividend of 5 per cent. on the ordinary shares, making 8 per cent. for the year (tax free); £5,138 has been carried forward.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 30	1,338	− 259	4	6,125	− 303
Airdrie	„ 25	211	− 20	25	5,412	− 108
Anglo-Argentine	July 1	37,633	+ 2,507	25	1,020,135	+ 59,102
Ayr Corporation	„ 3	300	− 77	7	2,086	− 20.
Baker St. & Waterloo Ry.	„ 3	3,210	+ 210	26	86,860	+ 7,710
Barnsley	June 25	163	− 13	25	1,154	− 156
Barrow	„ 25	237	− 37	25	5,391	− 387
Bath Electric Trams, Ltd.	...	...	...	...	...	...
Birmingham Corporation	July 3	6,612	+ 181	14	83,528	+ 650
Birmingham & Mid.	June 18	791	+ 30	24	19,634	+ 26
Blackburn Corporation	„ 30	1,053	− 232	14	15,973	− 468
Blackpool and Fleetwood	July 3	1,298	− 82	...	...	...
Bolton Corporation	„ 4	2,510	− 147	14	32,755	− 700
Bombay	June 3	R37,605	+ R933	21	R843,160	+ R52,526
Bournemouth Corporation.	„ 30	1,507	− 118	13	21,639	+ 118
Bradford Corporation	„ 26	4,742	− 391	12	61,745	+ 952
Brighton Corporation	July 4	1,023	+ 5	14	12,878	+ 702
Bristol Trams & Carriage	„ 2	5,876	+ 275	6	34,647	+ 1,165
Burnley Corporation	„ 3	1,345	− 75	14	18,012	+ 192
Burton Corporation	„ 4	263	− 18	14	3,633	− 84
Bury Corporation	„ 4	1,257	− 55	†14	16,473	− 522
Calcutta Tramways Co.	„ 3	R46,450	+ R5,828	26	R1,285,870	+ R124,628
Camborne-Redruth	„ 3	153	+ 35	27	3,279	− 75
Cardiff Corporation	...	...	...	...	...	...
Cavehill	June 25	89	− 51	25	1,903	− 205
Central London Railway	July 3	5,615	− 1,353	26	144,753	− 18,551
Charing C., Euston & H'stead	„ 3	3,820	+ 500	26	101,120	+ 16,450
Chatham & Dist. Lt. Rys.	„ 1	777	− 150	26	19,786	+ 1,137
City & South London Rly.	„ 4	3,257	+ 155	26	81,602	+ 1,514
City of Birmingham	June 25	2,741	− 48	25	68,173	− 1,037
Colchester Corporation	„ 30	217	+ 35	...	...	...
Cork Electric Trams Co.	July 1	537	− 49	26	10,504	− 985
Croydon Corporation	„ 2	1,164	− 143	13	20,036	− 13,147
Devonport & Dist. Trams	June 25	333	− 218	25	9,161	− 1,943
Dover Corporation	July 3	207	− 33	10	2,710	− 20.
Dublin & Lucan Railway	June 30	115	− 1	‡ 6	3,280	+ 252
Dublin United	July 2	5,834	− 793	26	132,754	− 341
Dudley-Stourbridge	June 26	781	− 59	25	19,310	− 541
Dundee Corporation	„ 30	1,202	− 89	†7	7,847	− 360
East Ham Council	July 3	958	+ 97	§13	13,746	+ 2,022
Exeter Corporation	„ 2	312	− 24	14	4,847	+ 558
Gateshead & Dist. Trams	June 25	1,144	− 92	25	24,723	− 140
Glasgow Corporation	July 3	17,126	− 1,500	‡5	83,910	− 1,645
Glossop Trams	„ 3	127	− 3	27	3,205	− 124
Gravesend—Northfleet	June 25	2.7	− 13	25	4,834	− 180
Great Northern & City Rly.	July 3	1,351	− 148	26	38,716	− 4,607
Gt. Northern, Piccadilly, &c	„ 3	5,650	+ 400	26	150,765	+ 9,775
Greenock & Port Glasgow	June 25	614	− 29	25	12,794	+ 203
Hartlepool Tramways	„ 25	246	− 26	25	5,390	− 138
Hastings Elec. Trams Co.	July 1	892	− 162	26	22,641	− 795
Hong Kong	„ 3	$8,822	+ $1,016	...	...	...
Huddersfield Corpn.	„ 3	1,633	− 18	13	22,619	+ 448
Hull Corporation	„ 3	2,562	+ 155	13	33,405	+ 317
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	June 30	1.0	− 8	13	1,732	− 144
Ipswich Corporation	July 3	418	− 48	14	5,259	− 21
Isle of Thanet Co.	„ 3	900	− 16	§31	14,555	+ 193
Jarrow	June 25	144	− 36	25	2,803	+ 237
Keighley Corporation	July 1	172	− 21	13	2,276	+ 37
Kidderminster & District	June 25	106	− 29	25	2,318	− 166
Kilmarnock Corporation	July 3	117	− 10	7	1,010	− 67
Lanarkshire Trams Co.	„ 1	1,402	− 44	26	31,782	− 1,900
Lancashire United	June 30	1,463	− 339	26	34,156	− 449
Leamington	„ 25	172	− 25	25	3,941	+ 129
Leeds Corporation	July 3	7,555	− 97	14	92,553	+ 3,270
Leicester Corporation	„ 3	2,301	− 48	...	...	...
Leith Corporation	June 26	588	− 13	6	3,705	+ 306
Lincoln Corporation	July 3	119	+ 5	14	1,737	+ 75
Liverpool Corporation	June 26	10,829	− 200	‖25	266,141	...
Liverpool Overhead Rly.	July 4	1,539	+ 46	1	1,539	+ 46
Llandudno & Colwyn Bay Ry	„ 2	426	− 4	31	5,597	+ 1,569
*London County Council	June 19	36,655	+ 963	§11	413,312	+ 20,355
London United	July 3	6,516	− 1,512	‖29	151,105	− 14,567
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	„ 3	184	− 22	13	2,473	− 205
Manchester Corporation	„ 3	15,512	− 921	14	204,605	− 2,033
Mersey Railway	„ 3	1,959	+ 155	26	51,219	+ 1,603
Merthyr	June 25	195	− 7	25	5,219	+ 12
Metropolitan Dist. Railway	July 3	10,343	+ 1,155	26	258,578	+ 25,066
Metropolitan Elec. Trams	June 25	6,338	− 195	25	146,995	+ 12,497
Middleton	„ 25	322	− 87	25	8,132	− 534
Nelson Corporation	July 3	132	− 18	§13	1,898	− 94
Newcastle-on-Tyne Corp.	„ 3	3,547	− 1,683	13	51,113	− 1,412
Newport (Mon.)	„ 3	679	− 56	14	9,239	− 252
Northampton Corporation	„ 2	475	− 24	§14	6,482	+ 102
Oldham, Ashton & Hyde	June 25	556	− 32	25	14,766	− 930
Oldham Corporation	July 5	1,908	− 122	14	27,699	− 1,799
Perth (N.B.) Corporation	June 30	160	− 4	§6	1,023	− 30
Perth (W.A.) Elec. Trams	July 2	1,372	− 1	26	37,451	+ 208
Peterborough	June 25	112	− 15	25	2,683	− 2.3
Portsmouth Corporation	...	...	...	...	...	...
Potteries	„ 25	1,825	+ 125	25	43,903	− 1,116
Preston Corporation	„ 30	700	− 103	13	9,437	− 131
Rotherham Corporation	July 1	571	− 58	13	8,030	− 228
Rothesay	June 25	318	− 72	25	2,903	+ 10
Salford Corporation	July 5	5,061	+ 49	‡14	64,000	− 2,271
Sheerness	June 25	52	− 13	25	1,162	− 165
Sheffield Corporation	July 4	5,718	+ 12	§14	81,556	− 1,238
Singapore Trams	„ 3	$9,366	+ $466	26	$318,137	+ $3,760
South Metropolitan	June 25	807	− 141	25	18,687	− 215
South Staffs	„ 25	793	− 66	25	20,573	− 1,218
Southend Corporation	„ 20	590	+ 12	13	6,128	+ 901
Southport Tramways	„ 25	281	− 55	25	6,520	− 181
Stalyb'dge, Hyde, &c., Jt. Bd.	July 3	770	− 98	§13	10,518	− 435
Sunderland Corporation	„ 4	1,506	− 71	14	15,578	− 709
Sunderland District	June 30	433	− 85	35	15,610	− 622
Swansea Trams	„ 25	910	− 53	25	22,833	+ 488
Swindon Corporation	„ 30	133	− 17	...	...	...
Taunton	„ 25	38	...	25	902	− 76
Tynemouth and District	„ 25	353	− 147	25	4,624	− 109
Tyneside Trams Co.	„ 30	593	− 131	26	11,670	+ 712
Wallasey District Council	July 3	958	− 20	§13	12,670	+ 353
Walsall Corpn.	„ 3	527	− 29	26	13,130	− 1,028
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	June 24	2,460	+ 65	12	29,053	+ 1,831
Weston-super-Mare	„ 25	158	− 40	25	2,021	+ 184
Wolverhampton Co.	„ 25	409	− 15	25	10,212	− 1,083
Wolverhampton Corpn.	„ 30	771	− 87	26	19,143	− 1,839
*Worcester	„ 25	371	− 38	25	6,428	− 93
Wrexham	„ 25	101	− 4	25	2,365	− 94
Yorkshire W.R. Trams	July 4	1,216	− 5	27	31,252	...
Yorkshire Woollen District.	June 25	912	− 30	25	21,997	− 151

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed. July 7	Rate % Yielded £ s. d.	Dividend Due.	Business Week to July 7: Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½—10	6 9 0	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞—10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼—10¾	5 11 6	Feb, Aug	10[illegible]	10[illegible]
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	[illegible]—103	4 7 6	Jan, July	..	..
5	3 6	Bromley (Kent) El. Lt. & Power Shares	4½—4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93—96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8—8½	5 17 0	March	..	.
5	3/6	Do. 7 per Cent. Pref.	8—8½	4 2 6	Mar, Sept	..	—
St.	4%	Cent l Elec. Sup. Co. 4% Guar. Db. Stock	97—100	4 0 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅞—4⅜	5 14 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4½—4¾	4 12 0	Feb, Aug	4½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96—99	4 1 0	Jan, July	9[illegible]	97½
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100—102	4 8 0	..	101½	101½
5	2/3	†Do. City Undertaking 4½% Cm. Pref.	3⅞—4⅛	5 0 0	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3⅞—4⅛	4 0 3	March	3[illegible]	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	100—103	4 7 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10½—11	5 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅛—12⅛	4 15 0	Jan, July	12½	..
St.	5%	†Do. 5 per Cent. Deb. Stock (red.)	120—123	4 1 6	June, Dec	..	..
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock (red.)	99—102	4 8 0	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1¾—2¼	—	April, Oct	—	..
5	5%	Do. 5 per Cent. non Cum. Pref.	3⅛—3⅜	3 11 5	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	8⅝—8⅞	5 15 6	Feb, Aug	[illegible]	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞—11⅛	5 8 0	Mar, Sept	11	1[illegible]
St.	4½%	†Do. 4½% Deb. Stock (red.)	104—107	4 8 6	Jan, July	104½	..
St.	4½%	Do. Second Deb. Stock	100—103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½—5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5—5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	98—101	4 9 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7¼—7⅝	5 11 6	April, Oct		..
5	4/0	Kensington & Knightsbridge Ord.	6⅞—7⅜	5 2 0	Feb, Aug	7[illegible]	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅛—6⅜	4 14 6	Jan, July	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97—100	4 0 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98—101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85—89	5 1 0	Jan, July	..	..
3	1/9⅗	London Electric Supply Ord.	1⅞—2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛—5⅜	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	92—93	4 3 6	Jan, July	91½	91
5	3/0	Metropolitan Electric Sup. Ord.	4¼—4⅝	5 13 0	April, Oct	4[illegible]	4[illegible]
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4⅞—5	4 10 0	Jan, July	4[illegible]	4[illegible]
St.	4½%	†Do. 4½ per Cent. Deb. Stock 1st Mort.	105—108	4 2 6	June, Dec	.	..
St.	3½%	†Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½—86½	4 1 0	Jan, July	87½	—
100	4½%	†Midland Elec. Corp. for P.D. 1st Mort. Db.	92—98	4 13 6	June, Dec	..	—
10	4%	Newcastle & Dist. Elec. Ltg. Ord.	4¾—5	4 3 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	84—86	5 5 11	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	4⅝—4⅞	2 13 1	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞—5⅛	5 0 0	Feb, Aug	..	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99—101	4 0 0	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	99—101	4 19 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	91—93	4 17 10	Jan, July	—	—
10	8/0	Notting Hill Electric Ord.	11½—12½	5 12 0	March	—	..
5	4 6	Oxford Electric Ord.	6—6½	5 8 0	March	6[illegible]	—
St.	4%	Do. 4 per Cent. Deb. Stock	94—97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8¾—9¼	5 8 0	Feb, Aug	8[illegible]	8½
5	3 6	Do. 7 per Cent. Pref.	7—7½	4 13 6	Feb, Aug	7[illegible]	—
St.	3½%	†Do. 3½ per Cent. Deb. Stock (red.)	84—88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1[illegible]—1[illegible]	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¾—3⅓	6 8 0	April	3[illegible]	2[illegible]
St.	5	†Do. 5% 1st Mort. Stk. Red.	10[illegible]—1[illegible]	4 17 6	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	—	—
1	0 8⅗	Do. 7 per Cent. Cum. Pref.	1[illegible]—1[illegible]	5 7 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100—103	4 7 6	April, Oct	—	—
5	2/6	Urban Electric Supply Ord.	½—1	—	April, Oct		..
5	2 6	Do. 5 per Cent. Cum. Pref.	1¾—2¼	..	April, Oct	1[illegible]	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80—84	5 7 3	April, Oct	81	—
5	5/0	Westminster Elec. Sup. Ord.	8¾—9¼	5 8 6	Mar, Sept	[illegible]	[illegible]
5	2/3	Do. 4½ per Cent. Cum. Pref.	5—5⅜	4 3 4	Jan, July	5[illegible]	—
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	98—101	4 0 0	Jan, July	99[illegible]	—
1	..	Bath Elec. Trams Pref. Ord.	¼—⅜	..	April	..	—
1	0/6	†Do. 5 per Cent. Cum. Pref.	[illegible]	6 13 9	Jan, July	..	—
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	87—91	4 19 0	April, Oct	.	..
St.	4½%	†B'ham & Midland Trams 4½ 1st Db. Stk.	87—90	5 0 0	Jan, July	[illegible]	..
10	6%	Bristol Tramways & Carriage Ord.	7¾—8¼	7 9 8	Feb, Aug	..	—
10	4%	†Do. Cum. Pref. (fully paid)	7[illegible]—[illegible]	4 17 0	..	..	—
St.	4%	†Do. 4 per Cent. Debs.	98—99	4 0 10	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅛—⅞	..	June, Dec	..	..
10	8/0	Do. 6 per Cent. Cum. Pref.	2⅜—2⅞	10 10 0	Feb, Aug	2½	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	83—92	5 8 6	April, Oct	[illegible]	88½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68—72	6 5 0	May, Nov	80	84½
St.	3½%	Central London Ordinary Stock	61—63	5 11 0	Feb, Aug	64	6[illegible]
St.	4%	Do. 4 per Cent. Pref. Stock	83—85	4 14 0	Feb, Aug	8[illegible]	8[illegible]
St.	2½%	Do. Deferred Stock	44—45	5 8 6	Feb	45	..
100	4%	Do. 4 per Cent. Debs.	101—103	4 17 6	Jan, July	1[illegible]	..
St.	4%	†Charing X, Euston & Hmpstd Per. Db. Stk	91—93	4 6 0	Jan, July	92½	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref	4¾—5¼	4 15 0	April, Oct	..	.
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97—101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	30¼—31¼	4 15 3	Feb, Aug	3[illegible]	[illegible]
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110—112	4 9 0	Feb, Aug	1[illegible]	1[illegible]
St.	5%	Do. (1895)	105—109	4 11 [illegible]	Feb, Aug	—	..
St.	5%	Do. (1901)	103—105	4 15 3	Feb, Aug	..	—
St.	5%	Do. (1903)	93—96	5 4 0	Feb, Aug	.	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	99—101	3 19 0	May, Nov		—
10	6/0	Dublin United Trams. 6 per Cent. Pref.	13—14	4 5 9	Feb, Aug	.	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%	¾—1	..	Feb, Aug		..
10	..	G. Northern, Picc. & Brompton 4% G. Pt	8—½	..	Feb, Aug	.	—
St.	4%	†Do. 4 per Cent. Deb. Stock	93—95	4 4 0	Jan, July	94½	93½
5	3/0	Hastings & District Elec. Trams. 6% C.P.	1¾—2¼	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	74—79	5 11 0	April, Oct	.	—
10	6%	Imperial Tramways Ord.	4½—5	12 0 0	Mar, Sept	..	..
10	6%	†‡Do. 6 per Cent. Pref.	6½—6½	4 12 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	83—85	5 6 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞—1⅛	..	Mar, Sept	..	—
St.	4%	†Do. 4 per Cent. Deb. Stock	58—63	6 7 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9[illegible]—10[illegible]	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½—90½	5 10 6	Jan, July	..	.
10	..	Liverpool Overhead Railway Ord.	8—[illegible]	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	5—5	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82—4	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	1½—2½	..	Jan, July	[illegible]	..
St.	4%	†Do. 4 per Cent. 1st Mort. Deb. Stock	65—67	5 19 3	Jan, July	6[illegible]	6[illegible]
St.	..	Mersey Con. Ord. Stock	1—2	—	Feb, Aug.	—	..
1	10⅗	Metropolitan Elec. Tramways Ord.	⅝—⅞	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April	'	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	-	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	90½—93½	5 1 6	Jan, July	92½	90¾
St.	½%	Metropolitan Railway Consolidated	3[illegible]—40[illegible]	1 1 9	Feb, Aug	4[illegible]	39½
St.	3%	Do. Surplus Lands Stocks	68—70	4 5 9	Feb, Aug	69	..
St.	3½%	Do. 3½ per Cent. Preference	89—91	3 17 0	Feb, Aug	90[illegible]	90½
St	3½%	Do. 3½ per Cent. "A" Preference	83—84	4 3 6	Feb, Aug	83	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82—84	4 3 6	Feb, Aug	83	82¾
St.	3½%	Do. 3½ per Cent. Debenture Stock	94—95	3 13 3	Jan, July	94½	—

In calculating the yield allowance has been made for accrued interest but *not* for redemption

* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., July 7.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to July 7 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—Continued.					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	92 —94	3 14 6	Jan, July	94	..
St.	..	Metropolitan District Railway Ord.	17¼—17¾	—	Feb, Aug	17¾	17¼
St	..	Do. Extension Pref. (5 per Cent.)	43 —45	—	Feb, Aug	44½	44
St.	3½%	Do. Asserted Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	65 —67	5 4 0	Feb, Aug	..	—
St	3%	†Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	76½	—
St.	4%	†Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	1½%	Do. Guar. Stock 4 per Cent.	90 —93	4 6 0	Mar, Sept	92	90½
St	6%	†Do. 6 per Cent Perp. Deb. Stock	139 —141	4 5 0	Jan, July	139	..
St.	4%	†Do. 4 per Cent. Ditto	93 —95	4 4 0	Jan, July	94½	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	1/16—3/16	—	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	...	—
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	82 —86	5 16 0	Jan, July	..	—
..	...	UndergdE.Rys.Lon.6% In.bds.with coup.8	37 - 39	..	June, Dec	37½	..
..	!	Do. 5% Prior Lien Bonds	102 —103	4 17 0	..	102¼	102⅛
—	4½	Do. 4½% Bonds with coup. 8	87 —89	5 1 0	..	88½	87½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	—	..	..	..
St.	4½	†Do. 4½ per Cent. 1st Debs.	84 —88	5 2 0	Jan, July	..	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	11/16—13/16	..	..	..	..
1	1 1½	Do. 6% Cum. Pf.	¾—⅞	6 17 0	April, Oct	¾	¾
1	2 4	Babcock & Wilcox Ord.	4½—4⅝	4 11 9	April, Oct	4 19/32	4 3/32
1	0/7½	Do. Pref.	1⅜—1⅝	4 0 0	..	..	..
5	6 0	British Insulated & Helsby Cables Ord.	7⅜—7⅞	6 9 6	July, Feb	7⅝	7½
5	3 0	Do. 6 per Cent. Pref.	6⅜—6⅞	4 9 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	1.3¾	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	...	..	Feb, Aug	..	—
100	..	Do 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	98¼	98
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock	33 —42	9 10 0	Jan, July	..	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	48 —48	9 8 0	Mar, Sept	..	..
St.	4½%	†Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	1½	Callender's Cable Con.Ord.	9¾—10¼	7 3 0	Jan, July	10⅛	10
5	2/6	†Do. 5 per Cent. Cum. Pref.	5⅝—6	4 11 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort Debs. (red.)	103½—104½	4 5 3	Nov, May	105½	..
1	1/0	Castner-Kellner Alkali Co.	1⅝—2	6 5 0	May, Nov	2	1 15/16
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 4 0	Feb, Aug	..	..
1	0 0¼	Chadburn's (Ship) Telegraph Ord.	13/16—1⅛	6 11 9	March ..	..	—
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	5 14 0	April, Oct	..	..
1	0/7½	Consolidated Electrical Co.	...	6 4 0	August ...	...	..
1	1/0	Consolidated Signal Co.	1⅛—1⅜	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	1 —1½	11 16 0	Jan, July	..	..
100	5%	†Do. 5 per Cent. 1st Mort. Debs. (red.)	91½—94½	5 6 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅛—1⅛	..	Mar, Sept	1	1/16
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1⅛	8 0 0	Sept ..	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1 5/16	4 16 9	Sept ...	1 7/32	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	½—¾	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	—
St	4%	†Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	..	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	60 —63	7 3 0	Jan, July	..	..
2	..	Electric Construction Co.	⅞—1⅛	..	Jan, July	..	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1 7/16—1 11/16	8	July	1 19/32	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59 —63	6 7 0	Jan, July	..	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mort. Db.St.	71 —77	6 10 0	..	..	..
10	6/0	General Electric (1900) 5% Cum. Pref.	7⅛—7½	6 13 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	10,3	Henley's Telegraph Works Ord.	11⅞—12⅜	6 2 6	Feb, Aug	12¼	..
5	2/3	Do 4½ per Cent. Pref.	5 —6	4 3 6	Feb, Aug	..	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 —107	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	11⅛—11½	6 10 0	Feb, Aug	11⅜	..
10	5/4	†Do 5 per Cent. Cum. Pref.	10½—10¾	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	..	..
1	..	National Elec. Construction Co.	½—¾	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	..—⅛	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	..—¼	..	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. Perp. Deb. Stock	81 —84	5 7 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	—	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	33 —34½	5 4 6	Mar, July	34	34
100	4%	†Do. 4 per Cent Deb. Bonds (1909)	99 —101	3 19 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 3/32—2 5/32	5 9 3	..	2¼	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1 3/32	4 0 6	..	1⅛	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db.Sk. (red)	101½—103½	3 17 0	June, Dec	103½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 5 6	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	106	105½
10	8	J. G. White & Co. 6% Cm. Pref.	9½—10½	7 12 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	..	—
1	3/0	Do. 6 per Cent. Cum. Pref.	2¼—3¼	9 4 0	Apr, Oct	—	—
St.	4%	Do 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	—	—
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3¼	—	June, Dec	..	..
100	5%	†Do 5 per Cent. Debs. (red.)	92 —95	5 5 6	June, Dec	..	..
St.	15,0	Anglo-American	57 —59	5 12 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	100 —101	5 19 0	F,My,Ag,N	100½	99¾
St	3 0	Do. Deferred	15¾—16¼	2 9 9	F,My,Ag,N	16⅛	15½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	89 —91	4 8 0	Jn,Ap,Jy,O	90	89½
10	6/0	Cuba Submarine Ord.	8¼—8¾	6 15 0	Feb, Aug	..	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	—
5	2/0	Direct Spanish Ord.	2¾—3⅛	5 18 0	April, Oct	3⅛	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8¾—9¼	5 12 9	April, Oct	—	..
50	4½%	†Do. 4½ per Cent. Deb.	99 —101½	4 9 0	Jan, July	..	..
20	4,0	Direct United States Cable	12¾—13¼	6 5 9	Ja,Ap,Jy,O	12 15/16	12 13/16
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 —101	4 9 0	June, Dec	..	..
St.	5/0	Eastern Ordinary	127 —130	5 6 0	Ja,My,Jy,O	129½	127
St	17 6	Do. 3½ per Cent. Pref. Stock	86½—87½	4 0 0	Ja,My,Jy,O	86½	86
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	106	104½
St	6,6	Eastern Extension	11½—12	5 16 9	Ja,Ap,Jy,O	11 15/16	11⅞
St	4%	Do. 4 per Cent. Deb. Stock	102½—104½	3 16 6	Feb, Aug	—	..
25	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	3 18 0	May, Nov	—	—
10	9	†G.N. of Copenhagen, Ex Coupon 76	25¾—26¼	6 2 6	Jan, July	26	25⅞
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db.(red.)	99 —101	4 9 0	June, Dec	..	..
10	5/6	Indo-European ...	61⅝—62½	5 16 9	May, Nov	62¼	..
..	$1	Mackay Companies Common	80 —84	4 15 0	Ja,Ap,Jy,O	—	..
..	$1	Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	—	..
1	..	Marconi's Wireless Teleg. Co.	1⅞—..	..	April	1⅞	1¾
..	4	Pacific & European Tel. 4% Guar. Dbs. (red.)	99 —101	3 19 0	June, Dec	..	..
..	3/3	West Coast of America	1⅛—1⅜	4 12 0	May	..	..
..	4	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
..	..	West India & Panama	1/16—1⅛	..	May, Nov	..	..
..	6/0	Do. 6 per Cent. 1st Pref	8¼—8¾	6 17 0	May, Nov	..	..
..	1 6	Do. do. 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
..	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	..	..
..	6/0	Western Telegraph	13⅛—13⅜	5 2 6	Mr,Jn,O,D	13⅜	13⅛
..	4%	†Do. 4 per Cent. Deb Stock (red.)	100½—102½	3 17 6	June, Dec	..	..
..	4%	Western Union Teleg. $1 000 4% Bonds	93 —96	4 6 0	..	..	..

Share	Last Dividend	Name	Price Wed., July 7.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to July 7 Highest	Lowest
		TELEPHONES.					
100	2$	†Amer. Telephn. & Telegh. Cap. St.	143½—144½	5 13 9	..	..	.
..	4%	‡Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	..	.
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	102 —104	4 16 0	Mar, Sept	..	.
5	3 0	Chili Telephone	8 —8⅝	4 16 0	August ..	8½	—
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..	—
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	107½—109	5 10 0	Feb, Aug	10..	9..
St.	6%	Do. Def. Stock	122½—124½	4 16 6	Feb, Aug	123½	2..
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¾—11	5 9 0	Feb, Aug	..	—
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10¾—11	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 7/16—5 11/16	4 6 6	Feb, Aug	5 9/16	..
St.	3½%	†Do. Deb. Stock 3½ per Cent. (red.)	97 —99	3 11 0	June, Dec	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	Jan, July	..	..
1	1/0	Oriental	1 5/16—1 7/16	5 7 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 3/16—1 5/16	4 17 6	April, Oct	..	..
St.	4%	†Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	87⅛	..
St.	4½%	†Telephone Co. of Egypt 4½% Db.Stk.(red.)	98½—100½	4 9 6	Jan, July	..	..
5	8/0	United River Plate	6⅞—7⅛	5 12 0	July	7	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	June, Dec	5 1/16	..
St.	4½%	†Do. 4½ Deb. St. Red.	102 —103½	4 7 0	Jan, July	102½	..
		FINANCIAL INVESTMENT, &c.					
5	8/0	†Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..	..
10	5,6	†Globe Telegraph & Trust	10¼—10¾	6 7 0	SpDcMrJu	10⅝	10½
10	3/0	†Do. 6 per Cent. Pref.	13 —13½	4 9 0	SpDcMrJu	13	13
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	†Anglo-Argentine 6% Cum. 1st Pref.	..	4 18 0	April, Oct	6¼	—
5	5/0	†Do. 10% Non-cum. 2nd Pref.	9 1/16—9 3/16	5 5 9	Jan, July	9..	..
St.	4%	†Do. 4% Deb. Stock	90½—91½	4 7 6	June, Dec	91½	..
St.	5%	†Auckland Elec. Trams. 5% Deb. (red.)	101 —103	4 17 6	Jan, July	104	..
5	3 6	Brisbane Electric Trams. Invest. Ord.	5⅞—6¼	4 19 0	May	—	..
5	2.6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	5⅛	5
St.	4½%	†Do. 4½ per Cent. Db. Prov. Certs.	100½—104½	4 4 0	Jan, July	.	.
St.	8%	British Columbia El.Ry.Df. Ord.	142 —145	5 10 0	Mar, Sept	144¼	14..
St.	6%	Do. Pref. Ord. Stock	121 —124	4 17 0	May, Nov	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	110 —113	4 8 6	Jan, July	111¾	11..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	.
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	100 —102	4 3 0	—	101½	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —101	4 19 0	Mar, Sept	100	99½
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	96 —100	6 0 0	Feb, Aug	..	..
5	2,0	Calcutta Tramways (1 to 137,610)	4⅝—4¾	4 14 9	Mar, Sept	4¾	4⅝
100	2/6	†Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	..	..
1	4½%	†Do. 4½% 1st Deb. Stock (red.)	97½—100½	4 9 6	Jan, July	..	—
St.	..	Cape Electric Tram Shares	⅛—⅜	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅝—5⅞	4 5 6	F,My,A,N	5¾	..
St.	4%	†Do. 4 per Cent. Deb. Stock	99¼—101	3 19 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	100	99½
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	81½	—
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 —96	5 4 0	Feb, Aug	—	..
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	—	..
..	..	Do. 5 per Cent. "A" Deb. Stock	88 —91	5 10 0	Jan, July	..	..
100	5%	Do. 6 per Cent. "B" Ditto	63 - 67	9 0 0	Jan, July	..	..
5	6%	Lisbon Elec. Trams. Ord.	1 1/16—1 3/16	4 14 0	July	..	..
5	1/0	†Do. 6 per Cent. Cum. Pref.	1 1/16—1 3/16	5 1 0	Jan, July	—	..
100	0/7½	†Do. 5 per Cent. Reg. Mort. Debs	94 —95	5 2 0	Jan, July	—	..
St.	5%	†Madras Elec. Trams. 5% Deb. Stk.	90½—92½	5 7 0	Jan, July	..	..
St.	5%	Manila Elec. Ry. $1,000 Gold Bonds	94 —96	5 4 0	Feb, Aug	—	..
..	5%	Mexico Trams Co. Com. St.	129 —132	3 16 0	..	184⅝	..
100	$1½	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92 —94	5 6 9	..	94	92½
..	5%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	.	..	—
St.	4½%	Perth Elec. Trams Ord.	⅜ —⅝	8 0 0	May	..	—
1	0/6	†Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—	..
St.	5%	†Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6⅜—6⅞	5 4 8	..	..	..
5	3/0						
St.	4½%	†Do. 4½% 1st Mort. Deb. Stk.	98 —100	4 10 0	..	..	
100	..	Rio Janeiro Tram, Lt. & P. Co.	90 —92	..	..	94½	91
..	5%	Do. 30 yr. Gold Bnds.	92½—94½	5 6 0	..	93⅜	92
100	5%	†Do. 10 yr. Mt. Bnds	84½—86½	..	..	86	84½
..	$2½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —150	6 17 0	..	147½	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	97½—99½	5 0 6	June, Dec	98½	..
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅝	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	—	
St.	4½%	†Do. 4½ per Cent. Deb. Stk. (red.)	93 —95	4 14 0	Jan, July	94¼	—
5	4,9	Calcutta Elec. Supply Ord.	5¼—5¾	6 19 0	April, Oct	5 9/16	5
100	$1½	†Canadian Gen. Elec. Co. Com. St.	116 —119	5 18 0	..	118¾	17
100	$3½	Do. 7% Cm. Pf. Stock	119 —121	5 16 0	..	121	20
100	5%	†Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	.
500	5%	Elect. Development Co of Ontario	86 — 88	5 13 9	..	..	.
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	..	..	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Deb Stock	...	5 8 0	Jan, July	—	..
St.	5%	†Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	85½ - 85½	5 13 0	Jan, July	67½	.
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	.
108	4	†Kalgoorlie Elec. Power & Ltg. Ord.	¼—⅜	..	..	..	—
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅝—⅞	6 17 0	April, Oct	1	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
500	5%	†Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	82 —84	5 10 0	..	84	81
St.	$1	Mexican Lt. & Power Co. Com. St.	65 —65	5 13 0	—	71	68
500	5%	Do. 5% 1st Mort. Gold Bnds.	88 — 90	5 11 0	..	89½	86
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	122 —126	4 15 0	F,My,A,N	..	.
1	1/7½	River Plate Electricity Co. Ord.	1⅜—1½	5 6 8	April	..	.
1	1 2⅝	Do. 6 per Cent. non-Cum. Pref	1 5/32—1 7/32	5 4 0	May	1 3/16	1⅛
St.	5%	†Do. 5 per Cent. Deb. Stock	102 —105	4 15 0	Jan, July	103¼	.
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 1/16—5 5/16	5 7 6	April, Oct	5⅛	—
100	$1	Shawinigan Water & Power Co. Ca	93 —95	4 5 0	—	94	..
..	5%	Do. 5 per Cent. Bds.	104 —106	4 14 3	Jan, July	104	9..
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	96 — 98	4 12 0	—	97	..
..	6d.	Victoria Falls Power Co. Pref.	⅝—⅞	5 14 0	Jan, July	..	..

* In calculating the yield allowance has been made for accrued interest but *not* to redemption. † Ex dividend ‡ The London Stock Exchange Committee have declined to quote

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NOTES.

The King and Technical Training.

In laying the foundation stone of the Imperial College of Science His Majesty the King sounded a note of warning to which it were well that an attentive ear should be turned. He even went so far as to say that "the very safety and existence of our country will depend on the equipment of the scientific and technical training of those who guide and control our industries." Technical education is a theme on which a great deal has been written and spoken, but, nevertheless, the majority of the people who live in this country do not know what it really means. We may, for instance, point to the hundreds of small "technical" classes throughout England which do little more than waste the time of both teachers and students. If the teaching of science and technical smatterings in these classes was discontinued and attention focussed on giving sound trade instruction there would be fewer complaints of insufficient pay in the correspondence columns of technical journals. Hitherto, a large number of persons have received technical instruction who were totally unfitted for it, and, on the other hand, many have been unsuccessful for want of it. The object of the Imperial College is to assist those who are really fitted to receive advanced technical instruction, and the King has been quick to recognise the importance of this.

Street Lighting in London.

Few, if any, large towns present such a heterogeneous display of public lighting as has been evident for some time past in the City of London. The reasons for this disjointed collection of many existing examples of street illumination are, of course, well known to electrical engineers, however much they may regret the results, which unfortunately are only too apparent. When the experimental flame arc lamps were installed in the City some 18 months ago, electrical engineers hoped that the era of progress had commenced. Following the flame arc lighting experiments, however, came the "Keith" high-pressure gas lamps in Fleet-street, which were regarded by the electrical industry as a retrogression; but when it was known that a deputation appointed by the Streets Committee was to inspect the public lighting in Continental cities and to report thereon, the interest of electrical engineers was again aroused. The report of the deputation has now been issued, and it will be seen that the members have evidently been greatly impressed by high-pressure gas lighting. The conclusions stated in the report are briefly: (1) That centrally hung lamps with lowering gear should be employed wherever possible; (2) that open spaces should be lighted by means of lamps upon standards, fitted with lowering gear; and (3) that high-pressure incandescent gas lamps should be adopted, electric arc lamps only being employed where it is impracticable to use gas. The last conclusion is the more remarkable, since of the eight Continental cities visited, the report states that five had no high-pressure gas lamps, whilst two others had between them only a total of 19 such lamps, which had not been installed long enough to allow of any results being stated. The deputation appears therefore to have based its conclusion on only one city—viz., Berlin, and undue prominence seems to have been given to one sentence in the report—viz., "In future incandescent gas lighting only will be used in Berlin." It is worth observing, however, that a note in the tables attached to the report states that in Berlin gas is sold at net manufacturing cost

for public lighting—viz., 1s. 4½d., against 3s. 6d. per 1,000 cubic ft. charged to ordinary consumers; and also that gas is manufactured by the municipality, but electricity is purchased in bulk from a private company. This probably accounts for the favour in which gas is held. In this connection it is interesting to refer to a Paper by Dr. BLOCH, published in THE ELECTRICIAN for January 1, 1909. It was there shown that the illumination obtained by the flame arc lamps used in Berlin was much better than that obtained with the most modern gas lamps.

WE think, however, that the third conclusion stated above, to which most attention is likely to be paid in the Press, is largely discounted by the first, since most engineers would, at present, hesitate to adopt centrally hung high-pressure gas lamps capable of being lowered to the level of the street. Apart from the difficulty of making the necessary connection with the gas service, the delicate mantles would undoubtedly suffer very much from such treatment. An important point in this connection is that no mention is made of a technically-trained official having accompanied the deputation, which comprised two architects, one auctioneer, a door spring manufacturer and an iron founder. The special qualifications of these members for dealing with the difficult question of street lighting are not apparent. It will be seen from our abstract of the report elsewhere in this issue that arc lamps are largely used in the cities visited, and it is interesting to notice that accidents from arc lamps suspended over the centre of the road are practically unknown. This method of suspension possesses many advantages, and we believe that the experimental lamps erected in this manner in Cannon-street, London, have given satisfaction. On the other hand, it must be admitted that in most cities gas lamps are employed for the illumination of side streets, but in this direction metal filament lamps have had, as yet, little time to be put to any extensive test; there is no doubt that they will in future play an important part in street lighting. In view of the importance which will be attached to any action of the City authorities, we hope that due consideration will be given to the matter before any decisive step is taken; and if further experiments are carried out, as suggested in the report, electrical engineers should spare no efforts in demonstrating the undoubted efficiency and adaptability of modern flame arc and metal filament lamps.

Electricity in Coal Mines.

IN the course of our Notes last week we dealt with the difficulty of earthing the frame of a coal cutter and referred to the fatal accident at the Clifton Collieries. On another page we publish a complete report of the inquest on the unfortunate victims, together with an excellent memorandum by Mr. ROBERT NELSON, Electrical Inspector of Mines. There is now no room for doubt that, if the type of gate-end switch to which we referred last week had been made use of, this accident would not have occurred. The connection to earth through a core of the trailing cable was not complete, there was nothing to prevent the closing of the gate-end switch, and consequently the cutter frame became alive through contact with a conductor from which the insulation had been accidentally rubbed off. While the electrician-in-charge should, of course, be held responsible that earth connections are maintained in good order and machines not in faulty condition, it will be agreed that the circumstances of this case were exceptional. Nevertheless, exceptional, as well as ordinary circumstances must be provided for, and it is evidently not sufficient to rely upon the human element. That is to say, the safeguards should be automatic, so that accidents would become impossible, except as a result of wilful tampering with mechanism. We believe that this end can be achieved if only the users and manufacturers of coal cutters will co-operate.

The "Flicker" Photometer and Metal Lamps.

To those who are accustomed to regard the "Flicker" photometer with confidence, the article by Mr. LANCELOT WILD, which we publish in this issue, will come as something in the nature of a shock. Mr. WILD states that this instrument gives for metal filament lamps results about 6 per cent. lower than the true values. He offers no explanation, but merely states the result of experiments. The investigation was carried on by means of three different types of flicker photometer, and the effect cannot, therefore, be due to the idiosyncrasies of one particular type. To say the least, Mr. WILD's conclusions are startling, and it is evident that the matter cannot be permitted to rest at this point. There must be some reason for this curious behaviour, and as a starting point for further investigation it might be instructive to compare the spectra of the lamps which he employed.

Press Telegraph Rates.—The following announcement has been issued to the Press:—At a committee meeting of the representatives of Telegraph Administrations transmitting telegraph traffic "via Eastern" and "via Teheran," between Great Britain and India, Australasia and South Africa, the following resolution was approved—viz., "That, provided the British, Indian and Colonial Governments are prepared to take their ratable share of the reduction, the Press rate between Great Britain and India, Australasia and South Africa be reduced to 9d. per word from August 1st next."

Co-operative Buying of Electrical Apparatus.—West Ham Electricity committee have arranged to include in their orders on their present contractors a supply of Osram lamps for Marylebone Council. This is, we learn, one of many similar co-operative orders which are likely to be given by electricity supply undertakers in London. There is a movement on foot, initiated by the Metropolitan Company, to promote co-operative buying amongst the whole of the electricity supply companies and municipal electricity departments in London. We are informed that the transaction, referred to above, between West Ham and Marylebone saves £200.

A Large Telephone Cable.—The first sections of a submarine telephone cable, designed for connecting San Francisco with Oakland, via Goat Island, were recently shipped from New York. The cable is 2⅞ in. in diameter and contains 63 pairs of telephone wires—20 pairs of No. 13 and 43 pairs of No. 19 conductors. On the big reel the first section, 4,250 ft. in length, weighed 26½ tons. The first two sections of this cable, having a total length of 8,500 ft., will extend from San Francisco to Goat Island. When the other two sections of 7,800 ft. arrive, they will be laid from the island to Oakland Mole. On Goat Island connection with the land cable is to be made. The entire 16,300 ft. of cable is one of the largest orders for paper-insulated submarine telephone cable ever placed.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Dakar—Conakry	May 13, 1909 ...	—
Tangier—Cadiz	May 19, 1909 ...	—
Tourane—Amoy	June 17, 1909 ...	—
Trinidad—Demerara	June 21, 1909 ...	July 12, 1909
Assam—Perim	July 8, 1909 ...	—

London, Brighton & South Coast Railway.—On Wednesday last the Board of Trade inspected the first section of the electrified route between Victoria and London Bridge.

Electric "Explosions."—Some of our provincial contemporaries reported on Tuesday alarming occurrences in Manchester, stating that explosions had taken place in Exchange-street and St. Ann's-square. In one report it was stated that the "blowing of police whistles and the procession of fire engines caused a great crowd to gather," but the trouble does not appear to have been so serious as the local pressmen imagined. Mr. S. L. Pearce, the city electrical engineer, writes us that—

The reports relating to electric explosions in Exchange-street and St. Ann's-square have been very seriously exaggerated. A service joint gave out in St. Ann's-square, but no material damage was done either to the mains or to the surrounding premises. The "fault" was quickly located and the main thrown off. The fumes from the burning service joint, however, made their way along a 6 in. telephone pipe into Exchange-street, and gave rise to further alarm that something was wrong with the mains in this latter street also. The whole matter was trifling, and too much has been made of it.

The Electrical Engineers (London Division).—During the fortnight ended July 10th, a detachment of this corps have been training at Weymouth, about 50 N.C.O.s and men being present under the command of Lieut. G. W. C. Kaye. The Electrical Engineers, it will be remembered, do not train together as a whole, owing to the fact that their work consists in running the search lights at the various defended ports, for which work only a relatively small number of men are required. The training at this particular camp was more than usually interesting, owing to the fact that a fair amount of repair work had to be done, thus giving an opportunity for the members to learn something of the internal economy of the plant which had to be run; it is to be hoped that they have benefited by this instruction. The members of the detachment were inspected on Thursday evening, July 1st, in the technical work by Lieut. J. Wood, R.E., and came through the ordeal fairly satisfactorily. A drill inspection was held on Friday morning, July 2nd, by Lieut.-Col. F. E. Skey, R.E., who expressed himself well satisfied with the bearing of the men and with the way in which they drilled. This camp was one of the early ones of the season, and members of the corps are at present undergoing training at Dover and Plymouth as well as Weymouth, at which stations similar work will be carried out. Some of the men returned to town at the end of the first week, but the majority remained for the whole period of 15 days.

The Institution of Mining Electrical Engineers.—At a meeting held on Thursday, the 7th inst., at the Belgrave Hotel, Ilfracombe, under the chairmanship of Mr. H. F. J. Stewart, it was unanimously resolved to form a branch of the above Institution, many prospective members being present, among them several mining engineers and managers from the Gloucester and Somerset coal fields, and the Cornish tin mines. The chairman, in opening the proceedings, said that the meeting had been called in accordance with the resolutions carried at the inaugural meeting of the Institution at Manchester on April 24th. He then gave a detailed explanation of the origin, aims, and progress of the Institution, and referred to the various organising and administrative points which would be settled at the next general meeting. In conclusion he remarked that the southern section would cover a very large district, but as a matter of fact its mineral area was almost entirely confined to the western counties, and London, therefore, as its centre was quite out of the question. On the other hand, the Ilfracombe district of Devon was about midway between the Gloucester mines and the wealds of the Duchy, and seeing the unique nature of its mining operations in these islands, he hoped the Stannaries would send strong support to the Institution. Altogether the number of applications already received was entirely satisfactory, the members and associates showing a total to date of 230. It was then resolved to form a local branch of the Institution, and several names were accordingly added to the list of members. It was further agreed that the hon. secretary should be asked to approach Mr. R. Hood Haggie with a view to his election as president of the section.

Electric Traction in Baden.—According to "Le Genie Civil" the Baden railway authorities are this year going to undertake the electrification of the Wiesentalbahn line, which connects Basel with Schopfheim. The daily service at present consists of 12 expresses, 51 local trains and 15 to 20 very heavy goods trains. The line will be operated by electric locomotives, as the standard rolling stock of the Baden railways will continue to be used on the line. Single-phase traction at a pressure of 10,000 volts will be employed, and the work is being carried out by Messrs. Siemens-Schuckertwerke, who have already erected several installations of the same type. Three-phase current will be generated at a pressure of 6,800 volts and a frequency of 50 in a central station on the banks of the Rhine. It will be transformed into single-phase current at a pressure of 10,000 volts and a frequency of 15 in a substation at Basel. Each of the two converters there installed will consist of a single-phase alternator with a capacity of 2,100 kw. coupled on one side with a three-phase synchronous motor, and on the other with a continuous-current dynamo connected to a buffer battery. When the demand for electrical energy is greater than a certain limit the dynamo will work as a motor and will furnish the excess energy necessary to the single-phase alternator. When, on the other hand, the consumption is lower than this limit the dynamo will charge the battery, which will be capable of taking up sudden loads to a maximum of 2,800 kw. The same principle which has been adopted in using buffer batteries on continuous-current railways will, therefore, also be utilised in this instance. Ten locomotives, which are being supplied by Messrs. Siemens-Schuckertwerke will suffice for drawing both the local and goods trains. The weight of a local train without the locomotive is 230 tons, and that of a goods train 500 tons. The mean gradient between Basel and Zell is about 0·57 per cent., with a maximum of 1 per cent. The locomotives will have three driving axles coupled together and a trailing axle at each end. The driving axles are connected by cranks and connecting rods to two single-phase motors placed above them. Multiple motors of the series compensated type, and having a continuous output of 390 H.P. will be employed.

H.M. the King and Science Teaching.—On Thursday, July 8th, H.M. the King visited South Kensington to lay the foundation stone of the new buildings for the Imperial College of Science and Technology. An address was handed to His Majesty by the chairman of the governing body, the Earl of Crewe, which stated that the Imperial College was founded by Royal Charter granted in July, 1907. It represented the most up-to-date development of scientific and technical education. At a time when small regard was paid to scientific and artistic instruction, the wise forethought of the Prince Consort anticipated what was now universally recognised as one of the prime needs of national life The earnest hope of the governing body was that the Imperial College thus honoured by His Majesty's approval that day might justify its title as being the centre of the most advanced teaching and research in science, not only for the United Kingdom, but for the whole of His Majesty's dominions, and that it might stand second in dignity and character to no other kindred institution in the world. In reply the King, having thanked the chairman for his address, said:

The concentration of various associated colleges in one institution, which was effected by our Order in Council on July, 1907, has always seemed to me to be an admirable scheme for the furtherance of scientific instruction which my dear father had so much at heart, and the names which appeared in the first list of the governing body were sufficient in themselves to give the college a very high status in the educational world. The purposes of the college, as stated in the charter, are to give the highest specialised instruction, and to provide the fullest equipment for advanced teaching and research in various branches of science, especially in its application to industry. In recent years the supreme importance of higher scientific education has, I am happy to say, been fully recognised in England, and as time goes on I feel more and more convinced that the prosperity, even the very safety and existence, of our country, will depend on the equipment of the scientific and technical training of those who guide and control our industries. It is impossible, however, for the most accomplished specialist to take full advantage of his knowledge without that complete provision of apparatus for research and instruction which this college will supply. The college has already given admirable results, and we may look for a steady increase in the number of students and the efficiency of the instruction provided. The thanks of the country are due to those public spirited donors through whose generosity a large portion of the funds has been provided for this great work, and I join in appreciation of their good offices. I think it is especially fitting that the great discoveries of the late Sir Henry Bessemer, to which the remarkable development of engineering industries in the last half-century is largely due, should be commemorated by the equipment of the new laboratories in this institution. I pray that the blessing of God may attend the future of the college and the high destinies that I anticipate for its work.

LIVERPOOL CORPORATION TRAMWAYS.

The tramways undertaking and also the electric light undertaking of the Liverpool Corporation are among the few municipal undertakings in this country whose financial year terminates on December 31. It is only fitting, therefore, that in making our annual analyses of the accounts of the various electric power and tramways undertakings we should give the first place to the Liverpool Corporation tramways.

In view of the prevailing commercial depression throughout the country during last year, it is perhaps not surprising to learn that the number of passengers carried on these tramways during 1908 shows a decrease of 1·7 per cent., compared with that of the previous year, a similar decrease being recorded in the receipts. The figures for 1908 are 121,927,883 passengers and £563,144 receipts, whilst the number of car-miles run was 12,244,353, the revenue per car-mile working out at 11·04d., compared with 11·24d. in 1907. Mr. C. W. Mallins, the general manager, points out in his report that in addition to the trade depression, which is bound to affect the prosperity of undertakings in a seaport like Liverpool, the falling off in the revenue, compared with that last year, can also be accounted for by the visit of the fleet to the city in 1907 causing an abnormal amount of traffic. It is noticeable, however, that the figures for 1908 compare unfavourably with those for the year 1906.

The question of Sunday traffic was carefully considered during the past year, and as the committee found that a steady decrease of traffic was taking place both on Sundays and weekdays they decided that all mileage which did not bring in 6d. per car-mile should be eliminated. This resulted in the car-mile earnings on week days being increased by 0·08d. and on Sundays by 0·10d. towards the latter part of the year.

The Liverpool tramways undertaking is one on which the introduction of half-penny fares has always been strongly opposed, and there is little doubt that the results have justified this policy, whilst the greatest attention has always been paid to extending the distance covered by the 1d. fare. Under these circumstances the 1d. passenger has become the backbone of the undertaking; in fact, practically 90 per cent. of the total number of passengers come under this fare, whilst 9·75 per cent. of the passengers pay a 2d. fare. The average fare per passenger amounted to 1·108d. and the length of the penny stage to 2 miles 737 yds. It will be remembered that owing to through-running facilities, passengers are able to travel from Liverpool to Prescot and St. Helens. This traffic will take some time to develop, but it is interesting to notice that 107,548 sixpenny tickets were issued for this route. Reference is also made in the Annual Report to the service for first-class passengers, inaugurated last October. We have, from time to time, commented on the progress made by this service, and our readers will remember that the Corporation decided recently to maintain the lower deck of the first-class cars for first-class passengers, whilst admitting passengers at the ordinary fares to the top deck.

The number of cars in use on December 31, 1908 was 534, 15 being single deck German cars with trailers, 12 single deck American cars with side entrance, and the remainder double deck cars, whilst the number of miles of track operated was 104, the same as in the two previous years. During the year 22 people, who had been knocked down, or fallen in front of cars, were pushed clear of the metals by the plough life-guard without any serious injuries. Eight fatal accidents have, however, to be reported; the number of fatal accidents caused by vehicles other than tramcars during 1908 amounted to 24. In regard to the tramway fatalities, these numbered 1 in 15,240,985 in 1908, as against 1 in 12,404,324 in 1907, and 1 in 30,523,632 in 1906.

During the year 28,246 articles were left on the cars, compared with 24,052 in 1907, 12,635 of the articles remaining unclaimed. Particulars of the lost property, which included three sets of false teeth, one gas meter and 1,195 purses, are given in the report.

From the analysis of the cost of working which we give below, it will be seen that the figures for 1908 differ very little from those for the previous year, but owing to diminished revenue the net profit, after providing capital charges, amounted to £74,574, compared with £83,379 in 1907. The general rate benefits to the extent of £24,858, whilst £49,716 is allocated to reserve, renewal and depreciation. The following tables give the most interesting figures in connection with the undertaking:—

		Cost per car-mile. 1908.	1907.
Traffic Expenses.			
Superintendence	£4,898	0·10d.	0·10d
Wages of motormen and conductors	101,456	2·00d.	1·97d
Wages of other traffic employes	14,834	0·29d.	0·32d
Cleaning and oiling cars	13,771	0·27d.	0·27d
Cleaning, salting and sanding track.	2,151	0·04d.	0·03d
Fuel, light and water	2,089	0·04d.	0·04d
Ticket checking	6,730	0·13d.	0·14d
Uniforms, badges, &c.	4,084	0·08d.	0·06d
Lighting routes and miscellaneous.	2,441	0·04d.	0·05d
Total	£152,454	2·99d.	2·98d
General Repairs and Maintenance.			
Permanent way	£30,206	0·59d.	0·62d
Electrical equipment of line	7,122	0·14d.	0·15d
Buildings and fixtures	2,053	0·04d.	0·03d
Workshop tools and sundry plant.	475	0·01d.	0·01d
Cars	44,770	0·88d.	0·83d
Miscellaneous	82	—	—
Total	£84,708	1·66d.	1·64d
Power Expenses.			
Cost of Current	£106,575	2·08d.	2·10d
General Expenses, including rates and taxes, management charges, compensation and law charges, &c.	£57,444	1·13d.	1·09d
Total Working Expenses	£401,181	7·86d.	7·82d
Rent of leased lines	£5,891	0·12d.	0·12d
Interest and sinking fund	109,547	2·15d.	2·16d
Total Expenses (including Capital Charges)	**£516,620**	**10·13d.**	**10·10c**
REVENUE	**£591,194**	**11·04d.**	**11·24c**
SURPLUS	£74,574		

The capital expenditure during the year amounted to £17,41[illegible] making a total at December 31, 1908, of £1,930,602. Thi[s] figure is made up as follows:—

CAPITAL ACCOUNT.

		Per cen[t]
Net purchase money paid to Liverpool United Tramways and Omnibus Co.	£484,001	25·2
Tramway lines	257,822	13·3
Reconstruction of tramway lines and extensions	505,025	26·2
Electrical equipment of lines	111,449	5·7
Land, buildings, &c.	138,988	7·2
Tools, &c.	8,904	0·4
Cars	312,041	16·2
Other rolling stock	4,680	0·2
Miscellaneous	1,947	0·1
Parliamentary and legal expenses, &c.	23,197	1·2
Capital issue of stock	49,467	2·6
Engineers' fees	2,967	0·1
Widening streets	9,857	0·5
Purchase of Garston & District Tramways Co.'s undertaking	20,257	1·1
	£1,930,602	100·0

CONDENSER TYPE OF INSULATION FOR HIGH-TENSION TERMINALS.*

BY A. B. REYNDERS.

Summary.—The principle and method of construction of hig[h]-tension terminals, with the insulation arranged in the form of conde[n]sers, are here described.

The manufacture of apparatus for pressures of 88,000 volts, [and] above, resolves itself into the proper selection and arrangement [of] insulating materials. Of all the problems involved in this selecti[on] and arrangement, that of insulating the terminal wires where th[ey] pass through the case presents the greatest difficulty. When t[he] terminal wires are carried through a metal cover the danger fr[om]

* Abstract of a Paper read before the American Institute of Ele[c]trical Engineers.

breakdown is increased, yet the tendency of the latest designs is toward the use of metal tanks and covers. Even with present voltages the greatest difficulty lies in bringing out the terminal wires through the case.

A method that takes care of both puncture and creepage has been proposed by Ryan, Smith, Nagel, and others. This method consists in dividing the dielectric by means of metal plates into a series of condensers of fixed capacities; each will then take its share of the stress in inverse proportion to its capacity. This principle has been utilised in constructing a terminal consisting of a small centre rod or tube just large enough to carry the current, the rod being surrounded by alternative concentric cylinders of insulation and metal having the ends tapered in steps as shown in Fig. 1. The distribution of stress or potential gradient through the dielectric owing to the metal layers is in this way changed from a curve to a straight line. Furthermore, the ends of the metal layers fix the distribution of voltage over the surface, which thus can be kept within safe limits. This design may be designated as a condenser type of terminal.

Before considering the mechanical design of this type of insulated terminal, the author discusses a few fundamental facts that

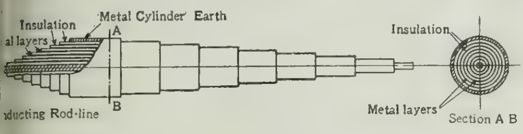


Fig. 1.—Condenser type of Terminal.

will limit the design. In order to obtain the maximum efficiency from the insulating material every part of it should be subjected to a stress proportional to its strength. Further, if the dielectric material is homogeneous throughout, every particle should be strained the same as every other particle. This means that in a series of condensers employing a homogeneous dielectric throughout, each one should have the same capacity as every other one. In order to obtain this desirable result various difficulties must be overcome.

The capacity of a condenser may be varied by changing either the thickness between the conducting cylinders, the length of the conducting cylinders, or the specific inductive capacity of the dielectric. The dielectric strength of ordinary solid insulating material does not increase proportionally as the thickness is increased. Thus it is evident that to vary the distance between the cylinders in order to secure equal capacities will cause some layers to be thicker than others, and hence there is a waste of material.

The second method of varying the capacity—by changing the length of the conducting cylinder—is determined approximately, when equal capacities in all condensers are desired, by making the surface area, or the product of the length by the diameter, equal for all conducting cylinders. When the diameters of adjacent layers are nearly equal—a condition approached as the diameters

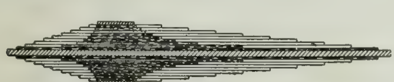


Fig. 2.—Condenser type of Terminal.

Layers of Insulation of equal thickness. Shaded portions show equal capacities throughout. Full lines show equal capacities on inside and outside layers, and capacities diminishing towards centre of insulation thickness.

increase—and the thickness of insulation remains constant, the ends of the layers come very close together, and failure is liable to occur by creepage. In other words, the most economical design for creepage is to make equal steps with an equal difference of potential between the ends of each step. This cannot be accomplished by varying the areas alone, as shown by Fig. 2. The shaded portion shows the shape which the ends must have for equal areas, while the full straight lines show the shape the ends must have if equal steps between layers are obtained. The best compromise that can be obtained is to make the inside area and outside area equal and to allow all others to vary. The result is that the stresses are greatest at the centre and on the outside, and decrease towards the middle.

The third means for obtaining equal capacity is limited by the variation in the specific inductive capacity of the available insulating materials. Unfortunately the available materials suitable for the manufacture of these terminals have very little variation in specific inductive capacity. It is, however, by the combination of this third method with the best arrangement secured by the second method, that makes it possible to produce a terminal having equal distances and equal voltages between steps, and thus obtain the maximum economy from the minimum amount of material.

We have, so far, only considered the capacity of the various metal plates with reference to each other, and neglected the capacity which each metal layer has to earth.

Fig. 3 shows in dotted lines what is possibly the static field surrounding a condenser type of terminal under service conditions. Fig. 4 shows an equivalent arrangement of condensers in which condensers A-X, B-X, &c., in parallel with portions of the main series, replace the leakages shown by dotted lines in Fig. 3. The net result of the leakage capacity is to decrease the apparent capacity of the condensers A-B, B-C, &c., at the line end and to increase the capacities at the earth end. To correct for this the calculated stresses at the earth end should be made greater than at the line end by a percentage determined by experience.

Terminals designed on these principles are constructed by rolling upon a metal tube, paper and mica, or paper alone, using as a bond some material like shellac. At regular intervals, say, $\frac{1}{16}$ in., a layer of tinfoil, making one complete turn, is inserted during the rolling process. Great care must be exercised to obtain accurate diameters, especially when the thickness of insulation is small. No air spaces or wrinkling of the paper is allowable, or poor results will inevitably follow. After being completely wound, the tube is placed in an ordinary engine lathe and the ends tapered in steps, the amount of taper depending on whether the end is immersed in oil or surrounded by air. During this turning process careful work is necessary to prevent the turning tool from "digging" into the insulation below the tinfoil, owing to concentric layers of insulation being irregular in shape instead of true circles. After the turning process is completed, the entire terminal should be treated with some insulating varnish

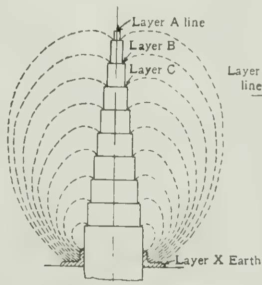


Fig. 3.—Static Field about Condenser type of Terminal.

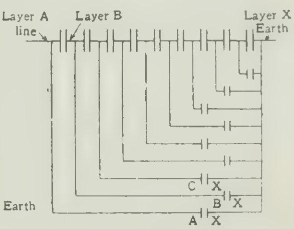


Fig. 4.—Diagrammatic arrangement of Terminal in Fig. 3.

in order to prevent the absorption of oil into that portion projecting into the oil, and the absorption of moisture in that portion which is in air.

With a terminal constructed by the above method, there yet remains one point of weakness; namely, the edges of the tinfoil are sharp, and the potential which exists between these edges and earth may be high enough to cause corona effects in the surrounding medium. If this medium is air the result of corona will be the formation of nitrous acid or ozone, which may cause a deterioration of the insulating material and an ultimate breakdown. Up to the present time no harmful effects are known on insulation from corona in oil.

It is virtually impossible to roll up a tube of insulating paper and tinfoil and obtain all layers concentric and true circles. This will be strikingly shown if the ends are tapered in a straight line. Moreover, with such ends, the tinfoil, which is usually of a maximum thickness of 0·0045 in., is drawn out to a sharp edge and hence the formation of corona by the breaking down of the air in contact with these edges is vastly increased. Again, it will be found that there is no fixed surface distance between the ends of the tinfoil layers, due to variations in the insulation between them. For these reasons these ends are always stepped instead of being in one straight line. Even with stepped ends, it has been found that with extremely high voltages, 250,000 and more, the tinfoil edges are sharp enough to cause the formation of a corona. As shown by Jona, Ryan, Berg and others, corona occurs when the stress on the small layer of air at the surface (edge of tinfoil) exceeds the maximum stress which the air will stand. The remedy for such a condition is to make the radius of the end of the tinfoil layer large enough to reduce the surface stress to safe limits. This is accomplished by adding a metal ring of suitable diameter at the corners where the

tinfoil ends (Fig. 5). This ring is electrically connected to the tinfoil. Furthermore, the addition of a metal bell of large diameter on the central rod at the top not only reduces corona from this rod, but acts as a shield or guard ring for the first few layers, with a resulting appreciable gain in the creepage strength of these layers. Illustrations in the Paper show the saving in size effected in using the condenser type of insulation.

The question naturally arises: If this type of insulation is effective for terminals, why could it not be used for the insulation throughout the transformer? Its effectiveness, however, is less and less as the diameters of the layers become greater, and the difference between diameters becomes less. In other words, as the layers approach nearer and nearer to a flat surface the potential gradient approaches nearer and nearer to a straight line. If the condenser type of insulation in the form of a tube is used between primary and secondary or primary and earth in a core-type transformer and the metal layers in the tube are connected electrically to points of equal potential in the windings, then not only is the distribution of stress in the dielectric fixed and hence the total dielectric strength increased, but the action of the condensers assists in the suppression of surges due to outside disturbances. It is probable that by the use of the above method of connecting the winding and the metal layers together, and the use of condenser type of terminals, trans-

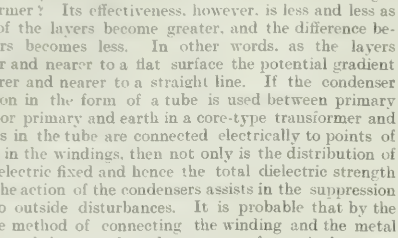


FIG. 5.—ARRANGEMENT FOR PREVENTING CORONA AT EDGES OF TINFOIL LAYERS.

formers for 300,000, 400,000, or 500,000 volts may be made on a commercial basis.

There is yet another possibility of the condenser type of terminal which may be mentioned; namely, its use for outdoor service. Such a terminal is constructed as mentioned above except that at the end of each metal layer is placed a bell-shaped metal cap in electrical contact with the metal layer. The space on the surface of the terminal between the caps is covered by a cylinder of porcelain or similar material. In one of 71 in. overall length shown in the Paper the metal caps had a maximum diameter of 9·25 in. and a depth of 3 in. Upon test in rain, falling at a rate of between 0·2 and 0·3 of an inch per minute, and driving horizontally at times, this terminal showed a faint spark at 125,000 volts, stood 150,000 volts for one minute with an occasional flash between caps, and broke down at 200,000 volts at the end of a few seconds. Such a terminal will stand rough handling, and will solve to a great extent the difficult problem of broken insulators. If the metal discs are replaced by porcelain, a gain will be made in the insulation strength, although first cost and maintenance will be greatly increased.

Government and the Telephones.—Mr. Sidney Buxton (the Postmaster-General) announced on Tuesday that he is endeavouring to complete the purchase of the National Telephone Co.'s undertaking earlier than Dec. 31, 1911. The negotiations are still pending.

THE DIVERSITY FACTOR AMONGST LIGHTING CONSUMERS.

BY F. FERNIE.

On a particular alternating-current network groups of consumers are supplied from transformers, the network supplied by each transformer being independent of the remainder. The ratio $\frac{\text{total kilowatts connected}}{\text{capacity of transformer in kilowatts}}$ has been worked out for 60 such transformers. This ratio is plotted against the number of consumers supplied by each transformer in Fig. 1 giving the irregular curve.

In the case of several transformers supplying the same number of consumers, the point on the curve corresponding to this number is the average of the ratios for these transformers. The smooth curve drawn through the irregular one is intended to be the mean of the points on the irregular curve. The equation of this smooth curve is $y = 2{\cdot}6 \log x$, where x = number of consumers. For values of x below 5, the curve represented by this equation does not represent the mean value of the irregular curve.

The capacity of each transformer (or, actually, the safe current-carrying capacity of the fuse on the high-tension side) has been adjusted just to equal the maximum load on the transformer, so that the capacity may be taken to represent the maximum load; so that

$$y = \frac{\text{total kilowatts connected}}{\text{maximum load}} = 2{\cdot}6 \log x.$$

If every individual consumer's maximum load was equal to his total possible or connected load, then y would represent the diversity factor. Since, however, each consumer's maximum load is nearly always (for private houses) less than his possible load, y must equal the diversity factor multiplied by some number.

Multiply the numerator and denominator of y by the sum of the consumer's maximum demands,

$$y = \frac{\Sigma \text{ consumer's max. demands}}{\text{actual max. load on transf.}} \times \frac{\text{total kw. connected}}{\Sigma \text{ consumer's max. demands}},$$

$$y = \text{diversity factor} \times \frac{\Sigma \text{ kw. connected}}{\Sigma \text{ consumer's max. demands}},$$

$$y = \text{diversity factor} \times \text{A}.$$

$$\therefore \text{ Diversity factor} = \frac{2{\cdot}6}{\text{A}} \log x.$$

A is the *average* value of the ratios $\frac{\text{kilowatts connected}}{\text{maximum demand}}$ of all the consumers, and is thus approximately a constant. One value of A is obtained from the figure, when $x = 1$, and diversity factor $= 1$. This value 1·4 is the mean of the ratios $\frac{\text{kilowatts connected}}{\text{maximum load}}$ of five consumers, each supplied by a separate transformer. It seems to be a probable value for the class of house (villas) here considered. The mean of some figures, obtained from maximum demand indicator readings, supplied to the writer comes to 1·6. A consumer's maximum demand probably occurs when he is entertaining people, and when guests are arriving or leaving quite two-thirds of the lights in a villa are likely to be in use. Taking A to be 1·5, the diversity factor$= 1{\cdot}7 \log x$; this curve is plotted in Fig. 1.

The consumers connected to the transformers mentioned above have anything up to 2 kw. installed, but the average is about 1 kw. They are practically all private houses. Some of them have radiators installed, in addition to lighting, but to no great extent. The transformers are not overloaded; the maximum loads on them have been verified in a few cases by actual measurement. The copper fuses oxidise and eventually melt if at all overloaded.

Mr. R. S. Hale (of the Edison Electric Illuminating Co., Boston) in a letter to THE ELECTRICIAN, of February 28, 1908, gives the "coincidence factor" of the average *residence* business as being between $2\frac{1}{2}$ and 5.

The diversity factor as estimated above is greater than it would be if calculated from maximum demand indicator read-

ings, because of the sluggishness of these instruments, and because they are short-circuited by the supply authority on request. In a previous article * the writer estimated the diversity factor for private house lighting at from 1·3 to 1·5. This figure was partly estimated from some maximum demand indicator readings, but after making allowance for that it is probably still too low. Offices and banks, &c., have a diversity factor among themselves hardly greater than unity, but the peak of this load is always well separated (in point of time) from the private house lighting peak all the year round, hence the addition of such a load to a private house lighting load probably raises the value of the diversity factor (general). On the other hand, the peak of a shop-lighting load (the diversity

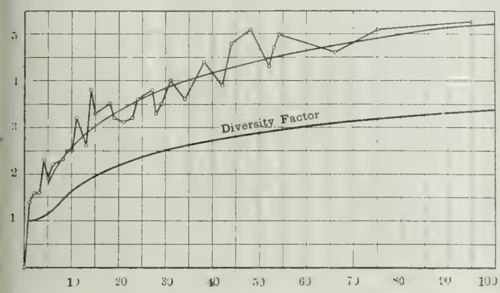
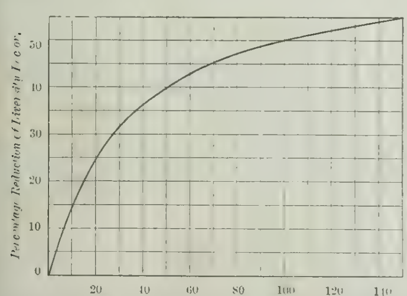


Fig. 1.

factor among which is about unity also) almost always coincides with the private house peak at some time during the year. In small towns all the shops frequently keep open late on one night during the week, often on market day or on Saturday nights. Nearly everywhere in Great Britain the shops are kept open, with all their lights on, during Christmas or New Year (in Scotland) week.

Of course, as regards the plant in the station, the overlapping of the respective peaks on one night in the year is as bad or, as regards load factor, worse than more frequent overlapping.

Fig. 2 shows the reduction in the (general) diversity factor by adding a shop lighting load to a private house lighting load. The private house diversity factor is assumed as 3 and the shop diversity factor as 1. It will be seen from the figure that



Shop Kw. (connected) expressed as a Percentage of Private House Kw. (connected).

Fig. 2.

if the shop and private house maximum loads are equal, the diversity factor is half what its value would be if the load consisted of private houses only.

It would appear that the price per unit charged by any supply authority for lighting must depend on what proportion the shop lighting bears to the total lighting. Both on account of diversity factor and load factor, shop lighting must be more expensive to supply than private house lighting. The difference in load factor is, of course, allowed for, if the maximum demand system of charging is employed.

* The Electrician Vol. LXI., p. 556.

ON TESTING THE INSULATION RESISTANCE OF LIVE CABLES ON DIRECT-CURRENT SYSTEMS BY THE KELVIN TESTING SET.*

BY R. G. ALLEN, B.Sc.

The chief advantages of working with the live cable rather than the dead cable when testing its insulation with a Kelvin or similar testing set are as follows: (1) The battery is dispensed with; (2) the insulation resistance of the cable is determined at working pressure; (3) the insulation resistance of each cable in a circuit can be determined as described below.

The circuit shown in Fig. 1 is supposed to be one of the sections fed from the main cables M_1 and M_2. A and B are the ends of the connections from the cables to the two terminals of the testing set ordinarily used for the battery. The terminal D is earthed. The insulation resistances X and Y of the cables are represented by the dotted lines. The test is conducted thus: (1) With G suitably shunted, place S on C and read the deflection. Multiply the latter by the shunt value used and call this number D_1. (2) Repeat a like operation with S on D, and so obtain D_2. (3) Leaving S on D, interchange the positions of the ends A and B and find D_3 in the same way as the other two values. Then the insulation resistances are given by

$$X' = \frac{D_1-(D_2+D_3)}{D_3} . G \text{ and } Y' = \frac{D_1-(D_2+D_3)}{D_2} . G,$$

where $X' = \frac{Xx}{X+x}$ and $Y' = \frac{Yy}{Y+y}$.

x being the insulation resistance of cable M_1 and all the right hand cables of the other live sections attached to it; y being the similar

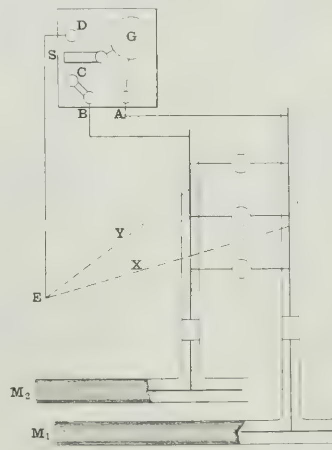


Fig. 1.

value for M_2: x and y will be found by the method just described, after first cutting out the section shown in Fig. 1, and joining A and B to two connections one on each of the cables M_1 and M_2.

The proof of the above values is given in the Paper. The application of this method enables the insulation resistance of each of the main cables and also of each cable in different sections fed by the main cables to be ascertained.

In the exceptional case of cables of higher P.D. than 400 or 500 volts (which can be used with a Kelvin set), the only alteration required in the method is to place a suitable high resistance between the cables, and use a fraction of the whole P.D. to give the deflection in the first operation of the test.

To determine the insulation resistance between the cables: First switch off all the lamps in the section, and connect as shown in Fig. 2. The galvanometer G will now act as a sensitive ammeter reading, if necessary, to a value as low as $\frac{1}{100}$ milliampere. X and Y are supposed determined by the previous method. Let S represent X + Y, and Z be the insulation resistance between the cables to be determined. Then, if D is the deflection of G suitably shunted,

$$\frac{E}{G + \frac{ZS}{Z+S}} = kD.$$

* Abstract (revised by the author) of a Paper read before the Dublin Local Section of the Institution of Electrical Engineers.

E being the P.D. between the mains measured by a voltmeter. Now remove the ends *a* and *b* and connect them to a few storage cells of voltage E_0. Then, leaving the same shunt on G as before, read the deflection D_0 and $\frac{E_0}{G}=kD_0$. From these two equations and the values found for X and Y the value of Z can be easily found. It is assumed in this test that the two insulation resistances of the mains M_1 and M_2 with the attached cables of the other sections are relatively high, compared with X and Y. This assumption does not enter into the case given below of testing the mains in this manner.

In the case of two-core cables, the test for the main cables is made by cutting out all the attached sections and applying the method explained in connection with Fig. 1, which will give X and Y, and in Fig. 2 to give Z. The test of each attached section can then be made independently.

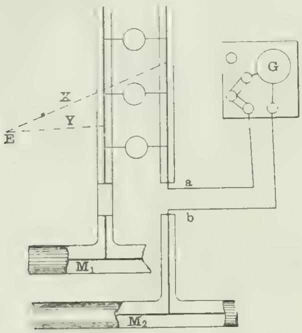


FIG. 2.

In the case of concentric cables, Z will be determined by the method used in connection with Fig. 2, with all the attached sections cut out. X, the insulation resistance between the outer conductor and the earth, can be found by disconnecting the inner conductor from its terminal at the dynamo and joining this terminal to the testing set—to be used as an ammeter—and connecting the other end of the set to earth. Then, if E is the terminal P.D. of the dynamo,

$$\frac{E}{X+G}=kD.$$

Now join the galvanometer to a few storage cells of voltage E_0 and obtain the deflection D_0, thus $\frac{E_0}{G}=kD_0$, and from these two equations X is readily found.

In the three-wire system of Fig. 3, Y, the insulation resistance be-

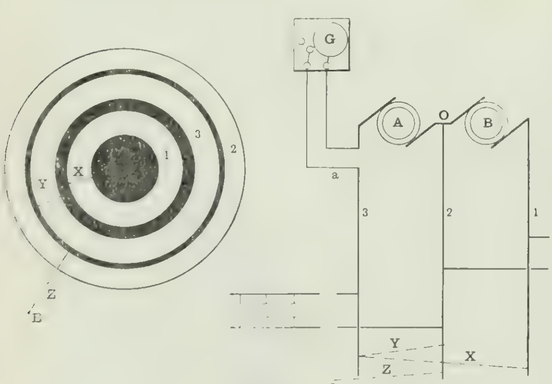


FIG. 3.

tween conductors 2 and 3, may be obtained by the method used in connection with Fig. 2. In this determination all the attached sections between conductors 1 and 2 and 2 and 3, as well as the dynamo B, are cut out, and connection made to the galvanometer as shown. The galvanometer of the testing set, used as an ammeter as already explained, gives the current going through the resistance G + Y, and this current equals $\frac{E}{G+Y}$, E being the terminal P.D. of dynamo A. From this relation, as explained before, Y can be found. X, the insulation resistance between conductors 3 and 1, can be determined by the same method. In this case conductor 2 must be disconnected from O and all the attached sections cut out as before. The connections to the galvanometer will be the same as in the preceding determination. In this test the P.D. will be the terminal value for the dynamos in series. Z, the insulation resistance of the outer cable from earth, can be found in the same way as X was in the case of the two concentric conductors mentioned at the end of the last paragraph. In this test the dynamo B and all the sections of the system must be cut out, conductor 3 must be disconnected from *a*, and *a* joined to earth. Conductor 2 is supposed to be in position—that is, joined to O. The readings of G are then taken and the value of Z found. It is hardly necessary to add that the test of the cables is quite independent of the state of the insulation of the machines.

The method described in this Paper lends itself readily to the case where an accurate registration of the insulation resistances of the main cables of a direct-current system is desired immediately after laying down.

THE PHOTOMETRY OF DIFFERENTLY COLOURED LIGHTS.

BY LANCELOT W. WILD.

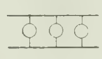
The difficulty of comparing lights of different colour with photometer screens of the equality of brightness type has long been realised. To overcome the difficulty photometers of the flicker type have been introduced, and have obtained a considerable usage. The great merit of the flicker type is that the same reading within about 1 per cent. can be obtained again and again, even though the lights differ in colour to a considerable extent, whereas with photometers of the equality of brightness type under the same conditions of colour difference the readings may lie 10 per cent. or more on either side of the mean, and, consequently, a very large number of readings must be taken in order to secure a true average.

It has often been questioned whether the flicker photometer really measures equality of illumination at all, and, as far as the writer knows, this point has never been settled either by theoretical considerations or experimentally. In view of the importance of this question, the writer has undertaken a series of tests with the hope that the character of the flicker photometer might thus be vindicated. Unfortunately, however, the tests only go to prove the exact opposite to what was hoped for, the general result being that a flicker photometer credits a tungsten filament lamp with about 6 per cent. too little candle-power when compared with a carbon lamp.

In order that the results should not be vitiated by some peculiarity unsuspected in the photometers experimented with, the writer made comparisons with three types of flicker head, a Bunsen disc and two entirely reflecting screens. The flicker heads were the Wild, the Whitman and the Simmance, and are probably so well known as to need no description.

The Bunsen disc was made of the usual materials—namely, blotting paper and wax; but was made by the writer's own process, which secures greater sensitiveness for mono-chromatic lights than is usually obtained.

Of the remaining two photometers, one was a Lummer and



the other somewhat similar. A white reflecting screen is fixed normal to the rays, as in the Lummer, and it is viewed by the agency of an equilateral prism and a couple of mirrors, so that the two reflecting surfaces are seen side by side with only the edge of the prism, which should be ground to a knife edge, between them. If very well made this photometer is as sensitive as a Lummer for mono-chromatic lights, and has the advantage that the eye-piece stands out straight from the bench.

The tests were made by comparing a Sunbeam tungsten filament lamp, taking 1·5 watts per candle-power, against a carbon filament lamp taking about 4·5 watts per candle-power. In order to neutralise any want of symmetry in the arrangements, the method of double balance was employed, the carbon lamp being first photometred against another carbon lamp with each photometer head, the standard then being replaced by the tungsten lamp. In order to guard against any change taking place in the lamps during test from vitiating the results,

readings were taken with the photometer heads first in one order and then on the following day in the reverse order. Ten readings were taken on each flicker head, 20 with the Bunsen disc, and 50 with the Lummer and Prism heads. All readings were taken by one observer, so as not to bring in another variable. It is most desirable, however, that the tests be repeated by another observer, and preferably in another environment.

Tabulated below will be found the maximum, minimum and mean scale readings obtained with all six photometer heads :—

heads :—	Flickers			Contrast.	Equality.	
	Wild.	Whitman.	Simmance.	Bunsen.	Prism.	Lummer.
Max. read ...	1·73	1·735	1·735	1·86	2·05	2·00
Min. read. ...	1·72	1·715	1·71	1·79	1·72	1·70
Mean	1·725	1·725	1·72	1·825	1·85	1·83

It will be noticed that all three flickers give almost the same mean reading, although they differ as to sensitiveness. The Bunsen, Prism and Lummer heads again agree together exceedingly closely on their mean readings, but the reading is no less than 6 per cent. greater than that obtained with the flickers. It would appear from these tests that, in spite of the greater sensitiveness of the flicker photometer, it will have to be discarded in favour of the Bunsen disc.

The Bunsen disc is not really an equality of brightness photometer, but may better be described as a contrast photometer. The so-called contrast Lummer is not a contrast photometer, but is in reality an equality of brightness photometer. When tried on red and green lights the so-called contrast Lummer shows a green centre on a red ground on one side, and a red centre on a green ground on the other side, and in whatever position the head is placed on the bar the two colour contrasts are still the same. The Bunsen disc, on the other hand, owing to the fact that the waxed portion reflects almost as much light as it transmits, shows a red area against a white area on one side and a green area against a white area on the other side. The adjustment is made till the red-white contrast appears equal to the green-white contrast. Each colour being compared with white, the difficulty of forming a judgment appears to be much less, and a much greater sensitiveness is obtained.

The conclusion from these tests is that, for testing tungsten lamps against carbon lamps, a flicker head must not be used. Equality of brightness photometers, on the other hand, fail on the score of insensitiveness, and contrast photometers of the Bunsen type alone fulfil the required conditions, though it is a pity that the sensitiveness of the flicker type can not be secured.

ALTERNATOR FOR ONE HUNDRED THOUSAND CYCLES.*

BY E. F. W. ALEXANDERSON.

Summary.—A description is given of the construction of an alternator giving an output of 2 kw. at 100,000 cycles. The mechanical features of the design, which present, of course, the main difficulties, are considered in detail.

The author first gives a brief review of the history of the high-frequency alternator, and then describes a 2 kw. 100,000 cycle alternator developed for Prof. Fessenden. From experience with earlier machines of this type it was apparent that a successful machine must have a stationary field winding as well as a stationary armature, and that the armature should not contain any iron. A type of machine was, therefore, developed in which the armature was made of wood, and the two rotating discs formed a complete magnetic circuit energised by a stationary field coil suspended inside the armature between the discs. This machine, however, could not be considered as the final development, since the rotating discs could not be made symmetrical and the centrifugal force at high speed changed the shape of the discs in such a way that the air-gap between the field and the armature was increased. The result was that the voltage of the generator did not increase in proportion to the speed, but reached a maximum at about 60,000 cycles and decreased at higher speed.

Fig. 1 shows the construction arrived at in a machine recently completed, which was built with two kinds of armatures for trial, one of iron and one with the winding placed in wood. The iron proved to be preferable, giving a higher output and a better mechanical structure. The success of the iron armature is largely due to the fact that the volume of iron subject to alternating flux is extremely small. The main part of the laminated armature carries a constant flux, while the pulsating flux occurs only in the teeth that separate the armature conductors. The alternator shows in every way the same characteristics as a generator of moderate frequency. The following are the constructional data of the machine: The armature has 600 slots with one conductor per slot of 0·013 copper wire, triple-silk covered and varnished. The wire is wound in a continuous wave up and down in the successive slots. The rotating field has 300 projections, which, as the machine is of the inductor type, correspond to 600 poles for a machine of the ordinary alternate-pole type. It appears from the electrical characteristics that the output of the generator depends largely upon the air-gap clearance, because the voltage of the machine is nearly inversely proportional to the air-gap. The characteristic curves have been given at an air-gap of 0·015 in., but the output of the generator can be doubled if a smaller air-gap be used; in fact, the machine has been operated with an air-gap as small as 0·004 in., though such a clearance would not be practicable for continuous operation. In view of this condition, it is desirable to regulate the air-gap so as to offset any wear in the bearings, and to select the gap which is suitable for the work to be done. If the machine is to be operated continuously without attention, a comparatively large clearance is necessary, while for a special experiment in which higher power is required a small gap may be used.

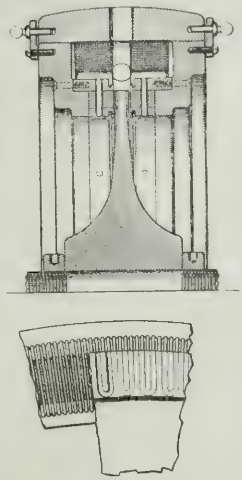


Fig. 1.

The sensitiveness of the air-gap regulation is one of the reasons why, instead of using the usual drum winding construction of the armature, the winding was applied on a radial face, as shown in Fig. 1. The armature is mounted on a frame that is threaded into the stationary field frame, and the air-gap can be set exactly by screwing the armature tight against the disc and then moving it back a distance corresponding to the desired clearance. For this purpose the stationary frame is provided with a scale, so that rotating the armature on its thread one division corresponds to one thousandth of an inch change of the air-gap.

At a speed of 20,000 revs. per min. it would not be practicable to use a rigid shaft. It was, therefore, necessary to adopt the principle employed in a well-known steam turbine—that of a flexible shaft which allows the disc to revolve round its exact mass centre, thus avoiding any strain on the bearings due to centrifugal force. The shaft has been designed like a stiff spring with uniform strength. It has a diameter of 1·25 in. in the middle and 0·625 in. at the ends, the length between the centre of bearings being 28 in. When the machine is brought up to speed, severe vibration occurs at two distinct critical speeds, one at 1,700 revs. per min. and the other at 9,000 revs. per min. The vibration increases gradually when the machine approaches the critical speeds. When the vibration has reached its maximum it ceases suddenly, and the machine runs smoothly and with surprisingly little noise. The first point of resonance is the one at which the shaft vibrates like a string, and the second harmonic is the one at which the disc vibrates around an axis perpendicular to the shaft, and the shaft assumes an S shape. The two critical speeds are calculated out in the Paper at 1,650 and 8,200 revs. per min.

The first machine built was belt driven. After a good deal of experimenting with different kinds of belts and pulleys it was found feasible to run the machine at 15,000 revs. per min., corresponding to 75,000 cycles. However, it also became apparent that this method of driving could not be accepted for practical use, so that the later machines have been equipped with gears. The gear ratio is 10 to 1.

The revolving disc is designed so as to have uniform stresses in

* Abstract of a Paper read before the American Institute of Electrical Engineers.

all parts, and consequently the greatest possible margin of safety. It is made of chrome-nickel steel, with an elastic limit of about 200,000 lb. per square inch. As the disc has 300 teeth on each side, which pass the face of the stationary armature at a rate of 1,000 ft. per second, with a clearance of 0·015 in., it can be readily understood that the air friction in the gap must be considerable. It was found that the machine heated up excessively due to air friction, but this has been overcome by filling the slots with non-magnetic metal, so that the disc offers a perfectly smooth surface. Another difficulty was encountered owing to centrifugal force acting on the fillers, each of which is subject to a centrifugal pull of 80 lb. During some of the first attempts, when the slots were simply filled with hard solder, it happened that some of the fillers broke loose. In the final construction, in which the fillers are anchored so as to stand the strain, they consist of U-shaped phosphor-bronze wires supported directly by the steel teeth, so that the solder is needed only to fill the joints.

The generator has four bearings. The outside ones support the weight of the revolving parts and are fed with a continuous stream of oil supplied by a pump. One of the functions of the middle bearings is to prevent excessive vibrations when the shaft passes the speeds of mechanical resonance. During normal operation the shaft does not touch the middle bearings, which are bored out to give $\frac{3}{64}$ in. clearance; at the critical speed, however, the shaft touches the bearings. The end thrust of the shaft is taken up partly on the middle bearings and partly on the end bearings.

A generator of this kind is always used in connection with a capacity, which is located in the aerial in the case of wireless telegraphy. The best method of showing the characteristics of the generator, without reference to any certain application, is to assume the load

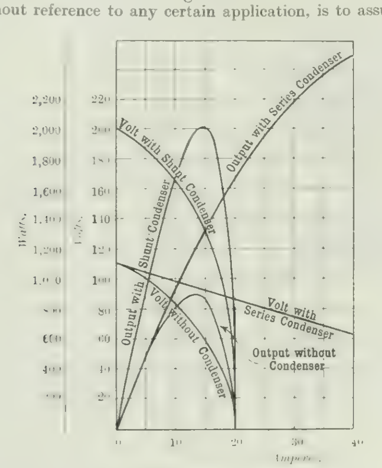


FIG. 2.—REGULATION CURVES.

to be non-inductive and to use a condenser of fixed capacity. The most typical performance of the generator operating in conjunction with a condenser is the one in which the condenser has an impedance equal to the inductive impedance in the generator winding, and is connected in series with the generator. This combination gives the generator a maximum output for any load. A condenser arranged in this way considerably increases the useful performance of the generator, and should be regarded as a part of the generating outfit. The tests of the alternator described here show that the reactance of the armature winding is 5·4 ohms at 100,000 cycles. The condenser which ought to be used in connection with the machine is, therefore, 0·3 mfd.

Fig. 2 shows that the combination of alternator and condenser gives the same terminal voltage at any load as would a generator which had the same E.M.F. and the same ohmic resistance but no inductive drop. In other words, the condenser completely offsets the reactance of the winding, and the regulation is determined entirely by the ohmic resistance.

The characteristics of the machine as given by test are the following: No-load voltage, 110; ohmic resistance, 1·2; short-circuit current, 20 amperes; continuous capacity at 45 deg. rise, 30 amperes. With the condenser the maximum continuous load of the alternator is 70 volts and 30 amperes, or 2·1 kw. The commercial rating has, therefore, been made 2 kw.

It would undoubtedly be of theoretical interest to be able to determine the properties of the iron core at the high frequencies dealt with in this generator. A test made at 60,000 cycles may be referred to for this purpose. The power required to run the whole set without excitation at the corresponding speed was 1,340 watts, and the additional power required to drive it at the same speed with full field was 330 watts. The only conclusion that can be drawn from this test is that the core loss is not higher than 330 watts. The main part of this loss is probably due to increased bearing friction by magnetic end thrust.

Regarding the possibilities of building high-frequency alternators of higher output, it may be mentioned that a machine for 50,000 cycles is being constructed of such dimensions that an output of 35 kw. can be expected. Also it appears probable that still higher frequencies than 100,000 can be reached by direct generation with revolving machinery.

ELECTRIC TRACTION ON RAILWAYS.*

XVI.—COLLECTORS FOR OVERHEAD CONDUCTORS.

BY PHILIP DAWSON.

(*Continued from page 504.*)

Summary.—Two forms of collector have been developed—the trolley wheel and the sliding bow. For railway work the choice and design of the collector depend on the line voltage (which, in a given case, determines the current to be collected) and the speed. The author considers that for main-line railway working with high-pressure currents some form of bow collector, preferably operated by compressed air, is indispensable. He then describes the types so far employed, viz., (1) the pantograph or scissors type, (2) the ordinary bow type, and (3) the rod collector of the Oerlikon type.

Where the space available when the bow is lowered is very limited, or when very large variations in the height of the contact wire have to be dealt with, another form has been adopted by Messrs. Siemens-Schuckertwerke. This bow is illustrated in Figs. 7 and 8, as fitted to a Midland Railway motor coach. In this case, in order to obtain continuous contact, the makers have fitted two bows per coach. These bows are fitted at the top with a separate collector bow, controlled, as shown, by separate springs. This form can work in either direction, although obviously its operation must necessarily be more satisfactory when the principal part is trailing than when it is, so to say, charging the line. It has been found necessary to fit this type of bow, owing to its length, with wind vanes, in order to prevent the wind at high speeds forcing the bow off the wire. The bow is kept against the wire by springs, and the springs are put into action by means of a piston operated by means of the vacuum pump which operates the brakes.

Fig. 9 is a view of the bow collector designed by the writer for the L.B. & S.C. Railway. Very special difficulties had to be contended with, due to the great variation in height of the overhead conductor—13 ft. 10 in. to 21 ft.—and to the very little space, only about 12 in., available for storing away the bow on the top of the motor coach, even with the special flat-ended roof adopted in the guard's compartment, as was illustrated in the section dealing with Rolling Stock.

In order to keep this flat roof as short as possible, it was found necessary to use only one collector on each motor coach for running in each direction instead of two, which, with this type of collector, has been the usual practice. In order to prevent any interruption of current caused by a bow jumping the wire, the top portion of the bow, as is seen in the illustration, is made in two parts, the trailing half being held from the principal bow by means of auxiliary springs shown in Fig. 9. This arrangement has proved itself to be very satisfactory; as this figure also shows, the bows are so constructed that when down they fold one within the other. The bows are held up by

springs, which are brought into action by means of a piston worked by compressed air. It will also be seen that the bow frame is doubly insulated by means of the porcelain insulators. The insulators are the same as those used in the section insulators on the overhead line work. The current is conducted from the bow frame by means of a solid copper conductor through a porcelain insulator to the high-tension conductor, as shown in Fig. 9, which also shows the aluminium collector strips and the grooves, which are filled with a hard grease for running. The original bows were operated by springs in compression, but it is proposed to replace these by springs in tension, the writer having devised a simple means by which this can be done. A metal shield connected to earth has been constructed round the bow, (but is not shown in the illustration), so as to prevent the possibility of any passenger being able to touch a live portion of the collector bow or frame from a station platform either with a stick or umbrella.

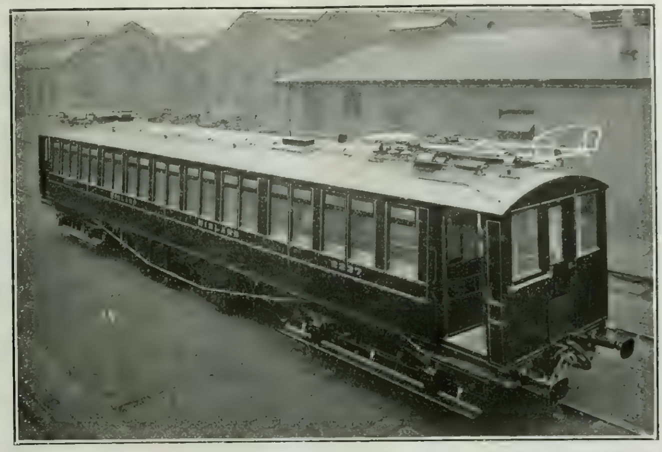


Fig. 7.—Midland Railway Motor Coach, showing Siemens Bow Collector down.

We now come to consider the most recent form of collector devised by Mr. Huber of the Oerlikon Company, and which possesses many novel and most interesting features. This collector is of the bow type, and consists essentially of a light curved metallic rod, the convex side of which makes sliding contact with the conductor. One end of the rod is unattached and the other is free to rotate about an axis parallel to the direction of the motion of the car. The point of connection of the rod is also capable of being moved a certain amount, more or less horizontally, in the direction at right angles to the length of the car. The necessary pressure between the collector and the wire is obtained by means of a clock spring, which tends to rotate the metallic rod about its pivot. When the weight of the rod acts in

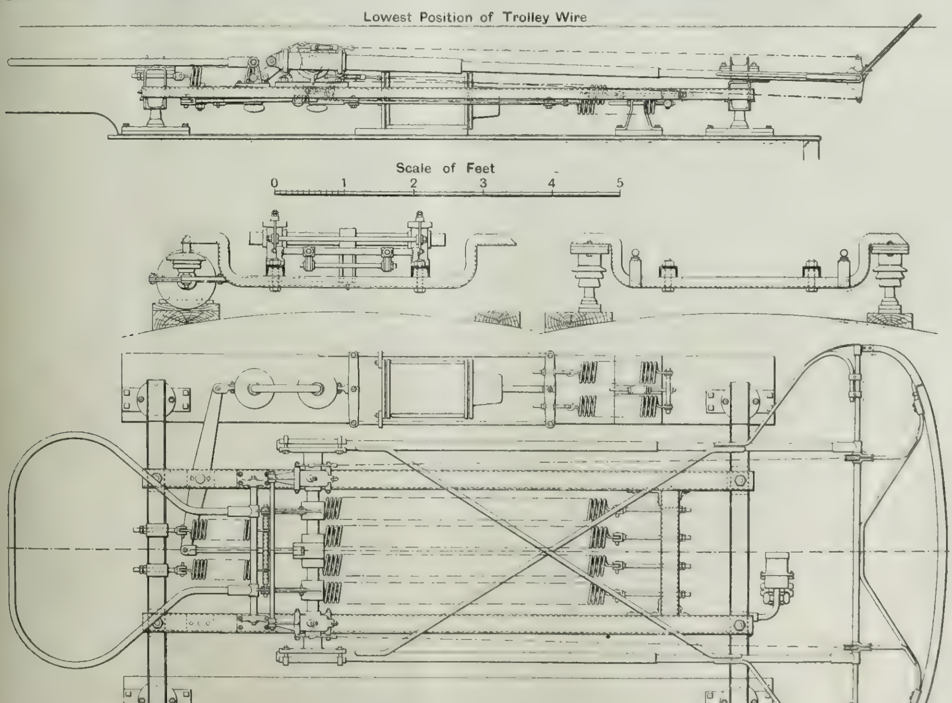


Fig. 8.—Details of Siemens Bow, fitted to Midland Railway Motor Coach. Scale, 1 : 25.

conjunction with the force of the spring the latter is exerting its minimum effect, being in the most uncoiled position. But when the weight of the rod tends to counteract the effect of the spring, the spring is most tightly coiled up, and thus exerts its most powerful torque. By this means a very uniform pressure is obtained throughout the whole range of positions.

The collector, by its rotation, automatically adapts itself to any change in position of the conductor. The lateral movement, which is indicated by the two positions drawn in the left-hand part of Fig. 10, is only required in special cases, and can also be automatic if desired. The motorman can at any time lift the collector out of contact with the wire. According to the position of the overhead wire, the rod rubs on the top side or bottom of the wire. The normal state of affairs is to have the wire running to one side of the track with the metallic rod making rubbing contact on the top of the wire.

There is a wide range of positions which the collector can assume, even without making use of the lateral motion which would still further extend its range. In tunnels and similar situations the wire can be situated directly over the

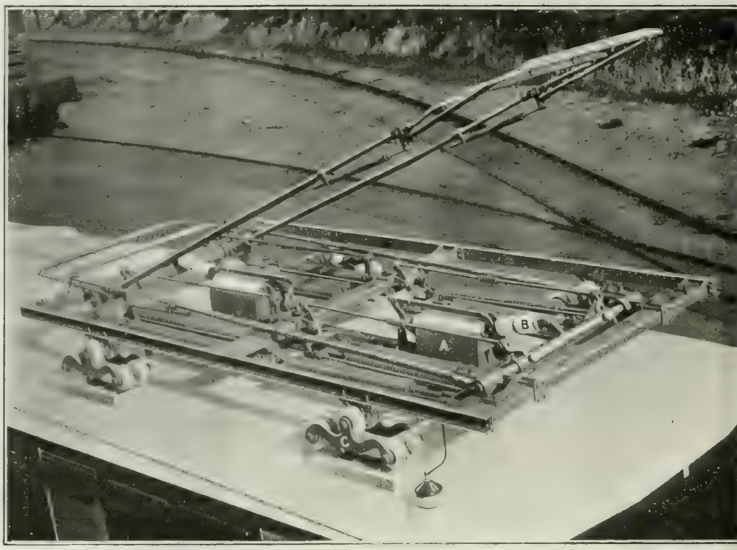
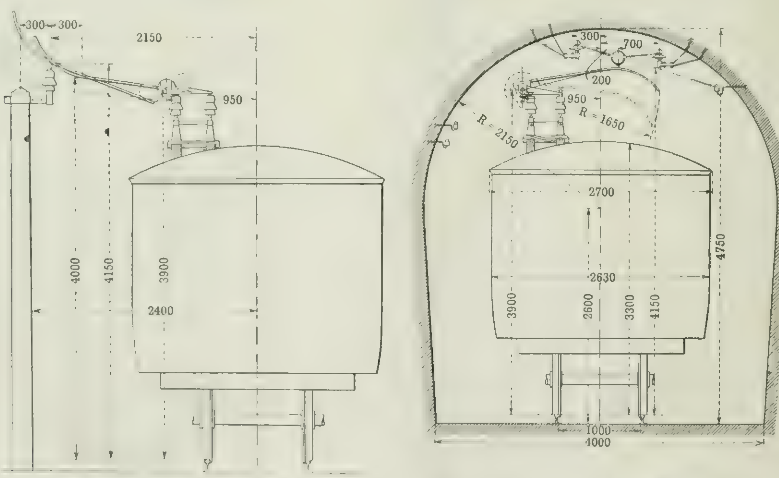


Fig. 9.—General view of Collector Bow designed by the Author for the London, Brighton & South Coast Railway.



Position of conductor at curves.

Conductor in tunnels.

Fig. 10.—Oerlikon Current Collector. (All dimensions in millimetres.)

track, in which the collector acts just like one of the ordinary bow type. Besides its great flexibility, the design embodies several other valuable features. The contact rod is very light, weighing less than $3\frac{1}{2}$ lb., and it is easily replaceable. The last feature makes it possible to cover it with some composition softer than copper, and thus to minimise the wear on the aerial line; should the collector rod catch in the overhead work, it is so slight that it would be the rod which would be damaged and not the overhead construction.

This collector has been adopted by the Oerlikon Company on the single-phase line which they have equipped between Locarno and Bignasco. Whilst for small units, utilising but small currents, the Oerlikon form of collector bow would appear to have given satisfaction, where high speeds and heavy currents have to be dealt with, as on the Swedish State Railways, the wear of this form of collector does not seem to have been as satisfactory as might be desired.

What has been said will suffice to give a good idea of what has been done as regards the design and construction of bow collectors for high-tension railway work. Every case must be dealt with on its merits, but the following are some of the principal points which must be borne in mind when deciding on a type or designing a type of collector bow to comply with given conditions: Double insulation is essential to satisfactory working; care should be taken that the design is such that neither ordinary conditions of dirt nor snow can bring about a short-circuit; porcelain is, for the present at least, the only insulator worth considering, and it should never be used except in compression; the number of articulations should be as few as possible consistent with the general requirements; the pressure at all heights should be as even as possible; the collector strips should be easily renewable and of such a material and design as will ensure as far as possible all the wear being taken up by the collector strips and not by the contact wire; the moving parts of the bow should be as light as possible, consistent with the general requirements; and there should be great transversal strength to prevent the collector tilting laterally.

Generally, that collector will be the best which will work without undue sparking and with the smallest pressure against the contact wire

In normal working conditions this pressure for a properly constructed collector should be found somewhere between 8 lb. and 12 lb. As far as possible all springs should work in tension, although it has sometimes been found necessary to operate springs either in rotation or in compression.

Care should be taken to surround the collector with an earthed shield so as to prevent the possibility of any passengers touching it with a stick when at a station platform or near a low bridge. Great care should be taken to get all the articulations working as easily as possible, and either ball bearings or roller bearings may certainly be found very useful in this connection. The actual contact breaking piece should be so arranged that any tendency to a horizontal as well as vertical knock should be easily taken up by the springs, and experience has shown that for main-line railway working trailing contacts are preferable to the stiff contact bars of the simple pantograph.

This latter arrangement is by far the hardest on the overhead construction, and the principal aim in designing a current collector should be to make it as easy for the line as possible and to absorb all shock, and all wear should take place in the collector bow and not in the contact wire.

(To be continued.)

THE TELEGRAPH SHIP "TELCONIA."

The Telegraph Construction & Maintenance Co. has just added a new cable-repairing steamer the "Telconia" to its fleet. This vessel constitutes the most improved form of telegraph ship. Distinctly yacht-like in general appearance, she is a twin-screw steamer 223 ft. long, her beam measuring 30 ft. 9 in., whilst her depth is 21 ft. 6 in. Her gross registered tonnage is 1,000. She has triple-expansion engines, two single-ended boilers with forced draught, and when indicating 1,050 H.P. her speed is 12 knots. A general view of the vessel afloat is shown in Fig. 1.

Anyone versed in the general arrangements of other vessels belonging to the telegraph fleet—now numbering over 50 ships—will recognise that in the "Telconia" we have a quite distinct departure from previous designs. The main novelty consists in the fact that the whole of the ship forward of the bridge is solely set aside to cable work. The importance of this feature will especially appeal to telegraph engineers, who know that the work is often prejudicially affected on many cable ships by having to be conducted in the midst of the crew's quarters and where the sailors and firemen congregate when off duty. In the forward half of this ship there are no quarters for the crew—no such place, indeed, as a forecastle. The officers' cabins and the saloon are located amidships. The sailors and firemen are furnished with roomy quarters in the after 'tween decks, while the petty officers—including boatswain, carpenter, foremen cable hands and quartermasters—are given comfortable cabins in an after deck house.

By this plan the forward 'tween decks is left quite clear for cable operations, and, with its rows of ports on each side, this part of the vessel presents the appearance of a light and roomy workshop. The middle of this space is occupied by the duplex picking-up machinery. This is necessarily as powerful as any of those fitted to larger vessels, in view of the great weight of the shore end types which frequently have to be dealt with. Noticeable features in the apparatus are the double-helical gearing in the picking-up machine, and the substitution of the tank in the ordinary Appold brake on the paying-out drum by a water-jacketed brake serving the same purpose without the splashing entailed by the brake drum running in an open tank. The gear is controlled from the upper deck, where the man in charge can see all that is going on in cable operations. The bow sheaves (made of cast steel) are especially light. They are wide and flat in the tread, thereby permitting an ordinary centipede grapnel being hove right inboard. At the sides of the 'tween decks (or main deck, as it actually is) grapnels, coils of rope and the various tools involved in cable work are conveniently placed ready to hand when required. Fig. 2 shows the picking-up machinery and gear. Fig. 3 shows the forward decks and gear, as well as the bow sheaves, dynamometer, &c.

The fore part of the upper deck is particularly free from obstruction of any kind, thereby allowing ample room for cable operations such as splicing, buoying, &c. All buoys are stored in the forehold to avoid the risk of having them carried away in bad weather, whilst also serving to keep the decks clear. They are located immediately under the derricks which lift them straight into the fore rigging in the required positions for letting go. The grapnel ropes, buoy moorings and chains are so placed as to be readily led on to the gear for paying out.

There are two cable tanks, giving a total coiling space of about 8,000 cubic ft.

The upper deck is constructed of steel sheathed with Oregon pine, and has the usual camber of about 6 in. The main deck is quite flat, rendering it very convenient for bolting down the picking-up machinery to, besides providing greater cabin comfort. In addition, the 'tween decks are thereby rendered loftier. This deck is of steel, covered throughout with "Litosilo," that composition providing a warm and non-slipping surface. The boats are carried in Welin's patent davits.

Fig. 1.—The New c.s. "Telconia," of the Telegraph Construction and Maintenance Company.

Fig. 4.—Test Room on the c.s. "Telconia," opening on to Main Deck.

Fig. 3.—The Upper Forward Deck of the New c.s. "Telconia," showing Gear, Bow Sheaves, Dynamometer, &c.

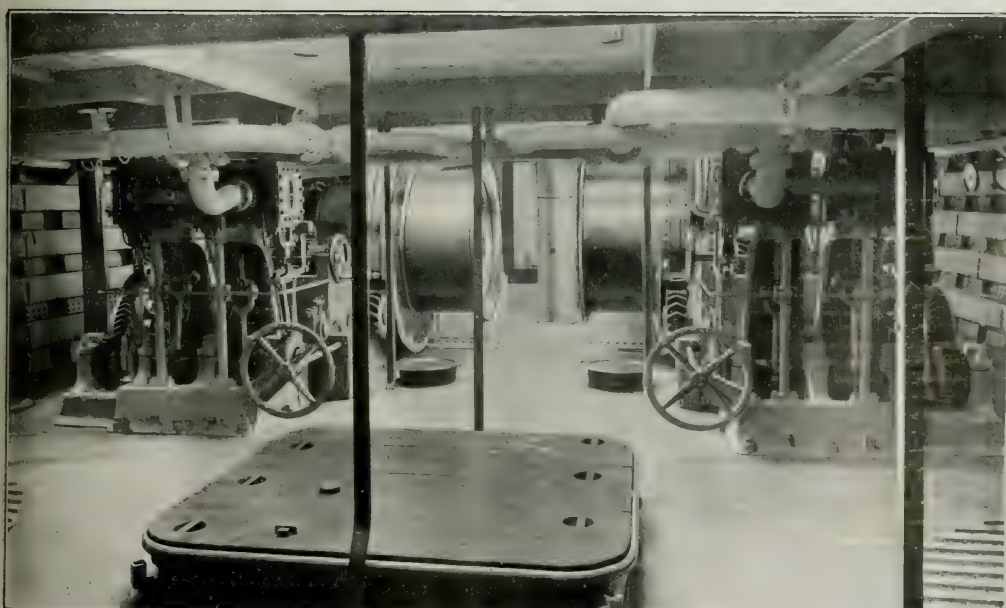


Fig. 2.—The New c.s. "Telconia," showing the Picking-up Machine and Gear.

[illegible] give great facility for swinging in and out and lowering [illegible] testing with ease and promptitude.

For the size of the ship, the electrical testing room (Fig. 4) is a spacious compartment, besides being excellently located under the bridge amidships; but the special feature about this testing room is that a direct view is obtainable from its three square windows on the fore side of all that goes on forward, thus enabling the electrician to be in close touch with the progress of the cable operations to see for himself, indeed, when the cable end is ready for testing, &c.

The captain's cabin (Fig. 5) is on the bridge deck, and is exceptionally convenient and roomy for a vessel of this class, and the same description applies to the officers' cabins (which are very comfortably furnished) as well as to the 'tween deck passages and staircases, which show no signs of cramping.

Fig. 5. Captain's Saloon on c.s. "Telconia."

No detail seems to have been thought unworthy of attention in the design of the "Telconia," for not only is the galley excellently placed on the upper deck, with special provisions for carrying away all the smells of cooking, but a "service" staircase provides direct communication with the pantry, saloon and mess rooms without going on to the open deck.

What strikes the visitor most with regard to this new ship is the altogether exceptional clear open space provided for the purposes of cable work as well as for getting about from one part of the vessel to another, and that everything is in its proper place, instead of, as is so often the case, exactly where it should not be. The latter point has a commercial value, when it is remembered that the wrong placing of materials employed in the work involves labour and time in shifting.

The "Telconia" was built on the Tyne by Messrs. Swan, Hunter & Wigham Richardson, the whole of the cable machinery and appliances being designed and manufactured by the Telegraph Construction & Maintenance Co., whilst the general arrangement of the ship in all its details is in accordance with the designs of Mr. F. R. Lucas, the managing director.

THE ELECTRIC POWER SUPPLY OF CHICAGO.

Although in this country we possess many electric generating stations of large capacity, and in economical power production we are second to none, it is to the United States of America that we must turn for examples of electric power supply on the largest scale, for generators of the largest capacity, and for the most rapid developments of electric supply undertakings. In this connection Chicago, to which so many records have fallen, offers, perhaps, one of the best examples of modern central station design.

Practically all the electric lighting and industrial service in Chicago, except street lighting, is furnished by the Commonwealth Edison Company. This company, which is the result of various consolidations, has a franchise covering the whole city. Besides furnishing electricity for lighting and power, the company also sells a large amount of energy in bulk to street and elevated railway companies and to inter-urban railways. In fact, all recent requirements for electric power supply due to developments of the railways and to the conversion of the cable tramways to electric traction have been met by the purchase of energy from the Commonwealth Edison Company.

As indicating the extent of its business, we may mention that its annual report for the year ended September 30th last showed gross receipts of nearly £2,000,000, and a gross profit of between £600,000 and £700,000. The connections to the mains on the same date were equivalent to about 250,000 kw., excluding a supply of nearly [illegible] kw. to street railways and other undertakings.

The supply is given from four generating stations, although two of these will eventually control most of the load. These stations [illegible] current to 53 sub-stations of the company and 11 sub-stations [illegible] to various railway companies.

We give in Fig. 1 the load curve for December 1, 1908, a clear day, [illegible] the maximum load recorded was 117,570 kw., the average load being equivalent to 58,570 kw., the cross-hatched portion of the curve representing the battery output. Fig. 2 is also interesting as showing the proportion of the total load on the same day which was accounted for by the supply for traction purposes, and also the growth of the load in the last five years.

The outputs of the three main stations—viz., Fisk-street, Quarry-street and Harrison-street—are indicated in Fig. 1. Of these stations Quarry-street has only recently been opened, and with its present rating of 42,000 kw., in three units only, is practically devoted to generating energy for railway load.

The Fisk-street station, the pioneer steam turbine power-house in America, was opened in 1903, and has now 10 turbo-generators, with a rating of about 100,000 kw. Although this is only about three-fourths of its ultimate rating, it was thought well to put in hand the Quarry-street station last year, and, in view of the magnitude of the operations of the company, this step was certainly justified from the point of view of reliability of operations. In conjunction with other companies, energy is transmitted a total distance of 100 miles to the south and 50 miles to the north, so that the total range of the power supply is no less than 150 miles.

The Fisk-street station lies on the south branch of the Chicago river, about 3 miles south-west from the centre of the business area, whilst the new Quarry-street station has been erected on the other side of the river and adjacent to the Fisk-street station. The two stations are entirely distinct, and a breakdown in one would not affect the other. On the other hand, there is one chief engineer for the two, and the station staffs of 350 hands can be transferred from one station to the other as necessary. The two stations thus, besides operating in unison, mutually support each other.

A direct-current supply of electrical energy is given at 115 and

230 volts in the central part of the city, and also 60 cycle 115 and 230 volt single-phase alternating current for lamps and for motors rated up to 5 H.P.; whilst three-phase current is supplied for motors rated above 5 H.P.

The greater part of the output is generated at 9,000 volts 25 cycles three phase and transmitted to sub-stations. Sub-stations for direct-current energy distribution contain step-down transformers and rotary converters. The sub-stations for alternating-current energy distribution contain motor-generator frequency changers, which receive three-phase 25 cycle 9,000 volt current and deliver 60 cycle current for four-wire three-phase energy distribution with 2,200 volts between each phase wire and neutral, and 3,800 between phase wires.

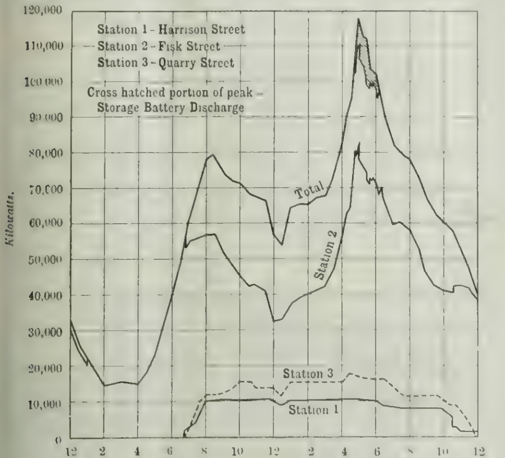


*FIG. 1.—LOAD DIAGRAM, SHOWING PROPORTION OF LOAD CARRIED BY DIFFERENT STATIONS.

The district in which a direct-current supply is given extends approximately 6·5 miles north and south along Lake Michigan and 2 miles back from the lake. The direct-current network, which was started many years ago, was originally supplied with energy from a small direct-current station in the heart of the business district. In 1892 a large generating plant was built on the Chicago river at Harrison-street, about 0·5 mile from the company's direct-current load centre. In the meantime small direct-current generating plants had also been installed. Later, various alternating-current plants which had been established in the residential districts were acquired. The Harrison-street station, originally started as a direct-current plant, became a combination of direct and alternating current. It now has half its 18,000 kw. rating in alternating-current generators and the other half in generators for feeding energy directly into the direct-current network. Some of the latter generators, however, are provided with alternating-current collector rings, so as to give either alternating or direct current.

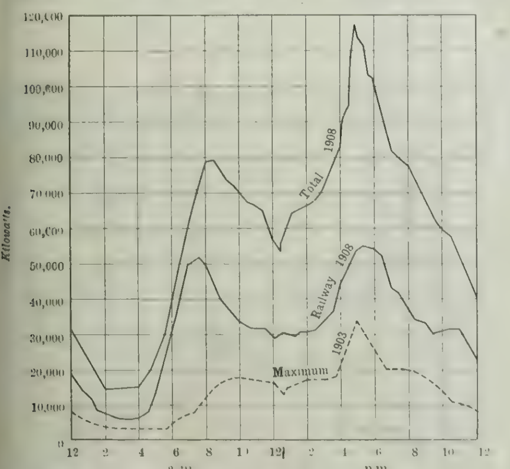


FIG. 2.—LOAD DIAGRAM, SHOWING TOTAL LOAD, 1908; RAILWAY LOAD, 1908, AND LOAD IN 1903.

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The transmission of energy to sub-stations was first accomplished by double-current generators. The E.M.F. was afterwards increased to 4,500 volts three phase, the energy being transmitted into sub-stations. Later the E.M.F. was doubled, making it 9,000 volts three phase, which is to-day the standard transmission E.M.F. of the system. As to frequency, the selection of 25 cycles made it possible for the supply company to offer electrical energy to the electric railway companies at such a voltage and frequency that it could be used in standard rotary-converter sub-stations erected by the railway companies. If at any time the railway companies wished to generate their own energy, no sub-station investment would be lost, and the generating apparatus used to supply energy to them could be applied to increasing the electric lamp and motor load. In this way neither company would take any risks.

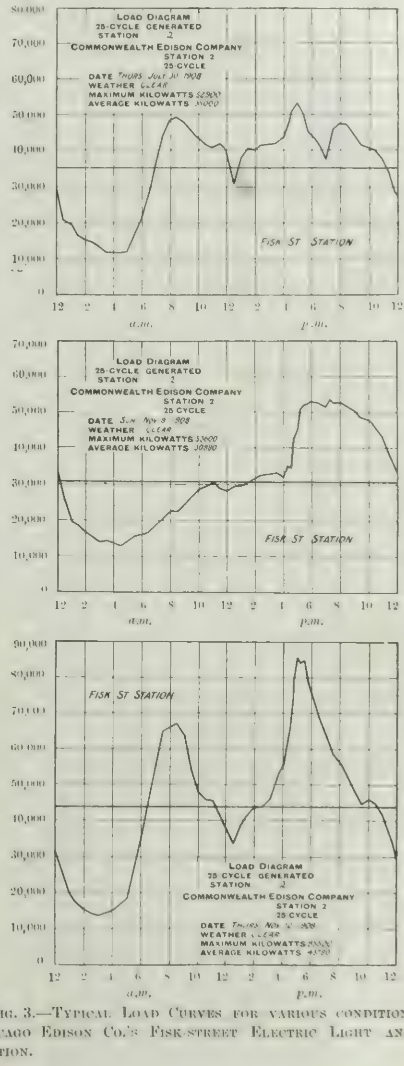


FIG. 3.—TYPICAL LOAD CURVES FOR VARIOUS CONDITIONS OF THE CHICAGO EDISON CO.'S FISK-STREET ELECTRIC LIGHT AND POWER STATION.

A feature of the direct-current network is the 15 storage batteries, which are kept floating on the line purely for emergencies. They

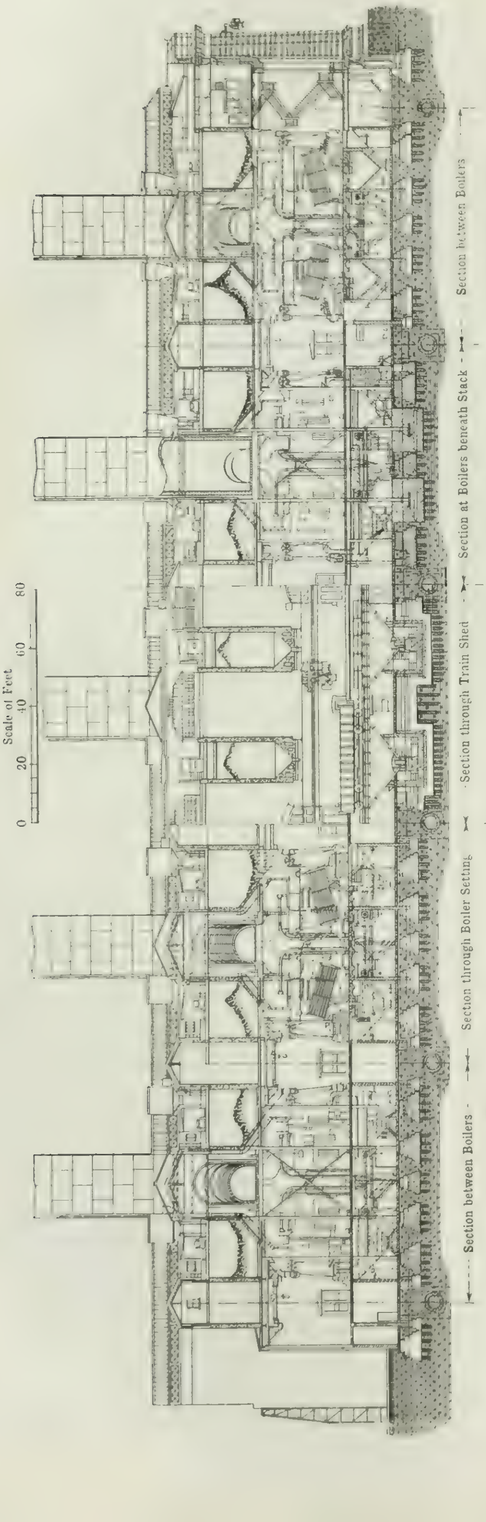


Fig. 4.—Longitudinal Sectional Elevation through Boiler Room of Fisk-street Station, looking West.

are located in converter sub-stations and occasionally in separate buildings.

Fisk-street Station.

This station, of which a view is given in Fig. 5, affords an excellent example of the progress made of recent years in generating plant for power supply, and also of the rapid growth in demand for energy. Some five years ago, when this station was under construction, it was arranged to instal 14 5,000 kw. turbine units—*i.e.*, a total

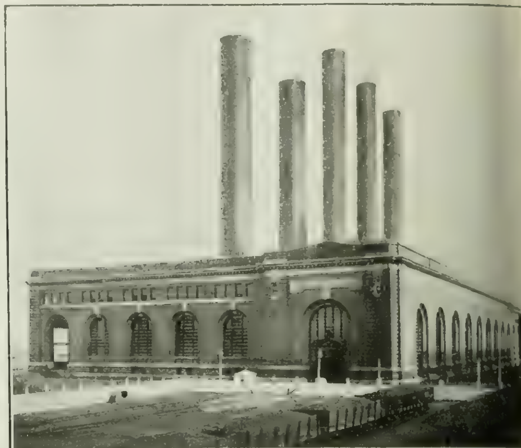


Fig. 5. Exterior view of Fisk-street Power Station of the Chicago Edison Co.

capacity of 70,000 kw.—which was considered as ample for the requirements of many years. Now, however, the station can carry a peak load of 100,000 kw., although it has not yet covered the whole of the site intended, whilst across the river the company has found it necessary to erect another huge station—the Quarry-street station—to meet the increasing demand.

The first three units installed in the Fisk-street station were each rated at 5,000 kw., with an overload capacity of 6,250 kw. The

Fig. 6.—Interior of Boiler House, Fisk-street Power Station of the Chicago Edison Co.

fourth unit was also of 5,000 kw. capacity, but its overload rating was 7,500 kw. The last six units are each rated at 8,000 kw., and can carry 12,000 kw., whilst the earlier units are now being replaced by units of 8,000 kw. capacity.

It is interesting to learn that over 1,000,000 kw.-hours are generated in this station each day, and this is the more striking when it is

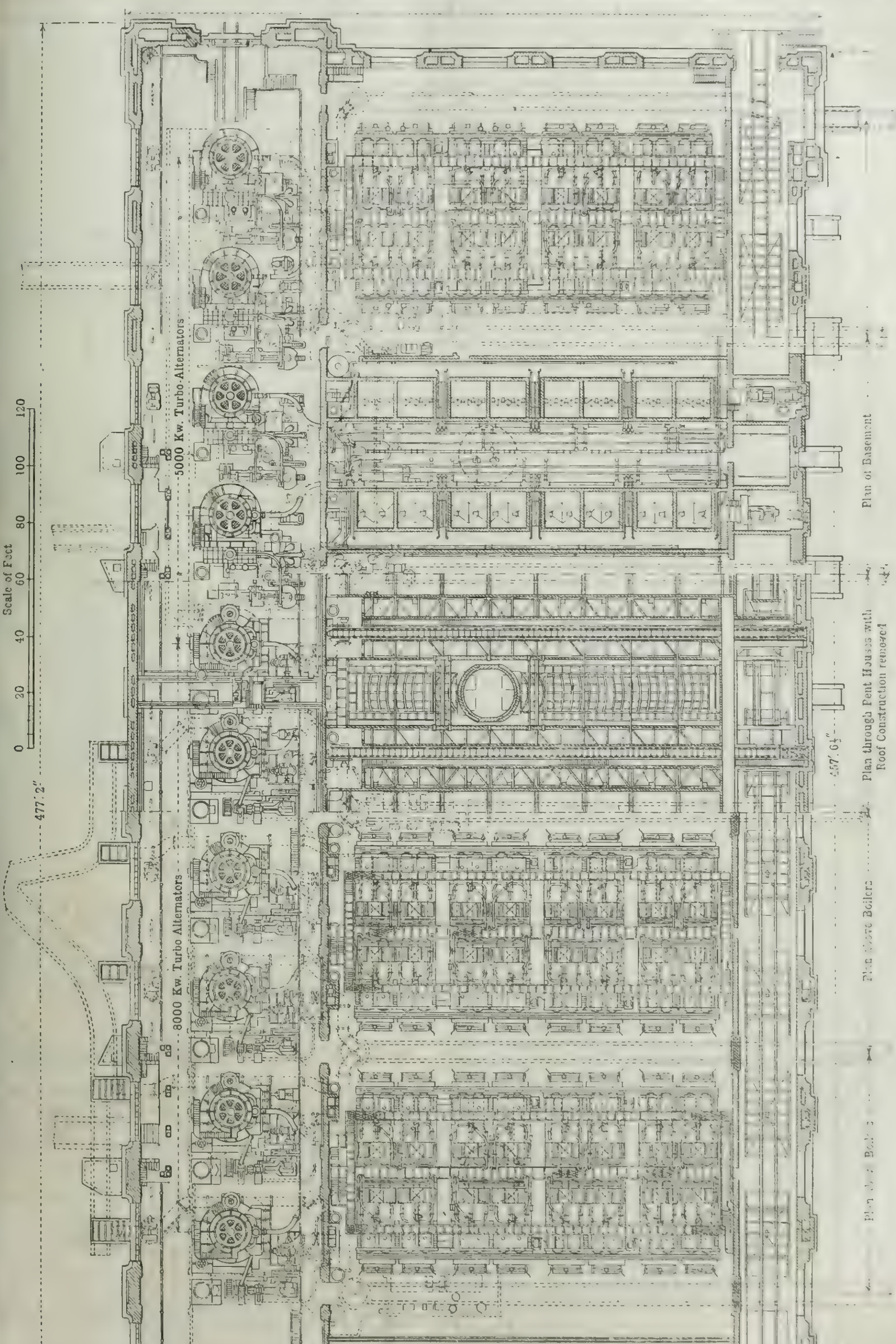


FIG. 7.—PLAN SHOWING GENERAL ARRANGEMENT OF PLANT IN FISK STREET STATION.

learnt that the first plant was only started up in October, 1903, whilst the first of the last six large units only came into use in September, 1906. One of the reasons for the rapid growth in the demand has been the ability of the company to offer current to various railway companies and other consumers at figures which are beyond the possibilities of independent generating plants. This is, of course, largely due to the economical steam consumption, 13·07 lb. per kilowatt-hour, and the low capital cost per kilowatt of the large plant units installed. In Fig. 3 are shown typical load curves of the Fisk-street station under different conditions.

Coal is brought in by rail, but as a canal exists on each side of the Fisk-street property, which is situated on the Chicago river, coal can in case of emergency be brought by water.

The general arrangement of the Fisk-street station is shown in Fig. 7 herewith, whilst longitudinal and cross-sectional elevations are shown in Figs. 4 and 8. Opposite each turbine unit, at right angles to it, is a battery of boilers of sufficient size to supply steam to that unit. The "comb" arrangement of apparatus is a very desirable one in many respects and makes a simple arrangement, all the boilers supplying steam to a single turbine unit on one floor in two straight lines. This plan simplifies the conveying and storage arrangements, and the piping is also not complicated. Part of the boiler house is seen in Fig. 6.

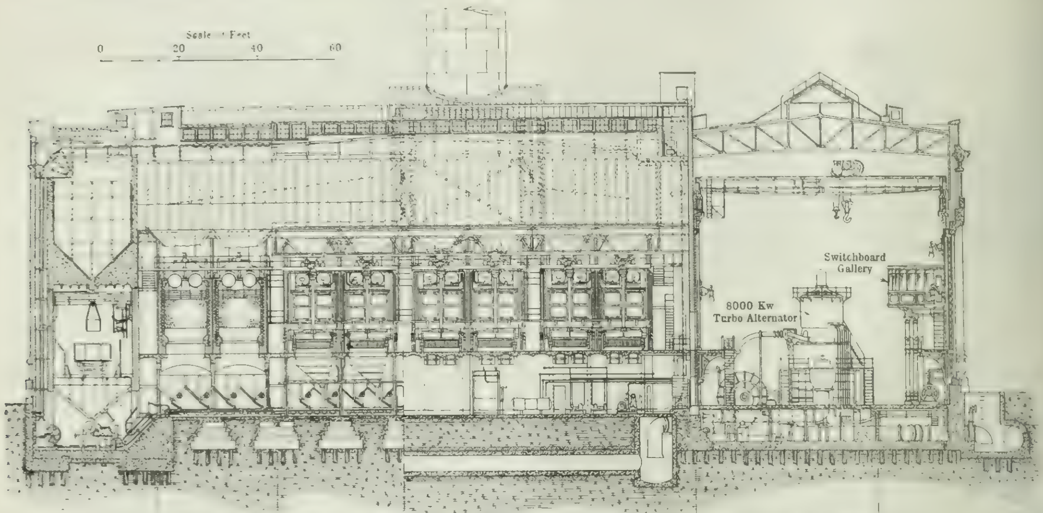


FIG. 8.—CROSS SECTIONAL ELEVATION AT FRONT OF BOILERS, FISK-STREET STATION, CHICAGO.

Coal is received in the train shed at one side of the boiler room. If it is in dump cars it is simply delivered into hoppers, from which it is taken by conveyors to coal bunkers over the boilers, as shown in Fig. 8. When dump cars are not obtainable (which is true with most of the coal delivered to the station) electrically-operated grab buckets are used to do most of the unloading. In this case it is, of course, necessary for labourers to clean out the corners of the cars. Each row of boilers has its conveyors, the same set of conveyors serving for both coal and ashes. Each conveyor can handle 75 tons per hour, the conveyor serving only one turbine unit. The station uses about 1,500 tons per day, and the bunkers can hold 10,800 tons.

For each turbine unit there are eight Babcock & Willcox water-tube boilers, with B. & W. chain-grate stokers, each boiler having a heating surface of 5,087 sq. ft. The usual rating of such boilers gives a nominal rating of about 4,100 H.P. for each bank of boilers. This rating, however, is largely of academic interest in connection with this station, where the rates of working the boilers and the economy of the turbines make it possible for a bank of these boilers to supply steam to turbines of 8,000 kw. rated output, working sometimes at 12,000 kw. The grate areas of boilers supplying steam to the first three units is 76·5 sq. ft. for a heating surface of 5,087 sq. ft. On unit No. 4 the boilers have a grate area of 8,325 sq. ft. On units 5 to 10, which have a rated output of 8,000 kw., the boilers have 90 sq. ft. of grate surface. These boilers are, therefore, worked at a very high rate of steaming. The steam pressure is 200 lb. per square inch. The boilers have superheaters of 900 sq. ft. surface, and the amount of superheat is 150 deg.

Turbine performance having been brought to a high state of efficiency, boiler-room economies are being strictly looked after. Boilers have been tested under very high rates of combustion up to 150 to 200 per cent. of their rated output. The best economies seem to be obtained under these conditions, the flue gas temperature being only a little higher than at lower rates of working. The coal used averages 10,430 B.Th.U. per pound.

In the regular operation of the Fisk-street station the aim is to vary the number of turbine units in operation from time to time, so as to have each machine run as nearly as possible at its rated load. Boilers not in use, but to be called for at some hour of the day, are kept under pressure with fires banked. The latest and most efficient units are, of course, operated as much of the time as possible, the first units installed being used only for peak load. The coal consumption during 24 hours averages about 3·33 lb. per kilowatt-hour.

The steam pipe line from each row of boilers connects to one turbine. Cross-connections are provided so that these boiler unit rows can be connected in pairs, but pairs cannot be connected together. In this way the station is completely sectionalised, so that trouble on the pipe lines of one unit cannot spread to others.

There is one stack for each two boiler and turbine units. Three of the stacks are 256 ft. high and 18 ft. 10 in. inside diameter. The other two stacks are 200 ft. high.

(To be continued.)

BOARD OF TRADE REVISED REGULATIONS.

Owing to the issue of the Home Office Regulations for the generation, transformation, distribution and use of electrical energy in premises under the Factory and Workshop Acts, 1901 and 1907, the Board of Trade have found it necessary, so as to prevent overlapping between the regulations of the two departments, to amend the regulations, made under the Electric Lighting Acts, 1882 and 1888, for securing the safety of the public and for ensuring a proper and sufficient supply of electrical energy. A new series of regulations has accordingly just been issued by the Board of Trade, and from July 1, 1909, these take the place of the regulations previously made by the Board, except as to so much of any electrical station as was constructed before July 1, 1908. After January 1, 1910, however, the new regulations will entirely supersede the older ones.

Special forms are, as before, provided to meet the following cases: (1) A local authority in the Provinces, (2) a company

in the Provinces or in the City of London, (3) a company in London except as to the City, and (4) a local authority in London. Only small variations exist, however, between the different forms, and we shall merely mention the principal alterations in the form relating to local authorities in the Provinces.*

The expressions "workshop" and "quarry" are now added, and are stated to have the same meaning as in the Factory and Workshop Act, 1901. The regulations as to pressure of supply to consumers and the introduction of a three-wire system into a consumer's premises do not now apply to factories, workshops, mines or quarries. Also, an extra high pressure shall not be given to any consumer's premises other than a factory, a workshop, a mine, a quarry, or electric traction works, waterworks, sewerage or drainage works, the consent of the Board of Trade being necessary in the four last-mentioned cases.

Regulations 9 and 10, relating to the earthing of transformers and the provision of an automatic device for protecting a consumer's wires from contact with or leakage from the high-pressure circuit of transforming apparatus, will not in future apply within the premises of a factory, workshop, mine or quarry, where the high-pressure transformer is under the jurisdiction of the Home Office.

"Due provision is to be made for ventilation and drainage in sub-stations." This sentence replaces in the regulations that in which it was stated the plans of sub-stations were to be approved by the Board of Trade.

No fuse or automatic circuit-breaker is to be inserted in the intermediate conductor of a three-wire system; the exception formerly made in the case of systems where the pressure between adjacent conductors did not exceed 125 volts is no longer allowed.

The approval of the Postmaster-General will in future be no longer necessary for the earthing of the intermediate conductor of a three-wire system.

SOLID RECTIFIERS.†

BY G. W. PICKARD.

Reference is first made to the early work of Braun on unilateral conductivity. The application of this to rectifying alternating or oscillating currents does not appear to have been considered until wireless telegraphy had been in use for some years, and the influence of Braun's incorrect crystalline-structure theory of the action has persisted to the present time.

Early in the present investigation the writer discovered the necessity of establishing for the second circuit terminal of the unilateral conductor a contact not only substantially perfect, but of large area. In the lack of such a contact of large area, the rectification obtained was not only variable as to direction, but was frequently entirely absent, owing to an opposing action at the second contact, which, if of small area, itself acted as an opposing rectifier, thereby reducing or even eliminating the observable rectifying action. Also the direction of rectification is always the same for the same conductor regardless of the position of the contact of small area with respect to the crystal faces or structure. This is clearly shown by the following experiment, which can be made with any asymmetric conductor. The conductor is first shaped into a rough cube, and one of its faces pressed into molten fusible metal, which is allowed to cool and solidify, thereby securing a perfect contact of large area. The remaining five edges of the cube can then be explored with an electrode of small area, with the invariable result that the rectification observed is always in one direction.

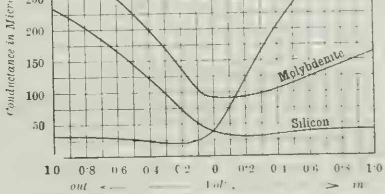
The writer has discovered a number of amorphous rectifying conductors. Among these are varieties of silicon, and solid solutions of certain metallic oxides (notably zinc oxide), in readily fusible silicates. Optical and other tests have shown the entire absence of regular crystalline structure in these conductors, yet they possess marked rectifying properties, the rectification being always in the same direction for the same conductor. A hydraulic analogy of the solid rectifier is then given by the author.

Among the many solid rectifiers discovered by the writer, there are three which have proved of commercial value in wireless communication. These are the silicon, perikon and molybdenite detectors, constructed respectively from the unilateral conductors, silicon, zinc oxide and molybdenum sulphide. Although these all act as rectifiers, they are not equally efficient as wireless detectors, the best being the zinc oxide or perikon detector. The characteristic voltage conductance curves of these three detectors, when in their most sensitive state as wireless detectors, are shown in the accompanying curves. The rectifying conductors were in all cases set in fusible metal, to insure a perfect contact of large area for the non-rectifying terminal, while the contact of small area, or rectifying terminal, consisted of a rounded brass point on both silicon and molybdenite, and a fragment of chalcopyrite, or copper-iron sulphide, for the perikon or zinc oxide detector. By varying the adjustment, it was found possible to produce much higher ratios between the "in" and "out" conductances than those shown in the curves, but with such adjustments the efficiency as a wireless detector was found to be materially reduced.

It has also been discovered by the writer that in all solid rectifier detectors investigated, the action is materially improved by the use of a small E.M.F. in the detector circuit, this being arranged so as to send current through the rectifier in the direction of the rectified current, its magnitude being such as to bring the conductance of the detector to the steepest part of the curve.

The author has no satisfactory explanation of the phenomena of rectification in solid conductors. In his early work he adopted the thermoelectric hypothesis for public explanation, not that it was satisfactory, but because it was at least understandable and fulfilled many of the conditions. Curiously enough, all of the rectifying conductors possess high thermoelectric power as well as high specific resistance (at least in comparison with any of the metallic conductors) and high thermal conductivity. There is undoubtedly a connection between high specific resistance and thermoelectric power.

In the early rectifying conductors examined by the writer the thermoelectric currents were in the same direction as the rectified



CHARACTERISTIC CURVES OF VARIOUS SOLID RECTIFIERS.

current. This seemed to support the thermoelectric theory of the action, but later a number of rectifying conductors, such as, for example, impure silicon, were found to have the thermoelectric current in the opposite direction to the rectified current, and when tested as detectors the resultant current was found to be in the reverse direction from that produced by heating the junction, thereby proving that the action could not be thermoelectric.

Although the author has no entirely satisfactory theory, he advances the following: As an extremely perfect contact of small area is one of the requisite conditions for the manifestation of the rectifying property, it is evident that the current flow in the rectifying conductor must be extremely constricted in the immediate neighbourhood of this small contact. Such extreme constriction of current path in material where the conduction is not metallic may lead to electronic impoverishment of either the positive or negative electrons, according as the conductor is an "in" or "out" rectifier, thereby making the passage of either "in" or "out" currents difficult, the conductor and contact of small area then acting as a rectifier. The improvement noted when a small E.M.F. of the proper amount and direction is employed in the detector circuit may perhaps be due to the further electronic impoverishment created by such a current.

* The previous regulations will be found in "THE ELECTRICIAN" Electrical Trades' Directory and Handbook, 1909, p. 217.

† Abstract from the "Electrical Review and Western Electrician."

BOOKS RECEIVED.

Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Exercises in Physical Chemistry." By Dr. W. A. Roth. Authorised translation by A. T. Cameron. (London: A. Constable & Co.) 6s. net.

"Proceedings of the Royal Society." Vol. LXXXII. No. A755. Series A—Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The thirty-seventh issue of the Supplement was published (Gratis) with the number of "THE ELECTRICIAN" for June 25.

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LARGE POWER STATION UNITS.

Some years ago, when the reciprocating steam engine still occupied the first place in all schemes for the production of electrical energy on an extensive scale, it was sometimes stated that no advantage would result from increasing the capacity of individual units beyond about 7,500 kw. The advent of the steam turbine and its rapid development have, however, considerably altered the conditions, and there would, at present, seem to be practically no limit to the economical size of this type of plant; in fact, the economy, particularly as regards capital cost, resulting from the use of units of what, even two years ago, would have been considered a phenomenal size has scarcely yet been fully realised, whilst the effect on the cost of production of electrical energy has not, up to the present, had time to become apparent.

Although in this country we have a few examples, on a smaller scale, of recent developments in turbo-generators, it is to America that we must turn to observe the rapidity with which the construction of this type of plant has advanced concurrently with the demands for electric power. Probably the most interesting example of such progress is provided in the case of the Commonwealth Edison Co., of Chicago. The engineers of that company have always been to the fore in appreciating the possibilities of steam

turbines. When the large Fisk-street station in Chicago was constructed some five years ago, it was designed for the installation of fourteen 5,000 kw. turbo-generators, which were, of course, at that time mammoth units; but after the installation of four units of that size it was decided to go in for still larger machines, and the next six machines were each of 8,000 kw. capacity, with an overload rating of 12,000 kw. It will therefore be seen that a station of about 100,000 kw. capacity was equipped in only a few years.

It might be thought that, with the already existing power stations, the demands of Chicago for electrical energy would be met for some time to come, but this has proved far from being the case, and last year it was actually found necessary to erect a new power station, known as the Quarry-street station. The most interesting feature of the new plant is, perhaps, that, although two years ago 8,000 kw. units were considered large, units each of 14,000 kw. capacity have been installed in the new station, two of them coming into operation for supply purposes towards the end of last year, whilst a third was installed last month. Even this does not appear, however, to meet the demands for electrical energy, since the 5,000 kw. sets installed a few years ago in the Fisk-street station are rapidly being removed to make room for sets of 8,000 kw. capacity. This shows how great an allowance for antiquation should be made under certain conditions. At present it has been decided to make the 14,000 kw. size of unit a standard, but in view of the developments just referred to, it is scarcely probable that a limiting size has been reached, and engineers in this country, where the two 6,000 kw. sets of the Manchester Corporation and the 5,500 kw. sets of the Newcastle Power Company are the largest examples of turbine construction, can only look on in amazement.

Such rapid growth in electrical power supply seems almost phenomenal, but it is due, to a considerable extent, to developments in electric traction, both tramways and railways; in fact, the new Quarry-street station, with its 14,000 kw. units, is to deal entirely with the traction load, although it can be coupled in parallel with the Fisk-street station when necessary. With plant of this magnitude it is obvious that capital charges are reduced very considerably, and it is interesting to learn that some of the large contracts made for power supply to railway companies are based on a figure of £3 per annum per kw. of maximum demand together with 0·20d. per unit, the maximum demand being based on the maximum consumption of energy in any one hour. The development of the industrial motor load also accounts very largely for the rapidly increasing demand for electrical energy, and with developments of the magnitude outlined above, the metal filament lamp problem—as it is known in this country—sinks into insignificance, even if it is experienced at all. Consideration of this fact should prove interesting to electric supply engineers in this country.

It will be understood that the rapid growth of the Chicago system and the equipment of the two large power stations have brought with them numerous problems, so that considerable interest will doubtless be taken by our readers in the description of the system which we are able to supply, an instalment being given elsewhere in this issue.

The question of reliability is one which, where the whole power and lighting supply of a city is being concentrated in one station, must be kept to the front, and one is forcibly reminded of the discussions which took place in connection with the London Power Bills. A comparison with London, however, cannot be made, for the conditions in the two cities are entirely different. In the case of Chicago the electricity supply undertaking has practically grown up within the last few years, whilst in London a large number of independent medium-sized power stations have existed for a long time, and the possibilities of extensive developments in electric power supply in London are, at present, comparatively limited. Although, perhaps, considerable economies could be effected by concentrating the power supply for London in one or two generating stations, any such saving would be more than offset by the loss due to "scrapping" existing plants capable of performing useful work. In a rapidly developing country such "scrapping" might be justified, but it is very doubtful whether it would pay under the conditions peculiar to this country. Much can be done, however, by co-operation between existing undertakings, to which point attention was drawn by Mr. S. L. PEARCE in his recent presidential address to the Incorporated Municipal Electrical Association. At the present time, although considerable developments in power supply for industrial and domestic purposes are likely, we shall probably have to wait for the wholesale electrification of suburban railways before power stations of a size now becoming common in the United States are laid down. In the meantime the installation of large units abroad will be watched with interest, and additional emphasis will be given to the mistakes so often made in installing units of a size sufficient only to meet temporary requirements.

REVIEWS.

Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Sammlung Elektrotechnische Lehrheite. Edited by FRITZ HOPPE. (Leipzig: Johann Ambrosius Barth.) Vol. I. "Grundgesetze der Allgemeinen Elektrizitatslehre." Pp. vi.—109. M 4. Vol. II. "Prinzip und Wirkings-weise der Technischen Messinstrumente fur Gleichstrom." Pp. iv.—61. M. 2.70. Vol. III. "Widerstandsbestimmungen." Pp. viii.—98. M. 4.

These books are apparently intended as the German equivalent of "The Electrician" Primers, and a series of 10 volumes is proposed, of which the three above mentioned are the first to appear. The first two volumes of the series are concerned with the fundamental principles of direct-current and of alternate-current engineering respectively: Vols. III. to V. will deal with direct-current and alternate current measuring instruments and supply meters; Vols. VI. and VII. with testing; Vols. VIII. and IX. with generators and motors; and Vol. X. will form a summary of the preceding.

In Vol. I., "Fundamental Principles of General Electrotechnics," a very clear and practical digest of the essential electrical principles is given, together with a good deal of valuable practical information. Starting from the hydraulic analogy, which is very well put, the author goes on to the fundamental principles of electrostatics and magnetism, and to a remarkably thorough discussion of units and dimensions. He then deals with electromagnetic induction, leading up to the essential theory of the dynamo machine; with primary and secondary batteries, and with general electrical calculations. There are a few blemishes, notably in the treatment of lines of force and of the resultant magnetic field due to several magnets; but as a whole the book may be warmly recommended for those who have had some elementary pre-

paration in electrical science, and require the essentials of electrotechnics summarised in a short space.

Vol. III., on the principles and action of direct-current measuring instruments, calls for little comment. It is elementary in character, and contains a fairly good description of the principal forms of galvanometers, electrometers, ammeters and voltmeters, with some useful information concerning their properties. Soft iron and hot-wire instruments receive the greatest amount of attention, and electrostatic voltmeters, including those for extra high-voltage measurement, are clearly explained. The latter part of the work contains a number of diagrams showing the connection of ammeters and voltmeters with selector switches for various testing and switchboard purposes.

Vol. VI., on resistance measurement, is a curious book. Containing as it does 94 pages and 120 illustrations devoted entirely to resistance measurement, it is certainly somewhat astonishing to find absolutely no mention of standards of high or low resistance, or of accurate methods of comparison, and very little information as to resistance alloys, &c. It devotes the first 16 pages to the methods of direct comparison, the ordinary slide wire bridge and the Siemens universal galvanometer, all of which one would have thought as extinct as the dodo. As a redeeming feature, the Carey-Foster method is mentioned, although it is almost unknown in Germany (but the connections given are very unsuitable for accurate work); and the German form of Kelvin double bridge, which is certainly superior to those employed here. The various methods of measuring the resistances of coils, insulation, batteries, galvanometers and armatures are very fully dealt with, but many of the methods seem redundant and obvious to any intelligent experimenter. The final portions, on insulation testing on supply systems and secondary batteries, and on fault testing on mains, seem sound, practical, and original.

C. V. D.

Electric Bells By S. R. Bottone. 7th edition (London: Whittaker & Co.) Pp. vii.—154. 2s. net.

The author devotes the first chapter to elementary facts relating to magnetism, and the second to "the choice of batteries for electric bell work." The latter is largely descriptive of the actions which take place within a primary cell. Mr. Bottone's literary style is highly diverting at times, as the following indicates: "When the entire surface of the zinc becomes resplendent like a looking glass, the rubbing may cease, and the zinc plate be rested up on edge to allow the superfluous mercury to drain off." He represents various elements and compounds by their chemical symbols "for brevity's sake"! Electromotive force is defined in a footnote as "power to set up a current of electricity."

Mr. Bottone gives a very large number of quotations, including one of apparently several pages from a Mr. Edwinson on the making of electric bells. Later on, in writing of signalling by bells, he quotes two more pages from Mr. Edwinson, "who has given much time to the elucidation of this system of bell signalling," the system being one in which long and short rings are employed to represent dashes and dots in the Morse code! We strongly recommend our readers to purchase this one of Mr. Bottone's many books when in need of light literature with which to while away the time if it should drag heavily.

STREET LIGHTING IN LARGE CITIES.

It will be remembered that last October the Streets Committee of the Corporation of London was authorised to appoint a deputation to visit certain Continental cities for the purpose of inspecting the various systems of public lighting and to report thereon. The members subsequently appointed to form the deputation were Messrs. C. A. Teuten (*chairman*), B. Turner, J. Stopher, J. Gunton and G. G. Stanham, who, between March 18th and April 1st, visited Brussels, Cologne, Düsseldorf, Berlin, Dresden, Vienna, Munich and Paris.

In the report of the deputation, which has just been issued, particulars of the various systems of lighting inspected are given, and also particulars of the lighting in the City of London. This latter the deputation consider can be materially improved, and their conclusions are as follows:—

1. That, wherever possible, streets should be lighted by means of centrally hung lamps with lowering gear. This is considered particularly important in the City of London where the number of obstructions upon the footways in the form of lamp posts, bins, letter-boxes, &c., is so large.

2. That open spaces should be lighted by means of lamps upon standards, fitted with lowering gear.

3. That high pressure incandescent gas lamps with inverted burners should be adopted as the illuminant, but where gas is impracticable, electricity with open arc and flame arc lamps should be installed.

The deputation think, however, that before suggesting any drastic alterations in the general lighting of the City the Streets committee should be authorised to arrange for some further experimental lighting of the city thoroughfares.

We give below a full abstract of the particulars of the various systems of street lighting as contained in the report of the deputation.

Brussels.—The main thoroughfares, squares and markets are lighted by means of electric arc lamps, with an ordinary incandescent gas burner on either side. The arc lamps are turned off at midnight, after which time the lighting is supplied by gas. The side streets are illuminated by incandescent gas burners. The total number of arc lamps is 238, supplied by direct current. The distance (not diagonal) between the lamps is 98 ft. to 115 ft., the average height of the lamps being about 20 ft. The width of the streets in which open lamps are used varies from 82 ft. to 98 ft. The cost per lamp per annum (half night only), including interest, depreciation and all other charges, is £14. 9s. 7d. There are only two centrally-suspended electric arc lamps in the Market Place (width about 200 ft.), taking 1,100 watts each, at an altitude of about 70 ft. No accidents have been reported to have occurred from this method of attachment. Electric glow lamps are not used in the public streets of Brussels. Incandescent gas lighting is largely used. The type of lamp most prevalent is a conic lamp with two upright burners, also inverted burners in groups of three or five. These lamps consume from 3½ to 8½ cubic ft. of gas per hour, according to the burner, the illuminating power obtained by the upright burners being equal to 55 candles and of the inverted burners 133 candles. There are no public high-pressure incandescent gas lamps in Brussels. The lighting of the city, both by gas and electricity, is carried out by the municipal authorities without the intervention of a contractor.

Cologne.—The important streets of the city are lighted by centrally-hung electric lamps, the open spaces by a combination of electricity and gas, as in Brussels, the minor streets mainly by incandescent gas lamps upon standards. The total number of arc lamps is 426, supplied by alternating current, both open and flame lamps being used. One-half of the lamps are centrally hung, the others being fixed upon standards. The distance between the open lamps is 88 ft. to 115 ft., and between the flame lamps 121 ft. to 148 ft. The lamps are fixed at a height of from 26 ft. to 33 ft. in streets from 23 ft. to 148 ft. wide. The cost per annum per lamp, including interest, depreciation, &c., is for open lamps £11. 5s. 6d. each, for flame lamps £9. 6s. 3d. each. The centrally suspended arc lamps are fixed about 30 ft. above the roadway, 110 ft. apart, and give a light equal to about 1,300 candles each. By a simple arrangement the lamps are drawn aside over the pavement and lowered for trimming, &c. Only one accident has been reported since the lamps were fixed.

117 electric glow lamps are used in the streets, of which 30 are carbon filament 14 c.p. lamps, and 87 metal filament 28 c.p. lamps. The lamps are fixed in groups upon columns about 100 ft. apart, at an average height of 11 ft. 6 in. The cost per annum per lamp, including interest, depreciation, &c., is, for carbon filament lamps, £2. 14s., metal filament lamps £2. 4s. 2d. There are only 10 high-pressure gas lamps, giving a light of from 460 c.p. to 1,080 c.p., and are purely experimental. Incandescent gas lighting (low pressure) is largely used, there being 192 miles of side streets. The gas per burner is about 4½ cubic ft. per hour, giving a light of 63 c.p. to 72 c.p. The cost per annum, including interest, depreciation, &c., is, for lighting up to midnight, £2. 11s. 8d., all night £3. 5s. 3d. Gas and electric lighting are provided by the municipality.

Dusseldorf.—The city is lighted in a somewhat similar manner to Cologne—arc lamps on standards and centrally hung, supplemented by incandescent gas. The total number of arc lamps is 334, of which 24 are supplied by alternating current and 310 by direct current. Open and flame lamps are used, each lamp taking about 650 watts. 149 of these lamps are fixed upon standards and brackets, centrally-suspended lamps to the number of 185 being used in narrow streets, the lowering gear being fixed to the sides of the houses, as in Cologne. The average distance between open lamps is about 164 ft., and between flame lamps 197 ft. to 394 ft. The lamps give a light of about 2,000 c.p., and are fixed at a height of about 30 ft. in streets from 33 ft. to 98 ft. in width. One-half of the lamps are extinguished at midnight. The total cost per annum per lamp, including interest, depreciation, &c., is £17. 13s. Electric glow lamps are used also; there are 120 carbon filament lamps of 14 c.p. and 22 c.p., and 111 metal filament lamps of 22 c.p. and 90 c.p.

Incandescent gas lighting is used generally in the streets and for ornamental lighting, and the lights are of the upright incandescent type, consuming about 4·4 cubic ft. per hour, with an illuminating power of 72½ candles. The cost per annum, including interest, depreciation, &c., is, up to midnight, £1. 14s., all night £3. 8s. 3d. There are no public high-pressure gas lamps. Gas and electricity are made and supplied by the municipality.

Berlin.—Gas is manufactured by the municipality, but electricity is purchased in bulk from a private company. The total number of arc lamps (open and flame) is 864, supplied by direct current. 664 of these lamps are fixed upon standards and 200 are suspended across the streets centrally hung. The distance between the open lamps is from 100 ft. to 130 ft. and 98 ft. between the flame lamps. The open and flame lamps are fixed at heights of 26 ft. to 31 ft., a few flame lamps being 52 ft. high; one-half of the lamps are extinguished at midnight. 212 electric glow lamps are used, 177 being of the Nernst type, 14 carbon filament 14 c.p. lamps, and 21 metal filament 440 c.p. lamps.

High-pressure gas lighting is very largely and effectively used in Berlin, 25 miles of streets being lit by 1,531 lamps fitted with upright and inverted burners, two and three burners in each lantern; they are supplied direct from four separate compressing plants at a pressure of about 53 in. to 78 in. (water gauge). The newest type of lamps—viz., the "Graetzin" high-pressure inverted lamp, being fitted with three inverted burners per lantern—give an illuminating value of over 4,000 c.p. for a consumption of 84·8 cubic ft. of gas per hour, two burners being extinguished at midnight. The distance apart of these high-pressure lamps is from 90 ft. to 100 ft., and the average height of the lamps above the roadway about 19 ft. The price of gas was stated to be 1s. 4½d. per 1,000 cubic ft. for public lighting purposes. The calorific value being 540 B.Th.U. This compares favourably with the porposed calorific standard for London gas—viz., 14 candles, 500 B.Th.U.—as inserted in the Gas Light & Coke Co.'s bill before Parliament this session.

The Berlin authorities have decided to spend £350,000 in installing the latest patterns of high-pressure gas lamps with inverted burners, in lieu of the existing gas and electric lamps. Expenditure in this direction has been going on for two years at the rate of £50,000 a year, and will be continued at the same rate for the next five years. The lamps used are graded according to the importance of the thoroughfares—at junctions of main streets, lamps of 4,000 c.p.; in main thoroughfares, lamps of 2,000 c.p.; and in other streets, lamps of 1,000, 600, 400 and 200 c.p., the 400 c.p. and 200 c.p. lamps being on low pressure. So far as gas is concerned, four-fifths of the city is lighted by the municipal authority. Incandescent gas lighting (low pressure) is used for the side streets, there being about 466 miles of streets lighted by 3,000 upright burners and 2,600 inverted burner lamps. The upright burners consume about 4½ cubic ft., and give 63 c.p. to 70 c.p., and the inverted burners consume about 3½ cubic ft. and give about 100 c.p. The lamps are fixed from 82 ft. to 92 ft. apart on the diagonal, at a height of 11 ft. 6 in. to 14 ft. 6 in. In future incandescent gas lighting only will be used in Berlin.

For the "Graetzin" high-pressure gas lamp, a three-burner inverted lamp, made to connect on to a compressing plant at about 54 in. to 67 in. pressure (water gauge), an efficiency of from 45 to 55 candles per foot of gas is claimed. Its dimensions over all are 3 ft. 9 in. by 2 ft. 2 in. Its weight is 86 lb. The mantles at the present time are in use for about nine days; it is, however, probable that the life of the mantle will be lengthened. One attendant serves about 50 lamps—that is, he has to clean them, replace the mantles, &c. The extinguishing and lighting are carried out automatically by change of pressure; after midnight, however, it is done by hand. The streets will be divided into six classes, the first three classes having inverted high-pressure gas lamps of 4,000, 2,000 and 1,000 c.p. respectively, and the three remaining classes low-pressure inverted lamps of 600, 400 and 200 c.p. respectively.

Dresden.—The total number of electric arc lamps is 425, supplied by alternating current, the type of lamps used being open (124), flame (301). 238 lamps are fixed upon side posts, 187 being suspended across the centre of the streets, with side lowering gear. The average distance between open lamps is about 148 ft., and flame lamps 180 ft. The lamps are fixed at a height of about 26 ft. in streets having an average width of 65 ft. The average cost per annum per lamp, including interest, depreciation, &c., is about £26. Electric glow lamps are largely used in the streets, and are fixed upon standards and brackets, and also centrally hung. 72 carbon filament lamps are of 14 c.p. and 22 c.p., and 437 metal filament lamps are of 22, 44 and 260 c.p. The lamps are fixed about 100 ft. apart at a height of 16 ft., and cost £2. 14s. per lamp per annum.

The side streets are lit by means of low-pressure incandescent gas in lanterns fixed upon brackets. The electric arc lamps are switched off at midnight, leaving incandescent gas lighting only. There are 11,715 low-pressure incandescent gas lamps, giving 82 c.p. to 109 c.p. for about 5 cubic ft. of gas per hour. The lamps are fixed about 10 ft. 6 in. above the roadway at distances of 50 ft. to 100 ft. apart, the cost per annum per lamp being £3. There are only 15 inverted burner lamps, and high-pressure incandescent gas lamps are not at present installed. Gas and electricity are made and supplied by the municipal authority.

Vienna.—The general arrangement for lighting is by means of electric lamps upon columns, with incandescent gas lamps fixed upon brackets below, the electricity being switched off at midnight. The total number of electric arc lamps is 1,155, of which 1,139 are supplied by direct current, 16 only being by alternating current. There are no flame arc lamps used for street lighting. There are five centrally-hung electric lamps, and in three cases arc lamps have fallen, but without causing injury to passers by. The open lamps are fixed upon standards at a distance of about 115 ft., at a height of 25 ft. to 40 ft. The average width of streets in Vienna is nearly 100 ft. The cost per annum per lamp including interest, depreciation, &c., varies from £16 to £35, according to the hours of lighting. There are 686 electric glow lamps in use for street lighting and 148 for the three bridges over the Danube. The electric glow lamps are fixed at a height of about 10 ft. At points where the traffic is heavy two lateral arms (each with one carbon filament lamp of 25 c.p.) are fixed to the arc lamp columns. These glow lamps are not switched on until 12 o'clock at night, when the arc lamps are extinguished. The annual cost of those burning all night is £6. 12s. 6d. per lamp, including interest and renewal of lamps, £3. 11s. 9d. per lamp being the estimated cost of running the half-night lamps.

Only nine high-pressure inverted gas lamps have been fixed for experimental purposes; these are of the "Graetzin" type. At present the lamps are only kept alight until 10 p.m. They are fixed upon standards at distances of about 90 ft. to 105 ft. apart, at an average height of 23 ft. The annual cost of these lamps cannot at present be given, but the cost of gas in Vienna is about 4s. per 1,000 cubic ft. Low-pressure incandescent gas lighting is largely used both with the upright and inverted mantles. The shadowless so-called "Ritter" lanterns are generally used, consuming about 4 to 4½ cubic ft. of gas per hour, and giving about 63 c.p. The cost per annum, including interest, &c., is for a single burner, evening £2. 3s. 7d., all night £2. 12s. 3d. The side streets are lighted generally with incandescent gas. Gas and electricity are made and supplied by the municipal authorities. There also exist two privately-owned gas companies and one private electric light company.

Munich.—The number of arc lamps is about 900, supplied by direct current. Open lamps of the "Alba-Carbon" type are generally used. There are also 78 flame lamps. About one-half of the lamps are fixed upon standards at distances of about 200 ft. apart, the lamps being about 33 ft. above the pavement level in streets about 80 ft. wide. The flame lamps are placed at average distances of 160 ft., at a height of 33 ft., in streets about 70 ft. wide. Centrally-hung lamps are fitted with lowering gear, and in some of the widest streets as many as three arc lamps are suspended across the road on a single line. The cost per annum per lamp for arc lamps, including interest, &c., is, for open lamps, about £29, flame lamps £27. Of electric glow lamps there are 96 in use, metal filament lamps being generally adopted. They are fixed on central posts (three in each lantern), and also on brackets, the distances between the lamps being about 162 ft., at a height of 13 ft. in streets about 33 ft. wide. The cost per annum per 55 watt lamp, including interest, &c., is £3. 8s. 8d.

High-pressure incandescent gas lamps are not at present installed. The cost of low-pressure 72 c.p. incandescent gas lamps, including interest, &c., is £4. 4s. 4d. per annum. Gas and electricity are made and supplied by the municipal authorities.

Paris.—The general arrangement for lighting the streets is much the same as in London, electric lamps upon columns being generally used. The total number of arc lamps is 1,899, of which 559 are supplied by alternating current and 1,340 by direct current. The lamps are fixed about 100 ft. apart at about 14 ft. to 18 ft. high, the main streets being 70 ft. to 100 ft. wide. A large number of these lamps are extinguished at 1 a.m. Electric glow lamps are not used in the public streets.

The types of incandescent gas lamps (low pressure) principally used are Bandsept, Denezrouze, La Couronne, Kern, Hondercle and Tirequet, &c., the 3 ft. per hour lamp giving about 66½ c.p., and the lamps are fixed about 80 ft. apart on columns on the sides of the streets. There is not any high-pressure gas lighting in Paris. Electricity and gas are supplied by companies under arrangements with the municipal authorities.

In an appendix to the report are given particulars of the street lighting in the City of London; our readers, however, have been fully informed of all developments in this connection. We may mention, however, that the total number of electric arc lamps is 450, and that 119 high-pressure Keith gas lamps are installed; whilst the number of low pressure gas lamps, principally single burners of the upright type, at the end of the year 1908 was 2,640.

CORRESPONDENCE.

DIFFERENTIAL BALLISTIC METHODS OF MEASURING HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I can merely repeat that I understand and share Mr. Wild's strong feeling of scepticism about our results with bundles; but the matter is one rather for experimental investigation than for open discussion, and had better be left in abeyance till I can resume the experiments which are temporarily suspended. I am only too happy to have suggestions from Mr. Wild as to likely sources of error, and if any mistake has been made I shall be the first to acknowledge it.

I should like, however, to satisfy Mr. Wild that, in the total loss method, due allowance has been made for the want of uniformity in the induction along the test-piece. There is, of course, a decrease in the hysteresis loss per cubic centimetre

towards the ends of a bundle of straight strips owing to the falling away of the induction. This may be taken into account in two ways, either (1) by applying a correction to the induction as measured, say, at the centre, or (2) by applying a correction to the measured loss.

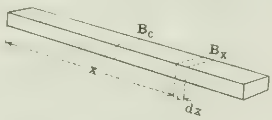
1. In the first place we may take the measured total loss in the whole specimen and ask: What uniform induction throughout the length of the test-piece would give rise to this loss? Obviously an induction less than that at the centre. Calling B_e this equivalent uniform induction and B_c the induction at the centre we may write

$$\mathsf{B}_e = \mathsf{B}_c \times \text{induction correcting factor.}$$

The induction correcting factor is less than unity, and its value can be arrived at by the following process: In a specimen of length l and cross-section A, let B_x be the induction at a distance x from one end. Then the loss in an element dx is $\eta A \mathsf{B}_x^{1\cdot6} dx$, and the total loss in the whole specimen is $\eta A \int_{x=0}^{x=l} \mathsf{B}_x^{1\cdot6} dx$, where η is the hysteretic co-efficient of the material. But if the induction were uniform throughout the length of the specimen and equal to the equivalent induction, the total loss would be $\eta l A \mathsf{B}_e^{1\cdot6}$. Hence, equating these two expressions for the total loss, we have

$$\mathsf{B}_e = \sqrt[1\cdot6]{\frac{1}{l}\int_{x=0}^{x=l} \mathsf{B}_x^{1\cdot6} dx} = \mathsf{B}_c \cdot \left(\sqrt[1\cdot6]{\frac{1}{l \mathsf{B}_c^{1\cdot6}} \int_{x=0}^{x=l} \mathsf{B}_x^{1\cdot6} dx} \right).$$

The quantity in brackets is evidently the induction correcting factor, and its value can be found once the relation of B_x to B_c is known. Assuming the relation between B_x and B_c given by Mr. Gill ("Phil. Mag.," Vol. XLVI., p. 488, November, 1898), it follows that for short bundles the induction correcting factor is constant and equal to about 0·74.



2. The other method of allowing for the variation of induction in the specimen is to take the measured loss and ask: What would this loss be if the induction were uniform throughout the length of the bundle and the same as that at the centre? Clearly the loss would be greater. If we are to refer the measured loss to the induction at the centre we must, therefore, introduce a correcting factor and write

$$\left\{\begin{array}{c}\text{Loss with induction uni-}\\ \text{form and equal to } \mathsf{B}_c\end{array}\right\} = \text{Actual loss} \times \left\{\begin{array}{c}\text{loss correcting}\\ \text{factor.}\end{array}\right\}$$

Since the actual loss is $\eta A \int_{x=0}^{x=l} \mathsf{B}_x^{1\cdot6} dx$ and the loss with a uniform induction B_c is $\eta A l \mathsf{B}_c^{1\cdot6}$ we have:—

Loss correcting factor

$$= \frac{l \mathsf{B}_c^{1\cdot6}}{\int_{x=0}^{x=l} \mathsf{B}_x^{1\cdot6} dx} = \frac{1}{(\text{induction correcting factor})^{1\cdot6}} = \frac{1}{(0\cdot74)^{1\cdot6}} = 1\cdot63.$$

The loss correcting factor, like the induction correcting factor, is thus constant for short bundles.

It is purely a question of individual preference which of the two methods of correcting for the want of uniformity in the induction is employed. In the first the actual loss is referred to an ideal uniform distribution of induction which would give rise to the same loss, whereas in the second the actual loss is increased so as to represent what the loss would be if the induction were uniform and equal to that at the centre. The first is the point of view from which we have regarded the matter in making our experiments, the second is the point of view which Mr. Wild appears to prefer; but in the final result there can be no difference whichever method is adopted. It is certainly most remarkable that in the second method the loss correcting factor, as deduced from Steinmetz's law of hysteresis and Gill's law of distribution of induction, should be almost exactly the same as the experimentally obtained discrepancy factor of 1·65 observed by us. But I do not see that there is any necessary connection between them, and I do not regard the coincidence in value as other than accidental. In any case I think it wise to await the completion of the experiments before any further discussion is entered up.

To correct for the non-uniformity of the induction in cut rings or jointed squares when arranged for total loss hysteresis tests, Mr. Wild has only to determine the distribution of induction round the ring or square, and calculate the required correcting factor by means of the expressions above given. Or, what amounts to the same thing, he has but to refer his measured loss to an equivalent uniform induction which is arrived at by evaluating $\sqrt[1\cdot6]{\frac{1}{l}\int_{x=0}^{x=l} \mathsf{B}_x^{1\cdot6} dx}$. In other words, the equivalent uniform induction in all such cases is equal to the 1·6th root of the mean value of $\mathsf{B}_x^{1\cdot6}$ round the ring or square.—I am, &c.,

Manchester University, July 10. ROBERT BEATTIE.

RAILWAY ELECTRIFICATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read your esteemed periodical regularly with a great deal of interest, as it is about the broadest paper in the electrical field. In your issue of June 4th I noted your editorial on railway electrification, in which you refer to the New Haven electrification and incidentally to a comparison between New Haven and New York Central service. Evidently the information furnished you has been somewhat misleading. I therefore call your attention to the following facts.

The New Haven and the New York Central engines are of very closely the same size and weight. They both weigh 100 tons in round figures. It takes two New Haven locomotives to haul the trains which are readily handled by one New York Central locomotive. It is true that the manufacturers of single-phase apparatus point out to the public that the New York Central locomotives are now used to Wakefield only, or for a run of about 13 miles, while the New Haven locomotives operate over a distance of 33 miles. They insinuate that this difference in length of haul explains the difference in performance of the two types of locomotives. But they know full well that the New York Central locomotives were bought on specifications which call for regular runs to Croton, a distance of 35 miles, as compared with the New Haven 33 miles to Stamford. They also know that the New York Central engines are fully up to their guarantees.

The New Haven installation, being the first and only American single-phase installation on trunk line scale, has naturally been used for advertising purposes a great deal. This means that some of its good points have been praised beyond measure, and some of its weak points passed over, even in Mr. Murray's recent Paper, which on the face professed to be a description of the weaknesses of the New Haven system.

The following are some facts admitted by the single-phase enthusiasts, but not generally mentioned.

The problem of electrification of the New York, New Haven and Hartford Railroad to Stamford, Conn., was put before the manufacturers in a call for locomotives capable of hauling a 200-ton trailing load at a schedule speed of 26 miles per hour, with stops of 45 seconds duration each, spaced an average of 2 miles apart. The single-phase system is said to have been adopted for the New Haven railway because it was believed to be cheaper in first cost and in cost of operation than any other system.

The original estimate shows a figure of $12,435 per mile for single-phase line equipment for four tracks and a figure of $30,000 a piece for single-phase locomotives estimated to weigh not over 76 tons. The actual cost of the single-phase line equipment was over $50,000 per mile, and the single-phase locomotives actually weigh 102·5 tons each and cost $45,000 apiece.

Justice demands in this connection to state that the New Haven single-phase line equipment was probably put in too heavy in a laudable attempt to secure the greatest possible

security against breakdowns. But even so, these figures plainly show that the first cost of the New Haven single-phase equipment was undoubtedly higher than it would have been for either continuous-current or three-phase alternating-current equipment.

As regards operating costs, these are very much higher for the single-phase system than for any other system, the New Haven operating costs showing an excess of something like 50 per cent. over those of similar roads operated on other systems.

The opinion seems to be abroad that American engineers are all gone crazy over the single-phase system. This is not at all so. We all realise the advantages offered by any alternating-current system for easily transforming electric pressures and thus covering long distances without much difficulty. But, except for those interested in the manufacture of single-phase apparatus, we all also realise the inherent defects in the single-phase alternating-current motor, and, while we admire the designers who have brought this machine up to its present state, we do not believe that it is justifiable to-day to recommend a repetition of the New Haven experiment, or, in other words, to use the single-phase system for real heavy traffic.

Trusting that this may serve to elucidate the situation and that you may, therefore, see your way clear to print this contribution in your valuable columns.—I am, &c.,

114, Liberty-street, New York, June 26. C. L. de Muralt.

[The information before us when writing the note to which Mr. de Muralt refers was that given in the discussion on Mr. Murray's Paper, and in which much of the criticism against the single-phase system on the New Haven line appeared to be fairly met. It is unfortunate that so much partisanship should be displayed over this question of the two systems, and it would be far better if all the facts were looked squarely in the face. We think it must not be forgotten that the New Haven line is not the last word on the subject of single phase, and we would repeat our opinion, which has been expressed more than once, that both continuous current and single phase have their spheres of usefulness in railway electrification.—Ed. *E.*]

RESEARCHES IN RADIOTELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In the lecture of Prof. J. A. Fleming, published in The Electrician, July 2, the invention of the radiotelegraphic antennæ of triangular form is attributed to Messrs. Bellini and Tosi. That is, however, quite incorrect. This particular type of antenna, and those of V and X form were invented by myself.

Official documents of the Royal Italian Navy prove that these antennæ of triangular form have been employed by me in connection with the Italian Royal Navy for wireless transmission between stations at Monte Mario (Rome) and Becco di Vela (Sardinia) in 1903 4.

It was found by the Italian Navy in 1903 1904 that when the currents were in opposition of phase and the aerials were not provided with secondary conductors, the maximum transmitting effect was coincident with the plane of the aerials.

I employed these triangular antennæ in the wireless station at Anzio for receiving the radiotelegraphic messages transmitted from the wireless station at Monte Mario (Rome), in the autumn of 1905, the disposition of the triangular antennæ being approximately in the direction of the transmission.—I am, &c.,

Turin, July 5. Alessandro Artom.

We have submitted the letter of Prof. A. Artom to Prof J. A. Fleming, from whom we have received the following reply:—

TO THE EDITOR OF THE ELECTRICIAN.

Sir: If Prof. A. Artom will read again the report of my lecture in The Electrician he will see that I have not attributed to Messrs. Bellini and Tosi the invention of antennæ of triangular form, but the employment of two nearly closed circuit antennæ with planes at right angles, with or without the association of a single open antenna, for the purpose of achieving directive radiation or the location of the sending station by means of their radiogoniometer. That is quite a different matter from the mere use of antennæ of triangular form. If the first use of nearly closed antennæ were in question, then a great many other names besides that of Prof. Artom would have to mentioned, and reference to these prior researches was made by me in a Royal Institution Friday evening discourse two years ago; but on this last occasion time did not permit of a recapitulation of the names of all those who had made contributions to the subject. Nevertheless, nothing was further from my intention than to deprive Prof. Artom of the credit due to him for his numerous and instructive researches in connection with radiotelegraphic antennæ.—I am, &c.,

London, July 12. J. A. Fleming.

THE "C.M.B." AUTO-CONVERTER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In connection with the article by Messrs. Macfarlane and Burge in your issue of July 9th, I would like, while congratulating them on the successful development of a new type of machine, to draw attention to certain disadvantages in the arrangement.

While possibly more economical and efficient than a two-commutator direct-current machine in the case where the supply voltage is to be divided exactly by two, the "C.M.B." auto-converter will certainly fall much short of this arrangement where a considerable reduction is required, as in the case of metal filament lamps, single arcs (or arcs in parallel) and the charging of low voltage batteries. Essentially the winding of the armature is a compromise between the high and low voltage requirements, and will therefore be wasteful of copper, due to its unsuitability to high voltage, and inefficient, on account of its unsuitability to low voltage.

Again, the field winding must be very wasteful of copper and energy in order that the ratio of field to armature ampere-turns may be sufficient on the low voltage side and the reactance voltage kept down. This latter will be particularly troublesome, because the brushes have to commutate the low-tension current in a winding of a large number of turns. In addition to this a ring winding must be used which still further considerably aggravates the difficulty.

When it is further remembered that some parasitic currents are also imposed on the armature, one can only pay an honest tribute of great admiration to the skill and enterprise of the designers and the manufacturers who have overcome these combined difficulties.

Against this the double commutator machine has the following advantages:—

1. The commutation is largely self-corrected.

2. The efficiency will be higher for all transformation ratios other than 1 : 1 on each section. (In this connection the authors mention an efficiency of 75 to 80 per cent. for a 2 to 3 kw. machine for metal filament lamp work. A double commutator machine for an output of less than 1 kw. may have an efficiency of well over 80 per cent.)

3. All the various regulation characteristics obtained on the "C.M.B." machine may be obtained by the use of an extra pair of series-wound poles.

4. The commutation, being divided between two commutators of probably less peripheral speed, will result in much less attendance being required.

Whilst, therefore, this new machine may have some scope in replacing double-machine balancers, I fear that its inherent drawbacks will prevent it doing much work where voltage reduction is required.—I am, &c.,

East London College, July 13. Leonard Murphy.

ELECTRIC LIGHTING ACTS (AMENDMENT) BILL.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: May I direct the serious attention of electrical companies to the grave danger of allowing this bill to pass in its present form? The bill does not give effect, as might be inferred from the memorandum accompanying it, to the re-

commendations of the Joint Committee of 1898, nor does it carry out the promises made by a former President of the Board of Trade. On the other hand, it imposes fresh conditions of a very onerous kind on electrical companies.

The effect of clause 6 is to empower the Board of Trade to authorise a local authority to supply outside its area and to compete with a company without the consent of such company; while a company can only be authorised to supply outside its area and compete with a local authority with the consent of such local authority.

Clause 13 relates to the audit of companies' accounts. Under this clause a company may be compelled to comply with the recommendations and requirements of the Board of Trade auditor in regard to matters affecting the interests of the authority empowered to purchase the undertaking. In view of the fact that many electrical lighting companies have agreed with the local authorities on special terms of purchase, this clause is exceedingly dangerous to the interests of such companies.

No one doubts the impartiality of the Board of Trade officials, but they cannot be expected to do more than fairly interpret the law, and if this bill becomes law many electric lighting companies are certain to suffer grievous injustice. It is safe to say that there is no precedent for this kind of legislation in the law affecting any other industry in this country.

Does any one still doubt the urgent necessity of the electrical industry possessing some organisation which will protect its interests in these matters?—I am, &c.,

Electrical Federation Offices, E. Garcke.
Kingsway, W.C., July 12.

We have received an anonymous letter from "A Student" in connection with the "C.M.B." auto-converter. If the writer will communicate his name and address we shall be pleased to publish the letter.—Ed. *E.*

THE FATAL ACCIDENT AT CLIFTON COLLIERY, NOTTINGHAM.

The fatal accident at Clifton Colliery, Nottingham, incidentally referred to in our editorial columns last week, was the subject of inquiry before the Nottingham city coroner (Mr. Rothera) on Tuesday last. The verdict of the jury was to the effect that the two deceased men lost their lives by accident, caused, firstly, by an oversight on the part of the official whose duty it was to inspect the interior of the coal-cutter motor and, secondly, by the failure of the apparatus designed to carry off to earth any leakage of current to the machine frame.

Mr. W. Walmer (H.M. Inspector of Mines, Midland district), assisted by Mr. R. Nelson (Electrical Inspector of Mines), had investigated the accident, and as a result Mr. Nelson handed in as evidence a memorandum which we reproduce.

MEMORANDUM.

At Clifton Colliery, Nottingham, electricity is used for driving coal-cutters in the form of three-phase alternating-current at 550 volts pressure. Though the Home Office Special Rules for Safety in working electricity in coal mines do not provide for the "earthing" of coal-cutter frames (that is to say, the connection to earth of the frames of the machines so as to provide against their becoming charged with electricity), nevertheless at Clifton Colliery the machine frames were, very rightly, connected to earth by a special wire as a precautionary measure.

Connection from the supply main to a three-phase coal-cutter is made by what is known as a trailing cable—a flexible cable with three or more cores usually kept in a coil and unwound as the coal-cutter recedes from the supply control switch, called the gate-end switch, fixed at the end of the supply main. At Clifton Colliery this trailing cable had in fact four cores, the extra or fourth core being for the purpose of providing the earth connection above referred to for the machine frame. The cause of the accident on June 28 was to all appearance the abrasion of the insulation from one of the wires forming part of the motor winding, coupled with the simultaneous failure of this earth connection. The insulation last referred to became worn through, probably by rubbing caused by vibration of the machine in working, and in this way live metal touched the inside of the machine casing, thus causing the whole machine to become "live." Had the earth connection been perfect, the machine frame could never have become charged to a dangerous pressure, and therefore, so far as can be ascertained, the sequence causing the accident may be expressed in this way:—

First—Failure of the insulation on a wire forming part of the winding of motor, causing leakage of current to frame of coal cutter.

Secondly—Failure of an earth connection which, had it been perfect, would have prevented the machine frame becoming charged to a dangerous pressure.

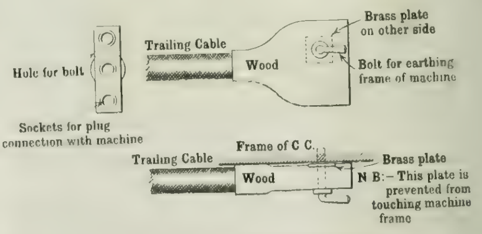
Each event, and the steps necessary to prevent or to minimise the chance of a recurrence, will need separate discussion.

Taking the failure of the motor winding first: As to the character of this failure it may be said that the failure of a motor winding through abrasion is uncommon, and there is therefore some excuse for the electrician-in-charge not realising that a dangerous condition was gradually arising. Nevertheless, attention must be directed to the fact that had Electricity Special Rule 39 been closely observed the accident might have been avoided. The wording of this rule is as follows:—

"The casings or inspection doors of all portable motors used underground, and the casings of their switches and other appliances, shall at least once a week be opened by a competent person appointed by the manager, and the parts so disclosed shall be cleaned and examined before the coverings are replaced."

Its object is to provide for periodical inspection of the windings of the motor where any danger exists of abrasion, and to provide that the interior shall be kept clean and free from oil. An inspection of this kind should have disclosed the fault before it became actually dangerous, but it must also be said that the design of the motor casing in question is such as to make an inspection of the kind indicated difficult; and more than this, there is a not inconsiderate risk of actually causing, in the act of replacing the casing, such damage to the motor winding as it is sought to avoid. The remedy lies in the direction of using only such machines as can conveniently be inspected without the danger last referred to, and no great practical difficulty exists in designing machines of this kind. The fault occurred in that part of the winding where three wires are led to the motor control switch. Special attention should, therefore, be given to the substantial support and fixing of these wires, so as to remove the possibility of abrasion at this part through vibration.

With regard to the second failure, that of the earth connection, this was due to an oversight in using a faulty piece of apparatus. The trailing cable above referred to was fitted with a wooden plug or "pommel" containing three sockets, which sockets were designed to fit over three prongs in the coal-cutter motor terminal box. The earth wire, forming the fourth wire in the trailing cable, was fastened to a small brass plate on the side of the timber pommel, and connection between this brass plate and the machine frame (upon which the earthing of the latter depended) was made by a ⅝in. diameter, bolt, provided with a lever handle for screwing into the machine frame. In ordinary circumstances these arrangements should provide a sufficient earth, but in the present case an oversight upset them. The brass plate to which the trailing cable earth wire is attached was fixed on one side only of the pommel, and unfortunately, as regards the particular coal-cutter with which it was being used, on the wrong side. The result was that the bolt was bearing on dry wood only, so that the earth wire was at least partially insulated from the machine frame. This fact would not necessarily have been fatal had the brass plate on the other side of the pommel been pressing against the coal-cutter, but this, again, was not so. The brass plate stood very little, if anything, above the flat side of the pommel, but in any event the rounded end of the pommel, where the trailing cable entered it, served to keep the plate from contact with the machine frame. This point will be made clear by reference to the sketch below.



Elevation and Plan of Pommel.

It is understood that the coal cutters in the pit differ somewhat in design at their terminal boxes; and that the pommel in use at the time of the accident, though unsuitable for the coal-cutter with which it was being used, was suitable for other coal-cutters. Pommels had always been regarded as interchangeable but they were not actually so, constituting an oversight on the part of the electrician-in-charge.

Where men without knowledge of electricity, and of what may be termed its properties, are placed in charge of the running of a motor, a special responsibility devolves upon those whose duty it is to provide for safety by maintaining the electrical apparatus in safe condition. In the present case the precaution of earthing the coal-cutter frame had been very rightly introduced, and it was this safeguard that failed. Had it been possible with the arrangements in use to make the earthing effective and had the accident been due to some subsequent neglect on the part of the deceased men, it might have been possible to say that the accident was such as could hardly have been foreseen. But in the circumstances it was not possible to make the earthing effective, and therefore, however

reluctantly, some degree of responsibility must be awarded the person responsible for the safe condition of the coal cutter on the day of the accident. Though that degree of responsibility cannot, in my opinion, be a very heavy one, in view of the fact that the failure to secure a good earth connection was due to the use of apparatus which, though it apparently fulfilled its object, was defective, the defect being one which only appeared upon close investigation.

To sum up the recommendations mentioned above so as to provide against such an accident in the future, they are four in number, namely :

1. Coal-cutter motors should be of such design as to admit readily of the weekly inspection called for by Electricity Special Rule 39, without introducing the possibility of damage as in the case under notice.

2. The wires inside the motor case forming the windings, and especially the end connections, should be substantially fixed and supported, so as to remove the possibility of the insulating material wearing away through abrasion caused by vibration.

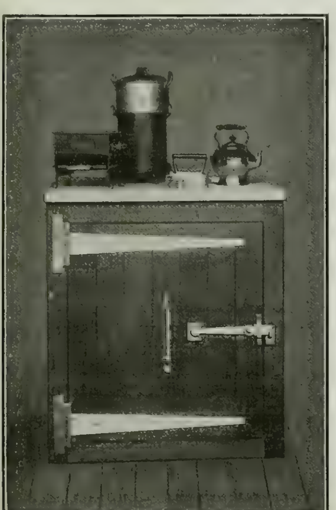
3. Machine pommels should be provided with a brass plate all over both sides, to remove the possibility of bad connection between earth wire and machine frame.

4. Some easy means (say, a few cells and an electric bell) should be readily available for occasionally testing the efficiency of such earth connections as that between the cable pommel and a portable machine frame, so that after overhaul the latter may be left beyond doubt in safe working order.

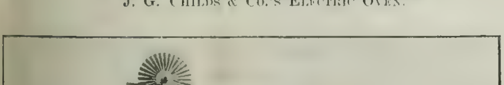
J. G. CHILDS & CO.'S SPECIALITIES.

ELECTRIC COOKING.

Among the exhibits at the Royal Agricultural Show at Gloucester at the stand of Messrs. J. G. Childs & Co., of Willesden Green, N.W.,



J. G. Childs & Co.'s Electric Oven.



Wind Turbine for Charging Accumulators of Electric Cars.

was a new type of electric oven. This is shown in the accompanying illustration.

Messrs. Childs claim for this oven that in its design particular attention has been given to insulation, and they point out that the oven differs from all other ovens in that it has a polished marble top and oak sides, and, consequently, looks like a piece of dining-room furniture rather than the conventional oven. It is claimed also that there is no external heat, and that the oven works on half the current consumption of other types of electric ovens.

This electric oven will run at a cooking temperature on a consumption of only 200 watts. The oven shown at Gloucester roasted joints, baked cakes, &c., the latter being distributed to the spectators. The whole of the current for this oven was produced by one of Messrs. Childs & Co.'s patent

WIND TURBINES.

24 ft. in diameter (of which an example is shown herewith) erected over their stand. This plant consisted of a 24 ft. wind turbine upon a steel tower 60 ft. in height, driving by means of a vertical shaft a special variable speed Morris Hawkins generator placed vertically, which charged a 28-cell Pritchetts & Gold battery, having a discharge capacity of 460 ampere-hours. The generator is provided with a special switch which enables it to be used as a motor when there is no wind, taking current from the battery. In addition to the cooking apparatus, the plant provided current for lighting the stand, and by special arrangement with the Country Gentlemen's Association lit their show cottage some 200 yards away. Besides this it ran an electric lift, cream separator, circular saw, butter churn, deep well pump, electric irons, fans and other apparatus. This plant produced in six days during the show, with the wind averaging 8 miles an hour, 50 B.O.T. units, and it was sold for an estate in Worcestershire, where it will be used for lighting the house and driving farm machinery, &c.

LEGAL INTELLIGENCE.

Seebold v. Page & Miles.

On Wednesday Mr. Justice Bucknill delivered a considered judgment in this case, which related to the provision of an independent electric lighting installation supplied by defendants to plaintiff, the lessee of the Worthing Theatre Royal. The arguments and evidence in the case appeared in The Electrician for May 7 and 14.

His Lordship said it was not, and could not be, suggested that there was anything the matter with the engine and gas producer, or with the generator and scrubber, but plaintiff's case was that these things were not carefully fixed up, and that through their being improperly and negligently fixed up plaintiff was injured, in that the work had to be stopped and he had to go to the Worthing Corporation and take current for lighting at a greater expense. He also claimed for expenses to which he had been put in making the plant do its work properly. To make the plant work properly it was requisite that it should be kept clean and treated with care. Plaintiff undertook to make the foundations of the engine, and these foundations required very careful building. It was alleged that the foundations were properly put in and that defendants had been guilty of negligence in not providing iron silencers instead of the brick chambers or pits. Defendants, however, were not bound to put before the plaintiff the alternative whether the brick chambers or the iron box should be used for silencing. He found, as a fact, that, but for accident, the silencers put in were efficient. Referring to the explosions, his Lordship said the man who was in charge of the engine seemed to be a man of limited intelligence. Before he took charge of the engine there had been no explosion, and the engine had been run for six months under the superintendence of defendants' foreman. The young man took charge in January, and the explosion took place in the following month, as defendants alleged, from negligence of the driver. He found that the explosion had not occurred in consequence of any of the things alleged against defendants, and that the installation was properly put together. He found that the objectionable smell had not been caused by any defect in defendants' work, and he found that, on the whole, the work had been properly carried out. Plaintiff's case failed on every point. An agreement had been arrived at on the counterclaim, and there must be judgment for defendants on the claim and for the counterclaim of £25, with costs on both.

Uxbridge & District Electric Supply Co. (Ltd.)—A motion for the appointment of a receiver of this company was before Mr. Justice Neville in the Chancery Division on Tuesday, but, with the consent of all parties, stood over for a week.

North Western Electricity & Power Gas Co.—The petition by Harper Bros. & Co., and others, for the compulsory winding up of this company was again before Mr. Justice Neville on Tuesday, and as the petitioners' debt had been satisfied his lordship dismissed the petition with costs.

ARC LAMP LOWERING GEAR AND ACCESSORIES.

It is no news to our readers that the London Electric Firm, of George-street, Croydon, have for some years passed specialised in Arc Lamp Lowering Gear and Self Sustaining Winches, but the extent to which this business has grown and the numerous items of manufacture which this specialisation covers may probably surprise many besides ourselves. The new catalogue which the firm has just issued (List No. 125) gives particulars of these, and the fact that there are 180 illustrations, the bulk of which relate to these manufacturing details, is complete justification for the company applying themselves exclusively to this branch. We have selected a few items for special mention, but it may be said that any particular selection from the catalogue is invidious. Fig. 1 shows the "G" type of Contact suspension gear with short-circuit device on lamps for long series systems suitable for voltages up to 4,000. The wire rope shown in the illustration can be equally well brought out from the top as from the side. Large numbers of this standard type have been supplied for street lighting and other purposes throughout the world.

Fig. 1.

Fig. 2 is a watershed double leading-in pulley, of which the manufacturers supply large numbers, and Fig. 3 shows a winch or counterweight hoist gear, with collapsible interwove cable. This consists of a self-sustaining winch, flexible wire rope, guide pulley, ceiling rose with pulley, and the cable or alternatively a counterweight may be used in place of a winch. It is claimed for this piece of gear that it does away with unsightly and dangerous festoon cables, and enables lamps to be burned in any position within its range, and to be lowered to the ground for trimming. The gear contains no spring.

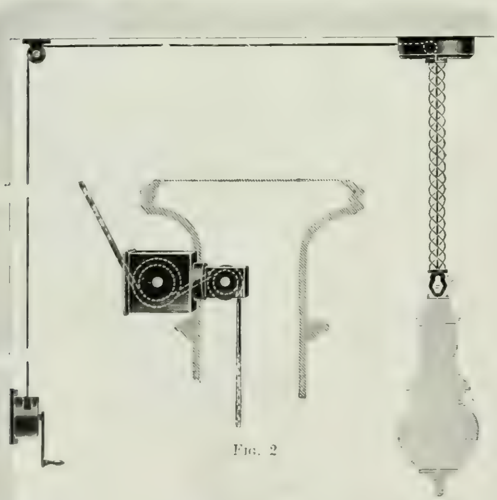


Fig. 2

Fig. 3.

As we have said, from a list which contains so many items it is invidious to select, and we must therefore refer our readers to the neat, well arranged, and well printed catalogue of over 100 pages which the company have now ready.

PARLIAMENTARY INTELLIGENCE.

Telegraph (Arbitration) Bill.—On Tuesday the Standing committee of the House of Commons (Mr. E. Wason chairman) considered this bill which was introduced by the Postmaster-General to facilitate the carrying out of the agreement to purchase the National Telephone Co.'s undertaking. Clause 1 provides for the reference to the Railway and Canal Commission of any difference between the Postmaster-General and any persons under the Telegraph Acts or under a licence on agreement.

Mr. McArthur proposed that the Commissioners should have power to allow costs. Under the existing law it was doubtful whether they had such power.

Mr. Buxton opposed the amendment and said it was clear that the Commissioners were not intended to have the power of awarding costs, except in the case of frivolous or vexatious proceedings. In the agreement between the Post Office and the National Telephone Co. it was provided, subject to the approval of Parliament, that the question of arbitration should be referred to the Commissioners, and that was the foundation of this bill. The company knew that the Commissioners were not entitled to award costs. He was glad to say, however, that both the Government and the company were anxious that, when the question of arbitration arose, it should be decided with the least possible delay.

The amendment was defeated and the Committee ordered the bill to be reported to the House.

Trunk Telephone System in Ireland—In the House of Commons on Monday the Postmaster-General informed Mr. O'Dowd that he was in correspondence with the Treasury on the subject of the extension of the telephone trunk system to Sligo, and he hoped shortly to obtain authority for the assistance of the guarantee which was completed in December last.

West Kent Electric Power Bill.—In the House of Commons on Monday this bill was read a third time.

North East London Railway Bill.—On Tuesday the Select committee of the House of Lords on unopposed bills, Lord Onslow presiding, had before them this bill to extend the time for raising half the necessary capital to commence the construction of the line, which is to extend from the City of London to Waltham Abbey. Under the 1905 bill five years were allowed. The preamble was proved, and the bill ordered for third reading.

Cleethorpes Provisional Electric Lighting Order Confirmation Bill.—This bill came before the same committee on Tuesday, and was sent for third reading.

Torquay and Paignton Tramways Bill.—This bill came before the same committee on Tuesday. It is promoted by the Torquay Tramways Co., and proposes to authorise the construction of an additional line of tramways in Torquay. The bill passed the committee, and was ordered to be reported with amendments to the House.

Morecombe Tramway Provisional Order Confirmation Bill.—Lord Onslow's committee on Tuesday passed and ordered for third reading this bill, which confirms the order granted to Morecambe Corporation, authorising the construction and working of electric tramways, &c.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An Italian engineering firm advertise for an engineer or person practically acquainted with ventilating apparatus, installation of fans for removal of dust, &c. (Italian preferred).

Mr. Edward Taylor, of West Ham, has been appointed fourth assistant engineer at Hammersmith.

Mr. S. W. Carty has been appointed an assistant engineer to take charge of the erection and maintenance of overhead equipment on the Liverpool Corporation tramways.

Bristol City Council have appointed Mr. A. J. Brooks station superintendent at Avonbank at £175, rising to £200 after six months' service, and then to £250 by two annual increments.

EDUCATIONAL NOTICES.

Borough Polytechnic.—The Education committee of London County Council propose to appoint a head of the chemistry department, in succession to Dr. F. Mollwo Perkin, at a salary of £300, rising to £400 a year by increments of £15 a year for four years and of £20 a year for the two following years; and the proposal of the governors to increase the salary of the head of the electrotechnics department (Dr. J. Henderson) to £340 a year, rising to £400 a year, has also been approved, provided that the increases be at the rate of £15 a year for two years, £20 in the following year and £10 in the succeeding year.

Heriot-Watt College, Edinburgh.—The training for engineers given at this College consists of three years in the College, and a three years' apprenticeship on the "sandwich" system in a local engineering works. The course in mining extends over two years, and is recognised by the Home Office as equivalent to two of the five years underground training required for the colliery manager's certificate.

There are also complete courses of instruction (extending over four years) for students preparing for the fellowship of the Institute of Chemistry, and practical training for technical chemists in the laboratories of the Corporations' gas works. The classes are recognised by the University of Edinburgh as qualifying for science degrees. Particulars of fees, bursary, &c., from the principal, Mr. A. P. Laurie, M.A., D.Sc.

City and Guilds of London Institute. The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

University of Manchester.—Prospectuses, containing full particulars of the lecture, laboratory and drawing courses in engineering, and the courses in physics (including electrical engineering, mathematics and chemistry, &c.), can be obtained from the Registrar. There are new and enlarged engineering laboratories which will be open to students in the new session commencing Oct. 5.

Acton.—The new public offices are to be wired.

Barrow-in-Furness.—At the Council meeting last week Councillor Ainsworth called attention to the minute of the Electricity committee referring to applications for increases in salaries.

He said the committee recommended that certain salaries be increased, but there was something like £400 to be made up by the ratepayers for the electricity department, which was not a paying concern, and he considered it inopportune for men to ask for a rise in salary. With regard to two salaries which it was proposed to increase to £165 and £150 respectively, he had nothing to say against these two men, but it was time these increases were stopped until the concern paid. He moved that the matter be referred back.

Councillor Ledgerwood was of opinion that the men were entitled to the increases. If the works were not paying that was no reason why the men should not get the salary to which they were entitled.

Ald. Smith considered the salaries were reasonable in proportion to the training and the requisite skill necessary. With regard to Mr. Heslop (the mains superintendent), whose salary was being increased to £150 and was to rise in four years to £175, his predecessor who left three or four years ago had £175, and at that time the mains were not so extensive as they were at present.

The motion to refer back was defeated by 20 votes to 4, and the report adopted.

Bath.—Notice of the intention of the Corporation to apply for a provisional electric lighting order for Bath rural district was submitted to the Rural Council last week. The Rural Council's own order has not yet been cancelled, and the matter was therefore referred to the Electric Lighting committee.

Notice was also received of the intention of Bath Electric Tramways (Ltd.) to apply for an extension of time for works in the Keynsham district.

Battersea (London.)—On June 9, the Council applied to London County Council for a loan of £1,500 for providing consumers with arc lamps and motors and wiring premises on the cash and hire purchase systems. The Lighting committee consider that to await sanction to this loan will cause delay, and £500 is to be taken out of current revenue to inaugurate the scheme.

Bodmin.—A proposal by Messrs. H. & W. Meager to provide a supply of electricity for lighting the streets, municipal buildings, the market house, &c., at £200 per annum, has been referred to the Council in committee.

Bradford-on-Avon.—The Council have decided to oppose an application by the Western Electric Distributing Corpn. for a provisional electric lighting order.

Brazil.—The report for 1908 of Mr. Archer, British Consul at Porto Alegre, states that the electrification of the tramways (formerly worked by mules) was completed during the year by a British firm. The two companies formerly owning the tramways have amalgamated and obtained what is practically a new concession for 40 years, and an offer for the purchase of the concession and undertaking by a London company called the Anglo-South American Public Works Co. (Ltd.) has been accepted. During the year the municipality have completed the installation of an electricity supply undertaking, chiefly for public lighting in the suburbs and in a part of the city not supplied with gas. A concession for supplying electric light to private consumers within a limited area (which is held by a native company called the Fiat Lux) expired in April so that the whole of the town, so far as private lighting is concerned, is open to all comers, as the Municipality does not reserve any monopoly to itself.

Bristol.—In presenting the statement of the Electrical committee for the past year, Ald. Pearson said, at the Council meeting on Tuesday, he would first move the adoption of the small report of the committee, which stated that they had received the resignation of Mr. H. H. Couzens, the deputy city electrical engineer, who had been appointed engineer and manager at West Ham, and that the committee recommended the appointment of Mr. A. J. Brooks as station superintendent at Avonbank at £175 per annum rising to £250. Ald. Pearson expersssed his regret at the loss of Mr. Couzens. The report was adopted. (The accounts of the electricity supply department are abstracted in another column.)

British Inventive Genius.—The "Iron and Steel Times" for July 8 contains the following correspondence of considerable trade and general interest :—

Sir : The attention of my directors has been drawn to a statement contained in your issue of June 24 last to the effect that in the installation of the electrically-driven rolling mills by Sir Alfred Hickman (Ltd.), at their works at Bilston, Sir Alfred Hickman had "sacrificed business to patriotic interests, and that he would have been better served, both practically and financially, if he had entrusted the important alterations in his company's plant to German contractors." The electrical work in question was (as appears from another article in the same issue of your journal) supplied and erected by this company. My directors are not aware that any such public statement as alleged by you has been made. If it has been made it is untrue, and its repetition by you is calculated to damage this company's business interests, and is, therefore, libellous. This being so, you will no doubt wish to withdraw the injurious statement referred to, and to apologise for having circulated it. My directors will accordingly expect to find in your next issue a suitable withdrawal and apology.

The Electric Construction Company, Limited.
David Willock, Secretary.
Dashwood House, 9, New Broad-street, London, E.C., July 8, 1909.

Sir : In your interesting article on this subject you quote a statement to the effect that in the installation of electrically-driven rolling mills at these works I "sacrificed business to patriotic interests" (by giving the work to British engineers) and that I should have been "better served, both practically and financially, if I had entrusted it to German contractors." I am happy to be able to give an emphatic contradiction to this statement. It is true that some difficulties not unusual in a new departure have been experienced, but, if I am correctly informed, they are far less than have attended a somewhat similar installation by a German firm at works in the North, the engineering staff of which have honoured me by repeated visits in order to obtain information and assistance.

The arrangements here are not yet perfected, but there has been no shirking of responsibility on the part of the contractors, and I have every confidence that in the end the work will be fully equal, if not superior, to anything the Germans have done, and the cost will certainly not be greater than they would have charged.

Staffordshire Steel Works, Bilston. Alfred Hickman.

Editorial comment on the above letters is appended in a note to Sir Alfred Hickman's letter as follows :—

The statement referred to by Sir Alfred Hickman was not made by us. The passage in our article to which Sir Alfred Hickman refers is as follows : "It has been publicly stated, and the statement has remained uncontradicted, that Sir Alfred Hickman sacrificed business to patriotic interests," &c. We are glad to be the means of contradicting the statement, for which we have not been in any way responsible, and to offer our congratulations to Sir Alfred Hickman, the E.C. Co. (Ltd.), Messrs. Lamberton & Co. (Ltd.) and the Premier Gas Engine Co. (Ltd.) in showing that it is not necessary to follow the example of other undertakings and to go to Germany for new plant—Editor, "Iron and Steel Times."

Brussels Exhibition, 1910.—The trades concerned with engineering, mining and metallurgy were approached last week at Newcastle by Lord Lytton and Mr. Wintour, on behalf of the Royal Commissioners for the Brussels Exhibition, and the Newcastle and Gateshead Chamber of Commerce passed a resolution cordially approving the steps taken by the Board of Trade for the organisation of the British exhibits. It was announced that Messrs. Armstrong, Whitworth & Co. will make an important exhibit.

It is the intention of the Royal Commissioners and the Board of Trade to make the British exhibit of machinery unrivalled. More than a third of the whole Machinery Hall, which covers 222,670 sq. ft., has been secured in two central bays for this country. The opportunity is thought to be one for redeeming the discredit of former occasions and pushing trade. The cost of exhibiting at Brussels can be estimated with certainty. All necessary services are to be rendered to exhibitors free of any charge but the 2s. 6d. per square foot for space. In view of the great efforts to be made by France, Germany, Italy, the United States and Belgium itself to display up-to-date machinery in a striking way, the Royal Commissioners have further resolved to defray half the cost of motive power charged by the Belgian administration, though the charges in the first instance are to be normal.

Meetings in other trade centres are to be held shortly. Full particulars may be had from Mr. U. F. Wintour, Board of Trade (Exhibitions Branch), Queen Anne's-chambers, Westminster.

Castle Lighting.—Ford Castle, Northumberland, the residence of Lord Joicey, is being wired for electric lighting.

Cheap Power Units.—A recent report by the electrical engineer (Mr. W. J. Leeming) to the Electricity committee of *Buxton* Council gives an explanation of the small cost of generation incurred, in some instances, for a limited day load. Following is an abstract of the report :—

With regard to the charges for electricity for power and heating, I am of opinion that more current would be used for these purposes if the price were reduced. The additional cost of supplying any extra day load would be very small, the only extra costs being fuel, about 0·7d. per unit, oil, waste, &c., about 0·04d. per unit, and a slight amount for wear and tear of machinery, or, say, a total of from 0·75d. to 0·8d. per unit generated. The cost of labour, interest on capital, repayment, management and property charges, &c., would not be increased at all. These figures are on the supposition that special plant has to be run for any increase in the power load; but all day the destructor plant is running, wasting steam and power. This plant is capable of generating 48 kw., and the average day load is from 15 kw. to 20 kw., so that, with hardly any extra costs, a day load of another 28 kw. to 33 kw. could be supplied. The destructor is working all day to dispose of refuse, and that amount of power and steam is being wasted day after day. In fact, I think the destructor is capable of generating much more steam than the present electrical plant can use. Therefore, I recommend a rearrangement of power charges, which at present are: 3d. per unit for one hour per day of the maximum demand, and 1¾d. per unit after, or 400 units per quarter at the flat rate of 1¼d. To encourage the long-hour consumer, I suggest the following charges: 2½d. per unit for the first hour and 1½d. after, or 2½d. per unit up to 300 units per quarter, 1¾d. per unit from 300 to 450, and above 450 1½d. per unit. A good day load would not interfere with the heavy lighting loads, as these occur in the summer and in the evening when workshops, &c., would in all probability be closed, whereas in the winter time, when power and lighting might come on together, the maximum loads are very low. The only time there might be any serious clashing of these two loads would be in the winter from about 7 a.m. to 8:30 a.m., when the gas engine would probably have to be run as well as the destructor, and the extra cost would be about 0·8d. per unit.

The Council have adopted the committee's recommendation that the charges proposed by Mr. Leeming be adopted.

At the last meeting of *Stockton-on-Tees* Town Council a discussion took place with regard to a proposal to continue the supply of electric power to the Stockton Forge Works of Messrs. Head, Wrightson & Co. for a further five years at ⅝d. per unit. Several members contended that this would not be equitable to other consumers.

Ald. Tomkins, chairman of the Electricity committee, said the contract obtained five years ago assisted them in turning their loss into a profit. The firm kept their works running during the daytime, and if the department lost the contract it would reduce their output one-third, and costs would go up, increasing the price of supply to other consumers.

Ald. Rudd moved that the recommendation be referred back, as he said the price was less than that at which the Corporation could produce energy.

Ald. Tomkins replied that Mr. Anderson (manager for Messrs. Head, Wrightson & Co.) had informed him they were buying electricity at a cheaper rate, and that he could supply it himself cheaper than the price asked by the Corporation.

Councillor Nattrass said he failed to see how they could make a profit upon an article they sold below cost price.

The motion to refer back the recommendation was defeated, but an amendment, moved by Ald. Hind, that the price charged to Messrs. Head, Wrightson & Co. be ¾d. per unit, was carried.

China.—The report for 1908 of British Consul H. Gaffe states that a Chinese company formed two years ago to generate and supply electricity at Wushu (Anhui, on the Yangtze river) expected to commence supply in April this year.

College Lighting.—Glasgow University Court decided on Thursday last to adopt electric lighting in St. Margaret's College at the earliest opportunity, and to obtain a scheme and estimates of cost.

Cowdenbeath (N.B.)—The Council will not assent to an application by the Fife Electric Power Co. for a provisional electric lighting order.

Customs Duties.—A supplement to the Australian Commonwealth Customs Tariff Guide states that the import duty on resistance coils with arc lamps (classified as electric appliances), both under general tariff and for United Kingdom goods, is 20 per cent. ad. val.

Darlington.—The electric mains are to be extended to Albert-hill for power supply, at a cost of £1,100.

Doncaster.—The Rural Council have approved a scheme of main sewerage for Bentley colliery village.

From the underground storage tank, which will be of reinforced concrete and sunk to a considerable depth, the sewage will be pumped by electric motors and centrifugal pumps to the existing sewage disposal works. Electric current will be supplied by the Bentley Coal Co. The engineers for the scheme are Messrs. D. Balfour & Son.

Dunfermline.—On Tuesday, the Town Council had before them an intimation that the Fife Tramway, Light & Power Co. intend to commence the construction of tramways under the Dunfermline District Tramways Order within 30 days from July 10.

Dundee.—The Electricity committee decided, on Tuesday, to recommend the acceptance of the tender of the Union Cable Co. for supply of various sizes of cable.

It is stated that the Union Co.'s prices were from 10 to 70 per cent. lower than those quoted by other firms for cables of English manufacture.

Mr. H. Richardson, the city electrical engineer, stated that a cable supplied by a foreign company had been working satisfactorily for the past two years. English manufacturers alleged that the foreign makers were subsidised by their Government and the foreigners declared that English manufacturers were banded in a ring to keep up prices. The acceptance of the Union Co.'s offer would save about £400 during the next 18 months.

A fire, which resulted in an interruption of the tramway traffic and the supply of current for lighting, occurred at the electricity works on Wednesday.

East Ham.—The Lighting committee have decided to reduce their charges for electric power, and the rates will be for 150 units or less per quarter 2d. per unit, up to 1,000 units 1½d., 6,000 1¼d., and special terms for demands in excess of 6,000 units, less 5 per cent. for prompt payment.

Electricity to the Rescue.—A Reuter's telegram states that in order to compel the directors of the Dominion Coal Co. to attend a conference called by the United Mine Workers of America the workers threatened a strike of the company's operators. As the company have for some time past anticipated trouble they have been making preparations to meet same, and amongst the preparations is (according to the telegram) the surrounding of the works with fences surmounted by an electric cable of 5,000 volts capacity. This is stated to have alarmed the workers, who have called upon the Government to prohibit the use of this cable in the manner indicated.

Exhibitions.—H.M. Trade Commissioner for South Africa (Mr. R. S. Holland) states that instead of an international exhibition at Cape Town on the occasion of the opening of the South African Federal Parliament, it has now been decided to hold a South African exhibition; but an international show of electrical appliances, machinery, agricultural instruments, &c., is to be added.

It is proposed to hold an international exhibition at Roubaix (France) in the summer of 1911.

Acting upon suggestions contained in communications received from Europe, the Executive committee of the International Exhibition of Railways and Land Transfort (which is to be held in Buenos Ayres from May to November, 1910) have decided that applications for space may be made in Buenos Ayres until Sept. 10 next, and to the delegates abroad until Aug. 10. Applications for the erection of special kiosks must be in by July 25.

We have received information as to the constitution and objects of a railway congress in connection with the exhibition, and which it is proposed shall be opened at Buenos Ayres from April 1, 1910, and closed not later than May 24. It is proposed to discuss, amongst other questions, systems of signalling, the relative advantages of various types of rolling stock, brakes, train lighting, heating and ventilation, motor-car services, electrification of suburban lines, elevators, &c.

We have also received the programme and rules of the International Agricultural Exhibition which is to be held at Palermo (Buenos Ayres) by the Argentine Rural Society from June 3 to July 31, 1910. The offices of the society are at 316, Calle Florida, Buenos Ayres, and the hon. sec. is Dr. L. P. Iraola. There are to be groups for apparatus for ploughing by means of cables and for ploughing by direct traction (steam, naphtha, electricity, &c.), machines and apparatus for felling trees, for the preservation of wood, &c., carts worked by mechanical traction (steam, electric, &c.), electric engines, apparatus for heating, lighting, ventilation, &c., and for electrical appliances in the camp.

Fire.—A fire resulting in damage estimated at £10,000 occurred on the premises of the Russian Westinghouse Co. at Moscow on Saturday.

Fixed Charges for Lighting.—Eccles Council decided last week to charge 6d. per house per week for electric lighting in the 12 new houses being erected for the Corporation in Corporation-road.

Mr. Forbes moved that the proposal be referred back, as he had found that the gas bill in a cottage with four lights had worked out at 30s. per annum, and there were to be eight electric lights in the Corporation's houses. Mr. Hurrell also knew of a five-light house where the gas bill amounted to about the same figure. Mr. Forbes' proposal was defeated. Mr. Evans said the current used in the row of houses would be registered, and if the experiment did not pay it would be discontinued. Mr. Gardner said they would save the cost of separate meters, which was £4. 10s. each. The engineer had made an experiment elsewhere, and was convinced that the further experiment at Corporation road was worth making. Metallic filament lamps were to be used.

Fulham (London.)—Additional condensing plant is to be obtained at a cost of £160.

Gillingham.—The Council having applied for a loan of £5,000 for the electricity department and the L.G. Board having only sanc-

tioned £2,804 and advised the Council to engage a highly qualified engineer to investigate the working of the undertaking and report on the best means of reducing the annual loss, it has been decided, on the casting vote of the mayor, to ask the president of the Institution of Electrical Engineers " to give six names for the Council to choose an expert from."

Hackney (London).—The Council last week adopted a recommendation by the Works and General Purposes committee that 10 ampere arc lamps be substituted for the present 7 ampere arc lamps in certain streets in the borough, at an additional cost of £225 per annum, and a recommendation by the Electric Lighting committee that it be referred to them to carry out the proposed improvements at a cost of £414.

Hammersmith (London).—A loan of £10,000 for the electricity department is to be applied for. The Finance committee propose that the surplus profits of £5,019 shall be applied in part payment for the turbo-generator, the contract price of which is £7,400, that the £510 received for the old generating sets be devoted to the same purpose, and that the remainder of the cost be taken from the profits of the current year.

Hereford.—The Council have received sanction to a loan of £7,038 for the electricity undertaking, including £1,838 for excess expenditure.

Heywood.—The Council decided last week to seal the agreement between Heywood, Rochdale and Bury Corporations, with regard to tramway intercommunication between the three towns.

Inquest.—An inquest was held this week by the city coroner, Mr. C. L. Rothera, at Nottingham, into the circumstances attending the deaths of Daniel Eyre and Samuel Higgs, at Clifton Colliery on June 28.

The CORONER said the men were using an electric coal cutter at the time when they met their deaths.

RICHD. COTTERILL, a cleaner in the pit, said when Eyre started the coal cutter by turning a small wheel, Higgs called to him to stop it, and witness then saw Higgs lying on the floor face downwards. Eyre had driven an electric machine about two years. Eyre generally examined the trailing cable, the switch and the machine before he started work. Eyre had generally used the rubber gloves which were supplied, and after the accident he found one of Eyre's gloves on the ground near him. Electricians had periodically examined the machine thoroughly. Witness did not know whether Eyre had examined the machine that morning.

JAS. DAVENPORT, the arm cleaner of the cutter, said Eyre went to the transformer switchboard and switched on. Eyre then sent witness for some oil, and when he returned in about 15 minutes he was told there had been an accident, and he switched off at the transformer, which was the nearest point to him. He did not know whether Eyre examined the machine that morning.

WM. MOULD, a workman, said artificial respiration proved unsuccessful and was ceased at his discretion.

Mr. R. NELSON, H.M. Electrical Inspector of Mines, said artificial respiration ought to have been continued until a doctor certified life to be extinct.

Mr. W. LEE, electrical engineer, spoke to examining the machine subsequent to the accident. He found a defect in the electrical connections of the machine. It was on one of the stator coils of the controller, the defect causing the rupture of the insulation. That resulted in the live wire touching the frame of the machine, and so making the whole machine "live." The defect was discovered inside the body of the machine, and no one could discover it without opening the machine. The machine was fitted with an earth circuit, but testing had disclosed that this provision had been rendered abortive by the fact that the connection was put through a hole that had not a brass collar, instead of through the one that had, and a break was thereby occasioned. With a 500 voltage test the break was bridged, but a very low test failed, as the strength was not sufficient. The machine had been in the state discovered, as regarded the pummel, since May 21, when the pummel was changed upon the breakdown of another machine. What was all right in the other machine was wrong in this respect in this, owing to slight difference in construction, and the defect was not discovered until afterwards. Since the occurrence extra precaution had been taken to make the insulation thicker. In his opinion, the cause of the rupture was pressure on the insulation, aided by the vibration. This part of the machine had not been examined since April. The pummels were interchangeable in every other respect save the one since discovered, which accounted for the overlooking of that fact. It was an oversight, but one which would easily occur in the circumstances. The current at the moment of the accident was 350 volts, a portion of which, he believed, would jump the break. The rule as to weekly examination would, if applied to the interior of the casing, have been dangerous, but he agreed that it was desirable the interior should be examined weekly, and that machines should be built to enable this to be easily done. The earth system was more than the rules required, but having been adopted it had to be kept in order.

Dr. H. O. TAYLOR said there were burns on the body and right arm of one man, and on the palm of the right hand of the other. In both cases death was due to the effects of electricity. Further efforts at respiration would have no useful effect in this case, but three-quarters of an hour was not too long under ordinary circumstances.

Mr. NELSON presented a report of the result of his examination of the coal cutter after the accident, corroborating Mr. Lee's view.

The jury found "That the two men met with their deaths by an accident caused by an oversight in the inspection of the working machines and the pummel not being in perfect order to carry the escaped current away."

We deal with this matter more fully in another part of this issue.

Keynsham.—Keynsham Electric Light and Power Co. have secured the contract for public electric lighting for one year at £260. 15s.

London County Council.—On Tuesday the Council had several electrical matters under discussion.

Wooden Fittings for Electric Cars.—The Highways committee submitted tenders received for supply of wooden fittings for electric cars which ranged from £771. 19s. 8d. (less $2\frac{1}{2}$ per cent. discount) up to £1,417. 11s. 6d. They stated, however, that the fittings could be supplied from the Council car works at Leytonstone at £558, it being possible to make them at this low amount owing to the fact that a quantity of timber had been taken over from the various tramway companies at a very low price, and, further, that a number of similar fittings are now being made at the car works.—It was agreed to carry out the work by direct labour.

Street Widening.—A report of the Finance, Highways and Improvements committees recommended that a former resolution of the Council as to the allocation of the cost of street improvements in connection with tramways be rescinded, and that, when the widening of a thoroughfare is entirely necessitated by the construction of a new tramway, or the doubling of an existing single line of tramway, and would not otherwise have been undertaken within five years from the time of such construction or doubling, the whole cost of the improvement shall be charged to the tramways account; that when the widening of a thoroughfare is partly necessitated by the construction of a new tramway or the doubling of an existing single line of tramway, the cost of such widening, or such balance as is not contributed by a metropolitan borough council, shall be allocated to the tramways account and the account of the improvement respectively; that, in cases not covered by the above, the metropolitan borough councils be asked to make some contribution.

A long discussion took place and, after various amendments, these recommendations were approved.

The Council's estimates of expenditure for the year ended March next include £2,089,955 for tramways.

Lowestoft.—It has been decided by the Council to slightly increase the tramway fares.

Maldens and Coombe.—Wimbledon Council propose to apply for a provisional order for this district.

Manchester.—In reference to the report of a special committee disowning any equitable liability of the Corporation to reimburse expenses incurred by the syndicate called the New Mutual Telephone Synd. (referred to on p. 522 of our last issue), Mr. Thomson has written to the Corporation asking that the matter should not be regarded as settled, and stating that the Syndicate's scheme was not rendered abortive in 1905 by the action of the Government, as stated by the Committee, but in 1899 by the Council's change of policy in determining to create a municipal service; and further that the Council stood possessed of the results of the Syndicate's expenditure of time and money from 1899 until 1905.

Mexico.—The "Mexican Herald" states that the Mexico Steel & Chemical Co. has been formed with a capital of a million dollars (about £102,000) to manufacture steel and chemical products by electric power.

Nailsworth.—Gloucestershire Electric Power Co. are applying for a provisional electric lighting order.

Newport (Mon.)—Osram lamps are to be substituted for 230 gas lamps for street lighting. The estimated annual cost of the new lamps is £2 per lamp.

North Berwick.—Crompton & Co. have notified their intention of applying for a provisional electric lighting order.

Northallerton.—The Northallerton Electric Light & Power Co. have secured the public lighting contract for the ensuing two years.

Norway.—British Vice-Consul Kjeldsberg, in his report on the trade of Trondhjem for 1908 states that the new electric power station at Lerfos was not finished as had been anticipated, but it is hoped it will be working before the end of 1909.

Provisional Electric Lighting Orders, 1909.—The Report by the Board of Trade respecting the applications and proceedings under the Electric Lighting Acts, 1882 to 1902, during the past year has just been issued. Of the 13 applications received in Dec., 1908 (compared with 27 in Dec., 1907) six were made by local authorities and seven by companies. The orders asked for by Dumfermline and Southampton Corporations, Cleethorpes, Herne Bay, Stourbridge and Turton District Councils, Messrs. Christy Bros. & Co. (for Holsworthy), the Coast Development Synd. (for Walton-on-the-Naze), and the Egham Electric Lighting Synd. were granted in the form

proposed, and the remaining four applications were dealt with as follows:—

Chesham Electric Lighting (Extension) Order, applied for by Chesham Electric Light & Power Co.: Order granted in respect both of Great Berkhampstead Urban and Rural districts, Northchurch, Amersham, Ashley Green, Chesham Bois and Latimer parishes, the borough of Hemel Hempstead and parishes of Bovingdon and King's Langley being excluded.

Chipping Norton (Borough) Electric Lighting Order, applied for by Chipping Norton & District Electric Light & Power Co.: The Board of Trade were not satisfied with the financial arrangements offered, and refused to grant order.

Hindhead and District Electric Lighting (Extension) Order, applied for by Hindhead & District Electric Light Co.: Order granted for area applied for, except Thursley and Witley parishes.

Skelmorlie and Wemyss Bay Electric Supply Order, applied for by Skelmorlie & Wemyss Bay Gas & Electric Supply Co: Application opposed by one local authority in area and by certain ratepayers, &c. Local inquiry was held and Board decided not to grant order.

In the case of the *Walton-on-the-Naze* Order, the local authority refused consent, but the Board decided to dispense with consent and granted order.

Since the date of the last report the Board of Trade have approved deeds transferring the powers, duties and liabilities under 12 orders (compared with 19 in previous year), the transfer being to companies in all cases except one (the Ince-in-Makerfield Order, transferred to Wigan Corporation).

Provisional Order Transfer.—The Board of Trade have consented to the transfer of the Whitefield Electric Lighting Order, 1900, to the Lancashire Electric Power Co.

Runcorn.—Notice of intention of Messrs. G. H. Cox and H. J. Falk to apply for a provisional electric lighting order was submitted to the Council last week.

St. Helens.—The Council have applied for a loan of £8,000 for plant and mains in connection with the supply of electrical energy to Sutton.

Sandwich.—Mr. Mark Parker is applying for a provisional electric lighting order for this district.

South Africa.—The "British and South African Export Gazette" says the weight of evidence before the Government Commission which is sitting, under the presidency of Sir Thos. Price, general manager of the Central South African Railways, on the subject of Transvaal power schemes, has been overwhelmingly in favour of electricity as a motive power for mining plant, on the grounds of decreased capital and working costs, economy of water and coal consumption, and greater efficiency and flexibility.

The joint undertaking of the Victoria Falls and Transvaal Power Co. and the Rand Mines Power Supply Co. is being pushed forward, the latest development being the placing of orders in Germany for turbine-type electrically-driven air compressors, which are to be capable of delivering 1,200,000 cubic ft. of compressed air per hour, and will be $3\frac{1}{2}$ times as large as any previously constructed in Germany.

Last year there were installed in Transvaal mines 218 electric pumps with a maximum capacity of 1,770,139 gallons per hour, compared with 374 air driven pumps with a capacity of 1,670,467 gallons per hour. The electrical horse power required was 8,329, against 7,397 in the previous year, while the power consumed by steam and air driven pumps each showed a decrease.

An electric lighting scheme for Queenstown (Cape Colony), to cost £11,000, is under consideration.

Orders have been placed by Boksburg Municipality for electrical appliances, including transformers, oil switches, &c., by Bantje's Consolidated Mines for 25 electric motors from $1\frac{1}{2}$ to 100 H.P.; by Johannesburg Municipality for 500 10 ampere and 50 25 ampere a.c. meters; by the Goch Gold Mining Co. for switchgear and transformers; by the Robinson Gold Mining Co. for 19 electric motors from 15 to 60 H.P.; and by the Cloverfield Mines for two 100 H.P. three-phase standard type motors.

It is understood that orders for three 2,000 kw. and two 6,000 k.w. Parsons turbo-generator sets will shortly be placed by the Randfontein Estates Gold Mining Co.

South Shields.—The Electrical committee claims £8,957 from the Tramways committee for current for traction during the year ended March last, but, as the tramways manager, Mr. L. E. Harvey, considered the current represented by this sum was in excess of actual consumption, the meters were tested and found to be defective.

At a meeting on Friday last representatives of the two committees agreed to reduce the amount to £7,107, representing 1.52d. per car-mile, the quantity indicated by the meters after re-calibration. This adjustment, if ratified by the Council, will enable the tramway department to show a profit instead of a loss on the past year, but it is also expected that it will prevent the electricity supply department from showing a net profit.

Stepney (London).—The Electricity committee propose to extend the system of advertising the electricity department by means of illuminated signs attached to arc lamp standards.

Stroud.—At the Council meeting last week a proposal by a syndicate to apply for a provisional electric lighting order for Stroud and Nailsworth was discussed. It was decided to take no action, pending the receipt of a further notice from the syndicate.

Swansea.—At the meeting of the Electric Lighting committee last week a letter was read from Mr. E. Harris, of Swansea, containing a proposal, on behalf of clients experienced in the development of electric power undertakings, for taking a transfer and reorganisation of the Council's electricity undertaking.

The promoters of the scheme offered to become responsible for the payment of the instalments of loan charges in respect of all debts contracted by the Corporation in connection with the undertaking, to extend the system of distribution and reduce the price of current.

The committee decided not to entertain the offer.

Switzerland.—The "Feuille Fédérale Suisse" states that M. F. Leder, of Berne, on behalf of a promoting syndicate, has secured an 80 years' concession for the construction and working of a single track metre gauge electric railway from Berne to Zollikofen, with a branch from Trefenau Bridge to Worblaufen. The expenditure is estimated at £26,000.

Messrs. A. Ribordy, H. Hallenbarter and J. Roth have obtained a concession for a similar line from Goppenstein to Blatten. Expenditure £50,000.

Tiverton.—Messrs. Foote & Milne have given notice of intention to apply for a provisional electric lighting order for this borough.

United States.—According to the report of British Consul John Leay for 1908 the exports of electrical machinery from Boston to the U.K. were of the value of £21,793 (against £116,467 in 1907).

Walsall.—At the Council meeting on Tuesday the Mayor moved the adoption of a recommendation of the General Purposes committee to apply to the L.G. Board for a loan of £35,000 for extensions of the electricity undertaking.

He pointed out that a special consultative committee had endorsed this proposal as the only step which could be taken, both in the interests of the concern and of the public. The recommendation was approved.

Wireless Telegraph Notes.—Mr. Stanley Coles, the Marconi wireless operator who made himself famous by his prompt and vigorous action on the ill-fated "Slavonia," which was wrecked off Flores, in the Azores, on June 10, has received the appointment of Marconi operator on the "Atalanta," a magnificent, new steam yacht built for Mr. J. G. Gould, the American millionaire.

Two large steam trawlers owned by the Cuxhaven Steam Fisheries Co., and operating in the North Sea, have recently been equipped with wireless telegraph apparatus.

The question of a reduced rate of insurance for vessels carrying a wireless telegraph equipment is under discussion in marine quarters. The subject has been mooted before, but is now coming nearer to the position of "practical politics." There is to be an International Conference of Underwriters at Baden-Baden on Sept. 12 at which the matter will form a prominent feature.

A wireless station, the first in Corsica, has been established on the coast at Aspretto, on the eastern side of the Bay of Ajaccio. The station has been erected by the French naval authorities for the use of the navy.

According to the London "Daily News" there has been "a mysterious failure of wireless" at Dover in connection with Mr. Latham's proposed flight across the Channel. This is how the story goes:—

There have been some very peculiar experiences with the special wireless telegraph installation set up in connection with the flight. For some reason these stations cannot get into communication with each other, although the Sangatte station and the North Foreland are taking each other's messages, and the Lord Warden Hotel station and Nieuport, Belgium, are in communication. The stations on either side are also continually receiving messages from shipping in the Channel.

It is stated that the Pacific Islands Radio-Telegraphy Co., recently incorporated in London with a capital of £60,000, will soon commence operations in the Pacific, and that a French company has been incorporated for the establishment of a wireless telegraph station at Tahiti. Up to this time the sanction of the Governor and the local Government has not been given for the erection of a station.

Wireless and Air Vessels.—The "Belfast News Letter" publishes the following from its New York correspondent:—

A good deal of mystery surrounds experiments which are being carried out here by Mr. Mark O. Anthony, a railroad electrical engineer, who has invented a system by means of which dirigible balloons can be operated from the ground through the medium of wireless impulses. The experiments are said to be going on at the instance and in the presence of representatives of a European Power, whose identity is kept secret. Said Power is credited with the desire to make use of Mr. Anthony's important invention for life-saving purposes.

Outing.—Colchester electricity department staff, to the number of 30, had their annual outing on July 3, at Blackpool, at which town Mr. A. R. Sillar was engaged in the electricity department prior to his appointment at Colchester.

Annual Holiday.—Messrs. Willans & Robinson notify that their works and offices will be closed for the fortnight from July 30 to Aug. 16. A small staff will remain to deal with urgent correspondence and the supply of replace parts, &c.

Sports.—The second annual athletic meeting of the staffs of the various works of Messrs. Vickers, Sons & Maxim took place at Carbrook, Sheffield, on Saturday. Competitors were supplied by Vickers, Sons & Maxim's Sheffield, Barrow and Erith works and London offices and by the Wolseley Tool and Motor Car Co. (Birmingham) and the Electric & Ordnance Accessories Co. (Birmingham). A 30 guinea silver challenge cup, to be held for one year, by the works securing the highest number of points, was won by Barrow with three firsts, three seconds and two thirds (17 points out of a possible 36), and other prizes to the value of £60 were also competed for. There were several open events, including two for local school children. The Master Cutler (Mr. Douglas Vickers) presented the prizes. At the conclusion Major J. H. Leslie, president of the Vickers Sports Club, proposed a vote of thanks to Mr. Douglas Vickers which was seconded by Mr. M. Bennet, N.C.A.A. (the handicapper) and carried by acclamation.

Liverpool tramway employés' sixth annual sports and children's carnival took place on Wednesday. The various events were well contested and the children (numbering about 500) were well entertained. The manager of the tramways (Mr. C. W. Mallins) designed the rose queen's throne, pavilion, &c., and superintended the proceedings generally. The Lady Mayoress officiated at the coronation and Ald. Sir Charles Petrie (chairman of the Tramways and Electricity committee) and other corporators and visitors were present.

Associated Telegraph Companies' Staff Flower Show.—At the London headquarters of the Associated Telegraph Companies, Electra House, Finsbury Pavement, on Wednesday, was held, the first of what may be come an interesting series of flower shows by the members of the head office staff. The show, which was confined to roses and sweet peas as a first effort, proved a great success.

There were three classes in roses and four in sweet peas; one class in the latter did not fill. In the sweet peas Mr. H. F. Porter, of the Eastern Extension Company, cleared the board of first prizes; 2nd prizes were taken by Dr. C. W. Curtis, S. G. Farmer, W. A. de Merall respectively. Other prize winners were E. A. Roberts and S. G. Farmer, with W. Hibberdine h.c.

Roses.—Class 1: 1st E. A. Roberts, 2nd W. J. Hall, 3rd H. F. Porter, h.c. A. R. Hardie. Class 2: 1st H. F. Porter, 2nd E. W. Ludlow. Class 3: 1st H. C. Woodcock, 2nd E. A. Roberts, 3rd W. A. de Merall, 4th H. F. Porter, h.c. A. R. Hardie.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bootle.—The accounts of the electricity department for the year ended March show total capital expenditure £112,981 (against £111,521 at March, 1908).

Income was £18,506 (compared with £18,223), working costs £9,892 (£9,539), gross profit £8,614 (£8,684), interest and sinking fund charges £6,808 (£6,722), and surplus £1,806 (£1,962). £887 has been applied to general district rate, and the balance placed to reserve and renewals funds. Works costs were 0·67d. (0·66d.) per unit sold, fuel accounting for 0·35d. (0·37d.), total costs 0·89d. (0·87d.) or including capital charges 1·5d. (1·48d.). Average revenue per unit for all classes of supply was 1·66d. (as in previous year). 3,006,000 (2,872,000) units were generated, 489,000 (480,000) supplied for private lighting, 687,000 (597,000) for power, 297,000 (323,000) for street lighting, and 1,202,000 (1,229,000) for tramways. There are 696 (672) consumers connected, and the total connections (exclusive of tramways) are equal to 2,891 kw. (2,719 kw.). The maximum supply demanded was 1,252 kw. (1,196 kw.).

The report of Mr. T. D. Clothier (borough electrical engineer) states that the use of metal filament lamps has not increased consumers. The committee hope to manage without resorting to an increase in the selling price, but they are forced to recognize that the new conditions materially affect the prospects and policy to be adopted. The committee have not yet thought it advisable to establish a showroom, but Mr. Clothier thinks if it were established with a suitable staff progress might be accelerated. The maintenance period of 10 years during which the British Insulated & Helsby Cables maintained the original mains system at their own undivided expense ended in March last. The renewals fund is now approaching the statutory limit. The total revenue was only 16·5 per cent. on the capital expenditure, which indicates that careful management must have been observed to secure the results shown.

Bristol.—The accounts of the electricity supply department for the year ended March show capital expenditure £810,747 (increase £41,307).

Revenue was £81,390 (compared with £79,887 in previous year), working and general expenses £38,226 (£36,761), gross profit £43,164 (£43,126) and net deficit, after meeting capital charges and placing £2,825 (£2,655) to reserve, £305 (compared with £474 net profit.) The reserve fund remains at £18,307 (against £17,059), and unappropriated funds of £6,230 are carried forward. The increase in equivalent 30 watt lamps was 92,785 (43 872), the total connections being 3,218 consumers and 493,693 equivalent 30 watt lamps. Units sold were 8,110,957 (7,650,074), for private lighting and power 7,288,595 (6,806,301), and for public lighting 822,362 (843,773). There are 1,119 (917) motors installed on consumers' premises, the aggregate horse-power of motors and heating apparatus being 10,179 (7,103).

The report of the city electrical engineer, Mr. H. Faraday Proctor, states that the installation of the two 3,000 turbo-generators, referred to in the last three annual reports, has not been satisfactorily accomplished, although one of these machines has been in regular use for some time. The manufacturers have not complied with the guarantees, and the plant has not been taken over. The power switchboard at Temple Back has been extended and another 500 kw. (e.h.t. to d.c.) converter added to the sub-station equipment. The total mileage of cables laid is 331 miles (increase 20 miles). The year has been an exceptionally bad one from a revenue-earning point of view, owing to trade depression and the extended use of metal filament lamps. Revenue was 2·409d. (against 2·431d.) per unit, and total cost 1·054d. (1·077d.), works cost accounting for 0·737d. (0·738d.). Instalments for redemption of capital were 0·601d. (0·566d.) and interest on capital 0·666d. (0·673d.).

Oldham.—The accounts of the electricity department for the year ended March last show capital expenditure £289,271 (increase £4,839).

Revenue was £44,588 (compared with £40,465 in previous year). After meeting working and general expenses, of which coal amounted to £10,195 (£8,792), the gross profit was £21,047 (£19,590). Interest required £8,064 (£8,649) and sinking fund £9,493 (£9,217), leaving surplus £3,451 (£1,724). Coal cost 0·407d. (0·405d.) per unit, works costs including coal, were 0·677d. (0·695d.), and total costs (exclusive of capital charges) 0·910d. (0·919d.). 6,569,065 (5,842,332) units were generated, 1,121,345 (983,874) supplied for private lighting, 570,897 (376,813) for power, 21,827 (21,961) for public lighting and 4,335,972 (3,888,404) for traction. There are 146,113 (equivalent) 8 c.p. lamps connected (against 117,183). The maximum load was 3,178 kw. (2,849 kw.) and the load-factor 21·73 (21·06).

The income of the tramways department during the past year was £100,651 (compared with £101,481 in the previous year).

Working expenses were £69,208 (£61,626), including £27,100 (£24,303) for power, at $1\frac{1}{2}$d. per unit. Gross profit was £31,443 (£39,855), and after providing for interest, sinking fund, income tax, &c., there was a deficiency of £1,193 (compared with a surplus of £9,011). 19,929,973 (20,082,367) passengers were carried, 2,055,450 (1,978,150) car-miles run, and 4,335,971 (3,888,402) units used 2·109 (1·96) per car-mile. Revenue per car mile was 11·752d. (13·312d.), working expenses (including power) 8·081d. (7·477d.).

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer. We would add that the portrait is mounted so as to be conformable as to size with "The Electrician" series of steel plate portraits, and is well suited for framing with the series.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

EDMONTON Guardians invite tenders for supply and installation of a private telephone equipment at the infirmary, consisting of a 100-line switchboard with direct lines to different parts of the buildings and operated by magneto-generator calling and clearing. Specification from Mr. Stuart Hill, 106, Cannon-street, London, E.C., on and after July 19. Tenders by 9 a.m. July 28. See also an advertisement.

Tenders are invited for supply of ten 100-number switchboards to the Postmaster General's Department, NEW SOUTH WALES. Tender forms, &c., at the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

DUBLIN Corporation invite tenders for (approximately) 12 months' supply of machinery oils for the electricity works, Pigeon House Fort, Dublin. Specification, conditions, &c., from the town clerk, Mr. Henry Campbell, to whom tenders by July 26. See also an advertisement.

The Electric Lighting committee of HULL Corporation invite tenders for the supply and laying of electric mains, &c., during the period ending March, 1910. Forms of tender and specification may be obtained on depositing one guinea with the city treasurer (Mr. T. G. Milner). Tenders to the chairman of the Electric Lighting committee, Town Hall, Hull, by noon July 29.

LONDON County Council want tenders by 11 a.m. July 21 for an installation of electric lighting and fans in the extension of Paddington Technical Institute, Saltram-crescent, W. Forms from the Chief Engineer, Spring Gardens, S.W.

SHEFFIELD Education committee want tenders by Aug. 10 for heating and electric lighting of the Training College Hall of Residence for Men. Specifications, &c., from Messrs. Gibbs & Flockton, 15, St. James-row, Sheffield.

HULL Corporation want tenders by 10 a.m. July 28 for supply of electric and gas fittings required for new public hall. Specifications, &c., from Mr. J. R. Hirst, Town Hall, Hull.

MILE END (London) Guardians want tenders for supply of six Aron-type wattmeters. Particulars from the Master of the workhouse.

LEYTON Council want tenders by 7 p.m. July 27 for electric wiring and fittings for Sybourn-street school. Specifications, &c., from Mr. W. Jacques, 2, Fen-court, London, E.C.

BRADFORD Tramways Department want tenders by noon July 30 for supply of eight automatic point controllers. Specifications, &c., from Mr. C. J. Spencer, 5 and 7, Hall Ings, Bradford.

LEEDS Corporation require tenders by 10 a.m. July 19 for supply, fixing, &c., of 500 kw. steam-driven generator and of condensing plant. Specifications from the Borough Electrical Engineer.

LONG EATON Council want tenders and schemes by mid-day July 20 for the installation of water-softening plant at the electricity works. Particulars from the Engineer and Manager.

Tenders are wanted by noon, Aug. 9, for creosoting telegraph poles for the GENERAL POST OFFICE. Forms from the Controller of Stores, 17-19, Bedford-street, London, W.C.

ECCLES Health committee want tenders by 10 a.m. July 19 for electric wiring and fittings for 12 houses in Corporation-road, Eccles. Specification, &c., from the Town Clerk.

Tenders are required by first post July 20 for supply, &c., of a storage battery at the County Asylum, HELLINGLY, Sussex. Particulars from the Resident Engineer.

Tenders are invited for the supply of 13¼ miles of bare hard-drawn copper cable, and also for the supply of 6,410 yds. of single conductor lead covered cables and 1,400 yds. of concentric lead covered cables to the City Council of MELBOURNE. Specifications, tender forms and conditions from the Agents for the City Council, Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., with whom tenders must be lodged by Friday, July 23.

The TRANSVAAL Department of Posts and Telegraphs require tenders for supply of 2,500 tapered iron telegraph poles and 20 tons of g.i. wire. Tenders to the Agent-General, 72, Victoria-street, London, S.W., by noon July 23.

Tenders are invited by the Public Works Department, MADRID, for a 60 years' concession for the construction and working of an electric tramway between Monachil and the suburbs of Gabia Grande (Granada). Tenders (with deposit of 3,588 pesetas = £130) to the Direccion General de Obras Publicas, Madrid, before noon August 26. The "Madrid Gazette" for June 21 containing further particulars, may be seen at 73, Basinghall-street, London, E.C.

The Spanish Department of Public Works, Madrid, want tenders by noon, Aug. 27, for a concession for the construction and working of electric tramways in BARCELONA. Tenders to be accompanied by a deposit of 40,596 pesetas (about £1,450). The Cia General de Tranvias have certain preferential rights in the competition.

COPENHAGEN (Denmark) Lighting Corporation want tenders by noon, July 17, for supply of 800 a.c. meters, and by noon, July 19, for supply of c.c. cable. Specifications &c., at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Stepney (London) Council received the following tenders for supply of carbons for two years :—

Sloan Electrical Co. (*accepted*) £1,091. 13s. 10d., Union Electric Co. £1,221. 16s. 8d., Crompton & Co. £1,144. 6s. 9d., General Electric Co. £1,183. 11s., G. Braulik £1,190. 1s. 5d., Siemens Bros. Dynamo Works £1,434. 0s. 3d. Four other tenders were not in accordance with specification.

The following tenders were received for two years' supply of meters :—

Reason Mfg. Co. (*accepted*), £671. 10s., *Bastian Meter Co. £281. 5s., *Electrical Apparatus Co. £402. 10s., *Gillespie & Beales £422. 10s., *British Westinghouse Co. £522. 10s., *G. Braulik £545, *Electrical Co. £577. 10s., and £650. 16s., *Simplex Conduits £590. 17s. 6d., *International Electric Co. £694, Siemens Bros. Dynamo Works £712. 15s., British Thomson-Houston Co. £761. 10s. 4d., Bat Meter Co. £767. 3s., Chamberlain & Hookham £878. 10s., General Electric Co. £933. 9s., Ferranti (Ltd.) £878. 10s. Those marked * were informal.

Stepney (London) Council have accepted the tender of the Reason Mfg. Co. for demand indicators at £563. 5s.

Warrington Council have accepted the following tenders for annual supplies :-

British Electrical Engineering Co., transformers ; Mawdsleys (Ltd.), d.c. motors (¼ H.P. to 5 H.P.) ; British Westinghouse Co., d.c. motors (7½ H.P. to 20 H.P.) ; British Thomson-Houston Co., a.c. motors.

Bradford Corporation have accepted the tender of Manlove, Allcott & Co. for the reconstruction of destructor cells at £2,472, and that of Gent & Co. for 100 electric impulse clocks, with master clock and wiring, for the Town Hall at £194.

Wolverhampton Council have accepted the tender of the Wolverhampton and District Electric Tramways for supply of 11 magnet equipments at £500.

The Adelaide (S. Australia) Municipal Tramways Trust have accepted the tender of the J. G. Brill Co. for supply of 50 car bodies at £36,673. The highest tender (by a local firm) was £45,361.

Wolverhampton Council have accepted the tender of James Hodgkinson (Salford), Ltd. (at £750) for coal conveying plant and coking stokers.

Stepney Council have accepted the tender of Rickett Smith & Co. for 250 tons of Babbington nutty small coal at 11s. 9d. per ton and 1s. per ton for storage at the company's Mile End depot.

Rotherham Council have accepted the tender of Felgate & Storey, for wiring the High School at £225.

Canterbury Council have accepted the tender of J. E. Dashwood for electrical work for six months.

Bristol Docks committee have accepted the tender of Johnson & Phillips for cables.

Swansea Education committee have accepted the tender of A. Arnold & Sons for wiring the technical schools at £289. 12s. 8d.

Dundee Electricity committee recommend the acceptance of the tender of the Union Cable Co. for various sizes of cable. See also under DUNDEE, p. 564.

The A.E.G. Electrical Co., of South Africa, have orders in hand for a 60 H.P., and two 7½ H.P. motors, and a transformer for Glynn's Lydenberg (Ltd.) ; 10 transformers and four panels for the Robinson Gold Mining Co. ; a 250 kw. transformer for the Geldenhuis Deep ; and 250 10 ampere and 100 25 ampere d.c. meters for Johannesburg Municipality.

SPECIAL NOTICE.

NOW READY.—Vol. LXII. of "THE ELECTRICIAN" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

Curtis Steam Turbines.—The British Thomson-Houston Co., have recently received a number of orders for Curtis steam turbines of the horizontal type for exhaust and mixed pressure. Repeat orders for vertical Curtis steam turbines have been received from Liverpool Corporation for Lister Drive station (where three vertical Curtis steam turbines are already installed), and for five vertical Curtis steam turbines for the County of London Electric Supply Co.'s stations.

Other orders for horizontal type Curtis turbines include Cleveland & Durham Electric Power Co. (Teesbridge), one 1,500 kw. two-stage plain exhaust three-phase alternating; Fife Coal Co., two 750 kw. three-phase mixed pressure; Earl Fitzwilliam Collieries, one 350 kw. mixed pressure a.c.; Wath Main Colliery, one 500 kw. plain exhaust a.c.; Broidwater Spinning Co. (Ireland), one 750 kw. mixed pressure a.c.; Bolsover Colliery Co., one 500 kw. a.c. plain exhaust; Lothian Coal Co., one 560 kw. mixed pressure d.c.; Shirebrook Colliery Co., one 500 kw. mixed pressure a.c.; Bolckow, Vaughan & Co., one 750 kw. mixed pressure a.c.; Carrongrove Paper Co., one 1,000 kw. high pressure a.c.; Oriental Timber Co., one 750 kw. mixed pressure a.c.; Watford Council, one 500 kw. high pressure a.c.; Hakota Electric Light Co., one 1,000 kw. high pressure a.c.

"**Harvest Your Health.**"—This phrase is a topical one, inasmuch as everyone contemplates the harvesting of their health by spending the holiday period at one of the many seaside resorts which abound in our beautiful country. The bracing breezes of the north-east and north-west coasts of England all possess great attraction for Londoners, and the traveller from the metropolis will find what he requires in the way of information concerning these beauty spots in the Excursion Programme published by the Great Central Railway. It contains a varied choice of seaside and country health resorts, and also shows many of the remarkably low fares covering the holiday period, whether for short or long holidays. Each Saturday during July, August and September these cheap tickets are available by restaurant car expresses to the various resorts. The provision of meals on the train at very reasonable tariff represents a special feature. The trains leave Marylebone (London) at convenient times, and travellers' luggage can be sent in advance and delivered at destination at the nominal fee of 1s. per package. A copy of the programme can be obtained free of charge at Marylebone station, or by post from the Publicity Department, 216, Marylebone-road, London, N.W.

BUSINESS NOTICES.

W. T. Glover & Co. have appointed Haslam & Schontheil, Cardiff, to represent them in South Wales.

Fredk. G. Gunbie and Frank H. Rees (trading as Gunbie, Rees & Co.), electrical and gas engineers, 7, Finsbury-square, London, E.C., have dissolved partnership. Debts by Mr. Rees.

The Newcastle address of the Union Electric Co. is now Collingwood Buildings, Newcastle-on-Tyne.

Patent Development.—The proprietor of Letters Patent No. 18,842/1907, relating to "Means for receiving intelligence communicated by electric waves," desires to dispose of the patent or to grant licences with a view to the adequate working of the patent in this country. Apply to Messrs. Cruikshank & Fairweather (Ltd.), 65-66, Chancery-lane, London, W. C.

CATALOGUES, &c.

ELECTRIC LOCOMOTIVES.—One of the most interesting pamphlets we have read for some time has just been ssued by Messrs. Siemens Bros. Dynamo Works. It contains details of the electric locomotives delivered and erected by the company up to the end of 1908, whence it appears that there are 486 of such locomotives with an aggregate horse-power of 47,200. The locomotives supplied cover a wide range, varying from the ordinary continuous-current type, driven from an overhead line or accumulators, to those designed for use on three-phase and single-phase circuits. The sizes of the various machines are also very various. Special attention may be called to mine locomotives dealt with in the first part. It is interesting to learn that these have lately superseded horse traction and locomotives driven by petrol or compressed air. Illustrations and data of two shunting locomotives, which have been supplied to collieries in this country, are given. With regard to single-phase traction, it is instructive to note that 39 locomotives of this type have been supplied with an aggregate horse power of 24,830. The pamphlet will be found of great service to all interested in traction work, marking as it does the great progress which has been made in this direction by Messrs. Siemens in late years.

"FORTITER" DIRECT-CURRENT MOTOR-STARTING SWITCHES.—In the last issue of the INDUSTRIAL SUPPLEMENT we gave some details of the latest Fortiter direct-current motor-starting switches manufactured by the Union Electric Co. This subject is dealt with in more detail in a catalogue recently issued by the company. Each type is illustrated, and enough information is given for the prospective buyer to realise which piece of apparatus is most suitable for his needs. Diagrams, connections and sectional drawings of the various apparatus form a special feature. We may, in this connection call special attention to the motor-starters fitted with oil-cooled, resistances, starters with field reversing switches, and also those with a step-by-step slow motion. An interesting starter with a multiple solenoid equipment dealt with in this catalogue has already been described by us.

SINGLE-PHASE MOTORS.—Messrs. T. W. Broadbent have recently issued a pamphlet dealing with single-phase motors in which a reduction of the starting current required is effected by means of a more effective "phase splitting" than is usual. We are pleased to learn that business appears to be flourishing with this firm.

A.E.G. SPECIALITIES.—The wide range covered by the Allgemeine Elektricitäts-Gesellschaft in the electrical field is well illustrated by a number of pamphlets we have received from the Foreign Department of this firm. The pamphlets deal with such varied subjects as the "Express" electric water heater, already described by us, induction motors of various types, ironclad switches for pressures up to 7,500 volts, electric annealing and tempering plants, and lift-controlling gear. Full information concerning these specialities is contained in the pamphlets.

M.A.N.—In our last issue we drew attention to the fact that the Maschinenfabrik Augsburg-Nurnberg had recently opened a London office at Caxton House, Westminster. We have now received from the firm, whose cognomen is M.A.N., a copy in English of their general catalogue. A glance through this will show how wide are the activities of the firm. First an interesting historical sketch of the development of the works is given, and then the chief manufactures are dealt with. These include boilers, automatic stokers, reciprocating engines and turbines, gas engines (these latter being of the well-known double-acting Nurnberg type), and Diesel engines. Other machinery turned out includes water turbines and, on the purely electrical side, cranes and tramcar equipment, while bridges and railway rolling stock are amongst other engineering work in which the firm takes an interest. We shall hope to deal in detail with some of these interesting specialities at a later date.

"FALCON" EQUIPMENT.—From Messrs. Tetley & Co., of Salford, we have received a catalogue and a number of leaflets dealing with their specialities. These include switches of various types as well as fuses, wattmeters and fans. A speciality is also made of ship and mill fittings, and liquid motor-starters. The firm, however, are principally known for their work in the switchgear connection, and much information as regards this useful apparatus is given in the pamphlets.

THE "FLIP-FLAP."—A postcard just received from the Electric & Ordnance Accessories Co. informs us that the "Flip-Flap" at the Imperial International Exhibition at Shepherd's Bush, is driven by a 100 H.P. motor supplied by them and is apparently none the worse for its winters' rest. The intrusion of the electric motor into pleasure details is well exemplified by this application.

PRESCOT WIRES AND CABLES.—The latest pamphlet of the British Insulated & Helsby Cables deals with the Prescot braided aerial cables and wires. These are thoroughly impregnated with what is claimed to be the finest weather-proof compound yet discovered. The sizes of the single conductors vary from 0 S.W.G. to 16 S.W.G. stranded wires. Stranded cable with sectional areas up to 1 sq. in. is also made.

LARGE CHAIN DRIVES.—Some details of large chain drives recently supplied by the Westinghouse Brake Co. are given in a pamphlet recently issued by them.

SIEMENS INSTRUMENTS.—We have received from Messrs. Siemens Bros. & Co. two reprints dealing respectively with current transformers for measuring instruments and switchboard instruments, the latter of these being a reprint from THE ELECTRICIAN of May 7 and 14 last. These reprints, in our opinion, form an excellent method of bringing a maker's specialities before the public. The interest once aroused by them can easily be fanned into flame by the financial details given in a catalogue of the ordinary type.

TACHOMETERS. We have received from Mr. Jens Orten-Böving a copy of a catalogue dealing with Dr. Horn's tachometers. We understand that these instruments are more widely used on the Continent than any other type and are also finding favour in this country. For example, five special turbine tachometers are now being installed on turbines for the Westminster Electric Supply Corpn. In all probability the manufacture of these tachometers will be taken up under licence in England with the result that a considerable reduction in prices will be effected.

HENLEY'S JOINTING MATERIALS. The latest list of W. T. Henley's Telegraph Works deals with jointing materials. It should be of considerable interest to all electrical engineers and contractors, as it sets out in convenient form particulars of a large variety of insulating and other tapes. It describes the various properties of the tapes and the purposes for which they are best suited, together with particulars as to prices, widths and weights. It is claimed that the tapes described in this list cover the whole range and that tapes suitable for any purpose can be found therein.

BANKRUPTCIES, LIQUIDATIONS, &c.

The first meeting of creditors of Wm. Thos. Harris (trading as T. Harris & Sons), electrical engineer, 460 and 464, Commercial-road, and 47, Emanuel-street, Portsmouth, will take place on July 19 at the O.R.'s, Cambridge Junction, and the public examination on July 26 at the Court House, Portsmouth.

A meeting will be held at 7, Hertford-street, Mayfair, London, W.C., on Aug. 19 to receive an account of the winding up of the Electric Taxicab Co. (Ltd.).

A meeting to receive an account of the winding up of the Chipping Norton Electric Light & Power Co. (Ltd.), will be held on Aug. 11, at 1, West-street, London, E.C.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during June, 1909, and (*b*) during the current year from Jan. 1 to June 30, with the increases or decreases compared with the corresponding periods of 1908:—

Electrical machinery (*a*) £41,544 (decrease £645), (*b*) £232,767 (decrease £94,242); telegraph and telephone cables (*a*) £21,605 (increase £14,557), (*b*) £62,475 (decrease £2,036); telegraph and telephone apparatus (*a*) £17,734 (increase £6,558), (*b*) £92,855 (decrease £6,772); other electrical wires and cables, rubber insulated (*a*) £7,210 (increase £1,411), (*b*) £29,036 (decrease £10,215); with other insulations (*a*) £8,431 (increase £2,993), (*b*) £53,808 (decrease £3,225); carbons (*a*) £10,812 (decrease £1,976), (*b*) £65,577 (decrease £21,194); glow lamps (*a*) £52,004 (increase £10,217), (*b*) £217,238 (increase £93,016); arc lamps and electric searchlights (*a*) £281 (increase £1), (*b*) £8,826 (increase £6,983); parts of arc lamps and searchlights (other than carbons) (*a*) £5,481 (increase £1,922), (*b*) £27,727 (increase £1,813); primary and secondary batteries (*a*) £3,420 (increase £83), (*b*) £24,533 (decrease £115). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £116,569 (increase £36,093), (*b*) £634,538 (increase £51,862).

Exports.—The exports of electrical machinery, material, &c., (*a*) during June, 1909, and (*b*) during the current year from Jan. 1 to June 30, and the increases and decreases compared with the corresponding periods of 1908, are as follows:—

Electrical machinery (*a*) £127,847 (increase £42,298), (*b*) £707,661 (increase £65,729); telegraph and telephone cables (*a*) £11,149 (decrease £1,919), (*b*) £193,428 (decrease £38,831); telegraph and telephone apparatus (*a*) £28,917 (increase £17,121), (*b*) £123,494 (increase £43,502); other electrical wires and cables, rubber insulated (*a*) £16,617 (decrease £1,530), (*b*) £126,777 (increase £89,147); with other insulations (*a*) £42,844 (increase £21,259), (*b*) £147,639 (increase £13,058); carbons (*a*) £839 (increase £161), (*b*) £4,200 (increase £347), glow lamps (*a*) £5,621 (increase £316), (*b*) £35,220 (increase £10,439); arc lamps and searchlights (*a*) £1,100 (increase £115), (*b*) £9,545 (decrease £1,108); parts of arc lamps and searchlights (other than carbons) (*a*) £906 (decrease £1,020), (*b*) £8,450 (increase £249); primary and secondary batteries (*a*) £10,297 (increase £776), (*b*) £56,493 (increase £21,589). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £146,543 (increase £38,330), (*b*) £885,636 (increase £43,651).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

[illegible] are open to public [illegible] are open for [illegible] in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.

[illegible]

[illegible]

12,826 to 12,831 HARRISON. Metal filaments of incandescent electric lamps.

[illegible]

[illegible] for telephone, telegraph or other electric conducting [illegible]

[illegible] Electric motor meters. (Date [illegible])*

12,905 FROST. Current-generating and motive-power machine.

12,917 MAVOR & MAVOR & COULSON. Controlling the speed of bodies driven by alternating-current electric motors.

12,918 E[illegible] & H[illegible]. Telephone transmitters.*

June 2, 1909.

12,931 KELVIN & JAMES WHITE & MILLS. Magnetic compasses.

12,937 HOUGHTON, ALLMAN & GRAY. Electric power traction systems.

12,970 LE BLANC. Electrically controlling searchlights.*

12,[illegible] LOWDEN. Electrically-heated cooking apparatus. (Date applied for, 12/6/08 Comprised in application No. 12,669/08, dated 12/6/08.)*

June 3, 1909.

13,008 PAPE. Box for preventing escape of electrolyte from electric storage batteries.

13,010 JOHNSON. Electrical torsiometer.

13,014 PAPE. Sparking plug.

13,036 & 13,037 C[illegible]. Electro-deposition of metals.

13,040 SIEMENS BROS. DYNAMO WORKS (Siemens Schuckertwerke G.m.b.H., Germany). Electric frequency transformer.*

13,041 SIEMENS BROS. DYNAMO WORKS & K[illegible]. Suppressing electric current due to harmonics in the wave form of alternating-current dynamo-electric machines.

13,059 GRAFTON & J[illegible] & PHILLIPS. Alternating-current generators.

13,080 EVERSHED & VIGNOLES & EVERSHED. Electric energy meters.

13,099 ADAMS. Telephone receivers.

June 4, 1909.

13,117 HUNTER & PAPE. Casting circular lead grids for electric storage batteries.

13,129 MONNIER. Distributing box for cables with multiple electrical conductors. (Date applied for, 6/6/08.)*†

13,135 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany). Manufacture of electrical condensers.*

13,142 CURTIS, MOULD & ADAMS MFG. CO. Electric rheostats, motor starters and the like

SPECIFICATIONS PUBLISHED.

1908 SPECIFICATIONS.

4,852 DOINIKOFF. Alternating-current commutator dynamo-electric machines.

5,781 PARTRIDGE & DAWSON. Supporting and insulating means for aerial and other electrical conductors.

6,963 B.T.-H Co. (G.E. Co., U.S.) Control of alternating electric current motors of the commutator type.

11,633 ALLGEMEINE ELEKTRICITATS-GES. Alternating-current dynamo-electric machines. (Date applied for, 29/5/07.)

11,870 HARTMANN-KEMPF. Apparatus for use in indicating or measuring the frequency of electrical or magnetic alternations. (Date applied for, 31/5/07.)

12,140 SHARMAN. Wireless telephony and telegraphy.

12,142 BOULT. (Electrical Mfg. Co.) Electric cutouts.

12,267 B.T.-H. Co. (G.E. Co., U.S.) Asymmetric electric conductor of the electrolytic type.

12,326 STERN. Speed regulation of induction motors. (Date applied for, 12/6/07.)

12,398 DIERMAN. Electric lamps having metal filaments.

12,498 MAVOR & MAVOR & COULSON. Control of electric motors.

12,656 TIMAR & VON DREGER. Arc lamps. (Date applied for, 8/7/07.)

12,720 S[illegible] FRANÇAISE D'INCANDESCENCE PAR LE GAZ (SYSTÈME AUER). Incandescent electric lamp filaments and apparatus. (Date applied for, 13/7/07.)

13,191 DEARLOVE. Electric telegraphy.

13,743 PIFER & AHLM. Dynamo-electric machines.

13,752 KITSON. Incandescence vapour lamps.

14,305 ALBERT THODE & CO. Sectional interrupters for the line wires of electric railways. (Date applied for, 9/7/07.)

14,695 WEST. Current collector for use in electric traction systems.

16,029 COBB. Telephone apparatus.

16,597 TRIER. Portable electromagnets.

18,653 COTE & PIERRON. Electric furnace for the continuous extraction of zinc from its ores. (Date applied for, 12/2/08. Addition to No. 5,100/07.)

19,457 AITKEN. Telephone instruments.

20,638 DE FOREST. Secrecy systems for wireless communication.

20,827 AKT.-GES. BROWN, BOVERIE & CIE. Starting of polyphase motors. (Date applied for, 3/10/07.)

22,319 AKT.-GES. BROWN, BOVERIE & CIE. Speed regulation of electically-driven ring spinning frames. (Date applied for, 27/5/08.)

23,800 ZUMSTEG & ZUMSTEG. Coupling dynamos and electric motors.

25,044 KUZEL. Metal filament electric glow lamp. (Date applied for, 14/5/08.)

28,130 STECKEL. Electrical induction clutches.

COMPANIES' MEETINGS AND REPORTS.

Electric Construction Co. (Ltd.)

The sixteenth annual general meeting was held yesterday under the presidency of Mr. WALTER S. B. MCLAREN.

The SECRETARY (Mr. David Willock) having read the notice convening the meeting and the auditors' certificate,

The CHAIRMAN said: Gentlemen, your directors present accounts which shows a marked improvement upon those of last year. Indeed, we have to go back to 1904 (when the last dividend was paid on the ordinary shares) to find net profits comparable with those of the past financial year, and, having regard to the general depression in trade and to the continued strenuous competition in the electrical manufacturing industry, I think that we have every reason to congratulate ourselves. As an illustration of what this competition means, I may mention the case of tenders which were submitted recently for the extension of a provincial electric lighting station. No fewer than 33 firms tendered, and in the aggregate 118 tenders were submitted. These ranged from a minimum of £2,751 to a maximum of £4,218, and while I do not suggest that the whole of the difference was represented by the electrical portion of the plant, still, the figures will give you some idea of the competition that prevails. I must repeat what I told you last year, that the electrical manufacturing industry is suffering severely from over-production. During the present decade about £7,000,000 have been invested in this branch of the business, the greater part whereof is earning no dividend, and you can realise what this has meant to older concerns like our own, for, although there has been a steady and increasing outlet for electrical plant, the power to supply has been grossly in excess of demand, in consequence of the huge increase in capital I have mentioned. A glance at the accounts will satisfy you that, if we had not been obliged to pay two years' dividend on the preference shares, the ordinary shares might have received 2½ per cent.

The accounts do not call for any special comments, but I may refer to the more important variations upon the previous year. On the credit

side of the profit and loss account you will have noticed an increase of £5,711. 10s. 8d. on manufacturing and contracting, and sundry receipts. This is due to causes I have already described, and is the most gratifying feature in the accounts, as it indicates that, notwithstanding the low prices which have prevailed, we can earn a moderate profit upon our products. As I told you last year, if a sufficient volume of business could be obtained, I should have no doubt whatever about our being able to distribute a reasonable dividend on our ordinary shares, and an increase in output is the crux of the situation. Whether that increase will be obtained this year I cannot say, and, of course, I may remark that our hopes for the current year are based upon keeping up a reasonable amount of manufacture. If manufacture falls off this progress cannot be maintained, but we shall do our very utmost to keep our order book as full as possible. Dividends on shares in other companies show a reduction of £2,338. 15s. 9d. The Electrical Power Storage Co. (Ltd.), in which, as you know, we are largely interested, has suffered from the general depression in trade, and for the first time for a period of 17 years finds itself unable to declare a dividend. The directors of that company report, however, that there are indications of a revival in business, and it is hoped that this improvement will continue and enable the Company to resume payment of dividends in the near future. Our holding in the Madras Tramways has yielded a somewhat better return. The directors of that company contemplate a further extension of the tramway, and if that is carried out, the return upon our deferred shares will be materially improved. The debit side of the profit and loss account calls for no particular remark. The net profit for the year, after paying £10,250 for debenture interest and crediting £5,000 as formerly to depreciation account, is £10,730.12s. 7d., and, after paying a dividend for two years on the preference shares, we shall carry forward £3,687. 16s. 8d. to next year, an increase of £1,941. 8s. 7d. on the sum brought in. The profit of £10,730. 12s. 7d. for the past year compares with £5,932. 6s. 9d. for 1907-8, and with a loss of £1,442. 2s. 10d. for 1906-7. I now move the adoption of the report and accounts.

Mr. P. E. BEACHCROFT: Although the figures do not show an extravagant result, it is an evidence, I hope and believe, of better times to come, and I think that the reason why we have been able to hold our own—and undoubtedly in the future shall be able to do so still more—is the fact that—say what you like—the Electric Construction Co. has the reputation for turning out quite the very best work in this particular trade. That is the reason why on this side of the table we feel justified in anticipating and looking for results in the future which will place us ordinary shareholders in a better position than we have been in the past. It is a satisfactory note in the accounts and report submitted to you that the financial position of the Company has become so very much more satisfactory than it has been in the past. I have been for 16 years associated with this Company, and during that time we have seen ups and downs, but I do not think that in any previous year have I personally, from the financial aspect, looked with such confidence to the future as I do to-day. I beg to second the motion.

After a brief discussion the resolution was carried unanimously.

The retiring directors, Mr. W. S. B. McLaren and Sir H. C. Mance were then re-elected, as were the retiring audirors. A cordial vote of thanks to the chairman, directors and officials brought the proceedings to a close.

Chili Telephone Co. (Ltd.)

The twentieth ordinary general meeting was held yesterday under the presidency of Mr. George Keith.

The SECRETARY (Mr. Edmund Petley) having read the notice calling the meeting and the auditors' certificate,

The CHAIRMAN said: The accounts show a very satisfactory improvement in the Company's business, very similar to what took place in the preceding year. The currency revenue in Chili has increased during the year 17 per cent., which was due partly to the expansion of business and partly to the higher rates charged in compensation for the lower value of the Chilian dollar. Currency expenditure for the year comes out at about 48 per cent. of the revenue, or nearly 2 per cent. less than it did in the preceding year. The income in Chili when converted into sterling shows an increase for the year of £3,815. Interest on investments and transfer fees has increased £59, while the London expenses and income tax are practically the same as they were last year. There is no charge for debenture interest, as was the case in the last year's account, and the net profit of the year comes out at £35,327, which, added to £2,777 brought forward from last year's account, makes a total of £38,104. An interim dividend of £6,600 was paid in January, and £17,684 has been transferred to the reserve. The Directors now recommend the payment of a final dividend of £11,000, which, with the interim payment, makes a total distribution for the year on the share capital of 8 per cent., free of income tax, and there remains £2,820 to be carried forward to the next year's account. £4,298 expended during the year on new extensions has been carried to the capital expenditure account, and £5,068 on replacements of plant has been taken from the reserve account, which shows an increase for the year of £13,000, while investments at cost are £10,339 more. The Company's plant and property at the various centres throughout the country have been considerably extended during the year. Amongst other works several new offices have been opened and connected up in the southern districts, and special attention has been given to improve and increase the trunk line communication in the Iquique district in order to meet the requirements of the nitrate industry. Steady progress has been made with the canalisation of the overhead lines in the City of Santiago in accordance with the electrical law which was passed some years ago for that purpose. This work is being carried out ahead of the repairing of the streets after the completion of the new drainage works. A new multiple switchboard has been installed in the central office at Valparaiso, replacing the temporary exchange with which the service had been worked since the earthquake disaster. This new installation has greatly improved the service, with the result that the business in Valparaiso is increasing very satisfactorily, and the outlook generally is satisfactory. I now move the adoption of the report and accounts.

The Hon. HERBERT T. ALLSOPP seconded the motion which was carried unanimously.

Resolutions approving the dividends, and re-electing the retiring director and auditors, were then passed, and a vote of thanks to the Chairman, Directors and staff of the Company, terminated the meeting.

BOMBAY ELECTRIC SUPPLY AND TRAMWAYS CO. (LTD.)—Sir E. Sassoon, M.P., at the meeting this week said the company's total revenue was £177,855. 11s. 9d., an increase of £49,935. 10s. over the previous year, and the expenses had increased by £23,749. 3s. 10d. They were this year adding further 10 cars, making 172. On the face of it, the increase in working expenses of the electric supply department appeared somewhat out of proportion to the increase in the receipts. This was accounted for by the fact that over 66 per cent. of the total units sold was sold to the tramways at about the cost of production. The benefit the electric supply section received from the sale of those units was reflected in the lower costs of generation in respect of the total number of units generated. Excluding the amount represented by the current supplied to the tramways, the gross receipts from the electricity supply branch of the business were £25,683, an increase of nearly £8,000. During the past year 215 consumers were added, representing 40,208 equivalent 8 c.p. lamps, and up to the end of May 135 new consumers with 20,629 8 c.p. lamps had been connected. Arrangements for erecting a new generating station at Kussara Basin had been completed, and negotiations were in progress for supply of electric power to the Bombay, Baroda and Central India Railway workshops at Parel, which would take a supply of about 500 kw. Other important contracts were also being negotiated, so that the supply thereunder might commence about the date when the new power station would be completed and working, which they anticipated would be early in 1911.

CITY & SOUTH LONDON RAILWAY CO. (LTD.)—The accounts for the half-year to June 30, after providing for debenture stock interest, payment of dividend on the 5 per cent. preference stocks, 1891, 1896, 1901 and 1903, and transfer to renewal fund of £1,500, show a balance sufficient to allow the payment of a dividend on the consolidated ordinary stock at the rate of 1¾ per cent. per annum, and to carry forward £1,411. The dividend for the corresponding period last year was at the rate of 1½ per cent. per annum, and the amount carried forward £1,868. The directors' report states that the total receipts were £89,563. 3s. 5d., and working expenses £39,975. 7s. 9d., leaving a profit of £49,587. 15s. 8d. Passengers carried (exclusive of season ticket holders) were 11,227,179 (compared with 10,891,535 in the corresponding half of 1908) and the traffic receipts (including season ticket holders) £84,245. 11s. 10d. (compared with £83,474. 11s. 3d.). The increase of receipts from all sources is the more satisfactory in view of the constantly progressing electrification of tramways which connect with and feed those already competing with the company's line. It has also to be remembered that as 1908 was leap year; the half year under review was shorter by one day than the corresponding period. An agreement has been entered into with the Central London Railway Co. in regard to the construction of a subway between that company's and this company's Bank stations. The St. Swithin's-lane portion of the proposed subway has been withdrawn from the Central London Railway Co.'s bill of this session.

DELHI ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The third ordinary general meeting was held on Thursday last. The chairman, Col. Sir B. Scott, said the delay occasioned by the failure of the contractors to complete their contract had handicapped the directors. The receipts, particularly of the tramway system, were seriously affected by an outbreak of malarial fever, by which from 60 to 70 per cent. of the population of Delhi were prostrated. The gross receipts for the five months were Rs.67,500 and total expenses Rs. 55,600, leaving net receipts Rs.11,900 (£793). Negotiations were in progress for the sale of the original power station and plant. 805,670 passengers were carried and 142,755 car-miles run.

GENERAL ELECTRIC CO. (LTD.)—For the year ended March 31 the net trading profits and income from investments, &c., was £78,200. 12s. 4d., and after deducting depreciation and interest (£26,987. 2s. 6d.), there remains £51,213. 9s. 10d., out of which preference dividend has absorbed £12,500, leaving £38,713. 9s. 10d., which the directors recommend should be appropriated to providing managing directors' and employés' bonus, £3,871. 7s., dividend on ordinary shares of 5 per cent., £18,697. 10s., to reserve £16,144. 12s. 10d., making the total reserve £136,488. 0s. 10d. The report states that the result of last year's working can be considered satisfactory in view of the prevailing depression in the engineering trades. The works at Witton, Salford, Birmingham and London have been profitably employed throughout the year, although they have not been working up to their full capacity. The osram metal filament lamp has established during last year a great reputation. A considerable proportion of lamps recently supplied have been produced at the new works at Hammersmith, and the quality has proved in every respect equal to those supplied by the Continental factory. The company's telephone works at Salford have been considerably extended. 1,342 further ordinary shares have been allotted to the directors and staff at par.

GREENWOOD & BATLEY (LTD.)—The annual meeting was held on Saturday, when Mr. Arthur Greenwood, who presided, said the year just passed was one of the worst on record not only as to orders received, but also as to remunerative work. The board regretted to have to pass the dividend on the ordinary shares, after having paid dividends which worked out practically at the average rate of 4 per cent. for the past 11 years, including the present year. The great falling off in work was largely in Orduance Department, particularly in torpedoes. That department was practically devoid of work, and they could not afford to keep it at the disposal of the Government unless the company were given a share of such work. The directors would be compelled to find other work for it, and the Government would find that when their needs were pressing they would not have it at their call. Their electrical department had been, and was, fairly busy, but competition was so keen that profits were small. They had considerable interests in the English De Laval Steam Turbine Co., in foreign and colonial works, and in electric traction and carriage undertakings, and in the judgment of the board the best plan was to transfer a considerable amount from reserve, so as to place the investments on a sounder economic basis. They had more orders on the books and more promising inquiries than last year, and doubtless more prosperous times would return, as they had done before, but the outlook was not brilliant.

MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)—At a meeting of this Company on Wednesday the resolution (passed at the ordinary general meeting) to modify the Articles of Association so as to enable the directors to pay a commission on shares, in accordance with the new Act, was confirmed.

NATIONAL TELEPHONE CO. LTD.)—The report of the directors for the half-year ended June 30 states that the income accrued in respect of the business of the half-year amounts to £1,546,837. 15s. 1d., compared with £1,452,569. 0s. 7d. for the corresponding period of 1908, an increase of £94,268. 14s. 6d. Working expenses amount to £893,767. 10s. 5d., compared with £828,969. 1s. 7d. for the corresponding period of 1908, an increase of £64,798. 8s. 10d. The net result (after deducting Post Office royalties amounting to £148,951. 6s. 3d.) is a profit balance of £504,118. 18s. 5d., compared with £484,068. 12s. 3d. for the corresponding period of 1908, an increase of £20,050. 6s. 2d. The rentals carried forward for unexpired terms of running contracts amount to £1,366,283. 9s., as compared with £1,314,591. 8s. 11d. at the corresponding period of 1908, an increase of £51,692. 0s. 1d.

Out of the available balance of £379,850. 5s. 8d. the directors recommend the payment for the half year of a dividend at the rate of 6 per cent. per annum on the first and second preference shares, 5 per cent. per annum on the third preference shares, 6 per cent. per annum on the preferred stock, and 6 per cent. per annum on the deferred stock, less tax in all cases. It is also proposed to transfer £150,000 to reserve, and to carry forward the balance of £11,100. 5s. 8d. £313,393. 15s. 6d. has been expended on capital account during the half-year in the erection of 12,848 additional exchange and private stations and in the construction of underground works.

NEW GENERAL TRACTION CO. (LTD.)—The general meeting of this company was held on Tuesday. Baron E. B. d'Erlanger presided, and said the accounts differed little from those of the previous year. Receipts from the Coventry property were the same as for 1907, those from Norwich were £913 less and from Douglas £58 less. On the other hand, the Philadelphia property paid them £482 more. The Norwich tramways had carried 7,190,351 passengers, a decrease of 377,845, the car-miles run being 1,049,175, against 1,081,221. Mr. I. E. Winslow (the company's engineer) said the costs per car-mile in Coventry and Norwich were about 5½d. in each case. The receipts per car mile were low in both cases, compared with a good many other cities.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The report of the directors for the year ended March 31 states that the gross receipts for the year in the River Plate were £237,054, against £250,750 last year. Deducting expenses in Argentina and London, debenture interest, dividend on preference shares and interim dividend on ordinary shares, and adding interest on investments, transfer fees, &c., there remains a profit of £89,233, and, adding £4,904 brought forward from previous year, an available balance of £94,138. After applying £32,000 to reduction of special replacement account and £25,000 to reserve, the directors recommend a final dividend of 5 per cent on the ordinary share capital, making a return of 8 per cent. for the year, tax free, that a sum of £2,000 be voted towards a staff provident fund, which is being formed among the company's employés in Argentina, and that £5,138 be carried forward. The board regret to have to record the death of Mr. Alfred Le Rossignol, who had been for many years a director of the company.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES, CHARGES, &c.

NEW COMPANIES.

GAVAN INRIG (LTD.) (103,894.)—Reg. July 6, capital £2,000 in £20 shares, to acquire business and assets of G. Inrig, of Great Eastern House, Bishopsgate-street Without, E.C., to develop and work foreign patents for France, Belgium, Spain, Italy, Germany, Switzerland, Portugal, Canada and U.S.A., and to carry on the business of electrical and general engineers, &c. Private company. G. Inrig, first managing director.

PREMIER ELECTRIC INSTITUTE (LTD. (103,969.) A private company with this title has been registered, with capital £100 in £1 shares, "to inaugurate an institute for selling curative electrical appliances and advising on electrical treatment, to carry on the business of manufacturers of and dealers in electrical specialities," &c. Reg. office, 133-5, Regent-street, London, W.

E. M. REDFERN (LTD.) (103,873.)—Reg. July 5, with capital £2,000 in £1 shares, to adopt agreement with E. M. Redfern, and to carry on the business of electricians, electrical engineers, &c. Private company. E. M. Redfern chairman and managing director for life. Reg. office, 9, Ethel-street, Birmingham.

WALTER SCOTT & CO. (EDINBURGH) (LTD.) (7,193.)—Reg. in Edinburgh July 8, capital £500 in £1 shares, to acquire business of electrical, mechanical and general engineers carried on at 148, Rose-street, Edinburgh, as Walter Scott & Co. Private company. First director, D. M. Fraser. Reg. office, 148, Rose-street, Edinburgh.

MORTGAGES AND CHARGES.

COWANS LIMITED.—A memorandum of satisfaction to the extent of £3,000, on May 4, 1909, of debenture stock covered by trust deed, dated Feb. 26, 1902, securing £5,000, notified July 5.

SOLIUM ELECTRICAL CO. (LTD.)—Debenture dated July 5, to secure £2,000, charged on the company's undertaking and property, present and future, including uncalled capital. Holder, Nottingham and Nottinghamshire Banking Co.

RECEIVERSHIP.

BRITISH ALUMINIUM CO. (LTD.)—Two notices of the appointment of Mr. A. W. Tait, Basildon House, Moorgate-street, London, E.C., as receiver and manager, have been filed.

W. FORREST & CO. (SHEFFIELD) (LTD.)—Notice of the appointment of A. D. Barber, C.A., Alliance-chambers, George-street, Sheffield, and F. Crawshaw, 28, Bank-street, Sheffield, as receivers, on July 2, under powers contained in first mortgage debentures, dated July 16, 1908, has been filed.

H. HOOPER & CO.—Notice of appointment of J. W. Vincent, C.A., 6, Holborn Viaduct, London, E.C., as receiver and manager, has been filed.

LIMITED PARTNERSHIP.

PILOT ARC LAMP MFG. CO. (211.)—Reg. June 30, manufacturers of and dealers in arc lamps, 298, Streatham High-road, S.W. Partnership for two years from June 22, 1909. Determinable at end of first year by six months' notice. General partners, J. Olto Voelk, 57, Lambeth Palace-road, S.E., and E. Weiss, 159, Lambeth-road, S.E. Limited partner, C. J. Robinson, 10, Streatham-common, S.W., contributing £150 in cash.

CITY NOTES.

MEMORANDA (July 15).—Bank rate 2½ per cent. (since April 1, 1909). Price of silver, $23\frac{7}{16}$d. per oz. Consols $84\frac{1}{8}$—$84\frac{1}{4}$ for money and $84\frac{3}{16}$—$84\frac{5}{16}$ for account. Consols Pay Day, Aug. 5; Stock and Shares Continuation Days, July 27 and Aug. 10; Ticket Days, July 28 and Aug. 11; Pay Days, July 29 and Aug. 12; Mining Shares Carry Over Day, July 26.

PRICES OF METALS (London).—*Copper*, cash, 58; three months $58\frac{11}{16}$. *Lead*, English, $12\frac{7}{8}$—$13\frac{1}{4}$; foreign, cash, $12\frac{9}{16}$—$12\frac{11}{16}$; three months, $12\frac{13}{16}$—$12\frac{7}{8}$. *Spelter*, cash, 22—22½. *Tin*, English, 129½—131½; foreign, cash, 131½; three months, 132¼—132⅜. *Iron*, Cleveland, cash, 48/- and three months, 48/8½. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BRITISH INSULATED & HELSBY CABLES (LTD.)—The interests in Canada of this company have been sold to the Canadian British Insulated Co. (Ltd.), Montreal, whose offices are at Power Building in that city.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and register of members will be closed from July 20 to Aug. 3 inclusive.

DIRECT UNITED STATES CABLE CO. (LTD.)—The directors recommend a final dividend of 4s. per share, together with a bonus of 1s. per share, both tax free, payable 31st inst., making, with the three interim dividends, a total distribution of 4½ per cent. for the year to June 30 last. After placing £5,000 to reserve, the carrying forward is about £3,596. The transfer books will be closed from July 13 to 27 inclusive.

HASTINGS & DISTRICT ELECTRIC TRAMWAYS CO. (LTD.)—The directors are not in a position to recommend any interim dividend on the preference shares.

LONDON ELECTRIC WIRE CO. & SMITHS (LTD.)—An interim dividend for the half year at the rate of 5 per cent. per annum is announced

NORTH MELBOURNE ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The accounts for the year to Sept. 30 last show a loss of £7,387, increasing the debit balance to £16,285.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted official quotations to 13,500 £10 fully paid ordinary shares of the *Gateshead and District Tramways Co.*, and a further issue of 12,800 £5 fully paid ordinary and 2,777 £5 fully paid 6 per cent. cumulative prefs. of the *United Electric Tramways of Monte Video (Ltd.)* The committee have been asked to appoint a special settling day in a further issue of 39,070 £5 fully paid ordinary and 39,070 £5 fully paid 7 per cent. cumulative preference shares of the *British Aluminium Co. (Ltd.)*, and to grant a quotation to 20,000 £10 fully paid 6 per cent. cumulative preference shares of *Hurst Nelson & Co. (Ltd.)*

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Amount.	Inc. or Dec. (a)
		£	£		£	£
Abi een Corporation	July 7	1,539	+ 77	5	7,664	− 226
Ab e	,, 2	228	− 20	26	5,41	− 128
An -Argentine	,, 8	39,001	+ 1,2?9	26	1,051,106	+ 60,511
Ay orporation	,, 10	375	+ 26	8	2,162	− 165
Ba St. & Waterloo Ry.	,, 10	3,335	+ 275	1	3,385	+ 275
Ba ley	,, 2	158	− 15	26	4,313	− 181
Ba w	,, 2	251	− 53	26	5,612	− 140
Ba Electric Trams, Ltd.	,, 10	861	− 8	15	13,294	+ 614
Bi ngham Corporation	,, 10	9,018	+ 2,537	15	97,8?7	+ 3,248
Bi ngham & Mid.	June 2?	829	+ 16	26	20,462	+ 43
Bl burn Corporation	July 7	1,130	− 23	15	17,163	− 537
Bl pool and Fleetwood	,, 10	1,018	+ 158	1	1,053	+ 155
Bo Corporation	,, 11	2,316	+ 166	15	35,102	− 531
ay	June 10	R36,203	− R1,163	22	R873,308	+ R5?,083
Bournemouth Corporation	July 7	1,589	− 45	14	23,227	+ 72
Br ord Corporation	,, 10	4,965	+ 272	11	71,774	+ 1,?03
Br ton Corporation	,, 11	9?6	+ 31	15	13,843	+ 753
Br l Trams & Carriage	,, 9	5,970	− 1,752	7	40,617	− 587
Bu ey Corporation	,, 10	1,259	+ 23	15	19,271	+ 220
B n Corporation	,, 11	275	− 11	15	3,909	− 96
B Corporation	,, 11	1,193	+ 57	†15	17,672	− 164
C tta Tramways Co.	,, 10	R53,815	+ R8,656	1	R52,815	+ R8,656
C orne-Redruth	,, 10	121	− 4	28	3,401	− 78
C ff Corporation	,, 3	2,226	− 317	14	29,425	− 901
C ill	,, 2	102	− 47	26	2,005	− 252
C al London Railway	,, 10	5,603	− 1,617	1	5,603	− 1,617
C ng C., Euston & H'stead	,, 10	3,990	+ 655	1	3,990	+ 185
C ham & Dist. Lt. Rys.	,, 8	860	+ 56	27	20,756	+ 1,011
C South London Rly.	,, 11	3,188	+ 4	1	3,188	+ 4
C of Birmingham	,, 2	2,917	+ 9	26	71,000	− 1,028
C ester Corporation	,, 7	193	− 42	1	195	− 42
C Electric Trams Co.	,, 8	623	+ 48	...	11,127	− 97
C lon Corporation	,, 9	1,551	+ 88	14	21,667	+ 24
D nport & Dist. Trams	,, 2	311	− 154	26	9,473	− 2,126
D r Corporation	,, 10	221	− 149	15	2,932	− 355
D n & Lucan Railway	,, 7	183	− 13	1	183	− 13
D n United	,, 9	5,699	− 137	1	7,320	− 342
D ey-Stourbridge	,, 2	785	− 76	26	20,035	− 617
E lee Corporation	,, 7	1,213	− 5	†8	9,0?9	− 383
E Ham Council	,, 10	1,044	+ 92	§14	14,790	+ 2,171
E r Corporation	,, 9	337	+ 1	15	5,184	+ 560
ead & Dist. Trams	,, 2	937	− 153	26	25,600	− 293
G gow Corporation	,, 10	6,720	+ 159	16	100,620	− 1,578
G op Trams	...	...	...	...	...	...
G esend—Northfleet	,, 2	2?7	− 44	25	5,051	− 221
G Northern & City Rly.	,, 10	1,365	− 81	1	1,365	− 81
G orthern, Piccadilly, &c	,, 10	5,675	+ 255	1	5,675	+ 255
G nock & Port Glasgow	,, 2	747	− 51	26	13,511	− 155
E epool Tramways	,, 2	256	− 30	26	5,645	− 160
ings Elec. Trams Co.	,, 8	1,0?5	− 20	1	1,035	− 30
Kong	,, 10	$8,188	− $86?	1	$8,188	− $867
dersfield Corpn.	...	...	...	...	...	...
Corporation	,, 10	2,595	+ 106	14	36,001	+ 424
d District Council	...	...	...	...	...	...
ton District Council	,, 7	131	− 4	11	1,873	− 149
lch Corporation	,, 10	432	− 2	15	5,691	− 25
of Thanet Co.	,, 10	985	− 74	§32	15,541	+ 119
w	,, 2	121	− 1	26	2,931	+ 236
hley Corporation	...	...	...	...	...	...
erminster & District	,, 2	125	− 16	26	2,473	− 152
arnock Corporation	...	...	...	...	...	...
arkshire Trams Co.	,, 8	1,585	+ 90	27	33,158	− 1,810
ashire United	,, 7	2,123	+ 723	27	35,284	+ 171
aington	,, 2	221	+ 13	26	4,151	+ 111
s Corporation	...	...	...	...	...	...
ester Corporation	,, 10	2,2?5	− 67	1	2,215	− 67
Corporation	,, 3	615	+ 10	7	4,320	+ 316
oln Corporation	,, 10	113	− 2	15	1,856	+ 73
rpool Corporation	,, 3	11,300	− 407	§26	277,441	− 3,615
rpool Overhead Rly.	,, 11	1,4?3	+ 32	12	2,982	+ 78
ndno & Colwyn Bay Ry	,, 9	410	+ 32	52	6,037	+ 1,601
don County Council	June 26	36,319	− 1,014	§12	449,661	+ 19,311
don United	July 10	6,988	− 690	§30	158,033	− 15,257
estoft	...	...	...	...	...	...
dstone Corporation	,, 10	181	− 35	14	2,657	− 240
chester Corporation	,, 10	17,395	+ 1,874	15	221,901	− 466
sey Railway	,, 10	1,933	+ 102	1	1,933	+ 102
thyr	,, 2	220	+ 9	23	5,139	+ 21
ropolitan Dist. Railway	,, 10	10,318	+ 926	1	10,318	+ 926
ropolitan Elec. Trams	,, 2	6,293	− 571	26	153,283	+ 11,926
dleton	,, 2	253	− 146	26	8,535	− 680
ton Corporation	,, 10	140	+ 11	§14	2,038	− 84
castle-on-Tyne Corp.	,, 10	3,710	− 13	14	57,822	− 1,426
port (Mon.)	,, 10	676	− 9	15	9,915	− 261
thampton Corporation	,, 9	409	+ 6	§15	6,590	+ 103
ham, Ashton & Hyde	,, 2	564	− 72	26	14,329	− 1,002
ham Corporation	,, 11	1,821	− 28	15	29,520	− 1,827
th (N.B.) Corporation	,, 7	162	− 14	7	1,186	− 48
th (W.A.) Elec. Trams	,, 9	1,265	− 13	26	38,721	+ 78
rborough	,, 2	119	− 11	25	2,803	− 251
tsmouth Corporation	...	...	...	...	...	...
teries	,, 2	1,847	− 179	26	45,810	− 1,290
ston Corporation	...	...	...	...	...	...
herham Corporation	,, 5	535	− 4	11	8,625	− 232
hosay	,, 2	377	− 112	26	3,281	− 102
ord Corporation	,, 12	5,075	− 303	§15	69,074	− 1,861
rness	,, 2	47	− 23	26	1,200	− 188
ffield Corporation	,, 11	5,199	− 64	§15	87,095	− 1,302
gapore Trams	,, 10	$3,578	+ $269	1	$3,578	+ $263
th Metropolitan	,, 2	811	− 165	26	19,801	− 380
th Staffs	,, 2	813	− 75	26	21,336	− 1,321
thend Corporation	,, 7	500	+ 72	11	6,008	+ 962
mport Tramways	,, 2	402	− 55	26	6,92?	− 236
yb'dge, Hyde, &c., Jt. Bd.	,, 10	746	+ 5	§14	11,264	− 430
derland Corporation	,, 11	1,?01	− 13	15	16,783	− 727
derland District	,, 7	473	− 48	36	16,084	− 670
nsea Trams	,, 2	1,007	− 50	26	23,841	+ 438
ndon Corporation	,, 7	137	− 35	1	127	− 35
nton	,, 2	4?	− 3	26	913	− 71
mouth and District	,, 2	320	− 9	25	4,811	− 119
eside Trams Co.	,, 7	461	+ 32	1	461	+ 32
lasey District Council	,, 10	1,043	+ 127	§14	13,733	+ 481
hall Corpn.	,, 10	503	+ 31	27	13,639	− 1,058
rrington Corpn.	,, 8	537	+ 152	11	5,183	+ 34
t Ham Corporation	,, 1	2,269	− 99	13	31,322	+ 1,732
ton-super-Mare	,, 2	216	− 45	26	2,237	+ 139
verhampton Co.	,, 2	400	− 61	26	10,613	− 1,143
verhampton Corpn.	,, 7	782	− 121	1	782	− 1,960
cester	,, 2	319	− 29	25	6,748	− 122
xham	,, 2	98	− 19	26	2,463	− 112
kshire W.R. Trams	,, 11	1,139	− 523	28	32,391	...
kshire Woollen District	,, 2	904	− 121	26	22,901	− 575

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 d ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	Name.	Price Wed. July 11	Rate % Yielded £	s	d	Dividend Due.	Business Week to July 1? Highest	Lowest
		ELECTRICITY SUPPLY.							
10	7 0	Bournemouth & Poole Elec. Sup. Ord.	9½ −10½			9	Mar, Sep		9½
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½ −10¼	4	9	0	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. Second Pref.	10½ −10¾	5	11	6	Feb, Aug	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	−103	4	7	6	Jan, July	..	..
5	3 6	Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	5	15	9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	94 −96	4	16	0	May, Nov	..	..
5	5 6	Brompton & Kensington Elec. Sup. Ord.	8 —	5	17	6	March	9	
5	3 6	Do. 7 per Cent. Pref.	7 −7½	4	2	6	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co 4% Guar. Db. Stock	97 −100	4		6	June, Dec	..	—
5	2 6	Charing Cross (W. End & City) El. Sup. Co.	3¾ −4	5	11		Feb, Aug		4
5	2 3	Do. 4½ per Cent. Pref.	4½ −4	4	12	0	Feb, Aug	4½	
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	9? — 9	4	1	0	Jan, July		97
St.	4½%	† Do 4½ per Cent. Deb. Stock (red.)		4		6	..	101½	101½
5	2 3	Do. City Undertaking 4½% Cm. Pref.	3¾ −4	5		0	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3¾ −4	4		3	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 −103	4	7		June, Dec	..	..
10	7 0	City of London Electric Lighting Ord.	10¾ −11	5	10	0	Feb, Aug		
10	6/0	Do. 6 per Cent. Cum. Pref.	12 −1	4	11	0	Jan, July	13	13½
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4	0		June, Dec	122½	122½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 −102	4	8		Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1¾ −2	—			April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3¼ −3½		17	8	April, Oct	..	..
10	6 0	County of London Elec. Supply Ord.	8½ −8	5	15	6	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10¾ −11½	5	8	0	Mar, Sept	11	1
St.	4½%	Do. 4½% Deb. Stock (red.)	103 −106	4	5		Jan, July	1 4½	103½
St.	4½%	Do. Second Deb. Stock	100 −103	4	7	6	May, Nov	..	..
5	3 6	Folkestone Electricity Supply Co. Ord.	4½ −5	5	10	0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 −5½	4	11	0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	98 −101	4	9	0	Feb, Aug	..	..
5	4 6	Hove Electric Lighting Ord.	7½ −7¾	5	11	6	April, Oct	—	..
5	4 0	Kensington & Knightsbridge Ord.	6¾ −7¼	5	2	0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6¾ −8¾	4	14	6	Jan, July	7	7
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 −10	4	0	0	..	—	—
St.	4%	Kensingtn. & Kngthg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3	19	0	April, Oct	..	..
St.	4½%	† Kent Elec. Power Co.	83 −87	5	3	6	Jan, July	..	..
3	1 9⅜	London Electric Supply Ord.	1¾ −2¼	3	6	8	Mar, Sept	..	..
5	3 0	Do. 6 per Cent. Pref.	5½ −5¾	5	11	6	Mar, Sept	5	.
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 −97	4	2	6	Jan, July	94	
5	3 0	Metropolitan Electric Sup. Ord.	4¼ 4¾	5	13	0	April, Oct	4	4⅞
5	2 3	Do. 4½ per Cent. Cum. Pref.	4⅞ −5	4	10	0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4	2	6	June, Dec	107	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock red.	83½ −86½	4	1	0	Jan, July	—	—
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	94 −97	4	12	6	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4¾ −5	4	2	1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	81 −85	6	5	11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4⅞ −5	2	10	5	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾ −5	5	1	3	Feb, Aug	..	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 −99	4	1	8	Jan, July	—	.
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4	19	0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..			Mar, Aug	..	..
10	4½%	Do. 4½ per Cent. Deb.	89 −91	5	0	0	Jan, July	..	..
10	8 0	† Notting Hill Electric Ord.	11¾ −12¼	5	11	6	March	—	..
5	4 6	Oxford Electric Ord.	5 −5½	5	8	0	March	6	—
St.	4%	† Do. 4 per Cent. Deb. Stock	92 −95	4	4	0	Jan, July	..	.
5	6 0	St. James' & Pall Mall Elec. Ord.	8¾ −9¼	5	8	0	Feb, Aug	9	9
5	3 6	Do. 7 per Cent. Pref.	7 −7½	4	13	6	Feb, Aug	..	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 −86	3	10	6	Jan, July	..	..
5	.	Smithfield Markets Electric Sup. Ord.	? −1½	..			Feb	..	..
5	4 0	South London Electric Supply Ord.	2¼ −3¼	6	8	0	April	..	..
St.	5	Do. 5% 1st Mort. Stk. Red.	10? −1 2½	4	17	6	—	1 2½	..
1	0/0	South Metrop'n Elec. Lt. & Power Ord.		4	14	0	..	..	—
1	0 3⅜	Do. 7 per Cent. Cum. Pref.	1½ −1½	5	7	0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −103	4	7	6	April, Oct	—	—
5	2/6	Urban Electric Supply Ord.	−1	—			April, Oct		..
5	2 6	Do. 5 per Cent. Cum. Pref.	1¼ −2¼	..			April, Oct	1¾	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80 −84	5	7	3	April, Oct	..	—
5	5 0	Westminster Elec. Sup. Ord.	8¾ −9¼	5	8	6	Mar, Sept		—
5	2/3	† Do. 4½ per Cent. Cum. Pref.	4¾ −5¼	4	8	0	Jan, July		..
		ELECTRIC RAILWAYS & TRAMWAYS.							
St.	4%	† Baker St. & Waterloo 4% Perp. Db. St	96 −98	4	2	0	Jan, July	100	97½
1	..	Bath Elec. Trams Pref. Ord.	½ −⅝	..			April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	−1	7	5	0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 −91	4	19	0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88 −91	4	19	0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	7½ −8	7	10	0	Feb, Aug	..	—
10	4%	† Do. Cum. Pref. (fully paid)	7½ −8	4	17	0	..	..	—
St.	4%	† Do. 4 per Cent. Debs.	98 −99	4	0	10	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅝ −⅞	..			June, Dec		1
10	3/0	Do. 6 per Cent. Cum. Pref.	2¼ −2¾	10	18	0	Feb, Aug	2	2½
St.	5%	Do. 5 per Cent. Perpetual Debs.	85 −90	5	11	6	April, Oct	90	88
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	65 −70	6	9	6	May, Nov		..
St.	3½%	Central London Ordinary Stock	61 63	5	11	0	Feb, Aug	6	62
St.	4%	Do. 4 per Cent. Pref. Stock	83 −85	4	14	0	Feb, Aug	84	84
St.	2½%	Do. Deferred Stock	13 −15		11	0	Feb	..	..
100	4%	† Do. 4 per Cent. Debs.	100 −102	4		0	Jan, July	10	..
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	91 −93	4	6	0	Jan, July	91	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼ −4½	4	10	9	April, Oct	5	..
100	4%	Do. 4 per Cent. 1st Mort. Debs	97 −101	3	19	0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31 3	4	11	9	Feb, Aug	31	30
St	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 −112	4	9	0	Feb, Aug		..
St.	5%	Do. (1895)	105 −109	4	11		Feb, Aug		..
St.	5%	Do. (1901)	101 −105	4	15	3	Feb, Aug	.	—
St.	5%	Do. (1903)	93 −96	5	4	0	Feb, Aug	9	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 −101	3	19	0	May, Nov	1	—
10	6/0	Dublin United Trams. 6 per Cent. Pref.	15 −11	4	5	9	Feb, Aug	.	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	½ −1	..			Feb, Aug		..
10	..	G. Northern, Picc. & Brompton 4% G.Pf	8 −3½	..			Feb, Aug		—
St.	4%	Do. 4 per Cent. Deb. Stock	93 −95	4	4	0	Jan, July	94	93½
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1 −	..			Mar, Sept	.	.
St.	4½%	Do. 4½ Db. St.	74 −79	5	13		April, Oct	74	75
10	6%	Imperial Tramways Ord.	1½ −5	12		0	Mar, Sept	.	..
10	6%	†‡ Do. 6 per Cent. Pref.	5 −6	5	0	0	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	83 −81	5	7	0	Jan, July	..	—
5	1 3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅜	..			Mar, Sept	.	—
St.	4%	† Do. 4 per Cent. Deb. Stock	58 −63	6	7	0	Jan, July		—
10	6/0	Lanarkshire Tramways	9 −10	5	18	6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ −90	5	10	6	Jan, July	.	
10	..	Liverpool Overhead Railway Ord.		..			Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	9 −9	5	6	8	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82 −84	4	15	3	Jan, July	..	..
10	2 6	London United Trams. 5% Cum. Pref.	−2	..			Jan, July	.	.
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	66 −9	5	19	3	Jan, July	6	64
St.	—	Mersey Con. Ord. Stock	1 −2	—			Feb, Aug		..
1	10½	Metropolitan Elec. Tramways Ord.	−1	—			..	..	..
1	—	Do. Deferred		..			April..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.		5	15	0	Feb, Aug	.	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 −97	4	12		Jan, July	93½	93½
St.	½%	Metropolitan Railway Consolidated	3 −40	1	5	0	Feb, Aug	40	34
St.	3%	Do. Surplus Lands Stocks	65 −70	4	5	9	Feb, Aug	69	68
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3	17	0	Feb, Aug	90	89
St	3½%	Do. 3½ per Cent. "A" Preference	8 −85	4	2	6	Feb, Aug	84	82
St.	3½%	Do. 3½ per Cent. Convertible Pref.	82 −84	4	3	6	Feb, Aug	83	82
St.	3½%	† Do. 3½ per Cent. Debenture Stock	92 −94	3	14	8	Jan, July	94	94

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*

Share	Last Dividend	Name	Price Wed., July 14.	Rate % Yielded £ s. d.	Dividend Due	Business Week to July 14 Highest	Lowest
St.	3½%	†Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 3	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.	17¼—17¾	—	Feb, Aug	17¾	17½
St.	..	Do. Extension Pref. (5 per Cent.)	44 —46	..	Feb, Aug	..	..
St.	3¼	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	65 —67	5 4 0	Feb, Aug	66¼	65½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	77¾	77½
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	1½	Do. Guar. Stock 4 per Cent.	92 —95	4 4 0	Mar, Sept	91⅝	..
St.	6	Do. 6 per Cent. Perp. Deb. Stock	139 —141	4 5 0	Jan, July	..	..
St.	4	Do. 4 per Cent. Ditto	93 —95	4 4 0	Jan, July	94½	93
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	[illegible]	..	April, Oct	..	—
1	1/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	...	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	82 —86	5 16 0	Jan, July	..	..
..	...	UndergdE. Rys. Lon. 6% In. bds. with coup. 3	37 - 39	..	June, Dec	37⅝	37
..	5	Do. 5% Prior Lien Bonds	102 —103	4 17 0	..	102¾	102¼
..	4½	Do. 4½% Bonds with coup. 3	87 —89	5 1 0	..	88½	87½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	—	March	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	84 —88	5 2 0	Jan, July	—	—

ELECTRIC MANUFACTURING, &c.

Share	Last Dividend	Name	Price Wed., July 14.	Rate % Yielded £ s. d.	Dividend Due	Highest	Lowest
1	..	Aron Electricity Meter Ord.	⅜—½	..	..	—	..
1	1/3½	Do. 6% Cum. Pf.	¾—⅞	6 17 0	April, Oct	..	—
1	2/4	Babcock & Wilcox Ord.	4¼—4⅜	4 13 9	April, Oct	4⅜	4 5/16
1	0/7½	Do. Pref.	1⅜—1½	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅜—7⅞	6 9 0	July, Feb	7 7/16	7⅜
5	3/0	Do. 6 per Cent. Pref.	6¼—6⅝	4 10 6	Jan, July	6 5/16	6¼
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	105	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	[illegible]	..	Feb, Aug	..	—
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	97 —99	6 1 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	..	..
St.	4½%	BrushE. Eng. Co. 4½%, Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	..	..
St	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	1/0	Callender's Cable Con. Ord.	9¾ —10½	7 3 0	Jan, July	10¼	9 13/16
5	2/6	Do. 5 per Cent. Cum. Pref.	6⅜—6½	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Debs. (red.)	104 —106	4 6 0	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	1⅞—2	6 6 0	May, Nov	1 31/32	1⅞
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 4 0	Feb, Aug	105	..
	1/0	Chadburn's (Ship) Telegraph Ord.	[illegible]—1 1/16	6 11 9	March	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1 1/16	5 14 0	April, Oct	..	..
1	0/8½	Consolidated Electrical Co.	[illegible]	5 4 0	August	..	..
1	1/0	Consolidated Signal Co.	1⅛—1¼	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	1 —1¼	11 16 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	91 —94	5 6 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1¼	8 0 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1 [illegible]	4 16 9	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	¼—½	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	..
St.	4½%	†Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 8 0	Jan, July	..	..
2	..	Electric Construction Co.	9/16—11/16	..	Jan, July	..	—
2	2/9	Do. 7 per Cent. Cum. Pref.	1 7/16—1 11/16	8 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59—63	6 7 0	Jan, July	..	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71—77	6 10 0	...	..	...
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛—7½	6 13 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	11⅜—12½	6 3 0	Feb, Aug	11⅝	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 3 6	Feb, Aug	5 [illegible]	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 —107	4 4 0	Mar, Sept	106	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14½—16¾	6 10 0	Feb, Aug	15 [illegible]	14¾
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—10¾	..	..	10⅝	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	—	—
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	[illegible]—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	81 —84	5 7 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1½	—	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	..	—
12	24/0	Telegraph Construction & Maintenance	33 —34½	5 4 6	Mar, July	..	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99 —101	3 19 0	Jan, July	—	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 [illegible]—2 [illegible]	5 9 3	—	2 [illegible]	[illegible]
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜ —1 [illegible]	4 0 6	—	1 [illegible]	1⅜
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	101½ —103½	3 17 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 18 0	..	..	—
10	6	†J. G. White & Co. 6% Cm. Pref.	9 —10	8 0 0	..	..	..
1	1/9	Willans & Robinson Ord.	⅜—⅞	3 15 0	Apr, Oct	..	..
5	1/0	Do. 6 per Cent. Cum. Pref.	[illegible]—3½	9 4 0	Apr, Oct	—	—
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	—	..

TELEGRAPHS.

Share	Last Dividend	Name	Price Wed., July 14.	Rate % Yielded £ s. d.	Dividend Due	Highest	Lowest
10	..	Amazon Telegraph	2¾—3¼	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	92 —95	5 5 6	June, Dec	..	..
St.	15/0	Anglo-American	57 —59	5 12 6	F, My, Ag, N	—	..
St.	30/0	Do. Preferred	100½—101½	5 18 6	F, My, Ag, N	101½	100½
St.	5/0	Do. Deferred	15⅝—16½	2 9 9	F, My, Ag, N	16⅝	16
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	89 —91	4 8 0	Jn, Ap, Jy, O	89¾	..
10	6/0	Cuba Submarine Ord.	8¼—8¾	6 15 0	Feb, Aug	..	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	—
5	2/0	Direct Spanish Ord.	2⅞—3⅜	5 18 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅜—8¾	5 12 9	April, Oct	8¼	..
50	4½%	Do. 4½ per Cent. Deb.	99 —101%	4 9 0	Jan, July	..	..
20	4 0	Direct United States Cable	12¾—13½	6 8 0	Ja, Ap, Jy, O	13	12⅞
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	96 —101	4 9 0	June, Dec	..	..
St.	25/0	†Eastern Ordinary	125 —128	5 9 6	Ja, My, JyO	129	126½
St.	17/6	†Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja, My, JyO	86	..
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	106	..
St	2/6	†Eastern Extension	11¼—11¾	6 18 6	Ja, Ap, Jy, O	11½	11¼
100	4%	Do. 4 per Cent. Deb. Stock	102½—104½	3 16 6	Feb, Aug	—	..
25	4%	Eastern & S. At. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	—	..
10	[illegible] 0	G. N. of Copenhagen, with Coupon 76	25¾—26	6 2 6	Jan, July	26⅛	25½
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 —101	4 9 0	June, Dec	..	..
25	52/6	Indo-European Tel.	51½—52½	5 10 9	May, Nov	52¼	51½
100	$1	Mackay Companies Common	80 —84	4 16 0	Ja, Ap, Jy, O	—	..
100	$1	Do. Preference	74 —79	5 1 0	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April	..	¾
1	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	99 —101	3 19 0	June, Dec	—	—
12	[illegible]	West Coast of America	1⅜ —1⅝	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
1	..	West India & Panama	½—⅝	..	May, Nov	½	..
10	6/0	Do. 6 per Cent. 1st Pref.	8¼—8¾	6 17 0	May, Nov	...	—
10	[illegible] 6	Do. 6 per Cent. 2nd Pref.	8 —9	6 13 6	May, Nov	—	—
100	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	—	..
40	[illegible] 0	Western Telegraph	13½—14	5 0 0	Mr, Jn, O, D	13¾	13⅝
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 0	June, Dec	102	101¼
..	4	Western Union Telegh. $1,000 4% Bonds	93 —95	4 6 0	..	..	—

TELEPHONES.

Share	Last Dividend	Name	Price Wed. July 14.	Rate % Yielded £ s. d.	Dividend Due	Business Week to July 14 Highest
100	2$	Amer. Telephn. & Telegh. Cap. St.	143½—144½	5 13 9	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	102 —104	4 16 0	Mar, Sept	..
5	3 0	Chili Telephone	8 —8⅜	4 16 0	August	—
1	0/7½	Monte Video Telephone Ord.	⅞—1	6 0 0	Nov	..
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	
St.	6%	National Co. Pref. Stock	108½—110	5 9 0	Feb, Aug	10[illegible]
St.	6%	Do. Def. Stock	126 —127	4 14 6	Feb, Aug	[illegible]
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¾—11	5 9 0	Feb, Aug	1[illegible]
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10¼—11	5 9 0	Feb, Aug	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5½	4 5 0	Feb, Aug	5[illegible]
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97 —99	3 11 0	June, Dec	9[illegible]
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	Jan, July	99[illegible]
1	1/0	Oriental	1 [illegible]—1 [illegible]	5 7 6	April, Oct	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1 3/16	4 17 6	April, Oct	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	87¾
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98½—100½	4 9 6	Jan. July	..
5	3/0	United River Plate	6⅞—7⅛	5 12 0	July	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	June, Dec	
St.	4½%	Do. 4½ Deb. St. Red.	102 —103½	4 7 0	Jan, July	103

FINANCIAL INVESTMENT, &c.

Share	Last Dividend	Name	Price Wed. July 14.	Rate % Yielded £ s. d.	Dividend Due	Highest
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	
10	5 6	Globe Telegraph & Trust	10¼—10¾	6 7 0	Sp De Mr Ju	10[illegible]
10	3/0	Do. 6 per Cent. Pref.	13¼—13¾	4 7 0	Sp De Mr Ju	13[illegible]
10	6%	Submarine Cables Trust (Cert.)	129 —134	4 11 0	April, Oct	129½

COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.

Share	Last Dividend	Name	Price Wed. July 14.	Rate % Yielded £ s. d.	Dividend Due	Highest
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	..	4 18 0	April, Oct	..
5	5/0	Do. 10% Non-cum. 2nd Pref.	9 [illegible]—9 [illegible]	5 5 9	Jan, July	[illegible]
St.	4%	Do. 4% Deb. Stock	91 — 92	4 5 0	June, Dec	9[illegible]
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	101 —103	4 17 6	Jan, July	.
5	3 6	Brisbane Electric Trams. Invest. Ord.	6 1/16—6 5/16	4 15 0	May	[illegible]
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	5[illegible]
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100½ —104½	4 4 0	Jan, July	
St.	8%	British Columbia El. Ry. Df. Ord.	143 —147	5 9 0	Mar, Sept	14[illegible]
St.	6%	Do. Pref. Ord. Stock	123 —126	4 15 0	May, Nov	12[illegible]
St.	5%	†Do. 5% Cum. Perp. Pref. Stock	108 —111	4 10 0	Jan, July	
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	102½
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	101½ - 103½	4 7 0	—	10[illegible]
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 — 101	4 19 0	Mar, Sept	[illegible]
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	98 —100	6 0 0	Feb, Aug	9[illegible]
5	2/0	Calcutta Tramways (1 to 137,610)	4⅜—4¾	4 14 9	Mar, Sept	[illegible]
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	..
St.	..	Cape Electric Tram Shares	⅛ —⅜	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅝—5⅞	4 5 6	F, My, A, N	.
St.	4%	Do. 4 per Cent. Deb. Stock	99¾—101	3 19 0	June, Dec	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	..
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	89 —92	5 8 6	Jan, July	9[illegible]
5	6%	Do. 6 per Cent. "B" Ditto	64 68	8 16 0	Jan, July	6[illegible]
5	1/0	Lisbon Elec. Trams. Ord.	[illegible]—1 1/16	4 14 0	July	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1 [illegible]	5 1 0	Jan, July	—
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	95 —99	5 1 0	Jan, July	—
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	90½ - 92½	5 7 0	Jan, July	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	94 —96	5 4 0	Feb, Aug	.
100	$1½	Mexico Trams Co. Com. St.	131 —134	3 11 6	..	13[illegible]
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92½—93½	5 6 0	..	93[illegible]
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb. Aug	..
St.	4½%	Do. do. (Nos. 1 to 4,000)	102 —104	4 6 6	.	10[illegible]
1	0/6	Perth Elec. Trams Ord.	⅝ —⅞	8 0 0	May	..
St.	5%	Do. 1st Mt. Db. Stock	100½ —103½	4 16 6	Jan, July	—
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6⅜—6¾	5 4 8	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	90 —92	..	..	[illegible]
..	5%	Do. 30 yr. Gold Bnds.	92 — 94	6 6 6	..	9[illegible]
100	5%	Do. 10 yr. Mt. Bnds	84 — 85	5 17 0	..	85
..	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —150	6 17 0	..	14[illegible]
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	97½—99½	5 0 6	June, Dec	98[illegible]
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 11 0	Feb, Aug	..

COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.

Share	Last Dividend	Name	Price Wed. July 14.	Rate % Yielded £ s. d.	Dividend Due	Highest
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 11 0	Mar, Sept	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93½ —95½	4 18 6	Jan, July	94⅞
5	4/9	Calcutta Elec. Supply Ord.	5¾—6¼	6 8 0	April, Oct	6[illegible]
100	$1¾	Canadian Gen. Elec. Co. Com. St.	116 —118	5 19 0	..	117[illegible]
100	$3½	Do. 7% Cm. Pf. Stock	117 —119	5 16 0	..	12[illegible]
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..
500	5%	Elect. Development Co of Ontario	85 — 87	5 16 0	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	..	..	Feb, Aug	..
St.	5%	Do. 5 per Cent. Deb Stock	...	5 8 0	Jan, July	—
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	83½ - 88½	5 13 0	Jan, July	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—
108	4	‡Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	[illegible]
1	0/7⅛	Do. 6 per Cent. Cum. Pref.	¾—[illegible]	6 18 3	April, Oct	
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	82 —84[illegible]	5 19 0	..	8[illegible]
St.	$1	Mexican Lt. & Power Co. Com. St.	64 —67	5 19 6	—	67[illegible]
500	5%	Do. 5% 1st Mort. Gold Bnds.	88 — 90	5 11 0	..	89[illegible]
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	123 —127	4 14 6	F, My, A, N	..
1	1/7½	River Plate Electricity Co. Ord.	1 [illegible]—1 7/16	5 11 0	April	[illegible]
1	1/2⅝	Do. 6 per Cent. non-Cum. Pref	[illegible]—1 3/32	5 1 6	May	1[illegible]
St.	5%	Do. 5 per Cent. Deb. Stock	102 —105	4 15 0	Jan, July	104¼
5	8/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 [illegible]—5 [illegible]	5 7 6	April, Oct	..
100	$1	†Shawinigan, Water & Power Co. Ca	91 —93	4 6 0	—	95¼
..	5%	Do. 5 per Cent. Bds.	104 —106	4 14 3	Jan, July	10[illegible]
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	96½— 98½	4 11 6	—	97[illegible]
..	6d.	Victoria Falls Power Co. Pref.	½—⅞	5 14 0	Jan, July	[illegible]

* In [illegible] the y[illegible] allowance has been made for accrued interest but not for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote [illegible]

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NOTES.

Things Electrical at Bolton.

To set the business of electricity supply on a firm basis it is necessary, while energy is sold at a price low enough to be attractive to a wide circle of consumers, to make adequate provision for depreciation and to establish a substantial reserve fund. But the question is also complicated by other considerations; and as local conditions vary so enormously, only a very general judgment can be passed, and then solely on the results obtained over a year's working. If, however, we see an undertaking selling energy for both power and lighting at low figures, paying adequate rates, contributing a sufficient amount for depreciation and yet making a profit, we may say that the undertaking is doing well. Such is the result which has been obtained in Bolton during recent years. The analysis of the accounts, given on another page of this issue, shows in detail the results of last year's working, and though perhaps not in every way so good as those of 1907-08 these results are highly satisfactory. Since 1901, in fact since the very beginning of the undertaking, the works costs have been steadily reduced, and have now reached the low figure of 0·45d. per unit—a result which compares favourably with those obtained at any other station, whatever its size, in the country. Further, the average price charged per unit for all purposes is only 1·23d., while for lighting it is 2·87d. and for power 0·849d. The former price is not obtained at the cost of the street lighting, for, unfortunately, gas is still used for this purpose. A sum of £3,200 was paid in rates, practically £6,000 allocated for depreciation and a net profit of £5,800 was obtained. Cheap power supply, in Bolton at any rate, evidently yields a profitable return; and the tendency is to cheapen the supply more and more. At the same time care is taken not to rush forward too quickly. Mr. A. A. Day is at present handicapped by his generating plant, but, seeing the results he has been able to obtain notwithstanding these disadvantages, it is quite possible that when he gets his new turbine station to work all previous records may be broken and certain "irreducible minima" which are now talked of may become irreducible no longer.

Tramway Fares.

The trade depression experienced last year has resulted in the annual accounts of many tramway undertakings showing reduced traffic returns and revenue, with, in some cases, smaller contributions towards the rates. The London County Council tramways undertaking has, however, to report a successful year's working, as is partly evident from the fact that the number of passengers carried exceeded that of the previous year by over 40 millions. Against the loss of £30,203 on the horse lines, a gross profit of £675,965 is shown by the electrified sections of the undertaking, the greater part of this being absorbed, however, by capital charges, whilst it is proposed to place the remainder, £107,570, to the renewals reserve fund. What seems to us an important feature of the summarised figures which have just been published is the growth in the number of passengers paying halfpenny fares, these amounting now to 24·22 per cent. of the total number of passengers, compared with 23·44 per cent. in 1907-8 and 20·12 per cent. in 1906-7. Where halfpenny fares are in force it is usually found that this class of passenger tends to increase to the detriment of those paying 1d. and higher fares, and it is probable that this tendency will prove of great importance when the car accommodation, which is already taxed very severely at "rush-hours," becomes totally inadequate.

WHILST the penny-fare passenger is becoming of decreasing importance on the London County Council tramways—only 48 per cent. of the passengers now come under this heading, compared with nearly 58 per cent. in 1907-8 and over 62 per cent. in 1906-7—it is interesting to notice that at the recent annual general meeting of the British Electric Traction Co. a suggestion was put forward that as a small addition to the customary penny tramway fares would make all the difference between success and failure, an agitation should be commenced for the provision of a new coin equivalent to 1¼d. Although we agree that in many cases tramway fares are too low, we are surprised that the above suggestion should have been seriously considered; the more rational method of meeting the situation would certainly appear to be to reduce slightly the distances passengers can travel for the existing 1d. fares, and to introduce in special cases, if necessary, a 1½d. fare where the 1d. fares do not overlap.

The Future of the Electrobus.

IT is unfortunate that the London Electrobus Co. should be again in financial trouble. Especially on account of the electrical industry it is to be regretted that a venture which promised so well, and still possesses an element of ultimate success, should be handicapped by conditions which apparently do not belong to the industrial side of the venture. It was the financial side of "Father Brush" which proved so disastrous in the early days of electric lighting. We can only hope that the Electrobus will emerge from its difficulties without dragging down with it the future of the electrical passenger vehicle. It is the most popular public conveyance on the streets of London at the present time, and there appears to be a possibility that its position might be maintained at least without loss. This is more than can be said for the majority of motor omnibuses.

University of London—King's College.—Dr. C. G. Barkla, of Liverpool, has been elected professor of physics in this college in succession to Prof. H. A. Wilson, F.R.S., who has been appointed professor of physics in the McGill University, Montreal.

The Wear of Rails on Electric Railways.—At the annual summer meeting of the Permanent Way Institution, held at Sheffield on Saturday last, the above subject was discussed. Prof. McWilliam, of Sheffield University, in the course of a lecture on steel, spoke of the toughening powers of manganese and silicon. The corrugation of the rails seemed to him to be a mechanical question—the result of the nature of the mechanism running on the rail, and all the metallurgist could do was to try to find something that would wear longer under the new conditions. Mr. Willox, chief engineer of the Metropolitan Railway, in seconding a vote of thanks to Prof. McWilliam, said that on steam railways, with the use of large wheels and springs, the life of rails was 25 years or more. But when the cars had a low centre of gravity and small wheels, the dead weights of the motors and axles, and the extraordinary acceleration and retardation reduced the life to about 25 months. His experience of the addition of silicon to rails, after about three years' trial, was that it increased the life by about 110 per cent.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Dakar—Conakry	May 13, 1909	July 18, 1909.
Tangier—Cadiz	May 19, 1909	—
Tourane—Amoy	June 17, 1909	—
Assam—Perim	July 8, 1909	—

University of Manchester.—On Thursday, July 15th, the new engineering buildings were opened by Sir Alex. Kennedy, F.R.S. The general scheme of the extension comprises four buildings, containing lecture rooms and drawing offices, hydraulic and testing laboratories, thermodynamic laboratories, and a workshop.

New Submarine Cable.—The c.s. "Colonia," belonging to the Telegraph Construction & Maintenance Co., has left St. John's (Newfoundland) to lay the new cable for the Commercial Cable Co. from Newfoundland to New York. This cable, a good proportion of which is of heavy type, is 1,321 nauts long. The "Colonia" has already laid the northern diversion of the cable, 270 nauts in length.

Institution of Electrical Engineers.—New Building.—We are informed that a special general meeting of members, associate members and associates will be held at the offices of the Institution on Thursday, July 29th, at 5 p.m., for the purpose of considering, and, if approved, of passing the following resolutions, namely:—

1. That the action of the Council in borrowing the sum of £26,000 from the Economic Life Assurance Society on the security of the leasehold property of the Institution on the Thames Embankment on the terms of the indenture of mortgage dated June 1st, 1909, a copy of which is now produced to the meeting, be and is hereby authorised and confirmed.

2. That an expenditure of a sum not exceeding £20,000 on structural alterations, furniture and fittings in connection with the institution building be sanctioned and approved, and that the Council be authorised to make such financial arrangements (including the borrowing of money on the security of the Institution building and of the Institution property in Tothill-street) as the Council may consider necessary for the above purpose.

Institute of Metals.—The autumn meeting of this Institute will take place at Manchester on Thursday and Friday, October 14th and 15th, and the arrangements, which are in the hands of a strong local committee, are already well advanced. A series of about half-a-dozen Papers of great interest, quite equal indeed to those presented at the Birmingham meeting of the Institute in November last, will be read and discussed at the two morning sessions of the institute. The afternoon of the first day will be devoted to a visit to the University of Manchester, where members will be officially received on behalf of the University by Vice-Chancellor Hopkinson. The new engineering laboratories will be open for inspection, and facilities will also be given for inspecting the Municipal School of Technology. In the evening a reception will be held by the Lord Mayor at the Town Hall. During the afternoon of Friday, October 15th, members will have the opportunity of visiting works of metallurgical interest in the neighbourhood of Manchester. Sir William White, K.C.B., F.R.S., retires from the presidency of the Institute of Metals at the end of the present year, and it is almost certain that Sir Gerard Muntz, Bart., will be nominated to the vacant office. The vacancy in the Vice-Presidency, caused by the recent death of Mr. Norman Cookson, of Newcastle-on-Tyne, has been filled by the election of Dr. H. C. H. Carpenter, of Manchester.

The Electrical Engineers (London Division).—On Saturday, July 17th last, a detachment of about 75 N.C.O.s and men of this corps, under the command of Capt. Levin, completed their annual 15 days' training at Plymouth. Favoured with excellent weather conditions a most interesting and instructive course of work was carried out on the defences at this station, while at the same time ample opportunity was given for the men to take advantage of the charming surroundings for which Plymouth is noted. As usual the detachment was attached to the local company of the Royal Engineers, with whom good feeling and comradeship was the order of the day. Three of the stations were taken over completely, and the engine-rooms, searchlights, &c., were run for the instruction of the detachment in the daytime and practice under service conditions at night. The members of the detachment were inspected in technical work on Wednesday evening, July 7th, by Major Caulfeild, R.E., who expressed himself highly pleased with the general running and also the individual members he examined. The drill inspection was made by Col

Hodder, R.E., on July 9th, who complimented the men on their bearing and appearance and the N.C.O.s on the smart way in which the various movements were carried out.

Fire at the Dundee Electricity Works.—A fire of somewhat mysterious origin occurred at the Dundee Corporation Electricity Works on Wednesday in last week. The first indication of anything wrong was the running away of a balancer owing to a heavy short-circuit on one side of the three-wire system. It was then found that the feeder cables in the basement of the station were on fire, and within a few minutes of the outbreak a serious conflagration was in progress. With the help of the city fire brigade, the staff were, however, able to get the fire under within half an hour from the outbreak, and it was then found that great damage had been done to the cables, and to some machinery which was lying in the basement. The other machinery, both in the generating and sub-stations, was practically undamaged. The staff at once set to work to get things running again, and in an extraordinarily short space of time, considering the damage that had been done, the supply was re-established. The material destroyed, the cost of which is fully covered by insurance, is valued at about £1,500, while the tramway department lost about £50 in revenue owing to the stoppage of the service. A certain amount of trouble was experienced on some consumers' premises, owing to the sudden rise of voltage, from burst lamps and blown fuses, but no damage to motors is reported. The origin of the fire is at present "wropt in mystery," and various theories which have been advanced to account for it are not yet substantiated. Great credit is due to Mr. Richardson and his assistants for the rapid way in which the supply was re-established.

The British Association.—As already announced in THE ELECTRICIAN, the meeting of this Association will be held this year at Winnipeg, during the last week in August, under the presidency of Sir J. J. Thomson, F.R.S. The Drill Hall at Winnipeg is to be used as a reception room, and the meetings of the various sections will be held in the buildings of the University of Manitoba, the Legislative Chamber of the Provincial Government, and of various schools in the town. We understand that Sir J. J. Thomson, in his Presidential Address to the Association, will touch on the following subjects: The importance of original research as a means of education; the advantages and disadvantages as a training for work in science of the systems of education now in force in our schools and universities; the light thrown by recent investigation on the nature of electricity; on the relation between matter and æther, and the part played by the æther in modern physics; and a discussion of some problems raised by the discovery of radium. As regards the various sectional programmes provisional arrangements have been made, but these are subject to alteration and also to considerable amplification. We give details below of the programmes in section A (Physics) and in section G (Engineering) which are likely to be of interest to our readers. Section A will meet under the presidency of Prof. E. Rutherford, F.R.S., and Papers on "Sun Spots and Magnetic Effects" will be read by Dr. L. A. Bauer, and on "The Effect of Temperature Variations on the Luminous Discharge in Gases for Low Pressures" by Mr. R. F. Earhart. Section G will be under the presidency of Sir Wm. White, K.C.B., F.R.S., and in addition to the presidential address a report will be presented by the committee on Gas Explosions, and a Paper on the same subject will be contributed by Mr. Dugald Clerk. Other Papers are as follows: "Skimming Boats," by Sir John Thornycroft; "The Isthmian Canal," by Col. Goethals; "The Work of the International Electrotechnical Commission," by Mr. Ormond Higman; "Torsion Tests on Materials," by Mr. C. E. Larrard; "Dielectric Stress in Three-phase Cables," by Prof. W. M. Thornton. Papers on "Grain Handling and Transportation in Western Canada," on "The Navigation of the St. Lawrence," and on "High-tension Overhead Lines" are in preparation.

Telegraphists under Fire.—It is natural that those who operate land line telegraphs should bear more risks than those whose business lies with the submarine side of telegraphy. In some parts of the world, at any rate, this has been proved, and members of the operating staff of the Indo-European Telegraph Co. have come in for their full share of such dangers. On several occasions during disturbances in the East, and especially in Persia, members of the Indo Company's service have shown that they know their duty and how to do it. The latest occasion for this exhibition of devotion to the company's and the public service occurred a few days ago at the stations at Teheran and Tauris, where for four whole days the work of transmission was carried on under real siege conditions. It stands to the credit of the operating staff that no interruption in the service, not even in the despatch of press messages, occurred. The story can be briefly told thus:—

The national forces entered Teheran on Tuesday morning about daybreak and captured nearly all parts of the city. Only one of the members of the Indo Company's staff succeeded in reaching the office before the gates of the city were closed. The remainder of the morning staff and Mr. T. Casey, the manager at Teheran, made several attempts under fire to reach the office by circuitous routes. Mr. Casey succeeded on the third attempt and five of the staff reached the office at 6 o'clock in the evening. The quarter of the town where the manager and the staff reside was swept continuously by heavy firing. The staff at once volunteered to remain at the office as long as necessary. One of the linesmen managed to repair some faults. This state of affairs continued till Friday, when the old Shah took refuge in the Russian Legation and hostilities ceased. The Indo stations were practically surrounded by the Royalist troops, who, in their turn, were surrounded by the Nationalists, with the result that incessant firing continued close at hand and sleep at the stations was out of the question. Notwithstanding the siege, little damage was done to the company's property and none to the staff personally, whose property at their quarters also escaped damage. This was not, however, the case with Mr. Casey's house, which was looted and loss and damage to the extent of over £1,500 was occasioned. Everything was carried off except the piano, which was damaged.

Mr. Casey refers with admiration to the services rendered by two newspaper representatives, M. Yanchevetsky (of the "Novoie Vremya," of St. Petersburg) and M. Haase (of the "Lokalanzeiger," of Berlin), who protected the ladies at the English Hotel and brought provisions through the firing lines for the staff on duty at the station. It was M. Haase's energy that saved the English Hotel from looting and protected the lives of its inmates. These latter included Mr. Casey's sister.

The directors of the Indo-European Company met on Monday, and after eulogising the action of the staff at Teheran and Tauris, resolved to increase the bonus which was granted some short time ago. The directors will take the occasion of Mr. Casey's early return to London to show their appreciation of his good work and excellent example. A handsome gold watch, suitably inscribed, has been presented to the clerk-in-charge at Tauris.

It will be remembered that the Indo Company's staff at Odessa were placed in a similar position of danger during the riots which took place in that city some time ago.

Forthcoming Books.—The following announcements will interest our readers:—

ELECTRIC TRACTION ON RAILWAYS.—This important subject, which is probably the most topical of all matters of an electrical engineering character, is very exhaustively dealt with in a new work by Mr. PHILIP DAWSON (whose earlier books on general electric traction are standard works in that branch). The new work will comprise over 1,000 pages and about 600 almost entirely original illustrations, and will be ready for the autumn market. The book, which will be handsomely bound, will be published by "The Electrician" Printing & Publishing Co., London, at 25s. net.

THE ALTERNATE-CURRENT COMMUTATOR MOTOR.—The subject of the design and construction of alternate-current commutator motors is at the present time perhaps one of the most important in connection with electrical engineering developments, and Dr.-Ing. RUDOLF GOLDSCHMIDT has made this subject his special study. The results are embodied in a new work by this author which will be published in time for the autumn market by "The Electrician" Printing & Publishing Co., price 8s. net.

ARRANGEMENTS FOR THE WEEK.

INSTITUTION OF MECHANICAL ENGINEERS.

TUESDAY July 27th, and WEDNESDAY, July 28th.

10 a.m. Summer meeting in the Municipal Central Technical School, Liverpool. Papers on "Indicating of Gas Engines," by Prof. F. W. Burstall, and on "The Electrical Operation of Textile Factories," by Mr. H. W. Wilson.

ELECTRIC TRACTION ON RAILWAYS.*

XVII.—FEEDERS AND FEEDING SYSTEMS.

BY PHILIP DAWSON.

Summary.—In this section the author discusses the arrangement and design of the transmission and distribution system. The most economical cross-section of cables, the heating of conductors, and voltage drop are considered, as well as the employment of aluminium both for overhead and underground lines. In conclusion, the use and action of booster transformers are described.

The question of designing a scientifically more or less correct and economical feeding and distributing system, as well, from the point of view of reducing as much as possible the first cost, as minimising the losses in transmission and distribution, is one which presents many difficulties.

The problem of planning out the best feeding system—and in this it is intended to include the whole transmission and distribution system, from the power station to the train—is one which varies with the conditions of each particular case.

There are certain limits of current-density in the cables, which we shall presently discuss, that are necessary to prevent deterioration and eventual breakdown of insulation. This feature, however, as well as many others, ultimately comes down to a question of cost, which renders a general solution for all types of cases an impossibility. The object kept in view should be to secure, for a given expenditure, the feeding system which shall be (1) the most economical in capital expenditure, (2) most economical in power consumption, (3) the best adapted for maintenance purposes, (4) rendering itself most subject to further extensions on the same lines.

The first thing to determine, after the type of cable has been definitely decided upon, is the section of cable to be adopted. There are several bases on which the copper cross-section can be determined. *They depend broadly upon* (1) economic considerations, (2) temperature considerations, (3) admissible voltage drop.

Most Economical Cross-section.

To show by an example how to find the most economical cross-section of copper for any current value let us take certain values for interest on capital and depreciation, price per unit, and cost of copper.

The question of interest and depreciation comes in the following way :—Suppose there is an alternative of spending £700 or £800 on a certain distribution by copper conductors, and that with the expenditure of £800 the cost to the producer of the power lost in distribution per annum is £35, whereas with an expenditure of £700 it is £40. By expending the larger amount the undertaking has, therefore, the opportunity of investing £100 at a certain 5 per cent. ; but in the event of its system ceasing to operate the £100 represented in copper and insulation will have considerably depreciated as regards its realisable value. If, however, the investment of a still further £100 above £800 in copper is contemplated, it will be found that 5 per cent. can no longer be obtained.

There comes a time, therefore, when the investment of further capital ceases to be a sound proposition, and it is this value which it is proposed to calculate. It must be borne in mind, however, that the extra capital so spent cannot be recovered at a moment's notice (or perhaps at all) as if invested, say, in Consols, and for this inconvenience the percentage should be higher.

Taking the following figures for constants :—

Copper, £70 per ton.
Total cost of power 0·5d. per unit to producer.
Interest and depreciation, 5 per cent.

Now, 1 sq. in. section of copper a mile in length has the following properties :—

Weight, 9·1 tons.
Cost, £636 at £70 per ton.
Resistance (60°F.)=0·043 ohms.

Any other cross-section, x, will have :—

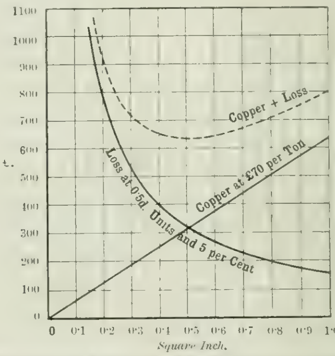
Weight=9·1 . x tons.
Cost=£636 . x.
Resistance=$\frac{0{\cdot}043}{x}$ ohms.

Suppose a current of 100 amperes is to be carried continuously. The equivalent capital of the energy loss in transmission for a current, I, will be

$$\text{£}\frac{I^2 r \times 24 \times 365 \times 20 \times 0{\cdot}5}{240 \times 1000} = \frac{15{\cdot}7}{x}\text{£},$$

and the first cost of copper is £636 . x.

Plotting these values with section x as abscissæ and capital as ordinates we get Fig. 1. It is a mathematical fact that the minimum total is the same as the point of inter-section of the two curves.



Copper £70 per ton. Energy 0·5d. per Board of Trade unit. Interest 5 per cent.

Fig. 1.—Most Economical Copper Section.

If we plot the sum of the two curves we shall get a measure of the allowable percentage error which will produce no appreciable change in economy. From this it will be seen that the minimum capital comes out for a cable having a sectional area of 0·496 sq. in., and is £631. The limits of section for a 5 per cent. rise on this capital, or a capital of £663, are, from the curve, 0·36 and 0·69, or a total variation of about 48 per cent. We thus see that the section can be varied within fairly wide limits, say 20 per cent. either way, without materially affecting the economy.

To establish the general formulæ for any other constants and any metal,

Let w=weight in tons of 1 mile having section 1 sq. in.,
r=resistance, „ „ „
p=price in pounds per ton (£ per ton),
h=per cent. interest required,
d=total cost of generated energy in pence per unit,
x=section required in square inches,
I=R.M.S. value or equivalent continuous current in amperes.

Then the capital expended in metal will be

$k=w \,.\, x \,.\, p$ in pounds sterling.

The capital equivalent of power consumed in transmission will be

$$K_2 = \frac{I^2 r \times 24 \times 365 \times d \times 100}{x \times 240 \times h \times 1{,}000}$$

in pounds sterling for copper

$$r = 0{\cdot}043, \quad w = 9{\cdot}1.$$

$$x = 10{\cdot}1312\sqrt{\frac{d}{hp}}.$$

Heating of Conductors.

Quite apart from the question of economy above discussed, one has to consider the question of heat generated within the conductor. Most costly damage may be done by overheating, so that the question is one deserving careful attention.

Most cable makers protect themselves in respect to their guarantees by specifying a current-density above which their cables must not be used. A common figure for this purpose is 1,000 amperes per square inch, although limits of 1,500 amperes for small sizes are frequently given. It should be remembered, however, that the heating effect rises more rapidly than the radiating surface, as the size of sectional area increases if the current-density is kept constant, so

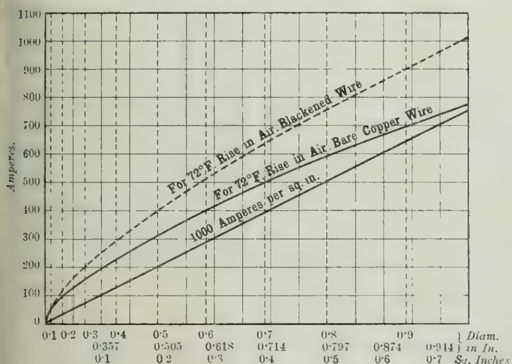


Fig. 2.—Curves showing Current for different Areas of Wires.

that any fixed ratio as the above will be either needlessly low for small sizes or may become dangerously high for large ones.

Since the work of Dulong and Petit (1805), who examined the phenomena of radiation and convection, some of the most important experiments have been those of Mr. A. E. Kennelly, in America.

For the purpose of this discussion, two curves have been taken, as given in Fig. 2. They have been derived from Abbot's work on transmission of energy, the curves there given having been transformed for our purposes to a square inch cross-section basis. These two curves show the current for a 72°F. rise for bare copper (full line) and for blackened copper (divided line). For insulated cables each case will have to be worked out for itself, as the safe current is a function of the material and thickness of the insulation and the manner of its laying. The safe limit for insulated cables is represented by a temperature of 150°F., *not* a rise of this amount.

Allowable Voltage Drop.

Since the motors, controller resistance, &c., of a train are designed to work with a certain voltage, it is a serious disadvantage in continuous-current work to have heavy voltage drops in the feeding system. The speed and starting torque of the motors are both reduced if the voltage drops off, so that it is necessary to fix an allowable maximum drop in designing the feeder system, and 10 per cent. is usually regarded as a good figure, although this is often exceeded in practice, especially in America. For continuous-current work the introduction of boosters, both positive and negative, has provided a more practical solution of the problem than that of adding an inproportionate amount of copper to the feeding system.

The heating effect in a cable over any period is given by the root mean square of current during that period, but the laws of applying the root mean square value must be used with caution, since a cable may be permanently damaged with an excessively heavy current lasting but a short time. In any case, the root mean square criterion shows at once that the better the load factor the greater power can be delivered by a given cable. It is impossible to give a measure of the increased capacity of a cable with increased load factor, since load factor is a purely arbitrary quantity, depending on the method of measuring the maximum load. For any given case, of course, the ratio of actual capacity to unity load factor capacity can be obtained by calculation. On constant potential loads the ratio would be the reciprocal of the form factor of the current curve, the form factor being the ratio of the root mean square value to average value. Suppose the illustration Fig. 3 to be a load curve for a station. The energy delivered in 24 hours is the product of the average current, station voltage and $\frac{24}{1{,}000}$ B.O.T. units, but the cables would have been heated to just the same extent and would have lost the same energy en route if they could have delivered the root mean square current continuously for the 24 hours. Hence the desirability of a good load factor.

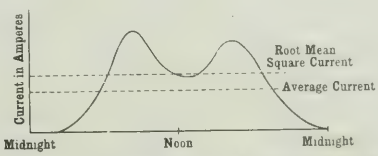


Fig. 3.—Showing difference between Average and Root Mean Square Current.

Although the form factor will be different in each case, yet a rough idea can be got by remembering the form factor for a sine curve and a sharp angle. For a sine curve the form factor is 1·11, the reciprocal of which is exactly 0·90. If the station load was nearly a sine curve the saving in transmission to be obtained by unity load factor would be 10 per cent. The load factor of the sine curve is 64 per cent., so that generally a greater saving might be effected.

For a straight line load from zero to a minimum the load factor is 50 per cent. The form factor is, however $\sqrt{\frac{4}{3}} = 1{\cdot}155$, of which the reciprocal is 86·6 per cent.

Calling this ratio $\frac{1}{f}$, (f being the form factor), we have

	Load factor.	$\frac{1}{f}$
Flat load	100 per cent. ...	100·0 per cent.
Sine curve	64 ,, ...	90·0 ,,
Straight line load	50 ,, ...	86·6 ,,

To return once more to the question of voltage drop, the cables should be calculated to give a 10 per cent. drop at maximum load, and the resulting size used as a minimum, remembering always that the current capacity size *must be* complied with, the voltage *should be*, and the most economical section depends entirely upon the two values adopted for these two factors.

The calculation of the drop in a simple feeder is, of course, quite a simple matter, but where a network is concerned it becomes more difficult. By systematically applying Kirchoff's laws any network may be calculated, but care must be used in keeping the signs right and in bearing the commercial side as well as the engineering point of view uppermost, for the sizes suggested on purely mathematical grounds may not always prove in practice either the most or permanently economical, and although theoretical considerations are essential, the same equally applies to practical considerations, and both modes should be carefully considered before any definite decision is arrived at.

Aluminium as a Conductor.

The recent reductions in the market price of aluminium have attracted a good deal of attention to the suitability of this metal for electrical purposes, both directly as a conductor and also in the construction of electrical machinery. In the former capacity, for overhead lines aluminium of the same price per ton as copper shows on paper a marked advantage, and is being installed for this purpose in America. The following figures show the relative properties of hard-drawn aluminium and copper wire.

Property.	Copper.	Aluminium.
Specific gravity	8·90 to 8·93	2·63 to 2·71
Conductivity	1·00	61·00
Section of equal conductivity	1·00	1·64
Diameter for equal conductivity	1·00	1·28
Weight of equal conductivity	1·00	0·496
Market price for Drawing No. 13	£12 per ton	£22 per ton
" " 15	£12 per ton	£27 per ton
" " 17	£12 per ton	£30 per ton
Tensile strength, tons per square inch diameter	21 to 22 (large sizes)	12 (large sizes)
Elastic limit	40 to 50 per cent.	40 to 50 per cent.
Wind pressure for equal conductivity	x	1·25 x
Total elongation	7 per cent	3·5 per cent
Current for same rise in temperature with section of equal conductivity	100 amperes	113 amperes

The best broad rules to remember about this comparison are: (1) for equal volumes aluminium is one-third the weight of copper; (2) for equal conductivity aluminium is half the weight of copper.

With regard to insulated cables the following information has been furnished by the courtesy of Messrs. Johnson & Phillips:—

For any cable having to stand a given potential, V, the necessary thickness of insulation between core and the sheath becomes smaller as the size of the core increases, owing to the decreased curvature of the core. This is due to a statical phenomena of surface density, which is also manifested by the greater discharge distance of points to flat plates for the same potential.

The total quantity of insulation is proportional to the product of thickness and mean circumference of the insulating belt. The former, then, decreases, but the latter increases as the core is made larger. There are, therefore, two critical diameters of core, one being for a minimum overall diameter, the other for minimum quantity of insulation. The minimum *overall diameter* is obtained if *the radius of the core* is equal to $\frac{V}{3{,}000}$ mm., V being the working pressure (alternating current). The minimum quantity of insulation is obtained with a core radius of 5/4 times this quantity, or

$$= \frac{1{\cdot}25}{3{,}000} V.$$

From this we can construct a table of best sizes for various pressures.

It must be noted that the above formulæ are based on a factor of safety of 6·6, using a breakdown dielectric stress of 20,000 volts per millimetre thickness for paper insulation.

Pressure in volts.	Size of circular conductor in square inches and diameter. For minimum overall diameter.		For minimum insulation.	
	Area sq. in.	Diam. inches.	Area sq. in.	Diam. inches.
1,000	0·00054	0·0232	0·00084	0·029
5,000	0·0135	0·116	0·0211	0·145
6,600	0·0235	0·153	0·0367	0·191
10,000	0·0540	0·232	0·0842	0·29
15,000	0·122	0·35	0·191	0·437
20,000	0·216	0·465	0·337	0·58
25,000	0·338	0·58	0·528	0·726
30,000	0·486	0·696	0·76	0·87
50,000	1·35	1·16	2·11	1·45
70,000	2·65	1·63	4·14	2·03

The above figures show that for high-pressure cables it may be desirable to use a jute packing inside the core, or to use a conductor of lower conductivity such as aluminium. The Author has seen test leads with a lead conductor to obtain the requisite diameter for 50,000 volts.

The question of the amount of current to be delivered has an important bearing on the above. For instance, if 100 amperes are to be delivered at 20,000 volts, it would only be necessary to have 0·1 sq. in. copper, or 0·163 sq. in. aluminium to carry the current, and yet for minimum overall diameter 0·216 sq. in. would be necessary. In this case, with drawn copper and aluminium at the same price per ton, the cost of the aluminium for any given cable would be one-third that of the equivalent cost of copper. For a cable of this class the ratio of total cost to cost of copper would be from 4 to 5, so that the saving by using aluminium for this cable would be about 15 per cent., but the transmission losses would be about 60 per cent. more for aluminium than copper.

With regard to bare wire overhead transmission, the greater radiating surface of an aluminium wire of equal conductivity with a copper one gives an increased carrying capacity in the ratio of the square root of the surface ratio. The surfaces for equal conductivity are: Aluminium 128, copper 100, so that the carrying capacity for same temperature rise will be, aluminium 113, copper 100. If the aluminium is reduced to give the same temperature rise the transmission loss will be increased, and, as it is usually the latter which determines the sizes in transmission schemes the advantage will not be available, except as affording greater security if the line should be overloaded in emergencies.

The lighter weight of the conductor with aluminium is partly offset by the increased area exposed to wind, snow, &c.; the weight ratio being 1 to 2, the equivalent area for equal conductivity 1·25 to 1.

The foregoing considerations are sufficient, at all events, to indicate the nature of the problems involved in the design of feeding systems with respect to the size and nature of the conducting cables themselves.

Booster Transformers.

With single-phase traction the variations in pressure of the contact wire do not involve the troubles incident to such variations in direct-current practice, since it is a perfectly easy matter to provide an extra running position on the controller corresponding to a higher transformer ratio (giving higher secondary pressure) than that normally used as the top-running speed. In continuous-current

ractice the full parallel running position employs the ighest available voltage on the motors, so that the speed n the trains at the end of a long system will be reduced wing to the drop, unless a positive booster is installed, inolving considerable expense. This constitutes an important advantage for single-phase working, since, in addition to the above, it enables one to transfer the return drop n the rails to the overhead wire by means of booster transormers.

The use and action of booster transformers are as follows: t various points in the track of a single-phase system a ub-station is provided into which *all* the high-tension outgoing) conductors are led, thus the whole current taken y the system beyond this point is brought into the subtation. This current is then passed through the primary f a transformer, the secondary of which is connected on ne side to the track and on the other to an insulated return cable. The connections are shown in Fig. 4.

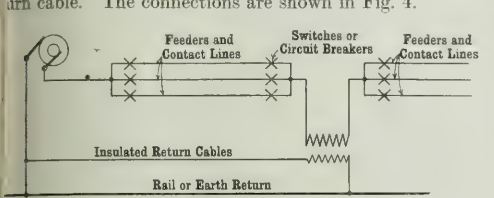


FIG. 4.

If the transformer is of one to one ratio, the only difference between primary and secondary currents will be he small current supplied from the primary side for magnetising the booster transformer. Neglecting this, the ntire current fed to points beyond the sub-station will be ucked back and returned to the power station through the nsulated return cable.

In a real case, of course, the placing of the sub-stations vould be governed by the proximity to signal boxes and tations, as well as the varying conditions of traffic. A eries of trials would have to be made by placing the train n accordance with the required service and the drop calulated therefrom.

Several methods of connecting have been proposed for ooster transformers, but they all depend on the principle xplained above.

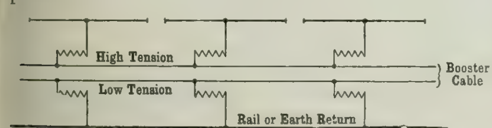


FIG. 5.

An arrangement of this kind is that due to Mr. W. M. Mordey, which consists in feeding each section separately from a single point, as shown in Fig. 5. In this arrangement, by making the sections equal, each transformer has the ame loading. Against this advantage, however, is the fact that the trolley is not used as auxiliary to the feeding able, and the capital cost of the installation may be thus greatly increased.

The arrangement shown in Fig. 4 is that advocated by the Allgemeine Elektricitäts Gesellschaft, of Berlin, and it should be noticed that each transformer deals with the whole current passing beyond it. However, as the transformers are of quite small dimensions (usually 10 kw. or less), this is not a serious objection, and this arrangement has the considerable advantage of using the trolley wires to assist the feeding system to sections beyond, which ensures continuance of service in the event of a breakdown in the booster or other feeding cables. Further, a breakdown of one booster transformer does not cripple the service, as it can be cut out of action and its functions taken over automatically by its neighbours on each side, the only result being a section of double the usual length.

THE MOST ECONOMICAL COMBINATION OF CAPACITY AND INDUCTANCE IN UNDERGROUND TELEPHONE CABLES.

BY B. S. COHEN.

In a recent note to the "Académie des Sciences" (February 22, 1909, pp. 478-481) entitled "On the Composition of Underground Lines which form the Telephone Circuits in Large Cities," M. Devaux-Charbonnel comes to certain conclusions which are opposed to general telephone practice, and the writer thinks that in the following criticism he will have the support of many who have studied this subject in the view that these conclusions are based to a great extent on misconceptions.

M. Charbonnel first obtains the following formula for the ratio P between the received currents over open aerial and underground cable conductors respectively, and he includes the effects due to the terminal apparatus:—

$$P=\frac{Z_1}{Z}\left(\frac{A+B}{2}e^{l\alpha}-\frac{A-B}{2}e^{-l\alpha}\right).$$

where $A=1+\frac{Z_t}{Z}$, $B=\frac{Z_t}{Z}+\frac{Z}{Z_1}$, α =attenuation constant, l =length of cable line, Z=cable line impedance, Z_1=open-wire impedance, Z_t=terminal instrument impedance.

No explanation is given as to how this formula is derived, and it has not been found possible to obtain it from Dr. Kennelly's formulæ, which give the following ratio:—

$$P=\frac{Z(e^{l\alpha}-e^{-l\alpha})+Z_t(e^{l\alpha}+e^{-l\alpha})}{Z_1(e^{l\alpha_1}-e^{-l\alpha_1})+Z_t(e^{l\alpha_1}+e^{-l\alpha_1})}.$$

In this formula α is the attenuation constant for the open wire. The other symbols are the same as in the previous formula.

M. Charbonnel gives a number of comparative figures which do not appear to have been obtained by the aid of his formula. These are given in tabular form. The first table gives the lengths of 5 mm. (roughly 600 lb. weight per mile) aerial conductor which will produce the same attenuation as the underground line considered. These figures are termed equivalent aerial lengths.

These figures are not confirmed either by calculation or by the experimental investigations carried out by the National Telephone Co. It is of little value to apply any analysis to the figures in the last column obtained for 5 mm. (600 lb.) conductor cable, as it has been very conclusively shown that telephone cables with conductors above 200 lb. weight per mile are practically uncommercial.

Table I.

Underground cable length.	Equivalent 5 mm. (600 lb.) aerial conductor length in km. for cables with conductors of the following sizes:—		
	1 mm. (25 lb.)	2·5 mm. (150 lb.)	5 mm. (600 lb.)
5 km.	157	76	110
10 ..	363	191	240
15 ..	565	320	370
20 ..	820	440	500

A few figures in connection with the 1 mm. cable, which it will be found agree with those that would be obtained by using

the ordinary transmission formulæ of Kennelly, G. A. Campbell, &c., may be of interest.

A 25 lb. (1 mm.) conductor having the following values is considered :—

Resistance, 43·5 ohms per kilometre loop.
Capacity, 0·0335 mfd. per kilometre loop.
Inductance, 0·62 millihenry per kilometre loop.

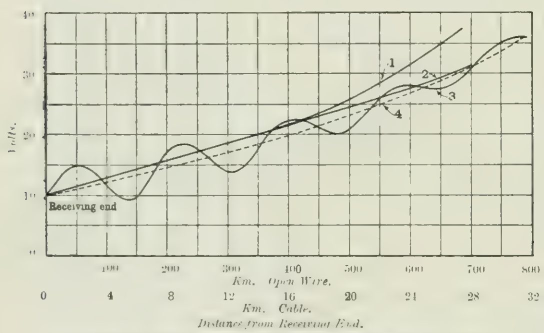
This cable line is compared with a (5 mm.) 600 lb. aerial line having a

Resistance of 1·84 ohms per kilometre loop.
Capacity, 0·0059 mfd. per kilometre loop.
Inductance, 2·05 millihenrys per kilometre loop.

The terminating instrument has an impedance of 500 |40 deg.

From these data it is possible to plot curves showing the variation of current or of potential with length of line. The curves illustrated in the diagram herewith are plotted from calculations made by Mr. A. J. Aldridge, of the National Telephone Co., using the above data.

It will be observed that the potential along the 600 lb. aerial line for at least 800 km. back from the receiving end passes through a series of maxima and minima values, and it is possible to find a number of different lengths of this type of line for which the received current is the same. This wavy current distribution is a familiar phenomenon, and can be readily demonstrated experimentally. On the other hand, the cable line, owing to its relatively greater resistance and capacity and smaller inductance, does not show this variation.



(1) 1 mm. 25 lb. cable, normal capacity. (2) 1 mm. 25 lb. cable, half capacity. (3) 600 lb. copper open wire. (4) Mean curve for open wire.

From this curve the following table can be obtained, which may be compared with the figures in Table I. given by M. Charbonnel :—

Table II.

Underground length.	Equivalent aerial length in km. for 1 mm· (25 lb.) cable conductor.		
	A.	B.	C.
5 km.	28, 83, 177	162	188
10 „	200, 255, 347	310	376
15 „	375, 455, 500	435	564
20 „	550	575	752

The figures in column A are obtained by finding lengths of 600 lb. aerial conductor which give the same current as the corresponding lengths of cable in the first column, and it will be seen that in the first three cases there are no less than three equivalent lengths of aerial conductor. Column B is obtained by using mean values drawn through the wavy 600 lb. aerial conductor curve. Column C gives the result obtained by taking the ratio between the attenuation constants for the cable and aerial conductors respectively and neglecting the terminal effect.

M. Charbonnel goes on to consider the improvements effected by adding inductance to the cable by means of Pupin coils, and he here makes the assumption that no reflection-reducing device is introduced into the loaded line to compensate for the considerable increase in the line impedance over the instrument impedance. The neglect of this important factor in improving the efficiency of loaded lines seems universal amongst Continental telephone engineers, and it can only be assumed that the improvement thus rendered possible has not been appreciated. In this country, as far as the National Telephone Co. is concerned, and in America, it may be stated that all those lines which are loaded so that the line impedance greatly exceeds the terminal instrument impedance are equipped with reflection-reducing devices.

Another assumption made by M. Charbonnel—viz., that a loading coil with an inductance of 0·1 henry will have an effective resistance of 20 ohms—does not hold for the best type of coils as used in this country and in America, which have a time constant of about five times as much as those referred to above. The following table of loaded line values for 1 mm. (25 lb.) cable as calculated by M. Charbonnel, together with a column of values for the same size cable derived from the actual values obtained here and in America for practically the same size conductor—viz., 0·9 mm., 20 lb.—will show how much M. Charbonnel's estimate of the improvement is below the actual result.

Table III.

Length of 1 mm. (25 lb.) underground cable.	Equivalent 600 lb. aerial conductor length for 1 mm. (25 lb.) cables.	
	M. Charbonnel's calculated value.	Actual value obtained in practice.
5 km.	82 km.	53·0 km.
10 „	180 „	92·0 „
15 „	240 „	130·0 „
20 „	310 „	168·5 „

It is now that M. Charbonnel comes to a conclusion that will be most seriously criticised. He investigates the improvement likely to result from doubling the thickness of the dielectric in an underground paper cable, and thus decreasing the capacity, and concludes that this can be easily and economically effected, and that the results will be superior to those obtained by increasing the inductance by means of Pupin coils. To begin with, a statement is made that by doubling the thickness of the dielectric the capacity is halved and the inductance is doubled. The latter part of this statement is, of course, incorrect, and the former not necessarily true.

As a matter of fact, taking a 20 lb. conductor (0·914 mm.) cable, with conductors at the average distance apart of about 1·93 mm., the inductance is found to be 0·00065 henry per kilometre, and when the conductors are removed to twice the distance apart the inductance becomes increased to 0·00072 henry, or only about 17 per cent. improvement.

M. Charbonnel arrives at the following table for a 25 lb. cable with the capacity halved :—

Table IV.

Underground length.	Equivalent 600 lb. aerial conductor length for 1 mm. (25 lb. cable).
5 km.	50 km.
10 „	100 „
15 „	140 „
20 „	170 „

Calculations have been made over here on a 1 mm. conductor cable, which is assumed to have its capacity reduced from 0·0335 mfd. to 0·0167 mfd. per kilometre loop, by doubling the dielectric thickness, and the inductance is, consequently, increased to 0·75 millihenry per kilometre. Curve No. 2 in the above diagram gives the relationship between potential and length for this type of line. From this curve the following table is obtained :—

Table V.

Underground length.	Equivalent aerial length for 1 mm. (25 lb.) cable conductor.
5 km.	162 km.
10 „	310 „
15 „	435 „
20 „	545 „

It will be seen that the low capacity cable gives results three times as bad as estimated by M. Charbonnel. Furthermore, a comparison with Table II., column B, shows that the reduced capacity effects no improvement until 20 km. of cable are considered, whilst Table III. demonstrates that the loaded line gives much the best transmission under all conditions. It should be mentioned that leakance has been neglected in all cases, as it would appear that this also has been neglected by M. Charbonnel. The effect due to leakance would be most pronounced on the 600 lb. aerial line, but would not in all probability introduce any considerable discrepancy.

In practice, a considerable length of aerial line would be terminated by a short length of underground cable, and this combination would tend to modify the wavy current distribution along the open wire by altering the reflection effects.

The following figures have been obtained for the equivalent length of 1 mm. cable in terms of 5 mm. open wire in the case of a non-homogeneous line, such as is met with in practice:—

Table VI.

Underground length.	Equivalent 600 lb. aerial conductor length for 1 mm. (25 lb.) cable.
5 km.	108 km.
15 ,,	387 ,,
15 ,, half capacity cable	322 ,,

The loaded line will have the same value in this case as in the case of homogeneous lines given in Table III. last column. It will be noted that in the three cases given the cable line has a decidedly less allowance at the end of an open wire conductor than without such an intermediate conductor between it and the sending end.

In conclusion, it may be stated that M. Charbonnel's assumptions as to the increased transmission value of low capacity cable cannot be upheld. The reduction of cable capacity is also an extremely costly matter, by reason of the increase in diameter of cable per unit number of wires, which not only increases the cost of the cable itself, but also of the duct into which the cable is drawn.

DIFFERENTIAL TESTING FOR HYSTERESIS LOSS.

BY PROF. ERNEST WILSON.

When making tests with the ballistic galvanometer for the purpose of obtaining a cyclical curve of magnetic hysteresis it is usual to vary the magnetic force from one maximum through zero to some prearranged value and observe an ordinate such as a in Fig. 1. The force is then raised to the other maximum. It is then reduced without passing through zero, and the ordinate b is obtained. A series of such observations enables the curve to be determined. It was thought that if, instead of performing the above operations, the force were changed so as to obtain the difference d as a direct quantity a greater accuracy might be obtained, especially when d is small. Three experiments were made with rings of pure iron* (solid), magnet steel (solid), and transformer iron (laminated). The method of test was the same as is described in a previous Paper.* In each case the force was varied from one maximum through zero to about the then value of the coercive force; it was then changed to the other maximum and back again to its initial value by short-circuiting a resistance in the circuit. In addition, the ordinates b and c were obtained in the ordinary way, and their difference compared with the directly obtained difference d. In the case of the solid specimens the difference d was very much smaller than the difference $c—b$, but in the case of the laminated specimen the agreement was close. The disagreement is attributed to the effects of eddy currents and magnetic viscosity.

* "Roy. Soc. Proc.," Vol. LXII., p. 369.

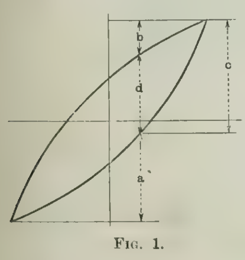


Fig. 1.

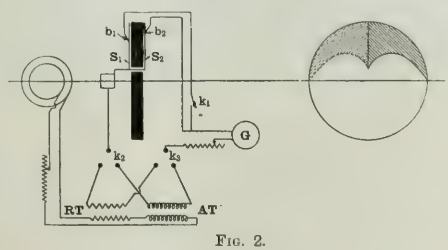


Fig. 2.

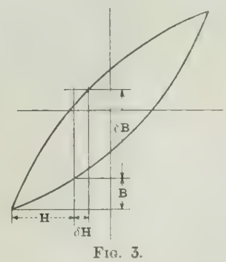


Fig. 3.

As it was desired to obtain by an independent method the hysteresis loss for low values of the magnetic induction (**B**)

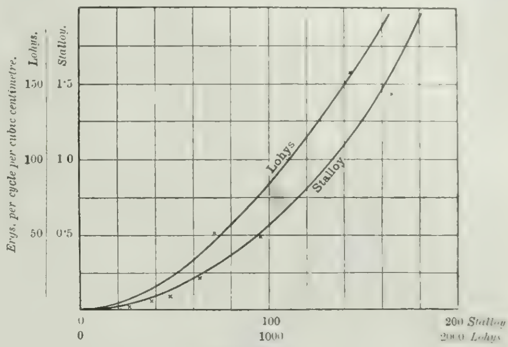


Fig. 4.

to compare with the loss obtained by the ordinary ballistic galvanometer method, the differential method of test was applied, as shown in Fig. 2. The ring to be tested (RT), which was laminated, had its primary coil placed in series with the primary coil of an air transformer, AT, and an alternating current was supplied by a direct-current motor fitted with two slip-rings. The wave-form of P.D. is very closely a sine curve. Two copper sectors (S_1, S_2) bedded in a disc of ebonite and supplied with brushes (b_1, b_2) are connected to a slip-ring and driven by the shaft of the motor-generator. One of these brushes (b_2) was permanently in circuit with a moving-coil galvanometer (G), and the circuit could be connected in series with the secondary coil either of the ring RT or of the air transformer AT by aid of a two-way switch, k_2, k_3. The brush b_1 could be put in parallel with b_2 if desired by the key k_1. An end view of the sectors S_1, S_2 is shown in Fig. 2, and they were so arranged that by adjusting either of the brushes b_1 or b_2 in a radial direction various angles of contact could be described. Thus, in Fig. 1, the brush b_1 could be made to close the circuit from the time of maximum current until the change b had been observed. The difference d was obtained by closing the key k_1, as the brush b_2 then closed the circuit during the

* "Roy. Soc. Proc.," Vol. LIII., p. 353, Fig. 2. A very interesting article on "Differential Ballistic Methods" has been published by R. Beattie, D.Sc., and P. M. Elton B.Sc. See THE ELECTRICIAN, Vol. LXIII., p. 299.

time that the change c was being made, the galvanometer giving a deflection proportional to the difference d. One had the choice either of making the forces causing the changes b and c respectively equal, by adjustment of the brushes b_1, b_2, or from known setting of the brushes of observing the difference of the forces as a direct quantity. This latter method was chosen, and Fig. 3 illustrates the quantities measured in this case.

The use of the galvanometer to give the required quantities rests on the following reasoning: Let A=the cross-sectional area of the ring RT, let n=the number of secondary turns, let B=the magnetic induction.

Then the E.M.F. of the secondary coil$=\frac{d\mathsf{B}}{dt}\times A\times n\times 10^{-8}$ volts.

If the current (x) in the galvanometer is proportional to the E.M.F., then $x=\frac{d\mathsf{B}}{dt}\times A\times n\times 10^{-8}/R$, where R is the resistance of the secondary circuit. The average value of x when interrupted after time t is

$$\frac{An10^{-8}}{TR}\int_0^t\frac{d\mathsf{B}}{dt}\,.\,dt=\frac{An10^{-8}}{TR}\{\mathsf{B}_t-\mathsf{B}_0\}.$$

where T is the periodic time. If D be the deflection of the galvanometer and k its constant, such that Dk=amperes,

$$\mathsf{B}_t-\mathsf{B}_0=Dk\,\frac{TR}{An\,.\,10^{-8}}=Dk\,.\,\frac{R}{Anf10^{-8}},$$

where f is the frequency. The self-induction (L) of the galvanometer is about 0·002 henry and the frequency in the experiments to be described was 10. The resistance of the galvanometer was 456 ohm, so that the value of $2\pi f$L is less than one part in 4,000 compared with the resistance, and has been neglected.

Referring to the air transformer AT, the average value of the current x is

$$\frac{Mm}{TR}\int_0^t\frac{dx}{dt}\,.\,dt=\frac{Mm}{TR}(x-x_0)=Dk.$$

where M is the mutual induction as between the primary and secondary coils, and m is the number of secondary turns. The maximum value of x could thus be obtained by setting one brush (b_1) and moving the other (b_2) until the deflection is a maximum, then keeping b_2 fixed and moving b_1 until the deflection is again a maximum. This gives the maximum value of the current x and thus the maximum of the magnetic force. An alternative to this method was used—namely, observing the maximum current by aid of an electrometer, revolving contact-maker and non-inductive resistance.

By this method it was possible to observe as a direct deflection of a moving-coil galvanometer (1) the ordinate B and the difference $\delta\mathsf{B}$, (2) the force H corresponding to B and the difference $\delta\mathsf{H}$. Thus the curve was determined and plotted.

Table I.

Material.	B (max.)	H (max.)	Permeability.	Ergs per cubic centimetre per cycle.	Method.
Stalloy (thickness of stampings 0·0485 cm., specific resistance at 15°C. 49·6 × 10⁻⁶ ohms).	35·6	0·0596	597	0·0820	Ballistic
	70·9	0·101	701	0·291	
	97·2	0·1235	788	0·620	
	109·3	0·139	787	0·660	
	157·0	0·178	882	1·405	
	264·0	0·246	1,073	4·5	
	1·135	0·00422	269	0·0000278	Disc
	5·67	0·0183	310	0·00055	
	7·95	0·0259	307	0·00382	
	8·15	0·0326	250	0·00314	
	26·1	0·0541	545	0·0296	
	38·9	0·0715	554	0·0698	
	47·2	0·0776	609	0·0974	
	62·75	0·0984	639	0·214	
	95·0	0·1348	705	0·496	
	165·0	0·181	912	1·43	
Lohys (thickness of stampings 0·037 cm., specific resistance at 15°C. 14·3 × 10⁻⁶ ohms).	97·4	0·200	487	...	Ballistic
	264·0	0·385	686	7·45	
	746·0	0·638	1,170	50·9	
	1,511·0	0·821	1,840	170·0	
	3,660·0	1·193	3,070	657·0	
	16·2	0·060	270	0·0102	Disc
	708·0	0·635	1,114	50·4	
	1,430·0	0·815	1,755	157·0	

In Table I. are given the results obtained by the two methods, and the curves in Fig. 4 show that at frequency 10 the loss due to hysteresis in laminated Stalloy is slightly less than that given by the ballistic test for a given change of B. The Stalloy has a high specific resistance, and the eddy-current loss is very small at the frequency adopted. With the Lohys ring the loss due to eddy currents is more important, and the ballistic test gives slightly lower values of hysteresis loss than the differential disc method. This method, if carried far enough, would enable very small values of B to be used, and this is a matter which is being further investigated.

The above experiments were carried out in the Siemens Electrical Engineering Laboratory, King's College, London. I have pleasure in acknowledging the help I have received from Mr. W. H. Wilson, Mr. G. F. O'Dell, Mr. C. E. Olive and Mr. H. W. K. Jennings.

THE ELECTRIC POWER SUPPLY OF CHICAGO.

(*Continued from page 552.*)

The last five turbines installed, of 8,000 kw. rated output, with ability to work at 12,000 kw. during peak load, which are seen in the view of the engine room given in Fig. 9, are Curtis five-stage machines running at 750 revs. per min. One is shown in Fig. 10, together with its auxiliaries. These turbines stand 34 ft. 8 in. above the floor. The governors are of the hydraulic type. The Worthington surface condensers, which are located in the base of each unit, have 25,000 sq. ft. of tube surface and can handle 216,000 lb. of water per hour. Each unit has its own condensing apparatus, feed-water heater, hot wells and feed pumps. A centrifugal hot well pump takes the condensed steam from the condenser and delivers it to the feed-water heater. This centrifugal pump is a 4 in. vertical-shaft two-stage machine driven by a 20 H.P. direct-current motor, seen in Fig. 10. The dry-vacuum pump and the centrifugal pump for circulating the condensing water are driven by a Corliss engine running at 75 revs. per min. The circulating pump is of Worthington make for handling 22,500 gallons per minute. Each unit has two vertical uniplex feed pumps 20 in. by 14 in. by 24 in., with a rating of 581 gallons per minute. The closed feed-water heater has 3,000 sq. ft. of surface, with ability to raise the temperature of 160,000 lb. of water per hour by 55 deg.

As regards the oil pumping for step bearings, each pair of units has a pair of duplicate pumps, an accumulator and a storage tank. When the accumulator falls below a certain point a motor-driven step-bearing oil pump is automatically started.

The floor area per turbine in this turbine room, including all the auxiliaries, is 273 sq. ft. The turbine room has two travelling cranes of 70 ft. span, one being a 50 ton and the other a 60 ton.

The general scheme of high-tension connections is shown in Fig. 12, as designed for the completed station with 14 units. Only 10 units have, however, so far been installed, as mentioned above. The sectionalising 'bus bars and the possible isolation of different parts of the station electrically to prevent spread of trouble is always a matter of considerable interest and concern in connection with a large plant of this kind. It will be seen from Fig. 12 that the first four units installed, which are of smaller rating than the last six, have a different scheme of connections. The first are connected through an oil switch to a short 'bus bar called a "generator 'bus bar." To this "generator 'bus bar" three oil switches are connected, one joining it with a section 'bus bar; the second with a "transfer 'bus bar," which extends through the whole station; and the third to a "line 'bus-bar," which is really a kind of sectionalised feeder 'bus bar to which the oil switches of the outgoing feeders are connected. Each of these line 'bus bars supplies energy to four feeders. It is evident that these feeders can receive energy either directly from a generator or from a section 'bus bar, or from some other section through the transfer 'bus bar.

For generators 5 to 10 there is a different arrangement. Each generator is provided with two oil switches, one of which may connect it directly to the transfer 'bus bar. The other connects it to its

generator 'bus bar. To the generator 'bus bar four outgoing oil switches are joined. From the generator 'bus bar two of these oil switches unite it to two sectional line 'bus bars, a third connects it to the section 'bus bar, and a fourth to the transfer 'bus bar.

The motor-driven oil-generator switches are operated from a remote-control board on a gallery of the turbine room, feeder switching, &c., being done in the switch house adjoining the station. All the 'bus bars, oil switches and meters, as well as the principal operating switchboard, are placed in this switch house. On the first floor are 'bus bar compartments and instrument transformers. On the second floor are the oil switches and the overload relays, instruments and switchboard. To aid in avoiding mistakes the mosaic floor of the switch room has in white lines a diagram indicating the 'bus bar relations of the circuit leading to each oil switch. It is, therefore, unnecessary for employés to enter the 'bus bar compartment rooms in order to trace the circuits. On the top floor of the switch house is the exciter battery and employés' rooms.

The relays which open the oil switches under an overload are of the bellows type, in which the rate of opening is dependent on the expulsion of air from a little bellows due to the magnetic pull of the relay, and hence is more rapid the heavier the short-circuit current. The punching occurred could be instantly determined. A further refinement has been evolved from this, however, and now the hourly readings of the watt-hour meter are recorded in numerals on a sheet of paper.

Transmission lines of 9,000 volt three-phase cable leave the station by six different routes north and two south, the two south going under the river in a tunnel. The separation of these conduit lines is a matter of great importance when dealing with such enormous outputs. A heavy short-circuit current on any one line of ducts has been demonstrated to be capable of fusing ducts, cable, sheaths and conductors into one conglomerate mass for 100 ft. or more of duct without causing enough disturbance to be noticed or to trip the overload relays.

Staff.—The amount of labour required in the operation of a generating station of this size is a matter of interest. The number of men actually in attendance on the machinery in operation is surprisingly small. The number of men employed on general work, however, increases the total number to over 300, including all working "shifts." The work is divided in eight-hour shifts. A better conception can be obtained by considering the number of men required per unit, a unit representing from 8,000 kw. to 12,000 kw.

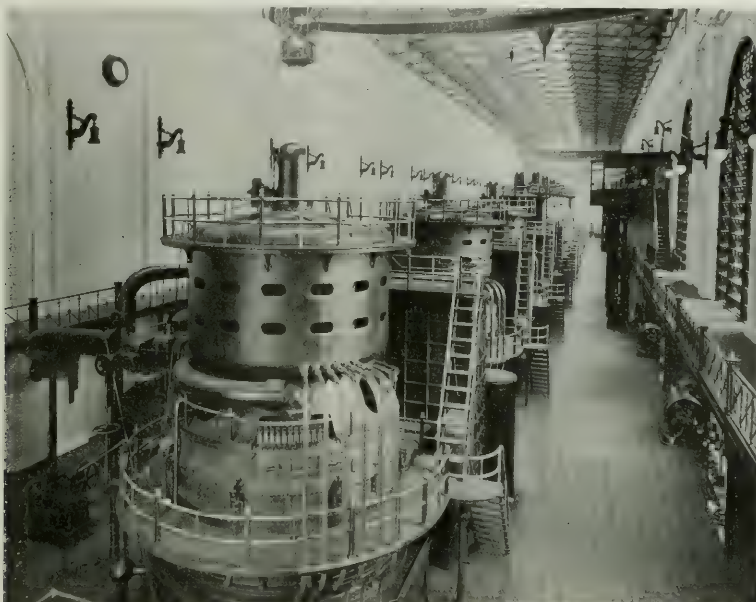


FIG. 9.—INTERIOR OF ENGINE ROOM OF THE FISK-STREET POWER STATION, CHICAGO EDISON CO.

The switchboards are arranged with 'bus bar diagrams on their faces, and handles are so placed as to indicate just what the connections are when the switches are thrown.

About half the output of the Fisk-street station is sold wholesale by watt-hour meter measurement at the generating station 'bus bars to various street and elevated railway companies. The rate consists in at least one case of 0·20d. per unit, plus £3 per year per kilowatt of maximum demand. The maximum demand in kilowatts is taken as equal to the largest number of kilowatt-hours during any one-hour period of the year.

As the measuring of this wholesale energy involves such large amounts of money, considerable study has been given to the methods of measuring and the accuracy of instruments. At first it was the practice to have the switchboard attendant read each railway watt-hour meter on the switchboard once each hour. This method was objectionable, because of the possible errors involved by not reading the meter exactly at the specified time. If such an error occurred during one of the heaviest load periods of the year a great difference would be made in the fixed or readiness-to-serve charge paid by the railway company. An instrument was then applied to the watt-hour meter whereby the position of the dial pointers was punched in a sheet of paper once each hour. Then, by putting this sheet of paper over a dummy dial the position of the pointers at the time the

The operating men per unit are equivalent to: In turbine room, 2; in oil room, 1; attending water, 0·5; fireman, 1; fireman's helper, 1; conveyor men, 2; turbine switchboard gallery, 0·3; exciter tenders, 0·2; switch-house attendants, 0·17.

Moreover, there is a general force for the station consisting of the following men: Chief engineer, first assistant engineer, second assistant engineer, chief electrician, assistant electrician, second assistant electrician, boiler-room foreman, fuel engineer. Besides these there are steam fitters, machinists, machinists' helpers, watchmen and janitors, all under their respective foremen, their number being varied from time to time.

The provisions for the comfort and welfare of employés around the Fisk-street station are as notable as the engineering features of the station. In providing these comforts the station employés are divided according to occupation. Beginning at the bottom, the coal heavers employed in unloading cars have washing and toilet facilities in the basement of the boiler room which are far superior to those usually provided for this class of labour. The boiler-room men are provided with toilet and bath facilities in the north end of the boiler room. Here both shower and tub baths are installed. The turbine room and electrical men have quarters on the top floor of the switch house. This floor contains offices for the chief engineer and clerks, the kitchen and several dining rooms, where meals are served some-

what below cost. All working "shifts" are served here. Sleeping rooms are provided for use in case of emergency work. Across one end of this floor is a large assembly room and library. The station, therefore, offers almost the facilities of a club for its occupants, and in emergencies men can live there in comfort for days at a time.

The experience at Fisk-street has demonstrated that the rise in temperature in a turbo-alternator under load takes place much more rapidly than in large slow-speed engine-driven units. Consequently, there is not so much difference between the temporary overload that a turbo-alternator can safely carry and the load which it can carry continuously, as there is in the temporary overload and continuous permissible load of large slow-speed units. The reason for this, of course, is that the body of copper and iron is larger in proportion to the heat losses to be dissipated in the slow-speed unit than in the high-speed turbine. The temporary overload rating of the turbo-alternator is, therefore, not far from its rating for steady load.

Distribution System.

The standard high-tension 9,000 volt three-phase underground feeder cable used for transmitting energy from generating plants to sub-stations is one having three No. 4-0 conductors, each with $\frac{9}{32}$ in. paper insulation and $\frac{4}{32}$ in. paper insulation over all three. The lead covering is $\frac{1}{8}$ in. An extensive 20,000 volt underground transmission system has, however, been developed during the last two years, and now aggregates about 55 miles in the form of two rings. A three-conductor cable having three No. 2-0 conductors is used, the insulation over each being $\frac{9}{32}$ in. paper, with $\frac{6}{32}$ in. paper over all.

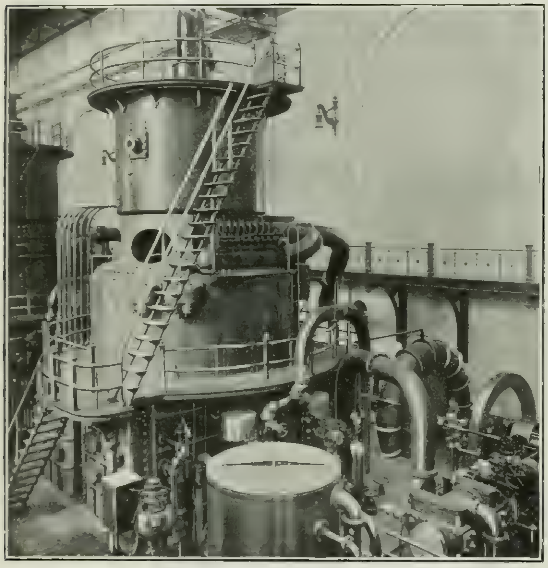


Fig. 10.—View of an 8,000 kw. Turbo-Generator and Auxiliaries. Fisk-street Power Station.

For the 60-cycle feeders, which operate at 4,000 volts, three phase four wire, a four-conductor No. 0 cable is used. Single conductor No. 0 cables are also used on the 60 cycle distributing system. The insulation of these cables is $\frac{5}{32}$ in. paper over each conductor and $\frac{3}{32}$ in. over all conduetors. For the single-conductor cable the paper is $\frac{10}{32}$ in. thick. A 60-cycle 12,000 volt three-phase system is also being developed for the remote sub-stations, and a vertical frequency changer of 5,000 kw. capacity is to be installed, comprising a 9,000 volt 25-cycle synchronous motor coupled by a vertical shaft to a 12,000 volt 60-cycle generator. It is also possible that some of the future 14,000 kw. sets of the Quarry-street station will be 12,000 volt 60-cycle machines, so as to generate 60-cycle current direct.

In the standard construction for high-tension cable ducts a single-duct tile is used with a $3\frac{1}{2}$ in. hole and with $\frac{7}{8}$ in. wall. The joints are staggered, both for mechanical strength and to prevent the spreading from one duct to another of trouble due to the escape of hot gases created by an arc through joints from one duct to another. When the ducts approach a manhole they are gradually spread out so as not to enter the manhole in a bunch. The manholes are made octagonal in shape. The object in keeping ducts as far apart as possible where they enter the manhole is to facilitate the work of running cables neatly through the manhole. At manholes the cables are not left exposed as in the old practice, but they are carefully and completely covered with split-tile duct, so as to isolate each cable as much as possible. The idea of this is, of course, to prevent the spread of a short-circuit in the manholes. Joint failures are almost unknown. Minerallac compound and tape are used in these joints, these products having originated with engineers of this company.

The sub-station buildings are of the highest class of construction. In districts where land is valuable the company employs as a sub-station the basement and first floor of a building, the upper floors of which can be used for office or other purposes. In the most congested districts the practice has been to obtain a long lease of basement space in high-class fireproof office buildings.

In a typical sub-station the 9,000 volt transmission lines from the generating plants enter through either motor-operated or solenoid-operated oil switches, which connect them to the sub-station 'bus bars. From the 'bus bars the various rotary converter or motor-generator units are operated. In case of a direct-current sub-station, a rotary-converter unit and its equipment, there is a motor-operated or solenoid-operated oil switch with overload relays, which controls the supply of high-tension alternating-current energy to the unit. From this oil switch the 9,000 volt energy is taken to a three-phase step-down transformer, which reduces the E.M.F. to 186 volts. Three-phase transformers rather than three single-phase transformers have been regularly used since 1902. Each unit occupies less floor area than three separate transformers. The transformer secondaries are connected six phase, and pass directly to the collector rings of the rotary converter through a motor-operated induction regulator. This regulator can be moved to raise or lower the direct-current voltage by a motor-controlled circuit terminating at the switchboard. The direct-current leads from the rotary converter, according to the latest practice with large machines, are not joined to the generator switchboard, but are connected and disconnected by a solenoid-operated switch, and only the control circuits are taken to the board. The neutral point of the converter is connected to the neutral of the direct-current three-wire system, so that balancer sets are not ordinarily required.

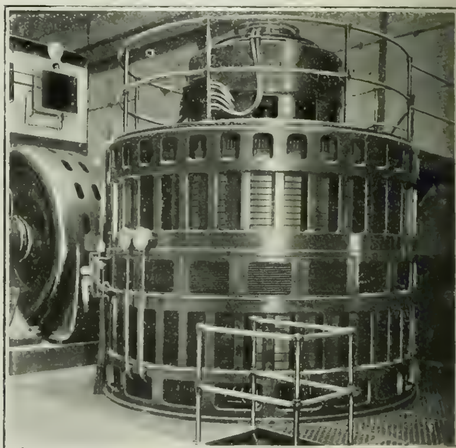


Fig. 11.—Vertical Shaft 2,000 kw. Motor-Generator.

In each sub-station where there is a storage battery the latest practice is to provide the transformers for one rotary converter with extra-high-voltage taps, so that an E.M.F. high enough to charge storage batteries can be obtained from that converter, so that a booster set for battery charging is not needed. The generator leads pass directly by the shortest possible route to 'bus bars, from which feeder switches connect to the various feeders. In sub-stations feeding energy over long distances three separate feeder 'bus bars are installed to make it possible to deliver three different voltages. In

certain of the sub-stations feeding energy over short distances only two sets of 'bus bars, however, are provided.

The special feature of the construction is that 'bus bars are placed horizontal, which makes work about the switchboard easier. Feeder fuses are located on the wall back of the switchboard, beyond which feeders immediately pass into tile ducts. These feeders are confined in ducts, not being again exposed until they reach the consumer's premises. Rotary converters are started from the direct-current end, sufficient storage battery reserve being maintained to keep the direct-current network alive in emergencies.

The latest rotary converters purchased are of the vertical-shaft type. One of these 2,000 kw. machines was described and illustrated in THE ELECTRICIAN, Feb. 7, 1908, p. 634. The weight of the armature is carried by a roller bearing. An oil step bearing can be substituted quickly for this should the roller bearing fail. The advantage of the vertical-shaft converter is a reduction in head room and floor area, more accessible commutator and brushes and less journal friction. There is also a saving of about 17 per cent. in the weight of the vertical-shaft machines as compared with the horizontal-shaft machines in service.

The alternating-current district is supplied with energy from motor-generator sub-stations which receive 25 cycle 9,000 volt three-phase current, and deliver 60 cycle three-phase current for distribution over a three-phase four-wire system, the neutral of which is earthed. The E.M.F. between neutral and any one of the outer legs at full load is about 2,200 volts, while that between the outer legs is 3,800. Single-phase lighting feeders are connected between the neutral and the outer leg of the circuit. Three-phase motor circuits are operated Y connected between the neutral and the three outer legs, thus obtaining the benefit of 3,800 volt three-phase transmission. This system combines the advantage of a standard 2,200 volt single-phase independently regulated lighting distribution with 3,800 volt transmission for heavy loads.

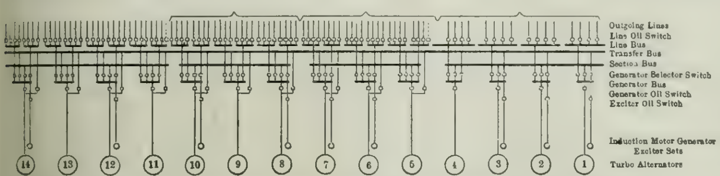


FIG. 12.—GENERAL SCHEME OF HIGH-TENSION CONNECTIONS AT FISK-STREET STATION.

In the motor-generator sub-stations, to maintain the 60 cycle generators at constant voltage, Tirrill regulators are employed in the field circuits of the exciters. The necessary raising and lowering of the E.M.F. on the feeders is accomplished by motor-operated induction regulators. One of these is connected in each lead of every outgoing feeder, so that the phases can be regulated separately.

Vertical-shaft motor generators were employed in these sub-stations before vertical-shaft rotary converters were perfected. A 2,000 kw. motor-generator with vertical shaft is illustrated in Fig. 11. This machine has a step bearing, the weight of the revolving shaft being carried by a film of oil under pressure, as in a Curtis turbine. The motor-generators are started through auto-transformers with alternating current. One advantage of the vertical-shaft machine with oil step bearing is a reduction of the initial starting current, because the standing friction of the step bearing is less than that of common horizontal bearings.

The three-wire direct-current distributing system from sub-stations forms a complete interconnected network in normal operation, but each block of mains can be separated from the network by the blowing of fuses in junction boxes, through which each section of the main is connected to the network. Many of the mains are constructed of the old Edison tubing. The newer circuits are of lead-covered cable in vitrified clay conduits. In the conduit construction, Tailleur junction boxes are used for the fuses which interconnect the mains. Short strip copper fuses are employed, the copper being much narrower at the middle of the fuse than at the terminals. These fuses are made so large that they will not blow at less than a heavy short-circuit current. In a 1,000,000 cir. mil cable a 2,000 ampere fuse is used. In addition to the service mains there are also some tie mains, so that feeders supplying energy to mains in one vicinity can assist the feeders supplying neighbouring mains in case of an extra heavy load at one point.

Neutral feeders and mains, when installed in conduit ducts, are of bare copper cable. Positive and negative feeders in the latest standard practice of the company consist of 1,000,000 circ. mil concentric cables. The concentric feeder cable has stranded inner and outer conductors. Woven in with the stranded outer conductors is a No. 14 insulated wire, the diameter of which over insulation is the same as the diameter of the bare wires forming the outer conductor of the cable. These are used as pressure wires, to which the sub-station voltmeters are connected for indicating the E.M.F. at feeder ends.

In most of the sub-stations three sets of 'bus bars are used to provide for three voltages—a high E.M.F. for the very long feeders, a low E.M.F. for the very short feeders, and a medium E.M.F. for the medium length feeders. In some sub-stations only two sets of bars are used. As sub-stations are being established at short distances apart, the tendency is to reduce the E.M.F. drop in feeders, so as to require a smaller number of 'bus bar voltages. The lamp E.M.F. is 115 volts. During the peak load on some of the short feeders the E.M.F. is from 118 to 122 volts at the sub-stations. On the longest feeders connected to the highest voltage 'bus bars the E.M.F. sometimes reaches 135 volts during peak.

Some portions of Chicago probably show the highest central-station load density to be found anywhere in the world. A half mile on State-street, which is the principal retail shopping street, has a load of 5,000 kw. Some portions of this distance show much greater density than this. In this half mile are many department stores. Not all of them, however, are purchasing energy from the company. Some of the large customers have feeders from two or three neighbouring sub-stations, as well as connection directly with the street service mains.

A number of storage batteries are located at various points in the direct-current distribution system. These batteries, however, are kept almost entirely as emergency reserve, and are not ordinarily discharged even during peak load. They are discharged about once a month to keep them in good working commission.

The concentric feeder cables are worked at about 1,100 amperes for an hour during peak loads if necessity requires. This is not likely to be continued long, however, because when the maximum load reaches that point additional feeders are put in service. The concentric feeder cables have paper insulation $\frac{5}{32}$ in. between conductors and the same outside.

In a typical example of service main construction in some recent work manholes are placed at street intersections and at the alley intersections. At street intersections service wires can be run off diagonally to any one of the four corners and at the alley, and branches are run each way, so that the chances are good for reaching most of the customers without requiring any extra hand-holes. Should there be a customer between the alley and the corner inaccessible from these manholes, the street is opened, a service main exposed, a hand-hole made and a branch line tapped into the main at the point where needed.

(To be continued.)

ANTENNÆ.*

BY G. W. PICKARD.

Summary.—The characteristics of the various antennæ in present use are discussed, and future developments are then outlined.

The antenna, as a radiating and receiving element of a wireless system employing electrical waves does not appear to have come into existence before 1880, when Prof. A. E. Dolbear, of Tufts College, Mass., commenced his experiments with wireless communication. While it has been frequently stated that Dolbear's system did not radiate true electrical waves, but was simply an electrostatic induction system, the writer has definite proof to the contrary. In the present Paper, however, he does not intend to deal with the historic side, but with the antennæ of to-day. We now find in almost universal use some form of the vertical wire antenna of Dolbear. Disguised as this may be by conductor multiplication, and departures from the vertical in the shape of spreading and converging fans of wire strands, it yet remains essentially a simple electrical conductor, reaching away from the earth's surface into free space.

The conductor, or conductors, composing the antenna is merely a means for guiding an electrical current, or moving electrical charge. Electrical waves are not radiated directly from the conductors of the antenna. If an electrical charge is moved, or varied in any way, a corresponding change in its electrostatic field takes place. If the intensity of the charge falls to zero, we say that the field collapses, or

* Abstract of a Paper read before The Wireless Institute, New York.

draws in on the conductor carrying the charge. This, however, is true only of the space in the more or less immediate vicinity of the varying charge. At a certain distance, depending upon the suddenness with which the charge varies, the lines of force are no longer able to collapse on the conductor, but are broken or nipped off, as closed lines of force. It is these detached loops of ether stress that form the electrical waves.

As these waves can only start at the boundary of that portion of the field capable of entirely collapsing on the conductor carrying a varying charge, it is apparent that the waves are not radiated directly from the antenna, but rather from points considerably outside. Radiation really takes place from an imaginary shell, surrounding the antenna, and distant from it perhaps a matter of miles. If electrical waves of the length employed in wireless communication were as visible to our eyes as those of light, a radiating antenna would look like a vast elipsoidal shaft of light, from hundreds of feet to even miles in diameter, and considerably higher than the antenna itself. Within this shaft exist simply collapsing and expanding lines of force, that is to say, merely a varying electrostatic field. Without this space, we have also a varying field, but this is in the form of electrical waves, spreading outwards as a series of ever widening ripples.

To radiate a large amount of energy as electrical waves, a large radiating surface is required. Considering the earth's surface immediately surrounding the wireless station as flat, the further away from the earth we place a charge, the wider will be its electrostatic field, and the larger the radiating surface. The new station shortly to be erected at Washington is a good example of the importance of vertical dimension. This station will probably be the most powerful station in the United States, perhaps in the world. The antenna will be upheld by a cement shaft, 550 ft. high; the highest wireless structure in the world, with the exception of the Eiffel Tower antenna. And, owing to the fact that the Eiffel Tower itself is not insulated from earth, this antenna is not as efficient as its length would indicate.

The next best thing we can do is to spread out horizontally, after we have attained our limit in vertical dimension. While this is by no means as good as increase in height, it does give a materially larger field, and consequently a larger radiating surface. For what may be well termed an "all around" antenna, that is to say, one capable of sending and receiving equally in all directions, the so-called "umbrella" or pyramidal type is undoubtedly the best. This the writer has verified by actual radiation measurement of antennæ of the same height, but of different shapes. This form lends itself well to erection on a single tall support, or mast. The ribs of the umbrella are simply wires converging to a point at the top, and stayed out in a wide ring around the mast, these lower ends coming near the earth, and being drawn in by nearly horizontal wires to the station at the base of the mast.

It not infrequently happens that we are limited not only in the matter of vertical dimension, but in certain horizontal dimensions as well. And, in addition, we often have available two neighbouring elevated points of support. Under these conditions, the best form is the "T" antenna, stretching from mast to mast, with its vertical portion depending from the middle of the horizontal part. The writer, although considering the "T" antenna the second best form, wishes to point out that it is not perfect. It is slightly directional, that is to say, radiates and receives best in its own plane, so that on shipboard better sending and receiving can be done fore and aft than abeam. Unless the antenna has much greater horizontal than vertical length, this directional effect is not serious, and often escapes observation.

A third form of antenna is the "L," or, more accurately speaking, the inverted "L" type, differing only from the "T" antenna in that the vertical portion depends from one end of the horizontal, rather than from the middle. Unfortunately, this type is in too common use on shipboard, and at other stations where its directional radiation and receiving properties are disadvantageous. With this type, radiation is strongest in the direction opposite to that to which the free end points, and receiving is best from a station lying in the direction of maximum radiation. For example, if an "L" antenna is erected on a vessel, with the vertical portion and wireless station aft, both sending and receiving will be at their best for stations lying astern.

It may be safely said that any departure from horizontal symmetry in a radiating or receiving antenna will cause it to become directional. The large Marconi stations at Glace Bay, Nova Scotia, and Clifden, Ireland, are perhaps the best examples of the properly used "L" antenna. These stations were built only to communicate with each other, and have antennæ of approximately 200 ft. in height, and 1,000 ft. horizontal. This directional effect is most apparent when receiving. In sending, after the wave has spread radially for a hundred wave-lengths or so, inequalities in the distribution of wave energy begin to disappear, and at very great distances, as Fleming has pointed out from theoretical considerations, and as the writer has to some extent proved by measurement, the intensity of the wave is sensibly the same in all directions.

Another very commonly used antenna is the loop form, with two legs, or sides, earthed through different values of inductance. This may be constructed in outward similarity to any of the preceding types, and its efficiency, directional and other properties depend upon the same considerations. In fact, the loop antenna operates in precisely the same way as does an ordinary "open" antenna, so far as the receipt of energy from a passing wave is concerned; but after the receipt of the energy the loop behaves in a very different manner from the ordinary antenna.

A form of antenna, depending upon a distinctly different principle than the open antenna with earth connection, is the writer's unearthed loop—a simple closed circuit erected in a vertical plane. Its operation depends upon the magnetic lines of force in the passing waves, rather than on the electrostatic component utilised by all other types. Both as a radiating and receiving antenna, this type is extremely directional, requiring that the sending or receiving station shall be in its own plane for best results, and not receiving from, or sending to, stations at right-angles to its own plane.

The writer considers the earth connection, when used, as a part of the antenna, and, unfortunately, a much neglected part. The time-honoured practice of digging down deep, thereby reaching a more or less permanently moist stratum, and then interring a few square yards of sheet metal, is probably one of the worst ways of making an earth connection for a wireless station. It is not sufficient that the earth connection should merely show a low steady current resistance, but it must be of small high-frequency resistance, or impedance, as well, and this is best secured by area, without regard to reaching moist soil, or using deep holes and trenches.

For a land station, probably the best earth connection that can be made consists of an acre or so of wire netting, or a radiating, cobweb-like network of wire, simply laid on the surface of the ground. This will not show good results when measured by the Wheatstone bridge, but its high-frequency resistance is but a small fraction of an ohm, owing to its large electrostatic capacity to earth. Perhaps the next best thing for an earth connection is the steel framework of a modern office building. This is well illustrated by the efficiency of stations erected on top of such buildings, despite the otherwise unfavourable conditions around such stations. On shipboard, a good earth connection is the rule, rather than the exception.

In the practical construction of antennæ, we should be governed more by mechanical than electrical considerations, at least in the matter of the wire itself. Contrary to the bulk of the publications, and the opinions of many engineers, it is almost immaterial from the electrical standpoint whether the wire is stranded or solid, or copper or aluminium, or insulated or bare. Compared with the other losses in the transmitting and receiving circuits, almost any metal antenna structure other than iron, that is mechanically strong and properly disposed, will have relatively small losses from ohmic resistance. The writer draws attention, however, to the importance of care in making joints.

Among the uses of antennæ may be mentioned that of direction finding, or the location of a distant station. This, as discovered in 1899 by the writer, may be accomplished by a long horizontal, or "L," antenna, either by having several of these, pointing to the principal points of the compass, or a single one that can be swung around, and noting the point where the signals come in loudest. This, however, will not determine, even under favourable conditions, the bearing to much less than 20 deg. of arc. Stone proposed the use of two vertical antenna, separated in space by a half wave-length of the radiation from a distant station. Apart from the commercial impracticability, because of limitation to definite wave-lengths, and the impossibility of using very long waves, this method will give the bearing of a distant station to within some 5 deg. or 10 deg. of arc, and is therefore of some utility. The writer's unearthed loop, mounted so that it can be rotated about a vertical axis, is capable of locating a distant station to within less than 1 deg. of arc, as determined by a series of careful tests at Dorchester, Mass.

In the future, we will probably have as the equivalent of the present antennæ a device which will mould, so to speak, the electrical waves. It will perhaps be some combination of circuits that will form the electrostatic and magnetic lines of force in their proper relation, intensity and dimension without the necessity for extremely large vertical or horizontal dimensions. In addition, it will be directive, and under exact control as regards direction, without the necessity of actually moving or rotating any large or extended conductor. It will be energised from some of the several sources of continuous or undamped waves, and will project a gliding beam of

electrical waves along the earth's surface, in as parallel and compact a bundle as is consistent with the wave-length employed.

Owing to the relatively great length of even the shortest electrical waves that can be used for practical wireless communication, it is out of the question to expect anything resembling the beam of light from a searchlight. But it is possible, and should be practicable to concentrate a relatively large amount of the electrical wave energy in radiation along a fairly definite path. To what extent this can be done over great distances is at present unknown. As the electrical waves used in wireless communication differ from those of light in that they glide along the conducting surface of the earth, it is likely that however parallel they may be at the start, there will be a certain amount of spreading out with increasing distance, as is the case with the radiation from the directional antennæ of to-day. The writer is at present engaged in some investigations along novel lines of antenna structure, that promise improved results.

Although wireless communication is now a simple engineering proposition for installations of small power and range, there are still many unsolved problems in long distance working. In addition to the losses caused by imperfect conductivity of the earth's surface, there is a still more serious factor, atmospheric absorption. The exact cause of this is still unknown, and the laws governing its variation are at present uncertain; but it can be minimised by a suitable selection of wave-length, it having been found that waves of the order of 3,000 metres, or longer, suffer relatively little absorption. Also, undamped waves suffer less absorption than damped waves of the same wave-length, for no very clearly understood reason.

In conclusion attention is drawn to the present want of standardisation of apparatus.

RECENT DEVELOPMENTS ON INTERURBAN ELECTRIC RAILWAYS.*

BY C. D. EVELETH.

Among recent developments in interurban lines the performance of the 1,200 volt system stands out prominently. In many ways it has proved to be a remarkable advance in economy, both in first cost and cost of maintenance, while the perfection of the system, as shown by operation, is the most phenomenal of any radical change in methods as yet applied to electric railways. Without exception, the results with 1,200 volts have been successful, and the apparatus after leaving the factory has given no more trouble than the standard 600 volt equipments. There are several fundamental reasons for the success with 1,200 volts. It differs in few details from the standard 600 volt system, so that the experience with the latter has been directly applicable. With the exception of circuit-breakers and control switches, the problem is purely one of insulation, a simple condition to meet.

The 1,200 volt interurban railway system has been installed on 41 miles of road of the Indianapolis & Louisville Company (the cars of the Indianapolis, Columbus & Southern Company also run over this track), 73 miles of single track of the Pittsburg, Harmony, Butler & Newcastle Railway, and also on 16 miles of track of the Central California Traction Company.

Maximum economy is obtained when the entire road can be operated from a single direct-current station located at the centre of distribution, doing away with all high-tension wires and sub-stations; such is the case on the Indianapolis & Louisville line. In the above station each generating unit consists of two 300 kw. 600 volt machines connected in series. There has been absolutely no trouble with this generating outfit or with the switchboard apparatus.

On the Central California Traction Co.'s line power is purchased at 60 cycles and changed to 1,200 volts direct current through a motor-generator set, the direct-current generator being wound directly for 1,200 volts. At first some trouble was experienced with the arc being maintained in case of a bad short-circuit, but this has been entirely overcome by better protection of brush-holders. On the Pittsburg, Harmony, Butler and Newcastle line power is generated three phase, 13,200 volts, 60 cycles, and transmitted directly to motor-generator sub-stations without step-up or step-down transformers.

The existing sub-stations are operated either with 1,200 volt motor-generator sets, the direct-current machine being wound directly for 1,200 volts, or motor-generator sets with two 600 volt machines connected in series. The preference and tendency at the present time is for two 600 volt commutators in series, since the same set is frequently called upon to supply not only 1,200 volts for the interurban running, but 600 volts for use in city service. While there are not as yet any 1,200 volt roads operating with rotary converters, this will probably be the most common form of sub-station, on account of the higher efficiency. Tests under all conditions corresponding to operation, including short-circuits with various combinations of conditions, have shown that there is no reason to anticipate any more trouble with two 600 volt converters operating in series as a unit than there is with converters operating in parallel. It may be of interest to know that six sets, each consisting of two 750 kw. rotary converters in series, have been sold to the Southern Pacific Railway Co. for its Oakland–Alameda division; that 15 300 kw. converters for series operation will be used on the Washington, Baltimore and Annapolis road, and that similar arrangements are contemplated for several other roads under construction.

In regard to overhead construction, at Pittsburg an interesting overhead construction has been developed. On other roads 600 volt material has been used, generally by the addition of strain insulators in series with standard hangers to give double insulation. Such construction has given no trouble and may be relied upon. On none of the roads has a case been known where service has been interrupted due to a trolley earthing, showing that the 1,200 volt overhead system is as reliable as the 600 volts. It has been found in case of the failure of an insulator or a trolley becoming earthed to a bracket arm that the insulation of the pole itself is sufficient to prevent leakage which would interfere with the service.

The Central California Traction Co. uses an under-running third rail very similar to that used in the New York Central terminal electrification. The rail is standard section, 40 lb. per yard, and is supported on ties 12 ft. apart. The operation has been successful from the start, and the maintenance has been practically nothing up to the present time. No difficulty has developed in working on either 1,200 volt trolley or third rail, and it has been found unnecessary to take off power when making repairs. A typical weight distribution for a 1,200 volt interurban car equipment is as follows: Car body, 30,000 lb.; trucks, 17,000 lb.; electrical equipment, 20,000 lb.; heaters, brakes, &c., 3,000 lb.; total, 35 tons. Seating capacity, 50 passengers plus baggage compartment, or 60 passengers without baggage compartment. 600 volt power for operation of control and lighting circuits is obtained by a small direct-current compensator or motor-generator, which operates automatically from the 1,200 volt trolley.

By the adoption of 1,200 volts and winding the motors for 600 volts on each commutator the problem of operating on both 1,200 volt and 600 volt lines has been much simplified. Cars using 1,200 volt connections may be run on the 600 volt sections at half speed with good economy for city service, or at full speed with all motors in parallel where there are 600 volt interurban sections. The control is giving entire satisfaction and the troubles from the start have been of a trivial nature. The trolley-wheel life is somewhat longer than with similar 600 volt service, averaging 5,000 or 6,000 miles.

Up to the present time there has not been a failure of insulation requiring replacement of a single armature coil or field coil in any motor. The actual life of brushes on 600/1,200 motors has not yet been determined as on no road have any brushes yet worn out, though a few have been replaced on account of breakage. Some sample brushes taken from a motor on the Pittsburg, Harmony, Butler and Newcastle line, which operates under the most severe interurban conditions, have run approximately 70,000 miles and show ⅛ in. wear; ½ in. may be worn off before the brush need be thrown away. It is, therefore, safe to assume that the life in some cases may be over 200,000 miles. No commutators have been re-slotted, and none has been reduced in diameter more than 1/32 in. by wear.

Th features of operation on 1,200 volt lines may be summarised as follows: (1) First cost.—Generally decidedly lower than for 600 volts, as less copper is required and fewer sub-stations. (2) Reliability.—In operation the equipments have in all cases proved as reliable as the best 600 volt equipments. (3) Maintenance.—Has proved as low, or lower, than for 600 volts, due to fewer sub-stations, greater distribution efficiency and low motor armature speeds. (4) Safety.—There have been no fatalities from employés or the public coming in contact with trolley, third rail or station apparatus. (5) Flexibility.—There are many places where the 1,200 volt trolley can be applied to existing 600 volt systems; an extension of 10 to 15 miles on present lines can be made by the simple addition of a 600 volt converter insulated for 1,200 volt operation and connected in series with the machines in existing 600 volt stations, which will then feed the trolleys from both 600 volt and 1,200 volt 'bus bars. This makes a simple and economical arrangement without additional sub-station attendants. The success of the 1,200 volt system is assured. It will probably be as common as 600 volts for interurban roads in a very few years. There are now either in operation or under contract 11 1,200 volt railway systems equipped with 50 H.P., 75 H.P. and 150 H.P. motors.

* Abstract, from the "Electric Railway Journal," of a Paper read before the Street Railway Association of the State of New York.

ON THE ADVANTAGES OF A HIGH SPARK FREQUENCY IN RADIO-TELEGRAPHY.*

BY L. W. AUSTIN.

Since practically all of the long-distance receivers used for radio-telegraphy make use of the telephone for the reception of signals, any circumstance which increases the sensitiveness of the telephone increases the sensitiveness of the receiving apparatus in the same measure. That the telephone is more sensitive for high frequencies has been noted by a great number of observers. Both Wien's results and Lord Rayleigh's show a remarkably rapid increase in sensitiveness up to a frequency of about 500, above which the change is slight, showing small maxima depending on the natural periods of the diaphragms. This high degree of sensitiveness continues, according to Wien, up to a frequency of about 2,500. It is remarkable in the light of these results that, in the attempts to increase the working range of radio-telegraphy, so little attention has been paid to the advantage of a high spark frequency. One cause of the neglect of this question is apparently the widespread though unfounded belief among commercial workers in wireless telegraphy that the newer types of high-resistance telephone, such as they ordinarily use, do not show any great change of sensitiveness with frequency. It was therefore thought desirable to carry out a similar investigation on telephones of the type used in radio-telegraphy. For this purpose a pair of Schmidt-Wilckes head telephones of about 800 ohms resistance was chosen for investigation.

The results of the experiment given in the paper show that the change in volt sensitiveness is approximately one thousand times between 60 cycles and 900 cycles, and of the same general type as that noted by Lord Rayleigh and Wien. Considering the results in their bearing on radio-telegraphy, it appears that we can, by increasing the spark frequency at the sending station, increase the effective sensitiveness of the receiving station many hundred times. This can be done, too, without entailing the difficulties connected with an increase in the sensitiveness of the wireless receiver itself. An additional advantage in using a high-pitched muscial spark is that the ear picks out such signals with ease in the midst of ordinary interference and atmospheric disturbance.

The difficulties of installing apparatus with high spark frequency do not seem to be serious, as the author believes that efficient alternators giving a frequency of 400, *i.e.*, 800 sparks per second, can be produced without difficulty, and the question of cooling the spark gap settled by means of some type of rotary gap (a form being suggested by the author).

In increasing the spark frequency the energy per spark is of course reduced, which is disadvantageous in cases where a receiver of the recording coherer type is used, but experiment shows this reduction in energy per spark to be far more than counterbalanced by the increased sensitiveness of the receiving apparatus, where the telephone is employed. There is another quite distinct advantage in spreading a given amount of energy over several sparks instead of concentrating it in one, in that the potential differences are reduced, resulting in a reduction in the condenser losses, which in the average station amount to a considerable share of the total power.

* Abstract from the "Bulletin of the Bureau of Standards."

PHYSICAL SOCIETY.

At the meeting held on June 25, at the Imperial College of Science, Dr. C. Chree, F.R.S., president, in the chair, a Paper entitled

"A Transition Point in Zinc Amalgam"

was read by Prof. H. S. Carhart. The Paper gave the preliminary results of an investigation which has for its primary object the determination of the heat of dilution of zinc amalgams. This heat of dilution is negative, that is, the dilution of zinc amalgam by the addition of mercury absorbs heat. In the course of the experimental work, which was conducted by Dr. W. D. Henderson, phenomena so extraordinary were encountered that the speaker ventured to call the concentration at which they occur a transition point in zinc amalgam. The method employed was electrical, by means of a concentration cell, the only difference between the two legs of the cell of H-form being in the concentration of the amalgam composing the electrodes. The ratio of the zinc to the mercury, expressed as a percentage, was in every case twice as great in one leg of the cell as in the other. This relation was secured by weighing out pure mercury in two portions as one to two, and depositing in them the same quantity of zinc electrolytically by connecting the two in series with anodes of pure zinc, and both in series with a silver coulombmeter. The operation was conducted in an atmosphere of hydrogen, and the concentration cell was exhausted of air and filled with hydrogen to avoid oxidation.

Such a concentration cell is reversible and the Gibbs-Helmholtz equation applies to it. This equation is $E = \frac{H}{nF} + \frac{TdE}{dT}$. In this case the H stands for the heat of dilution only, all other forms of heat absorption or evolution being equal and of opposite sign on the two sides of the cell. The second term is the equivalent of the Nernst equation for the E.M.F. of a concentration cell, both being directly proportional to the absolute temperature T. It is then obvious that the Nernst equation applies only to solutions or amalgams so dilute that the heat of dilution is negligible. By measuring E at a known temperature and determining dE/dT, the equation gives the heat of dilution H in passing from any concentration to one half as great. From a concentration of 0·5 per cent. to about 2·2 per cent. the E.M.F.s fall only slightly and all lie on a straight line. The same is true of dE/dT and H. But at a concentration of about 2·3 per cent. the line denoting E.M.F. abruptly changes direction downward, while the value of dE/dT increases five-fold. Also the heat of dilution changes from negative 450 joules per gm.-mol. of zinc to negative 8,700 joules. The three curves then again become nearly straight lines. When zinc amalgam of 3 per cent. concentration is diluted to one-half, the absorption of heat is very nearly 10,000 joules per gm.-mol. of zinc. These abrupt changes indicate a transition point in the zinc amalgam.

Mr. F. E. Smith congratulated the author and asked if it would be possible to obtain a zinc amalgam which could be used in a Clark cell so as to give a small temperature coefficient.

Prof. C. H. Lees expressed his interest in the experiments and hoped that they would provide definite information as to the state of the zinc at the particular point described.

The Author, replying to Mr. Smith, said he had not given attention to the point raised, but it appeared to him that a Clark cell set up with zinc amalgam of a concentration below this transition point would have a temperature coefficient larger than that of the normal Clark cell.

A Paper on

"A Method of producing an intense Cadmium Spectrum, with a proposal for the use of Mercury and Cadmium as Standards in Refractometry,"

was read by Dr. T. M. Lowry. Of the 26 wave-lengths that have been used in the study of rotatory dispersion (Proc. Roy. Soc. LXXXI., p. 472, November 19, 1908) the following seven have been found to be the most suitable for general use :—

Li	Cd	Na	Hg	Cd	Cd	Hg
6,708	6,438	5,893	5,461	5,086	4,800	4,358

In refractometry it has been customary to use the series :—

$H\alpha$	Na	$H\beta$	$H\gamma$
6,560	5,893	4,861	4,341

This series has the disadvantages (1) that the chief standard Na 5893, is a doublet, and (2) that the other three lines are of such weak intensity that they are useless for the majority of optical measurements. It is therefore urged that—in view of the readiness with which the mercury and cadmium spectra can now be produced—the mercury green line should be generally adopted in place of sodium as chief standard in optical work of all kinds, and that the hydrogen lines should be abandoned even as secondary standards in favour of the series of wave-lengths set out above. In support of this proposal it is pointed out that the green mercury line occupies a convenient position in the spectrum, is exceedingly brilliant and of such a high degree of purity that a sharp extinction can be obtained in reading a rotatory power of 5,000 deg. ; that the cadmium lines are equally brilliant and of an even higher order of purity ; and that the wonderful intensity of the violet mercury line is more than sufficient to compensate for the drawback arising from the presence of two weak satellites. In the measurement of optical and magnetic rotatory dispersion, the ratio Hg 4,358 to Hg 5,461 is sufficient to characterise the substance under examination, and similar considerations will probably be found to apply in the measurement of refractive dispersion.

In order to produce a cadmium spectrum of sufficient intensity for polarimetric work, advantage is taken of the favourable properties of the silver-cadmium alloys. On account of their isomorphism the two metals form an excellent series of alloys which are characterised by good mechanical properties and very high melting-points (an alloy with 60 per cent. Cd melts as high as 700°C.). In striking contrast to the behaviour of the pure metal, the alloy gives a steady arc which can be kept true to centre by rotating the electrodes in opposite directions. The spectrum shows the silver as well as the cadmium lines, but these are so far separated that even with a low resolving-power the slit of a spectroscope can be opened to its full

width without any overlapping of the brilliant "blocks" of light which take the place of the usual "lines."

Mr. TWYMAN remarked that during the last few weeks he had seen a cadmium tube, similar to a mercury lamp, working with satisfactory results. Such tubes had been used for some time by Paschen and Röntgen. He agreed with the author with regard to the greater use of mercury light for spectroscopic and similar purposes

Dr. A. E. H. TUTTON said that he had been working lately with cadmium tubes and found that they worked well for a considerable time. With regard to the measurement of refractive indices he was astonished that more use was not made in this country of the monochromatic illuminator, which he described some years ago. The instrument was used in Germany and gave satisfactory results.

The AUTHOR said that in some cases it was necessary to work with many wave-lengths, and under such circumstances Dr. Tutton's monochromatic illuminator would be useful. It was also useful, however, to have seven wave-lengths as standard lights.

Mr. A. CAMPBELL read a Paper

"On the Measurement of Wave-Length for High-frequency Electrical Oscillations."

The experiments had for their object the calibration of wavemeters for the measurement of the high frequencies (200,000 up to 1,000,000 ∿ per second) used in wave-telegraphy. Two wavemeters (A and B) were tested, both being of the type consisting of a series of self-inductance coils used singly (L) in series with a variable air-condenser (K) and a thermo-ammeter, the reading of K being obtained by altering the capacity until the circuit shows resonance with the working circuit. The coils of wavemeter (A) were wound with solid wire, those of (B) with stranded wire (7/36), each strand being separately insulated. The absolute value of the frequency was determined by photographing spark-trains in the primary circuit by means of a rotating mirror running at a constant and accurately measured speed. As the following table shows, the values of the frequency n_1 deduced from the measured values of K and L with wavemeter (B) were in close agreement with the actual n deduced from the spark-photographs.

n. ∿ per sec.		n_1. ∿ per sec.
290,300	....	290,500
516,800	....	516,800
818,000	....	821,200
1,042,000	....	1,039,000

With wavemeter (A) the agreement was naturally not nearly so close, but was much improved when the values of the self-inductances of the solid wire coils were corrected to the high frequency values by the formulæ of Heaviside and L. Cohen. The results in the above table show that the inductances of the stranded wire coils are practically unaltered for frequencies from 0 up to 1,000,000 ∿ per second.

Mr. W. DUDDELL said the Paper was a valuable one because accurate experiments on self-induction and capacity at high frequencies were required. With reference to the photographs he asked if the author had used his method to photograph arcs and, if so, with what results. It would be interesting to know how low it was possible to get the apparent resistance of a coil with high-frequency currents by stranding the wire.

Dr. ERSKINE-MURRAY, referring to Mr. Duddell's remarks, said that in actual practice the resistance could not be reduced more than about 10 per cent. by stranding.

Mr. TAYLOR congratulated the author, and pointed out that the wavemeters described could only be used at the transmitting station. Wavemeters were required which could be used at receiving stations. Referring to the question of stranding he pointed out that it was possible to overdo the stranding and obtain less satisfactory results than could be obtained by stranding with a fewer number of wires.

Mr. G. B. DYKE called attention to experiments similar to those described which were being carried out by Dr. Fleming at University College. With reference to the spark-photographs he was surprised that an accuracy of 1 in 1,000 could be obtained.

The AUTHOR, in reply, stated that as the whole distributed capacity of the inductance coils had very little effect on the frequency of resonance, the dielectric hysteresis of the ebonite would be negligible except as regards damping. Sparks appeared to give sharper and more accurately measurable photographs than vacuum tube discharges or arcs, except mercury arcs, which gave the clearest and best pictures.

A Paper on

"An Electromagnetic Method of studying the Theory of and solving Algebraical Equations of any Degree."

by Dr. RUSSELL and Mr. ALTY, was read by the Authors. They point out that the problem of finding the roots of an algebraical equation of the nth degree is identically the same as that of finding the positions of the "neutral points," that is, the points where the resultant force due to the earth and definite currents in n long vertical wires is zero. The n wires are arranged at any convenient distances apart in a plane which is at right angles to the magnetic meridian. The currents in the wires are then adjusted to certain values which are readily found by the methods of partial fractions. If x_1 and y_1 be the co-ordinates of one of these neutral points measured with reference to certain definite axes, $x_1 \pm y_1\sqrt{-1}$ is a pair of roots of the original equation. All the real roots lie on the axis of X which cuts the wire at right angles. The positions of the neutral points thus determine all the roots real and imaginary of the given equation. The peculiar advantage of the method is that we can see, in many cases almost at once, what effect varying the value of the coefficient of any power of x will have on the roots of the equation. A simple apparatus which the Authors have devised for students' use is described. The positions of the neutral points are determined by means of a small charm compass. In this way all the roots can be determined with a maximum inaccuracy of 1 per cent.

Dr. C. V. DRYSDALE exhibited

A new Féry Thermoelectric Calorimeter.

This form of calorimeter can be used continuously and permits the value of the gas produced in a gas-works or producer-plant to be watched from time to time. The principle of the instrument is that of burning the gas to be tested at a constant rate in a special burner consuming from 5 to 10 litres per hour. This burner heats a recuperative thermopile, of which the cold junction is traversed by the air employed for the combustion, while the hot junction is heated by the products of combustion. The thermopile contains 15 junctions which enables a P.D. of 0·2 volt to be obtained. The energy produced is sufficient to obtain a trace with a recording instrument similar to that obtained with the Richard recording thermometers and barometers.

Mr. R. S. WHIPPLE expressed his interest in the calorimeter and said he was surprised at the accuracy which could be obtained over large variations of the rates of consumption of the gas. There was a great need for a satisfactory calorimeter of the kind exhibited.

A Paper by Mr. F. W. JORDAN on

"An Instrument for Measuring the Strength of an Intense Hortizonal Magnetic Field"

was read by the Author. The method consists in measuring directly the transverse force on a conductor traversed by a current in a direction at right angles to the field. Two copper strips of uniform width, each cut to form three sides of a rectangle, are fastened together and connected by short tinsel leads to terminals, so that the current can be sent in the same direction through each of the insulated conductors. The framework is suspended in the field to be measured from a helical spring of phosphor-bronze. The tension in the spring can be adjusted to bring the framework into a sighted position. To make a measurement the horizontal conductors are arranged at right angles to the field and a known copper weight is suspended from the centre. A current is passed through the wires and its strength adjusted until the framework is again in its sighted position. The strength of the field is then easily calculated. The results obtained with the apparatus using fields from 1,000 to 13,000 gausses agreed with those got by the ballistic method to 1 part in 400.

A Paper entitled "THE SINE CONDITION IN RELATION TO THE COMA OF OPTICAL SYSTEMS" was also read by Mr. S. D. Chalmers, and Papers by Prof. Poynting and Mr. Todd "ON A METHOD OF DETERMINING THE SENSIBILITY OF A BALANCE" and by Mr. Todd on "THE BALANCE AS A SENSITIVE BAROMETER," were taken as read.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Science Abstracts." June 25, 1909. Vol. XII. Part VI. Section A—Physics: Section B—Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. net.

"Electrical Installations of Electric Light, Power, Traction and Industrial Electrical Machinery." By Rankin Kennedy. Vol. IV. (London: The Caxton Publishing Co.)

"Der Betrieb Elektrischer Licht-und Kraftanlagen." By H. Pohl. Vol. C. of "Bibliothek der gesamten Technik." (Hanover: Dr. Max Janecke.) M.2.50.

"La Pratica delle Costruzioni Elettromeccaniche." By G. Pardini. 2nd edition. (Milan: E. Bignami & Co.) L. 4.

"Die Fernsprechtechnik der Gegenwart." By C. Hersen and R. Hartz. (Brunswick: F. Vieweg and Sohn.) M. 2.50.

"Ein Neues Schnellbahn-System." By August Scherl. (Berlin: August Scherl.)

"Les Découvertes modernes en Physique." By O. Manville. 2nd Edition. (Paris: A. Hermann.) Fr. 8.

"Matriculation Directory," June, 1909. (Cambridge and London: University Correspondence College.) 1s. net.

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PATENT SYSTEMS AND INDUSTRIAL PROGRESS.

There can be no question that the granting of patents is a very powerful inducement to the inventor to go forward in the hope of reaping some monetary return. If this inducement were wanting, progress in invention would be restricted to those who can appreciate a certain sport in devising new ways of doing things, or who are prepared to work for the common good without seeking personal reward. Such persons, however, form but a small minority.

The earliest patent system appears to have originated in this country. Other countries followed, and the granting of patents, although by no means a uniform procedure in all countries, is at least well recognised, and is worked to some extent by international agreement.

In a Paper read recently by Mr. F. P. FISH, before the American Institute of Electrical Engineers, stress is laid upon the importance of the patent system in the United States in promoting industrial progress. It is not disputed that the system often involves difficulties and annoyances to the inventor, but, nevertheless, in the author's opinion, it stimulates and encourages invention to a marked degree. The cost of obtaining a patent is not great, and once the fee is paid there are no more payments during the life of the patent, which period is comparatively long, running to 17 years. As there are no restrictions the patentee is free to do what he likes during that term. Most of the important

inventions patented elsewhere are also patented in the United States. Thus, what is going on in other countries is more readily at the disposal of the American inventor, the specifications being issued at the cheap rate of $2\frac{1}{2}$d. each. This diffusion of patent literature is not without its importance, as one invention leads to another, and the trend of inventions in other countries can be kept easily in view. It has at times been suggested that there should be a certain discrimination against foreigners. No such course has so far been taken, so that all are on an equal footing.

Although it is only natural that the American system should be regarded as the best in that country, it is, perhaps, a question whether our own system, with its many modifications, is as good as it might be. The recent resolve on the part of the Government to make the working of patents in this country compulsory is a matter on which opinions are not altogether unanimous. In regard to foreign patents taken out in Great Britain, an immediate advantage has been reaped by our home labour and certain of our trades. This benefit, however, may be somewhat transient, and it remains to be seen what the ultimate result will be. There are also indications that measures of retaliation will be taken against English patentees in other countries if the revocation of foreign patents is carried out in this country to any serious extent. It appears that less advantage will be taken of our patent system by foreign inventors than hitherto, greater reliance being placed upon secret processes, and, if that is so, less information will be disclosed to the inventors of this country. It should be borne in mind, however, that information is not the only key to success. The inventor who has a large organisation or factory at his back has an immense advantage over any rival concern which has to go through the process of getting together a business, even if the same process is placed at its disposal. A recent well-known case under the Patent Act has given good evidence of this fact. Apart from the foreigner, however, the Act also affects the home inventor. Patents are sometimes taken out before the industry is ready for them, and the patentee may have to wait some years before any use can be made of his invention. In such cases a revocation might take place, simply because the invention, although valuable, is before its time.

It is a great question, however, whether the remarkable progress made in the United States is due so much to the patent system as is claimed by M. FISH. The patentee is only one side of the combination leading to success in a matter of this kind. The best patent in the world is useless without the necessary capital and business ability wherewith to work it, and these are seldom supplied by the inventor. We are inclined to think that the very marked progress in the United States is not merely because the inventor is eager, but rather because capital is willing to respond. In that country greater risks are taken than here, but there are correspondingly greater rewards. In this country capital too often wishes to see its reward guaranteed from the start, but under these conditions progress must be less marked than in such countries as the United States, where the spirit of "speculation" is decidedly keener than here.

REVIEWS.

Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

The Electrical Laboratory Course. By R. D. ARCHIBALD and R. RANKIN. (London: Blackie & Son.) Pp. 93. 1s. 6d. net.

This book is written with the object of replacing MS. instruction sheets in the laboratory, and the authors can fairly claim to have succeeded in arranging a very complete and comprehensive course for the type of student for whom it is intended.

In all, 57 experiments are described, and the procedure in each is clearly and concisely stated. Whenever necessary, care has been taken to prevent the student from arriving at erroneous conclusions, so that little difficulty should arise, even with junior students.

A characteristic of the book is the number of simple experiments in which the value of the current is at once read off from an ammeter. The principle of the potentiometer is emphasised by the frequent use of the potentiometer wire, not only for actually comparing P.D. but also for such purposes as altering the sensibility of the galvanometer, &c.

In experiment 14 a modification of Ampère's swimming rule is worthy of special mention, and in experiment 15 the mnemonic for the rule for winding an electromagnet ought to be better known by students than is usually the case.

On p. 19 the statements made, with regard to the intensity due to a magnet alone, are incomplete and require amplification; also in experiments 21 and 22 we should prefer the expression "a battery of constant E.M.F." for "a battery giving a constant current"; but, nevertheless, the book bears the stamp of the practical teacher, who well knows students' difficulties.

The price is extremely low for the excellence of the contents, and the work can be heartily recommended for the class of student for whom it has been produced.

Elektrotechnische Messungen und Messinstrumente. By GUSTAV WERNICKE. Part 13 of "Elektrotechnik in Einzel-Darstellungen." Edited by Dr. G. Benischke. (Brunswick: F. Vieweg & Sohn.) Pp. viii.—133. M. 5.

This book is a meritorious, if somewhat unsuccessful, attempt to cover, in the space of 130 pages, the whole field of electrical and magnetic measurements. The impossibility of such a task is almost self-evident, but it can hardly be said that the author has always made the best use of the space allotted to him. For example, on p. 1, we are told that "the ohm is the unit of electrical resistance," and this remark is followed by a long extract from the German Act of Parliament covering the legal definitions of the various electrical units. In other places, on the other hand, the information given is meagre in the extreme. For example, less than a page is allotted to a discussion of the various methods of fault localisation on networks. However, it is easy to criticise, and opinions are bound to differ on the question of what should, and what should not, be included in a book of this description.

Some sections are excellent. For example, that devoted to the measurement of power on three-phase systems and those dealing with magnetic measurements, the latter being of particular interest, since it is a subject on which it is difficult to obtain information in a concise form.

On p. 41 we are told that the deflection of an electromagnetic ammeter, and, in fact, of all other alternating-current instruments, depends on

$$\sqrt{\frac{2}{T}\int_0^T i^2 dt}.$$

Not every engineer will, perhaps, feel inclined to challenge this statement as it stands; but, unfortunately, its accuracy is by no means equal to its complexity, for, were it true, it would follow that all alternating-current instruments were absolutely independent of wave form, whereas, in point of fact, the majority are well known to be very susceptible to such errors.

In dealing with the shunted pattern of dynamometer

meter, the author says "the temperature coefficient and also the ratio of ohmic to inductive resistance, must be the same in both branches" (that is, in the instrument and in its shunt). Quite so; but, unfortunately, this cannot be attained in practice. Again on p. 62, an illustration appears of a wattmeter and an ammeter worked *in parallel* on the secondary of a current transformer. Similar instances of slovenly treatment could be multiplied, and they seem particularly unfortunate in a book which appears to be intended chiefly for students' use.

In view of the limited space at the author's disposal, it is, perhaps, hardly to be wondered at that the instruments described are exclusively those of German origin, but it is somewhat surprising that when dealing with oscillographs the name of Duddell should not even be mentioned, nor that of Jona in connection with extra high-tension electrostatic voltmeters.

The majority of tl e illustrations are somewhat of the catalogue order, and, unfortunately, in several instances are so indifferently printed as to be almost undecipherable.

K. E.

Uber die Oxydation des Stickstoffes im gekuhlten Hochspannunsbogen bei Minderdruck. By D. ADOLF KOENIG. (Halle, A.S.: Wilhelm Knapp. Pp. 76. M3.

This little work opens with the usual discussion as to the importance of nitrogen for agriculture, and the manner in which it can be given to the soil so that vegetation may be able to assimilate it and ultimately animals and mankind. So much has been written of late years about this subject that one is rather inclined to skip these introductions. Thus we are told what is the annual world's production of sulphate of ammonia, and how much of this is taken by England and her Colonies, and how much by Germany, and so on. The author then informs us that in the near future Chili saltpetre will be exhausted, and finally that if the world is to go on and the inhabitants be fed, the atmosphere is the only source of nitrogen. He then describes briefly the various processes which have been developed for fixing atmospheric nitrogen.

Part II. is theoretical, and is headed "Is the Nitrogen Oxidation in the Electric Arc a Thermic Reaction?" This part commences historically by mentioning the work of Priestley and Cavendish. The theoretical chapter is rather long, rather mathematical and not particularly new.

Part III. is the experimental part, and commences with the description of experiments carried out under reduced pressure with two electrodes, which could be cooled. The second experimental portion deals with reactions at low pressures with non-cooled electrodes. The gases after passage past the electrodes were shaken up with water, and the acidity tested for by titration with barium hydroxide. On p. 37 the main experimental work is mentioned, and then follows a considerable amount of methematical and theoretical detail. The actual arrangement of the experiment and the apparatus is not described until p. 48 is reached.

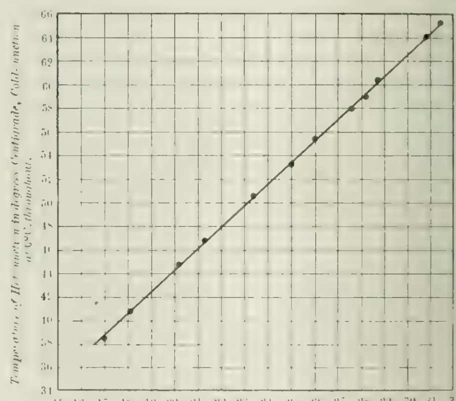
There is a good deal that is interesting in the little monograph, but it is not exactly of technical value. It will, however, be useful to all who are carefully studying the question of the utilisation and fixation of atmospheric nitrogen.

New Electric Hoist.—A new type of electric hoist, which has recently been patented by Mr. W. P. Robertson, is described in the "Mining World." Compactness is secured by placing the electric driving motor inside the revolving drum, the motor and drum being independently supported. Running through the inside of the drum, and supported by the proper bearings on the upright castings, are four axles upon which are attached eight steel wheels, four on each end of the drum. These wheels support the drum and allow it to revolve freely. The motor rests upon, and is firmly secured to, steel supports, which in turn are firmly secured at each end to the upright castings. The motor drives the internal gear on the drum through a train of gear wheels. The controller and brake lever are conveniently placed directly behind the drum. A number of improvements have been made in this type of hoist in the design of the supporting guide wheels by which wear can be readily taken care of, and in the construction and support of the motor, by which all parts are made readily accessible.

THE THERMO-E.M.F. OF A TANTALUM-COPPER COUPLE.

BY R. L. PEARSON.

In view of the fact that it is possible to obtain tantalum in the form of a fine wire, its thermo-electric properties are not without interest. The particular specimen used in the investigations described below was procured from a broken-down tantalum lamp and was some 40 cm. in length. Considerable care had to be exercised in handling the filament, although, considering the extremely small diameter of the filament (0·055 mm.), little difficulty was experienced in avoiding breakage. A piece of white paper behind it made it clearly visible in the somewhat subdued light of the laboratory. At the outset it was found to be impossible to solder it to copper when using ordinary fluxes, and the electro-plating process was therefore adopted. Two pieces of No. 30 S.W.G. double silk-covered copper wire were prepared, and each end of the tantalum was twisted round one end of each piece of copper. The two junctions were then connected up to form the kathode in a solution of copper sulphate, while the anode consisted of a small strip of copper; current was supplied by a single Daniell cell. In the course of about half an hour excellent junctions were effected—at all events, from an electrical point of view. It was noticed, however, that whereas the tantalum alone was not brittle, it became so to a considerable extent when covered with copper. The result was that fractures occurred more than once at the junctions themselves. This was subsequently



avoided largely by using an extremely low current density in the electrolytic cell, when the plated tantalum became much more pliable. Suitable junctions having been effected, one was immersed in paraffin oil contained in a silvered Dewar vacuum vessel, while the other was immersed in the same liquid contained in a test tube surrounded by melting ice, and thus maintained at 0°C. In order that the junctions and the tantalum filament might be held firmly in position, they were fastened to thermometers by small rubber bands, the junctions themselves lying flat against the thermometer bulbs. Thus vigorous stirring could be effected in the vessel containing the hot junction without any fear of injury to the junction or leads. The galvanometer used was of the Ayrton-Mather moving-coil type, having a resistance of 17·3 ohms, and giving a deflection of 5·1 mm. on a scale 84 cm. away for 1 micro-ampere. It was ascertained that the thermo-electric current flowed from tantalum to copper at the hot junction.

From the accompanying curve it will be seen that the thermo-E.M.F. of this particular specimen, when employed with copper, is not large, and that the curve is practically a straight one between the limits of temperature taken.

The foregoing work was performed in the physical laboratory of University College, Reading, and the author desires to acknowledge his indebtedness to Prof. G. J. Burch, F.R.S., for some exceedingly useful suggestions.

DETERMINATION OF THE LEAKAGE OF ALTERNATING-CURRENT WINDINGS.*

BY M. SCHENKEL.

Summary.—The present article shows how the well-known method of measuring the stator leakage of an alternating-current machine when the rotor is removed (or vice versa), can be made to give accurate results by correcting for the altered conditions when the leakage is measured in this way. The correction consists in the calculation of the flux in the stator bore by means of a simple formula, and can be applied directly to machines with large gaps, *e.g.*, alternators.

When the rotor is removed from the stator and an alternating-current is sent through the winding of the latter, the flux interlinked with the stator winding can be divided into four parts :—

A. The flux inside the slots.

B. The flux from the top of one tooth to the top of the two neighbouring teeth.

C. The flux passing out of the teeth of one pole, through the bore, into the two adjacent poles (*i.e.*, along same path as main flux when rotor is present).

D. The flux associated with the overhang (or coil ends) of the winding.

In the case of a machine with a large air-gap, *e.g.*, an alternator, the parts A, B and D will not be materially different when the rotor

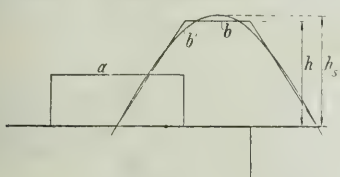


FIG. 1.

is present from that when it is removed, but the part C only exists as leakage flux when the rotor is absent. Now, all the four components, A-D, are included in the measured value of the leakage when the latter is taken with the rotor removed, so that if such a measurement is to be used for ascertaining the leakage flux under actual conditions, it is necessary to be able to find the part C—which passes through the stator bore and may reach 40 per cent. of the total leakage flux—and deduct it from this measured value. The remainder can then be taken, with very fair approximation, as equal to the actual leakage flux when the rotor is present.

In the original article the path and the magnitude of the flux Φ passing through the stator bore was investigated both experimentally and mathematically. It was found that in a two-pole stator (*e.g.*, turbo), the flux in the bore existed in the form of straight lines, and had the same density at all points. In the case of a four-pole

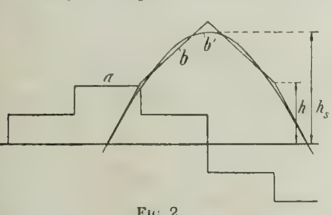


FIG. 2.

machine, the lines of force in the bore were hyperbolae, the density being proportional to the distance from the centre of the bore, where it is zero. For the magnitude of the flux, Φ, per pole passing through the bore, the following simple formula was developed :

$$\Phi=2 \cdot \frac{4\pi}{10} \{i_0 z_0\} L.$$

Thus Φ is independent of the number of poles and also of the radius of the stator bore. In the above formula

L = axial length of stator stampings,

$\{i_0 z_0\}$ = sum of all the ampere-bars inside a half-pole pitch.

This simple formula also holds when we suppose the stator turned inside out like a glove, in which case the flux from one pole to its neighbours passes through the surrounding space. Consequently the same formula applies to a rotor when removed from its stator, in the same way as to the stator when removed from its rotor.

* Abstracted from "Elektrotechnik und Maschinenbau."

In the development of the above formula it has been assumed that the ampere-bars are sinusoidally distributed over the circumference, so that the diagram of the M.M.F. is a sine curve with its amplitude equal to $\{i_0 z_0\}$. In practice, however, such windings are not used, but it is quite sufficient if we take the actual M.M.F. diagram and replace it by a sine curve of equal area.

The following shows how this is done for a normal three-phase winding. Let

q = number of slots per pole and phase,

z = number of conductors per slot,

I_0 = amplitude of the current in a conductor.

Consider the two cases when the current in one phase is zero and when the current in one phase is a maximum I_0.

The diagrams of the M.M.F.s of these two cases are shown to scale in Figs. 1 and 2 respectively, along with the corresponding sine waves of equal area. In these diagrams "*a*" denotes the distribution of the ampere-bars, "*b*" the distribution of the M.M.F., and "*b′*" the equivalent sine curve. In the following table the several magnitudes are given :—

	Fig. 1.		Fig. 2.
Current in one phase...............	0	......	I_0
Current in the other two phases	$\frac{1}{2}\sqrt{3}I_0$	......	$\frac{1}{2}I_0$
Height h	$qz\frac{1}{2}\sqrt{3}I_0$	......	$qz\frac{1}{2}I_0$
Height h_s	$1{\cdot}046h$	......	$1{\cdot}833h$
	$0{\cdot}908 I_0 qz$		$0{\cdot}916 I_0 qz$

Hence $\{i_0 z_0\}$ will have the mean value $0{\cdot}912 qz I_0$.

From this the flux in the bore due to a three-phase winding will be :

$$\Phi=2 \cdot \frac{4\pi}{10} \cdot 0{\cdot}912 \cdot qz I_0 L.$$
$$=3{\cdot}24 qz I L.$$

where I = effective current in amperes. This flux, in the case of a three-phase winding, rotates with a frequency c and induces in the stator winding an E.M.F. E_B whose magnitude is :

$$E_B = 4{\cdot}24\, c \cdot p \cdot qz\Phi 10^{-8} \text{ volts per phase,}$$

where $2p$ poles are connected in series ; hence for a star-connected winding we have, substituting for Φ,

$$E_B = \sqrt{3} \cdot 13{\cdot}75 \cdot c \cdot p \cdot L \cdot (qz)^2 I \cdot 10^{-8} \text{ volts.}$$

This is the E.M.F. which must be deducted from the pressure (as measured) required to send the current I through the stator (with rotor removed). The remainder then represents with very fair approximation the leakage pressure corresponding to the current I.

BOLTON CORPORATION ELECTRICITY DEPARTMENT ACCOUNTS.

The first of the annual accounts of electricity supply undertakings for the year ended March 31 last, which we propose to analyse, are those of the Bolton Corporation Electricity Department. The past year has provided unusual conditions in most industries, due to trade depression and strikes, and in this particular instance there has been depression in the cotton trade, which was severely felt in Bolton, and a strike lasting seven weeks, during which all the mills were shut down. Conditions, therefore, have been unfavourable. Metal filament lamps also have had considerable effect in reducing the output.

The result is that the total output of units has decreased from 10,791,105 to 10,677,764—*i.e.*, 113,341 units, private lighting accounting for over 24,000 of this decrease, whilst the sales of current for power purposes—viz., 4,923,519 units, show a diminution of 157,120 units. Fortunately, however, the tramway department required an increased amount of energy, the total being 4,183,853 units, thus preventing the decrease in the output of the electric supply station becoming so marked. In fact, due to a large increase in the number of units used on the works and in those unaccounted for, the total number of units generated showed an increase of over 70,000, compared with the previous year. Under these conditions very little change is to be recorded in the costs of generation and distribution, but owing to a very considerable increase (about £1,000) in the rates the total costs show a small increase, and are 0·59d. per unit sold, which, nevertheless, is a very creditable figure, particularly as the load factor for the year works out at only 24·75 per cent., compared with 27·35

per cent. in the year 1907-8, the maximum demand having increased from 1,501 kw. to 1,925 kw.

In addition to diminished sales, the average price per unit received for private lighting was only 2·81d., compared with 2·95d. in the previous year, and for power 0·849d., compared with 0·868d., so that considerable reductions are shown in the revenue from these items; but notwithstanding that the average price received per unit only amounted to 1·23d., a net profit of £5,804 is shown, the rates benefiting to the extent of £6,500, on account of a balance brought from last year, whilst a generous allowance is made for depreciation. This result, considering the unusual difficulties experienced by the department during the past year, and the low charges for current, reflects great credit on the management of the undertaking.

In spite of the great economies possible with the new types of lamps, the rate at which consumers were connected shows but little change, steady progress, however, being recorded. Thus, 192 new consumers were connected during the past year, compared with 177 in the previous year and 163 in 1906-7. The total connections to the mains now total 11,670 kw., an increase of over 1,400 kw., compared with the previous year, an equal increase being recorded a year ago. No additions were made to the generating plant during the year, its capacity remaining, therefore at 7,600 kw., but about $7\frac{1}{2}$ miles of new mains have been laid.

As will be seen from the figures given above, the motor load and the units sold for the electric tramways are the mainstay of the department; considering that 126 motors, equivalent 1,528 H.P., were connected to the mains during the past year, a great development should be shown in the total output of energy, as soon as the conditions become normal, whilst the reduction in the price of coal, which only came into force during the latter months of the period in question, should assist in bringing about a substantial reduction in the works costs. It is interesting to notice that the total horse-power of motors connected to the mains was in March last 9,219; whilst averaging the connections during the 12 months, 583 units were sold per horse-power connected, the equivalent revenue obtained being just over £2.

We give below an analysis of the expenditure during the past financial year, together with the cost per unit sold, the costs of the previous year being also included for the sake of comparison.

		Cost per unit sold. 1908-9.	1907-8.
Generating Costs.			
Coal, &c.	£11,696	0·25d.	0·28d.
Oil, waste, water, &c.	991	0·02d.	0·03d.
Salaries and wages at station	3,498	0·08d.	0·07d.
Repairs and maintenance	3,840	0·09d.	0·10d.
	£20,025	0·45d.	0·47d.
Distribution Costs.			
Wages	£311		
Repairs and maintenance of mains, fuses, &c.	664	0·03d.	0·03d.
Meters purchased out of revenue	354		
	£1,332	0·03d.	0·03d.
Management Expenses.			
Salaries	£1,272	0·03d.	0·03d.
Printing, stationery, &c.	92	0·00d.	0·00d.
Miscellaneous	397	0·01d.	0·00d.
	£1,761	0·04d.	0·03d.
Rents, rates and taxes	£3,204	0·07d.	0·04d.
TOTAL COSTS (*ex* Capital Charges)	£26,322	0·59d.	0·57d.
Capital Charges.			
Interest	£8,280	0·19d.	0·17d.
Sinking fund	12,829	0·29d.	0·25d.
Depreciation	5,918	0·13d.	0·13d.
	£27,027	0·61d.	0·55d.
TOTAL COSTS (including Capital Charges)	£53,349	1·20d.	1·12d.
TOTAL RECEIPTS (from all sources)	£59,153	1·33d.	1·31d.
NET PROFIT	£5,804	0·13d.	0·19d.

To this net profit of £5,804 is added a balance of £4,376 from the previous year, making a total of £10,180, of which £6,500 is handed over to the District fund in aid of rates, £1,000 is written off the Duncan-street sub-station, and the balance of £2,680 carried forward to next year's accounts.

During the past year the capital expenditure has been augmented by £25,842, mains accounting for £12,873 of this sum, and machinery £11,449, both sums being less than in the previous year's working. The total capital expenditure on March 31, 1909, amounted to £345,122. We give in the following table the amounts which have been expended on the various sections of the plant, together with the cost per kilowatt installed.

Capital Account.	Total.	Per kw. installed.
Land	£4,709	£0·62
Buildings	46,628	6·14
Machinery	147,313	19·35
Mains	110,540	14·43
Motors	12,546	1·65
Transformers	9,305	1·22
Meters	12,005	1·58
Instruments	443	0·06
Well sinking	1,603	0·21
	£345,122	£45·31

DEPRECIATION OF ELECTRICITY AND TRAMWAY UNDERTAKINGS.

In the case of income tax assessment of electric lighting and tramway undertakings, much uncertainty has existed in the past in regard to allowances for depreciation. As the result of prolonged negotiations between the authorities at Somerset House and the Associations representing the respective municipal and company-owned undertakings, the following arrangement has now been agreed upon :—

TRAMWAYS.

Permanent Way. The life is to be taken as 12, 14 or 16 years, according to the average car-mileage per mile of track per annum of the financial year preceding the year of assessment—viz.: (1) Not exceeding 50,000 car-miles per mile of track—14 years. (2) Over 50,000 and not exceeding 75,000 car-miles per mile of track—16 years. (3) Over 75,000 and not exceeding 125,000 car-miles per mile of track—12 years. (4) Over 125,000 car-miles per mile of track—special consideration. Where there are special circumstances, such as exceptional gradients, and the compulsory use of wood paving, &c., tending to show that the car-mileage does not fairly represent the wear and tear of the track, each such case is entitled to special consideration. The cost of renewals, including setts or other paving, but excluding concrete foundations, should be taken at £4,400 per mile of single track until the general renewal of the track takes place.

No allowance should be made in computing the assessable profits in respect of any expenditure on repairs or maintenance of the permanent way, but the allowance for depreciation should be computed at such a sum per annum as will in the aggregate over the determined life of the permanent way be equal to the cost of renewal as above fixed, plus the estimated repairs for that period. The amount to be added in respect of ordinary repairs should be determined by taking the actual average expenditure as shown in the accounts of the undertaking for the last three years, or such period less than three years as the undertaking has been in existence. Repairs under this head should be understood to include renewals of special track work at junctions and cross-overs, which occur at frequent intervals.

As the expenditure on repairs is expected to increase as the track begins to wear, the amount of such estimate should come up for revision at the end of every five years, and an adjustment should be made by increasing or diminishing the allowance as the circumstances require, having regard to the basis of calculation outlined above. A strict account should be kept by the Corporation and the surveyor of the annual allowances, and of the actual expenditure on repairs and renewals; and at the end of 10 or 15 years (*i.e.*, the second or third revision), or at such time as the general renewal of the track shall have taken place, the amount to be annually allowed should be reconsidered and increased or diminished for succeeding years as the ascertained facts shall show to be necessary provided that under no circumstances shall the allowances for previous years be re-opened.

All expenditure on extensions and improvements should be excluded from the working expenses for income-tax purposes; and the necessary additional allowance for depreciation on the lines suggested above (*i.e.*, mileage) should be at once allowed on such expenditure, and added to the sum already allowable. The allowance of £4,400 for renewal of permanent way mentioned above is intended to apply to the overhead trolley system. Special arrangements should be made in the case of the conduit, surface contact or other system.

Cables.—In addition to repairs, depreciation should be allowed at the rate of 3 per cent. per annum on the written-down value.

Overhead Equipment.—No depreciation should be allowed; all expen-

diture on maintenance and renewals should be charged as working expenses as and when incurred.

Cars and other Rolling Stock.—Subject to the ensuing clause, expenditure on maintenance and renewals should be treated as working expenses, and allowed in lieu of depreciation. Depreciation, however, should be allowed in lieu of renewals where the circumstances justify such an allowance, provided that a strict account is kept of all renewals, and that if such renewals are charged to revenue account they shall be shown separately in such account and added back in computing the assessable profits. The allowance in such case should be 7 per cent. per annum on the written-down value. In any case, the annual expenditure on repairs is to be allowed as a deduction in computing the assessable profits.

General Plant and Machinery.—All other plant and machinery, including standards, brackets and workshop tools, but excluding loose implements, office furniture and small articles which require frequent renewal, should be bulked together and depreciation allowed thereon at the rate of 5 per cent. per annum on the written-down value, in addition to the cost of repairs.

Electric Lighting Undertakings.

Cables.—In addition to repairs, allowance for depreciation may be granted at the rate of 3 per cent. per annum on the written-down value.

Plant and Machinery.—On all other plant, exclusive of loose tools, meters and office furniture, depreciation may be allowed at the rate of 5 per cent. per annum on the written-down value, in addition to the cost of repairs.

Conduits.—No allowance should be made for depreciation; but annual expenditure on repairs and renewals may be allowed as working expenses as and when incurred.

Meters, Loose Tools and Office Furniture.—No allowance should be made for depreciation; but annual expenditure on repairs and renewals may be allowed as working expenses as and when incurred.

General.

In all cases where depreciation allowances are granted, a strict account should be kept of the annual expenditure on renewals (and repairs in the case of tramway tracks), including replacements due to obsolescence, and of the amounts allowed for depreciation and obsolescence, whether under this arrangement or under any arrangement made prior hereto, and a readjustment should be made for the future, if necessary, at the end of every five years, as detailed under Tramways (Permanent Way), subject, however, to the special provisions applicable to Tramways (Permanent Way). Where depreciation allowances other than those for the permanent way of tramways are granted, renewals should be carefully distinguished, and, if charged against revenue, they should be notified to the surveyor, in order that they may be added back in arriving at the income-tax liability. "Written-down value" means original prime cost, plus subsequent additions, less all allowances actually granted by the revenue in respect of wear and tear. These proposals are to take effect for the year 1908-9, and for years preceding in cases where claims of depreciation are at the present time awaiting settlement. The computations necessary for any future adjustment should be duly made, agreed and recorded each year, whether the accounts for the particular year under review show any assessable income-tax liability or not. Where in any cases allowances for depreciation have been made which are now to be discontinued, and they have not been exhausted by renewals already effected, the amount of such unexhausted allowances should be determined by agreement between the surveyor and the Corporation or company, and deducted from the expenditure on future renewals as and when they are effected. All cases of dispute should be referred to the Board through the Chief Inspector of Taxes.

CORRESPONDENCE.

THE "C.M.B." AUTO-CONVERTER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to the letter in your issue of July 16th by Mr. L. Murphy, in which he criticises the "C.M.B." auto-converter, and compares the same with a double commutator machine, we must state that his conclusions are entirely incorrect.

In the first place Mr. Murphy alleges that our machine is at a disadvantage as regards efficiency and commutation when used for transformation ratios other than 2 : 1. In our article, published in your paper on July 9th, it is clearly shown that the short-circuited brushes are placed on the commutator in a position corresponding to the required division of the voltage, and also that the copper and iron of the two magnetic circuits are proportioned in a similar manner, so that all material is used to the best advantage; but the chief reason why the "C.M.B." machine can show such a high efficiency is that the whole of the conductors are common to either the motor or generator fields, whereas in the double-wound machine with an auxiliary or generator magnet the motor conductors only are common to both fields, whilst the generator conductors are only influenced by the generator field, thus requiring many more conductors. The commutation is rendered perfect by employing a sufficiently narrow armature core without resorting to an abnormal number of commutator parts, and the ring armature is not inferior to the drum type in this respect.

As an example, in transforming from, say, 200 volts to 50 volts—*i.e.*, 4 : 1, with voltage regulation from 0 to 50 volts, as is required for working an arc lamp without steadying resistance, or for charging accumulators, the two-pole double wound machine, operating on the autotransformer principle, must be provided with primary and secondary commutators and armature windings, and auxiliary magnet poles and field coils for the purposes of regulation (mentioned by Mr. Murphy), which embrace the whole of the secondary armature winding but only part of the primary armature winding, the former being influenced by the auxiliary magnet poles only. The armature C^2R loss in such a machine will be actually $3\frac{1}{28}$ times greater than in the corresponding "C.M.B." type, having the same weight of armature copper and same amount of material and losses in the field magnets, which in a 3 kw. set gives an advantage of 17 per cent. in the efficiency in favour of the "C.M.B." type.

Similarly, for any other practical voltage ratio, the single wound armature has less copper loss than the double-wound armature. Even in a double-wound machine made without an auxiliary magnet (in which case it is not even possible to compensate for pressure drop in the machine) the armature C^2R loss is not less than in the "C.M.B." type, owing to the larger core size required in the former to accommodate the two separately insulated armature windings.

There is no question, therefore, that the double commutator machine has the following disadvantages: (1) Lower efficiency than the "C.M.B." type for the same amount of active material. (2) The cost of labour in the manufacture of two armature windings and two commutators is twice as great. (3) Risk of breakdown of the insulation between the two armature windings.

In conclusion, the "C.M.B." machine is without doubt a considerable improvement on all other split voltage machines, as verified by actual tests on the numerous machines already manufactured.—We are, &c., Jas. C. Macfarlane.
Chelmsford, July 21. H. Burge.

RESEARCHES IN RADIOTELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to Prof. Artom's letter in your issue of this week I should feel obliged if you would allow me to make a few explanatory remarks. Prof. Artom claims priority as regards the invention of the triangular aerial. Now there are two types of such aerial: (1) The aerial radiating and receiving circularly or elliptically polarised electromagnetic waves in the direction perpendicular to its plane; (2) the aerial radiating and receiving plane polarised electromagnetic waves in the direction of its plane.

The first type of aerial, which, as a matter of fact, has yielded no results, is certainly due to Prof. Artom. The second type of aerial was patented in 1899 by S. G. Brown. Latterly, M. Blondel has laid claim to priority, but in any case it is not due to Prof. Artom, who only employed this aerial comparatively recently; and, on the other hand, this arrangement is not described in any of the latter's numerous patents.

Unfortunately it is not possible to ascertain the contents of the records of the Italian Navy cited by Prof. Artom, since these are official and secret documents.—I am, &c.,
London, S.W., July 19. E. Bellini.

ELECTRIC LIGHTING LEGISLATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to my letter, which you were good enough to insert in your last issue, I am now glad to be able to report that, as a result of the efforts which have been made, substantial amendments have been obtained in the bill now passing through Parliament.

Clause 6 has been altered so as to make it quite reciprocal between local authorities and companies.

Clause 13, relating to audit of accounts, has been struck out and the following clause has been substituted :—

The Board of Trade shall from time to time make a return to Parliament giving such particulars as they may think proper with regard to the reports made by any auditors appointed by them to audit the accounts of any undertakers and any action taken on such reports by the Board and by the undertakers.

Clause 2 has also been amended with regard to sub-stations. The bill passed the Standing Committee yesterday, and until we see a revised print we cannot be sure that all points have been satisfactorily met, but it is believed that there will be no further necessity to oppose the passing of the bill. The bill is not entirely satisfactory, because many important matters referred to by the Select Committee of 1898 have not been dealt with, but the bill contains some good points, and the particularly dangerous clauses have, it is hoped, been satisfactorily amended.—I am, &c.,

Electrical Federation Offices, W.C., July 21. E. GARCKE.

ASSOCIATION OF TEACHERS IN TECHNICAL INSTITUTIONS.

As the outcome of Papers, discussions and inquiries, extending over a long period, among members of the London arts and crafts section, the following resolutions have been agreed upon and are considered to be urgently needed in the interests of English craftsmanship.

1. *General.*—If the standard of English craftsmanship is to be maintained it is imperative that boys should be trained in the principles and practice of the crafts. At present this type of training is non-existent. The London artistic trade and craft teachers therefore strongly urge: (*a*) That national and local education authorities should provide this training; (*b*) that the establishment of day trade schools is the only satisfactory method of accomplishing this work. They further urge that boys trained to some craft have better opportunities of becoming good citizens than boys who are not trained. The interests of the employers, the craftsmen and the crafts would be promoted by a constant supply of well-trained youths: the highly-skilled craftsman meets with no opposition on account of his skill from either employer or fellow craftsman.

2. *Concerning Apprenticeship and the Need for Trade Schools.*—(*a*) Apprenticeship in London in the artistic trades and crafts has almost ceased to exist, and where it does exist there is no guarantee that boys will be properly taught the trade at which they are working. (*b*) For reasons of economy, masters generally train a "one-process" boy, and such training is held to satisfy their legal obligations. (*c*) The section is of opinion that parents, guardians, apprenticeship societies, &c., fail to appreciate these facts, and it is therefore most desirable that definite information from the trades concerned should be available for their use. (*d*) The training of boys under the present industrial conditions would be better carried on in day trade schools than in shops. (*e*) The trade schools would discover the boy's natural bent, and by directing it and giving the boy a definite purpose in life would prevent wastage. (*f*) The section is of opinion that time spent in the schools should count as part of apprenticeship, or be accepted in place of apprenticeship, the boy going into the craft as an "improver."

3. *Concerning Opportunities.*—Every parent should have the opportunity of providing a training at a day trade school for his children should he desire it. To accomplish this it is necessary (*a*) that there should be established an increased number of day trade schools, and (*b*) that there should be a generous provision of scholarships and free places in day trade schools.

4. *Concerning the Curriculum in the Schools.*—All the theoretical and practical principles of the craft should be taught in the schools, as far as the age of the boy will allow; public money should not be spent in training a "one-process" boy.

5. *Concerning the Teachers.*—It is strongly urged: (*a*) That all teachers in trade schools should have had workshop experience. (*b*) That the want of academic or technical certificates should not be a bar to the appointment of a good teacher. (*c*) That to maintain the supply of craftsmen teachers, to give opportunities for training in teaching, and to ensure efficient teaching assistants should be appointed where classes are large. (*d*) That heads of trade schools and heads of departments should be men of reputation in some trade or profession other than the teaching profession.

6. *Concerning Committees of Management.*—The section strongly urges the desirability of appointing advisory committees (where such are not in existence) to each trade school, such committees to include representatives of employers and craftsmen.

7. *Concerning Evening Trade Classes.*—Evening trade classes have done, and are doing, valuable work, though often at the sacrifice of necessary recreation and sometimes of health. The section therefore urges the establishment of earlier evening classes for the younger boys, pending the establishment on a large scale of day courses of instruction. At these evening classes there should be adequate provision in the way of scholarships and free places.

PARLIAMENTARY INTELLIGENCE.

ELECTRIC LIGHTING ACTS (AMENDMENT) BILL.

On Tuesday this bill came before Standing Committee C of the House of Commons. Sir F. A. Channing presided, and the bill was in charge of Mr. H. J. Tennant, Parliamentary Secretary to the Board of Trade.

On clause 2 Mr. A. H. SCOTT moved to insert in line nine, after the word "direct," the words "to the local authority of the district in which the land is situate and"; to omit "land" and insert "dwelling houses"; in line 12 to leave out "those" and insert "such local authority"; and at the end of line 13 to add "This section shall not apply to any station for transforming, converting or distributing electrical energy."

This amendment was agreed to.

Mr. SCOTT also moved to insert at the end of clause 4 (page 3, line 8) the following words: "Provided that a provisional order authorising the breaking up of roads outside the area of supply of the local authority or company by whom the supply is to be given shall not be granted by the Board of Trade except with the consent of the local authority in whose district the road is situate, unless the Board of Trade in any case in which the consent of any such local authority is refused are of opinion that, having regard to all the circumstances of the case, such consent ought to be dispensed with, and in that case they shall make a special report to Parliament stating the ground on which they have dispensed with the consent."

This amendment was accepted by Mr. Tennant and agreed to.

On clause 5, which deals with the supply of electricity to railways, tramways and canals partly outside the area of supply of the authorised distributor for the purpose of haulage or traction, Mr. HOLT moved to add words giving the same privileges to a dock company.

Mr. TENNANT said that the clause had been the subject of much negotiation between the Board of Trade and various parties interested, and he appealed to the Committee not to reopen the question.

The amendment was negatived.

Mr. SCOTT moved to omit a sub-section of the same clause, under which power is given to the Board of Trade by provisional order to authorise any local authority, company or person to supply electricity to be used for purposes incidental to the working or lighting of the railway, tramway or canal.

Mr. TENNANT opposed the proposal, and said it would obviously be to the convenience of a railway or canal company to be able to take its supply of electricity from the one source.

The amendment was negatived.

On the motion of Mr. HOLT, it was agreed to add to clause 5 (page 4, line 14), after "laboratories," the words "or observatories or laboratories now or hereafter erected, owned or managed in pursuance of any present or future statutory enactment."

On clause 6 certain amendments were agreed to.

On the motion of Mr. TENNANT, clause 13 was omitted and a new audit clause was inserted.

Mr. J. PARKER moved to strike out the words inserted in clause 16 in the House of Lords, which prohibited local authorities who own electrical undertakings from supplying lamps, meters and other fittings except through a contractor.

Mr. TENNANT said the clause, as it was originally introduced, was intended to embody in the bill a model or standard clause. He was informed that 75 local authorities, including all the London boroughs, possessed the power to supply fittings, and the Government proposed in the bill to give all local authorities in future similar powers. They considered that the amendment introduced by the House of Lords was a very unfortunate one. It prejudiced the supply of electrical fittings by local authorities for all time; even if a Select Committee were disposed to grant those powers, they would not be able to do so. He, therefore, accepted the amendment, but the Committee must realise that the Government might have some difficulty, and it would be their duty to try and negotiate the matter.

The amendment was adopted, as also was one removing meters from the list of appliances to which the clause related.

On clause 22, which is designed to protect County Councils,

Mr. TENNANT moved an amendment to meet an amendment made in the Lords. The original idea of the clause, he said, was to protect town councils from having to pay for damage done by laying of lines over county bridges. In the Lords, however, the clause was altered so as to extend the protection to roads and railway bridges. He did not agree with the extension, and he therefore moved its omission.

The amendment was agreed to.

The following new clauses were, on the motion of Mr. TENNANT, added to the bill:—

(1) "Money borrowed under the Electric Lighting Acts shall not be reckoned as part of the total debt of a local authority for the purpose of any limitation on borrowing under the enactments relating to borrowing by the local authority."

(2) "The Board of Trade shall from time to time make a return to Parliament giving such particulars as they may think proper with regard to the reports made by any auditors appointed by them to audit the accounts of any undertakers and any action taken on such reports by the Board and by the undertakers."

Mr. FALCONER moved a new clause providing that electric apparatus let on hire, though fixed to the premises, should remain the property of the undertaker.

This was agreed to, and the bill as amended was then ordered to be reported to the House.

LONDON COUNTY COUNCIL TRAMWAYS AND IMPROVEMENTS BILL.

A Select Committee of the House of Lords, presided over by Lord Clifford of Chudleigh, considered this Bill from 13th to 19th inst. inclusive.

Mr. Erskine Pollock, K.C. (for the L.C.C.), first dealt with the clause authorising a proposed extension of the Council's tramways in Farringdon-road from the present terminus to Charterhouse-street (the City boundary) and a short connecting line to enable cars to run directly off the proposed new tramway on to the lines along Clerkenwell-road which run westward to Bloomsbury and to the Holborn to Embankment subway and eastward to Blackwall, Hackney, Stamford Hill, &c.

The clause was opposed by the Great Northern Railway Co., on the ground that the new lines would interfere with the use of their depot in Farringdon-road and that works in connection with the tramways would obstruct the light of property of the company beneath street level. It was also opposed by the prosperous hawkers who stand in Farringdon-road.

Tradesmen in Farringdon-road and the Smithfield Markets favoured the Council's proposals.

The Committee sanctioned a short continuing line to Charles-street but refused the larger extension, thereby pleasing the costermongers.

The proposed reconstruction of the Highgate Hill tramway and road widening in connection therewith was then discussed. The Council proposed to demolish Fairseat House, on the top of Highgate Hill, of which they hold the lease with 16 years unexpired, and to carry the tramway over this site.

This was opposed by the owner of the freehold (Mr. T. Bloxam) and Sir A. Binnie submitted a scheme for carrying out the widening on the other side of the road.

The Committee, while passing the preamble of this part of the Bill, decided that not more of Fairseat Park should be included within the limits of the deviation than was required for road widening.

The remaining clauses having been adjusted, the Committee ordered the Bill to be reported for third reading.

Central London Railway Bill.—On Tuesday this bill was considered by Lord Onslow, chairman of Committees of the House of Lords. The principal proposal is the extension of the Central London Railway from the Bank to the station of the Great Eastern Railway at Liverpool-street. The extension was opposed by the Metropolitan Railway Co. on the ground of competition, but the promoters have agreed to the insertion of a clause protecting the interests of the Metropolitan Co., and their opposition has been withdrawn. The bill was ordered to be reported for third reading.

Gateshead & District Tramways Bill.—On 16th inst this bill came before the chairman of Ways and Means at the House of Commons. The bill authorises the Gateshead & District Tramways Co. to construct additional tramways and to raise additional capital. The objection was that if the bill passed as it stood it would take away the power from the local authority to purchase the overhead equipment of the tramways. The chairman said the consideration of the bill must be postponed.

LEGAL INTELLIGENCE.

Consolidated Nickel, Tin & Copper Mines (Ltd.) v. Crompton & Co.

Mr. Muir Mackenzie, K.C., Official Referee, on Friday last delivered his considered judgment in this case (reported in The Electrician for May 7, 14, 21 and 28 and June 4). He said a licence was granted in June, 1906, to three gentlemen (said to be trustees for the company), and the licensees were to erect a pump capable of pumping 1,000 gallons of water per minute at a depth of 120 ft., and the licence was liable to be withdrawn if this provision was not complied with. Plaintiffs' case was that defendants agreed to supply such a pump, but had failed to do so within the time agreed or at all. The first thing he had to do was to inquire as to what was the contract. In his opinion it was clear, from the letters which passed from defendants to Messrs. Worthington in 1907, that plaintiffs' requirements were fully known to defendants. The specification was for plant capable of delivering 1,000 gallons a minute against a total head of 120 ft., including friction. Plaintiffs had the right to expect and to believe that their contractors were offering to them a plant capable of performing that work, and he had finally decided that that was the contract. Defendants undertook to supply and were responsible to supply a plant consisting particularly of a gas engine, alternator, producer and pump, and under the terms of the contract was to be delivered and erected not later than May 24, 1907, and there was to be a forfeit by defendants of what he would call a penalty, for the sake of description, of 1 per cent. of the contract price per week for the first three weeks after the date for completion, and 10 per cent. of the contract price per week afterwards for each week after the date for completion stated in the contract had passed, and it was also stated in the contract that this forfeit was not to be enforced if the delay was due to causes outside defendants' control. There was delay, and the point he had to then consider was whether the forfeit was a penalty or liquidated damages. In his opinion it was clearly liquidated damages. The result of delay in delivery as regarded loss and damage being uncertain, plaintiffs had pre-estimated what the amount of the damage was to be. There were expressions in letters in April, 1907, which showed that defendants were aware that the penalty of delay would be very heavy. Defendants purchased the pump from the Worthington Co., but they would not bind themselves to any particular date of delivery. The Worthington Co. did not make the pump themselves in England, but employed a German firm of manufacturers to make it, and, according to the practice in Germany, part of the work was sub-contracted by the German manufacturers to another firm. Defendants said the delay which had occurred was due to causes beyond their control. In his (the Referee's) opinion that was clearly not so, and he, therefore, found that the delay was not due to causes beyond the control of defendants. Having referred to the evidence on the question of delay, he said he had, upon his findings of fact, to consider what the damages recoverable by plaintiffs were. He considered that with regard to delay up to Oct. 19 plaintiffs were entitled to damages in respect of the diminution in value between the installation which they contracted for and the installation which they got. That diminution in value must be, from the evidence he had received, more or less a matter of conjecture, but he assessed it at £100. Totalling the figures up, liquidated damages £2,296 and adding the £500 made £2,796, and the £100 for diminution in value made £2,896. On the counterclaim he found there was £1,040 due, together with some items that were admitted, making £118. 1s. All those items in the counterclaim which were not admitted he could not award. Therefore, these came to 1,158. 1s., which, deducted from the £2,896, left a balance in favour of plaintiffs of £1,737. 19s., for which sum judgment would be entered, with costs.

Cuthbert Hall v. Marconi's Wireless Telegraph Co. (Ltd.)

In the King's Bench on Thursday last week, Mr. Justice Ridley heard an action for £2,583. 6s. 8d. damages for alleged breach of contract.

Mr. Castle, K.C., for plaintiff, said that, by an agreement dated April 8, 1908, when plaintiff (Mr. Henry Cuthbert Hall) was retiring from the position of managing director of the defendant company, defendants agreed, for certain considerations, to allot and issue to him, before May 7, 1908, 10,000 fully-paid shares of £1 each in the company, and to "use their best endeavours" to procure a quotation for them on the London Stock Exchange. The shares were allotted, but plaintiff alleged that defendants, in order to prevent the shares from being sold pending an issue of 250,000 preference shares which they were bringing out, took no steps to get the special settlement till about May 30, the result being that there was no quotation of the company's shares till the mid-July account, and plaintiff's shares were eventually sold at an average price considerably lower than he would have otherwise obtained, the total alleged loss being £2,583. 6s. 8d., the amount claimed. He contended that plaintiff lost the difference between 12s. 3d. and 7s. 1d. per share.

Mr. Justice Ridley held that the contract did not bind the directors to obtain the quotation at such a time as to enable plaintiff, by throwing £10,000 shares on the market, to injure the prospects of a successful issue of preference shares. It did not bind them to disregard the interests of the company of which they were directors. Without calling upon defendants, he held, on the construction of the agreement, that there was no case, and therefore gave judgment for defendants, with costs. He also expressed the view that there was no damage, as the shares appeared to stand at a higher price at the present time than in May and June, 1908.

W. R. Sykes' Interlocking Signal Co. (Ltd.) v. McKenzie & Holland (Ltd.)

By this action, heard by Mr. Justice Parker in the Chancery Division on Thursday last week, plaintiffs claimed an injunction in respect of an alleged wrongful representation by defendants that they were licensees of Sykes' patents for block and electric interlocking signals.

Mr. Gore Browne, K.C., said plaintiffs owned a system of block and electric signalling, certain patents in respect of which had ceased to exist. At one time defendants were licensees of the Sykes patents, and were the principal agents for the Sykes system of block and electric interlocking signals. Their rights as to England, however, expired in 1903, and in the Colonies in 1905. In September, 1907, plaintiffs noticed an advertisement to the effect that defendants were the sole licensees of the system, and they wrote to defendants who promised that the advertisement should be withdrawn. Consequently no further action was taken in the matter. In 1908 from communications the plaintiffs had from the Agent General of New Zealand they were led to believe that the defendants were still representing themselves as the agents of the Sykes system, and in August of that year they again communicated with defendants, who replied that through inadvertence the statement had not been removed from the latter paper in New Zealand, but they were cabling out instructions to get the matter right. As, however, they said the Sykes system was no longer in existence they denied any liability. The matter again dropped but in November, 1908, plaintiffs found that the advertisement originally complained of was appearing. Plaintiffs issued the writ in the present action in December, 1908.

Mr. Romer said he admitted that defendants were not entitled to represent themselves as the licensees of the Sykes patents, though he did not admit that plaintiffs were entitled to restrain them from using the word Sykes. Under these circumstances he was willing to submit to an order in a limited form and pay the costs of the action.

Mr. Gore Browne said plaintiffs were willing to take an order in the terms offered. Mr. Romer desired to say that the reason defendants offered to pay the costs was that they felt it was through their carelessness that the advertisement was not withdrawn, and under the circumstances, plaintiffs were justified in bringing the action.

His Lordship made an order in the terms agreed.

Sale or Return Conditions.

In the City of London Court on Friday, before Judge Lumley Smith, K.C., the Armorduct Mfg. Co. sued Mr. A. Fearnhead, 354, Caledonian-road, London, for £8. 5s. 11d. for electrical goods and fittings supplied. The claim was admitted, but defendant counterclaimed £6. 13s. 6d. for the price of electrical radiators supplied to plaintiffs. DEFENDANT said that in February, 1908, he saw plaintiffs' sales manager about some radiators, and he agreed to take them. They were sent as samples on "sale or return," but plaintiffs, he urged, must pay for them now, as they had kept them for 10 months and then sent them back damaged.

The JUDGE said he supposed if the plaintiffs had returned the radiators in a fortnight defendant would have taken them back? Defendant thought he might.

Mr. DWYER, plaintiffs' traveller, said they were waiting for months for an invoice in respect of the radiators. That was why they kept them so long, as they did not know whether they were to be charged. They had never given a specific order for the radiators. It was a well-known practice in the electrical trade for goods to remain as long as 12 months in shops on approval.

DEFENDANT said that was not so as applied to radiators. Had the goods been electroliers he would have been willing for plaintiffs to have kept them for nine months, and would then have taken them back. Radiators were a season trade.

The JUDGE said when goods were taken on sale or return the property passed to the holders, if they did not send them back within a reasonable time, or give notice that they would not retain them. There was a difference where goods were sent in to be shown. He was satisfied that these radiators were sent in to be looked at to get orders from, and were not bought. The counterclaim therefore failed. Judgment would be for plaintiffs on both claim and counterclaim, with costs.

Re Uxbridge & District Electric Supply Co. (Ltd.)—On Tuesday Mr. Justice Neville heard a motion by the Metropolitan Electric Supply Co. for the appointment of a receiver of this company.

Mr. BRAMWELL DAVIS, K.C., in support of the motion, said that some time ago a petition was presented for winding-up the company and a liquidator was appointed who was carrying on the business, but it was felt that the company could only be successfully carried on if fresh capital was forthcoming. Fresh capital could only be raised by a receiver in the debenture holders' action. The debenture holders' security had crystalised, and a receiver had been appointed, but owing to the liquidation it was necessary before he could do anything that he should be appointed a receiver of the Court. Counsel understood that the point would be taken that this being a statutory undertaking no receiver could be appointed. There was authority against that proposition, though no doubt, with regard to a company having statutory obligations, creditors could not obtain a manager.

Mr. PETERSON, K.C., for the liquidator, said he did not propose to take that point. His case was that a receiver was unnecessary

His Lordship accordingly appointed the official receiver to be receiver in the debenture holders' action until further order.

British Aluminium Co. (Ltd.)—On Tuesday Mr. Justice Neville had before him petitions presented by Dick, Kerr & Co. and A. Schonfield & Co. for the winding up of this company.

Mr. MARTELLI, K.C., for the first petitioners, stated that they were creditors for over £1,000, and in June last the debenture holders commenced an action, and had obtained the appointment of a receiver. There was evidence that the company was now doing a profitable business, and that the assets largely exceeded the amount of the debentures. A scheme of reconstruction, which he supposed would include payment of unsecured creditors, was in preparation, and the petition was opposed by a number of shareholders, creditors and debenture holders. He suggested that both petitions should stand over until the second petition day in next term.

Mr. YOUNGER, K.C., said the company had assets to the amount of £2,241,000 odd, but owing to the works taking longer to perfect than was anticipated, they were in a temporarily embarrassed position. The company has now large works at Loch Leven. It was anticipated that the company would be a very great success.

All parties assenting, his lordship directed the petition to stand over until the second motion day in next sittings.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of head of the electrical engineering department at the Technical College, Sunderland. Salary £250, rising to £300 per annum by two equal annual increments. Applications to the secretary, Mr. T. W. Bryers, Education Offices, 15, John-street, Sunderland, by Aug. 23. See advertisement.

Applications are invited for the Professorship of Physics in the Royal College of Science, Dublin. Applications by Aug. 16 to the Secretary, Department of Agriculture and Technical Instruction for Ireland, Upper Merrion-street, Dublin, from whom further information.

The lectureship in electrical engineering at University College, Galway, is vacant. Salary £120. Applications must be sent to the Secretary, Mr. Robt. Donovan, Royal University-buildings, Dublin, by Aug. 31.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

A firm near London advertise for a designer with experience in a.c. and d.c. motors and generators, and also transformers.

A first-class turner is required, accustomed to electrical work and capable of winding and repairing small armatures. See advertisement.

Epsom Council have appointed Mr. A. C. Gilling (first assistant in the electricity department) to be resident electrical engineer at a salary of £200, rising to £250 per annum. Mr. Foster his predecessor, is to be retained as consulting engineer.

Mr. T. C. Baillie, M.A., D.Sc., head of the physics and electrical engineering department at Sunderland Technical College, has been appointed principal of the Croydon Polytechnic, in succession to Dr. W. Beckit Burnie, who was recently appointed to a similar position at the Brighton Municipal Technical School. The salary is £300 per annum, rising in two years to £350.

EDUCATIONAL NOTICES.

University of Manchester.—A complete theoretical and practical training is given at this University to students preparing for the higher positions in the electrical engineering profession. This subject may be taken as part of the courses preparing for the B.Sc. degree in both the honours classes of engineering and physics. A special course has also been arranged extending over three years and preparing for the certificate in electrical engineering. The John Hopkinson laboratories and dynamo house are fitted with modern electrical machinery and offer excellent facilities for educational and research work. The session commences on Oct. 5. Prospectuses from the Registrar.

University of Birmingham.—The full course in engineering extends over four years and students who enter after matriculation, and who pass the examinations at the end of each year will be entitled to the degree of B.Sc. in the branch of engineering to which they devote themselves. Some particulars of the instruction given in the technical engineering classes, engineering laboratory, &c., are given in an advertisement. The session, 1909-1910, commences on Oct. 4, and detailed syllabus with full particulars of University Regulations, lecture and laboratory courses, fees, &c., may be obtained from the Secretary.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

City and Guilds of London Institute.—At a meeting of the Council on Tuesday it was resolved to award the diploma of "Associate of the City and Guilds of London Institute" to 28 matriculated third year students of the Central Technical College who had completed a full course of instruction in electrical engineering, to 65 students in civil and mechanical engineering and five students in chemistry. The Bramwell medal in civil engineering was awarded to Mr. T. E. Beacham, and Mr. F. H. Bramwell obtained the Siemens memorial medal and premium. The following are the names of the students in electrical engineering:

F. H. Bramwell, A. Hutt, C. Higgins, H. Grinsted, R. A. Mack, A. Schmidt, C. G. Hawes, S. L. Smith, S. N. C. Whitehead, D. H. Hammonds, E. L. Reinert, F. P. Swann, W. C. McCallum, T. A. F. Dixon, J. Hollingworth, H. C. Hannam-Clark, L. G. S. Dodwell, C. D. Stoneham, R. W. Canning, H. G. Biggs, A. J. Ando, A. Weiss, B. A. Turkhud, W. B. Burford, J. O. Archer, J. R. A. Willey, E. H. Balcombe and J. H. P. Burchett

In addition to the above, certificates have been awarded to 20 matriculated third year students who have completed a full course of instruction at the Central Technical College and to 59 students who have completed a full course of instruction at the Technical College, Finsbury.

University College, Nottingham.—The instruction in the engineering department of this college includes courses in mechanical and electrical engineering for the B.Sc. degree and mining diploma, and ordinary courses. The session begins Oct. 4. Prospectuses may be obtained from the Registrar.

Heriot-Watt College, Edinburgh.—The training for engineers given at this College consists of three years in the College, and a three years' apprenticeship on the "sandwich" system in a local engineering works. The course in mining extends over two years, and is recognised by the Home Office as equivalent to two of the five years underground training required for the colliery manager's certificate. There are also complete courses of instruction (extending over four years) for students preparing for the fellowship of the Institute of Chemistry, and practical training for technical chemists in the laboratories of the Corporations' gas works. The classes are recognised by the University of Edinburgh as qualifying for science degrees. Particulars of fees, bursary, &c., from the principal, Mr. A. P. Laurie, M.A., D.Sc.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

Acton.—The Council have increased the charge for current for lighting from 4d. to 6d. per unit.

Alleged Embezzlement.—At Airdrie on Tuesday Arthur Delves, late manager of the Airdrie & Coatbridge Tramways, was charged with embezzling about £200 of the Company's money, and after evidence had been taken, was committed for trial.

Argentina.—The "Review of the River Plate" says the project of Messrs. Lacroze for supplying current for lighting and power in Buenos Ayres has been favourably reported upon by the technical advisers of the Municipality.

The electric lighting contractors at Casilda have informed the Municipality that unless their account for public lighting is paid the supply will be suspended. The Municipality state that they have no funds.

Australasia.—The "Australian Mining Standard" states that Mr. Harold C. Lord, hydraulic engineer, of Latrobe, has reported to the Railton (Tasmania) Improvement Association on the contemplated construction of an electric railway to connect Railton with Sheffield, a distance of 8 miles.

Mr. Lord reports that it would be impossible to get the necessary water power from the Minnow river, as suggested, but that it could be got from the Dasher Falls, where there is sufficient power to supply 95 H.P., which could be increased by building a dam, for which materials can be found on the spot. He recommends the use of a single-phase locomotive to draw 50 tons on a 3 ft. 6 in. line at an average of 15 miles an hour. Assuming that 30,000 tons were hauled at 2s. a ton, the annual income would be £3,000 and the annual expenses £2,980, including 5 per cent. on the capital expenditure of £15,000. At the request of the Agent-General for Tasmania the Brush Co. have prepared three schemes for a line on the same route (1) to run three cars each way (four cars per hour, and to use two 100 kw. steam sets with Babcock boilers and one stand-by boiler and steam set (total cost £11,000); (2) for four cars each way (eight cars per hour, and with two 150 kw. sets and watertube boilers (cost £12,500); and (3) for six cars each way (12 per hour, with two steam sets of 200 kw. and watertube boilers (cost £14,000).

The N.S.W. Government passed an Act last session providing for the examination of and granting of certificates to mining electricians. At the first examination, which took place at Newcastle (N.S.W.) on May 4 and 5 and at which the examiners were Mr. Wm. Corin (consulting electrical engineer to the Department of Mines and electrical inspector under the Coal Mines Act) and Messrs. E. O. Sellars and A. E. Warburton (mine managers), 43 candidates sat and 18 passed. A similar examination was held at Sydney on May 11 and 12, but the results have not yet transpired.

A public inspection recently took place at the municipal electricity works at Newcastle (N.S.W.), of the plant which has been converted by Messrs. Noyes Bros. from single phase to three phase since the appointment of Mr. Brydon as chief engineer some 12 months ago. There are now 400 H.P. of motors connected (compared with 80 H.P. at June, 1908) and a new Babcock boiler of 320 H.P. has been put in and also a chain grate stoker and superheater, the use of which has resulted in a saving of 27 per cent. in the consumption of fuel.

The receipts of the St. Kilda Brighton electric tramway for the nine months ended March last were £8,620 (against £8,140 in the corresponding period of 1907-8).

The Mayor officially started the plant of the Deniliquin (N.S.W.) Electric Lighting & Power Co. on May 1.

A conference of mining inspectors presided over by the Minister of Mines (the Hon. R. McKenzie) was recently held at Wellington (N.Z.), and, amongst other matters, the conference decided that the Mining Act should be brought into line with the Coal Mines Act in regard to practical electricity being included among the subjects set for the examination of mine managers; that a uniform code of shaft signals in mines throughout the Dominion be arranged; that where necessary fans be provided for the better distribution of ventilating currents to the working places in mines; that shot-firing in gold mines by electricity be compulsory; that in gaseous mines the use of permitted explosives only should be enforced and that they shall be fired by electrical apparatus or by Bickford's safety fuses.

The Electrical Traders' & Contractors' Association of Victoria was inaugurated, at a meeting of 20 of the leading Victorian electrical firms at Melbourne, on May 18. Membership is limited to master electrical traders and electrical contractors and managing resident representatives of electrical trading or contracting firms having their head offices outside Victoria. The entrance fee is £1. 1s. and the annual subscription £2.2s. Mr. P. Rosling was elected president, Mr. C. Newton and Mr. A. U. Alcock vice-presidents, Mr. L. G. Hinwood secretary, and Mr. A. T. Vickory treasurer, while the committee are Messrs. W. Cumming, W. Ashman, H. Rowe and G. L. Just.

In 1908 the quantity of coal obtained by electric coal cutters in N.S.W. was 1,428,160 tons, compared with 484,127 tons by compressed air machines. The annual report of the Mines Department states that of the seven accidents that have occurred with electric coal cutters none were primarily due to electricity, and that they might all have occurred with any other motive power.

The Electric Supply Co. of Victoria have submitted to Bendigo Council a proposal to extend their tramways to White Hills within 12 months or, if this is found to be too expensive, to adopt the trackless trolley system for this extension. Bendigo Council favour the former but do not approve the latter proposal.

The Political Labour League at Bendigo recently passed a resolution that in their opinion the City Council should not make longer contracts than 12 months for the supply of electric light and that a referendum be taken at the next elections on the question of municipal ownership.

Eaglehawk (Victoria) Council recently decided to invite tenders for lighting the borough electrically.

Zeehan (Tasmania) ratepayers, at a meeting held recently, decided to borrow £7,000, of which £6,000 is required for extensions of plant at the municipal electricity works and £1,000 for wiring on the easy payment system.

The Victorian Premier (Mr. Murray) on May 26 formally switched on municipal electricity supply at Sunbury. The initial capital cost of the undertaking was £5,000 and the Government have had 1,400 lamps fitted in the local asylum for which current is taken from the municipal supply.

Arrangements are in hand for taking another plebiscite of the ratepayers on the subject of the construction of electric tramways in Launceston (Tasmania).

Mr. W. N. Kernot, consulting engineer, has reported to the Poowong and Jeetho (Victoria) Shire Council on the nine tenders received for the equipment of electricity works at Korumburra, but his recommendations have not yet been published. The lowest tender is £1,890, the highest £3,175, and the total cost if the outlay for purchase of lands, erection of buildings, poles, &c., be added to the amount of the lowest tender, is estimated at £2,400.

Bacup.—The Bacup electric tramway $2\frac{3}{4}$ miles in length (of which Rawtenstall have a 30 years' lease) is opened to-day (Friday).

Barnstaple.—The workhouse and cottage homes are to be wired.

Bath.—The Rural Council have decided to ask the Corporation to take a transfer of the Electric Lighting Order for the Rural District.

Bedford.—The L.G. Board have called the attention of the Electricity committee to the fact that the last loan sanctioned was repayable in 23 years, but the usual period for loans for public lighting by electricity is 10 years, and therefore the Board could not accept the committee's proposal as to street lighting submitted to the Council on May 19. The Council decided last week to undertake to repay in 10 years such portion of the loan as is used for substituting electric for gas lamps.

Bray (Ireland).—The L.G. Board have intimated to the Council, in regard to their recent application for sanction to a loan of £2,600 for extensions of the electricity works, that—

As regards the item of £1,162. 7s. 9d. for recoupment to revenue account of cost of extensions defrayed therefrom, these extensions appeared to have been carried out in 1904, 1905 and 1906, and the Board could not now with propriety sanction a loan in respect of these works. With regard to the item for a new switchboard, the Board were of opinion that the cost of providing this must be regarded as a maintenance charge, and as such must be defrayed out of revenue. The Board were prepared

to sanction a loan of £1,000 for gas plant, disconnecting boxes and contingencies.

On the recommendation of the Electricity committee it has been decided to communicate with the Board in regard to the rejected items.

British Medical Association Exhibition. Belfast.—This annual exhibition is being held at Belfast, and amongst a number of novelties is a striking exhibit of Messrs. Siemens Bros. & Co. In the X-Ray department this firm is specialising, and have a large variety of instruments and apparatus on show. The exhibit includes a new Siemens X-ray outfit with rotary high tension rectifier, comprising a special transformer with sub-divided primary, which is connected direct to an alternating-current supply.

The alternating current is stepped up to the pressure necessary for the tube, and is then commuted by means of a rectifier, which is rotated by a self-starting synchronous alternating-current motor, also connected direct to the mains. Where only a continuous-current supply is available, a rotary converter is connected to the mains; this generates alternating current and also rotates the rectifier. The chief advantages of this system are that inverse radiation is entirely eliminated and the plant provides a large reserve of energy, suitable for instantaneous radiography.

Messrs. Siemens are also showing one of their new "G.P." X-ray outfits, which has been designed to bring the price of such apparatus within the means of the general practitioner, whilst the workmanship and material are very high class. The outfit consists of a 16 in. spark induction coil, spark gauge, switch table and Wehnelt interrupter. All the apparatus is mounted on a protective screen lined with lead and provided with a lead glass window.

There is also shown the so-called universal and safety protective tube stand, a general utility apparatus for holding the patient securely in the standing or sitting position, and protecting him and the radiographer from the harmful effects of X-rays, and permitting free movement of the fluorescent screen or dark slide in any direction in relation to the patient.

Another electrical novelty is the clinical temperature recorder outfit, comprising a platinum spiral in a quartz glass tube, known as the "resistance thermometer," which is inserted into a suitable part of the human body, a 4 volt accumulator battery, a regulating apparatus, and a recording milli-voltmeter of the well-known Siemens type, as used for thermo-electrical measurements, &c. This instrument is supplied either with suspended or pivoted moving coil, and both patterns can be provided with slow or quick recording device. The charts are graduated longitudinally into units of time and transversely into degrees of temperature from about 5°F. to 115°F. With this apparatus investigations can be made over periods of several days, and continuous curves obtained in order to demonstrate the progress of pathological cases and the effects of the administration of drugs, &c.

Chili.—A special committee appointed by the Government have recently prepared a report on the question of the electrification of the railway from Santiago to Valparaiso.

Derby.—An unopposed L.G. Board inquiry was held on Tuesday into the application of the Corporation for permission to borrow £7,300 for extensions of the electricity supply undertaking. The Town Clerk said the proposed extension was chiefly for power, and they had orders for current for 600 H.P.

The borough electrical engineer (Mr. T. P. WILMSHURST) also gave technical evidence and said the current sold last year was 637,000 units in excess of the previous year. There was no opposition.

Edinburgh.—At the meeting of the Electric Lighting committee on Tuesday it was reported that this year's surplus on the electricity undertaking was £2,071. 16s. 4d. Mr. A. A. Murray moved that the surplus be applied towards the redemption of the capital debt on the undertaking, while Mr. Lyon, seconded by Mr. Rawson, moved that it be applied towards the relief of the rates. By seven votes to six, Mr. Lyon's motion was carried. It was agreed to recommend that the rate of charge for lighting be allowed to remain unaltered.

Electrically Operated Bridge.—The new bridge across the Esk at Whitby, which has been built by Messrs. Heenan & Froude, and the 70 ft. opening span of which is operated by electric motors, will be formally opened to-morrow by the Hon. Gervase Beckett, M.P. for Whitby.

Electrolytic Disinfectant.—The annual report of Dr. F. W. Alexander, medical officer of health of Poplar, London, states that the cost of repairs, renewals and improvements of the plant established by him for the production of electrolytic disinfectant has been under £45 during the year 1908.

The quantity of the disinfectant manufactured during the year was 28,280 gallons, the total cost of materials being £56. 2s. 5d., including £10. 9s. 3d. for chloride of magnesium, £9. 18s. for salt, £5. 17s. 4d. for caustic soda, £1. 10s. for water and £28. 7s. 10s. for 4,543 units of electricity (at 1½d. per unit). Wages were about the same as in 1907, although an additional depot was open, and include one man manufacturing (at 35s. per week), one man at 32s., and two men at 30s. each, distributing the fluid. The public health department has purchased no disinfectants for the last three years, but in 1905 (previous to the installation of the electrolytic disinfectant plant) it paid £856. 1s. 9d. for disinfectants, bottles, labels, &c., and wages.

Dr. Klein, the eminent bacteriologist, has tested the preparation, and states that 1 oz. of the fluid to 150 oz. of water (nearly one gallon) will kill the cholera or typhoid fever germs in 2½ minutes. The germ of plague would be killed by a more largely diluted solution.

Epsom.—An electrical exhibition is to be held during the autumn.

Greenock.—The Law and Finance committee have agreed to dispense with a condition proposed on behalf of the Corporation for insertion in the agreement for the supply of current to the Admiralty's new torpedo factory that a minimum payment of £20 per month be made from a specified date, provided the Admiralty give four months' notice of the date on which they will commence to take the supply.

Hampstead (London).—An electrical exhibition is to be held in the autumn.

94 incandescent gas lamps are to be converted into incandescent electric lamps. The estimated saving is put at 4s. 6d. per lamp.

Handsworth.—The tramways committee on Wednesday recommended the Council to complete the purchase of the portion of the City of Birmingham Tramway Co.'s undertaking in Handsworth for £72,174, in accordance with the award of the arbitrator, Mr. H. Graham Harris.

Heckmondwike.—St. Saviour's Church is to be wired.

India.—The "Indian and Eastern Engineer" says Mussoorie was lighted electrically for the first time on May 31.

Mr. F. B. Rylands, the Ceylon Government electrical engineer, has prepared a scheme for the electric lighting of Nuwara Eliya.

The Government of Travancore contemplate the construction of a tramway between Kottayam and Mundakayam; the latter is likely to become one of the chief planting centres in Travancore.

Experiments are being made on the Kalka-Simla road with Mr. Louis Brennan's mono-rail system of electric traction.

The Bombay, Baroda & Central India Railway Co. have engaged an assistant electrical engineer who will be stationed at Bulsar and the company's chief electrical engineer, Mr. R. E. Pigott, will continue to reside at Bombay.

Institute of Chemistry.—The pass list of the June–July examinations has been issued.

Of 29 candidates who presented themselves for the intermediate examination, the following 17 passed: W. Caw, A. P. Clark, R. L. Collett, B.A., W. Dickson, S. Elliott, R. H. Ellis, N. Evers, J. E. Hackford, A. D. Heywood, F. E. Laughton, J. R. Nicholls, W. M. Paulley, B.A., G. C. Petrie, E. F. Pollock, S. Robertson, T. Schwarz and J. A. L. Sutcliffe. One candidate presented himself for a general examination for the associateship and passed: L. Knight, A.R.S.M.

Six candidates presented themselves for the final associateship examination in the branch of mineral chemistry and four passed: H. L. Allen, B.Sc., R. H. Findlater, R. Gawler, B.Sc. and G. A. Smiley, B.Sc. In the branch of metallurgical chemistry, of five examined, three passed: A. Marcan, A. Marks, A.R.C.Sc. and A. W. Schultz, A.C.G.I. Of seven candidates who presented themselves in the branch of organic chemistry the following three passed: R. Boyd, B.Sc., C. S. Garland, B.Sc., A.R.C.Sc. and J. Young. In the examination in the chemistry of food and drugs and of water, of nine who presented themselves five passed: F. S. Aumonier, W. G. Carey, R. D. Carty, A.R.C.Sc.I., T. R. Greenough, B.A. and C. E. Sage. One of the candidates, C. E. Sage, was examined for the fellowship.

Ironmongery and Hardware Trades' Exhibition.—The eighth annual Ironmongery and Hardware Trades' Exhibition is now being held at the Agricultural Hall, Islington, London. Among the exhibits there is very little of electrical interest, though one or two items will possibly appeal to our readers.

For instance, we may mention the exhibit of Messrs. JOHN RUSSELL & Co., who are showing numerous wrought iron and steel tube fittings, some of which have been galvanised by a special process which we hope to describe in more detail at a later date. A number of very artistic electric light fittings are also on view carrying "Maxim" metal filament lamps. Another interesting piece of apparatus on this stand is the Talbot patent tapping machine for tapping water and gas mains under pressure, which should appeal to all who have anything to do with this kind of work.

The HARQUIN PENDANT Co. are showing a patent electric pendant and absorber which contains no sliding contacts and no weights. The flexible is taken up by means of a spring drum. It is claimed for this fitting that it can be easily adjusted for any reasonable weight and will stay in the position in which it is first placed. There are no rubbing

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer. We would add that the portrait is mounted so as to be conformable as to size with "The Electrician" series of steel plate portraits, and is well suited for framing with the series.

connections, so that all chance of leakage, it is claimed, are done away with. In our opinion, more should be heard of this device.

The ALBANY ENGINEERING Co. are showing examples of their patent "Blizzard" propeller, which is specially adapted for electrically-driven fans. A number of small direct-current motors are also shown on this stand.

Italy.—The "Bolletino Finanze, Ferrovie ed Industrie" (Rome), states that the Italian Government have granted a concession to the Commune of Clusone, and to Signor P. Fogaccia for the construction of an electric railway from Ponte Nossa to Clusone.

Launceston.—Messrs. Foote & Milne have notified their intention of applying for a provisional electric lighting order. The Electric Supply Corpn. obtained an order for the district some years ago.

Light Railways.—The Board of Trade have confirmed the Lampeter, Aberayron and New Quay Light Railway (Amendment) Order and the County of Middlesex Light Railways (Extension of Time) Order.

London County Council.—At the meeting of the Council on Tuesday the following business was transacted :—

New Tramways.—An estimate of £690 was approved for the construction of a junction line at Streatham High-road and an additional estimate of £1,520 for the construction of the Dulwich Library to Forest Hill tramways.

Highgate Hill Tramways.—The Highways committee recommended that, subject to Parliament confirming the provisional agreement with Hornsey Corporation and the Highgate Hill Tramways (Ltd.) in respect of the purchase of the undertaking of the company, expenditure on capital account to the extent of £18,920 be authorised for the reconstruction of the Highgate Hill cable tramways.—*Postponed.*

Woolwich Tramways.—A recommendation to extend the Beresford-square and High-street, Woolwich, tramways at an estimated cost of £5,350 was adjourned.

Parliamentary Proposals for New Tramways.—The Highways committee submitted proposals for obtaining Parliamentary sanction for 23 miles odd of tramways in various parts of London at an estimated cost of £417,080. The longest tramway proposed is from Chalk Farm to Childs Hill, about 5½ miles. The proposal will be discussed next week.

London County Council Tramways.—At Tuesday's meeting the Highways committee submitted the accounts of the tramways department for the year ended March 31.

On March 31 the tramways system extended over a total length of 127⅝ street miles, being 85⅝ miles of electric lines and 42 miles of horse lines. The whole of the system is worked by the Council, with the exception of ⅜ mile (double line) in Archway-road (worked by the Metropolitan Electric Tramways) and about ⅜ mile (double and single lines) in Lea Bridge-road (worked by Leyton Urban Council). The capital expenditure up to March 31 amounted to £9,483,561. 18s. 1d., of which £1,068,971. 2s. 2d. represents expenditure during 1908-9. The total debt repaid amounted to £1,074,345. 4s. 11d. out of revenue, and £282,519. 12s. 8d. from the proceeds of sales of horses and old materials, &c. The debt outstanding was £8,126,697, or, deducting £83,558 for value of surplus land, £8,043,139. The Council decided on June 23, 1908, to repay the debt (estimated at about £960,000) on the capital which will be obsolete at March 31, 1914, owing to the electrification of horse tramways, within 15 years from that date. The amount of obsolete capital (less proceeds of sales) on March 31, 1909, was £1,344,093. 17s. 3d. Deducting the debt in respect of such capital repaid out of revenue (£302,637. 13s. 5d.), the outstanding debt is £1,041,456. 3s. 10d. The total receipts during the year and the working expenses were as follows :—

	Electric traction.			Horse traction.			Total.		
Total receipts	£1,572,251	8	7	£275,199	1	7	£1,847,450	10	2
Working expenses...	896,286	4	7	305,402	0	2	1,201,688	4	9
Surplus	£675,965	4	0	£30,202	18	7	£645,762	5	5
				(deficiency)					
The debt charges are :—									
Interest (gross)...	£268,132	11	4						
Repayment of capital...........	254,968	6	0	£523,100	17	4			
Income-tax				7,593	7	5			
Annual payment to London Street Tramways Co........................				7,078	17	6			
Parliamentary expenses				1,463	19	10			
Deficiency on Drake-buildings (re-housing).........................				160	0	1			
				£539,397	2	2			
Less—Net interest on cash balances &c.				1,205	3	11	£538,191	18	3
Leaving balance							£107,570	7	2

The Council decided in June, 1908, that provision should be made for renewals at the rate of ⅗d. per car-mile on the total car-mileage run on the electric tramways each year ; and that the question of the adequacy or otherwise of this provision should be again considered at the expiration of five years. Provision for 1908-9 at this rate, amounting to £88,785, has been made, and the balance (£18,785) has been transferred to the renewals fund towards deficiencies for past years. Had provision on the present approved basis been made in each of the years of electrical working the fund would, with interest accumulations, have amounted at March 31, 1909, to £285,632 (after taking expenditure into account), compared with £264,837 on the fund at that date. The general reserve fund now amounts to £35,270.

The total operating expenses for electric traction were £896,286. 4s. 7d. (including £4,999. 2s. 2d. for special charges), or 6·74d. a car-mile run, compared with 6·79d. a car-mile in 1907-8. The total working expenses in connection with horse traction amounted to £305,402. 0s. 2d., or 10·24d. a car-mile run. Considerable loss was sustained during the reconstruction of horse lines to electric traction. The system in operation on April 1, 1908, included about 68 miles of electric tramways, and during the year a further length of about 17 miles was opened, making a total of about 85 miles. The total number of passengers carried and the car-miles run during the year were :—

	Electric traction.	Horse traction.	Total
Number of passengers	344,705,937......	68,207,904	412,913,841
Number of car miles run...	31,962,784.....	7,156,688......	39,119,472

Of the total passengers 24·22 per cent. were carried at ½d. fares, 48·04 per cent. at 1d., 9·29 per cent. at 1½d., 9·89 per cent. at 2d., 1·49 per cent. at 2½d., 2·15 per cent. at 3d., 0·17 per cent. at 3½d. and 0·04 per cent. at 4d. The number of exchange tickets issued amounted to 4·71 per cent. The average fare per passenger on electric traction was 1·07d., against 1·08d. in 1907-8, and on horse traction 0·93d. against 0·96d., in 1907-8. The average fare per passenger on the whole system was 1·05d., the same as in 1907-8.

Long-distance Telephony.—It is announced that the Postmasters-General of Spain and France have signed an agreement providing direct telephonic communication between the two countries. Four new circuits are to be laid, Bordeaux–Madrid, Cette–Barcelona, Bayonne–San Sebastian, and Perpignan–Gerona. Each of these four systems will be in direct connection with the whole of the telephone systems of both France and Spain.

Marriage.—Mr. Geo. Gregory, late of the General Electric Co., and now of the Electric Battery Co., was married at St. Andrew's Church, Stoke Newington, London, on Saturday to Miss Olive Hawes.

Morecambe.—The Council (which takes over the local company's tramways on Monday next) decided on Monday to apply for a loan of £9,000 for tramway purposes. A recommendation of the Tramways committee to appoint ex-Alderman Carleton as manager was rejected.

Obituary.—We regret to announce the death of Mr. John Brailsford Bright, eldest son of the late Sir Charles Tilston Bright. Deceased, who was 55 years of age, was a Barrister-at-Law.

Sheffield.—Mr. H. Ross Hooper held a Local Government Board inquiry on Wednesday into the application of the Corporation for permission to borrow money for various purposes.

Amongst other sums £56,000 was required for the electricity department (£43,000 for mains, distributors, &c., £7,000 for sub-stations, and £6,000 for services) for use as a suspense account to meet work needed from time to time, and also £1,300 for the provision of electricity supply for Tinsley. On a portion of the inquiry which related to another sum (for street works) it was stated that the work was being done by the ordinary Corporation workmen, and the inspector having stated that it was a rule of the L.G. Board not to grant loans for work done in that way, the town clerk (Mr. R. M. Prescott) said he thought the time had arrived when the question might be raised whether it was fair to ask the Corporation to deal with expenditure in that way. With regard to the £56,000 required for the purposes of the electricity undertaking, Mr. Prescott said the demand for electricity was increasing, and, to compete with the gas company, whose charges were the lowest in the country (from 1s. to 1s. 4d. per 1,000 ft.), the department must be able to deal promptly with the demands made upon them. With regard to the supply to Tinsley, the Corporation would apply for a provisional order, and they wanted the L.G. Board to say they could negotiate the loan when they got the order. Messrs. Edgar Allen & Co. were prepared to take a supply from the Corporation if it could be provided at once, but if not they would lay down their own plant.

The INSPECTOR said the Board could not entertain the application until the Corporation got their parliamentary powers, but they might, under these special circumstances, do the work out of revenue and then apply for the loan.

Mr. PRESCOTT thanked the Inspector for the hint.

Southampton.—A sub-committee is to report on a communication from the electrical engineer (Mr. H. F. Street) on the question of obtaining powers to carry on free or assisted wiring.

The Parliamentary committee is considering the advisability of reconstructing certain portions of the existing tram lines at an estimated cost of £2,680, and the committee is also to consider a proposal to extend the Shirley line to Anglesey-road at a cost of £520.

Southend.—Sanction to a loan of £13,715 for extensions of the electricity works has been applied for by the Council.

Stretford.—Mr. T. L. Miller has been re-appointed consulting engineer to the electricity undertaking for one year from Nov. 1 last, at a fee of 25 guineas. An additional CO_2 recorder is to be purchased at a cost of £43.

The Thwaite Fund.—We are pleased to learn that the committee of the B. H. Thwaite fund has now received from Mr. Carnegie a cheque for his generous contribution of £500.

The conditions attached to Mr. Carnegie's offer—namely, that a further £500 should be forthcoming from subscriptions from those who recognised the value of the services rendered to certain departments of science and industry by the late Mr. Thwaite—have not been complied with up to the hilt, as the subscriptions did not reach a quite equal sum, but Mr. Carnegie was doubtless influenced in his decision by the successful efforts of the Committee in regard to Mr. Thwaite's son, who has been elected to the Yorkshire Society School, and we understand that arrangements are in progress for placing Mr. Thwaite's daughter in a suitable school. The committee desire to express their gratitude to Mr. Carnegie for his generosity and kind consideration, to all who by their subscriptions have helped to make up the required sum, and to those who have so substantially assisted by placing the deceased gentleman's son in the above school.

Watford.—An estimate has been passed for £37,990 for the construction of a tramway at Watford from the terminus at Callowland via St. Alban's-road, Station-road, Woodford-road, and High-street, to London-road near the scheduled site for a generating station. The Metropolitan Electric Tramways is to take a lease for 42 years of the line on similar terms to those on which the Barnet tramway is leased (a fixed rent of 5 per cent. per annum upon the capital outlay).

West Ham.—The Education committee are to obtain tenders for wiring the Abbey School, at a cost of £375.

Widnes.—A committee will consider the question of carrying out the Council's provisional order, 1901, as Messrs. G. H. Cox and H. J. Falk notify that they will apply for an order.

Wireless Telegraph Note.—It is announced that the wireless land stations on the Australian coast recently tendered for are not likely to be established for at least another year. It is probable that the localities chosen for the stations will be Fremantle, Kangaroo Island, and points between Adelaide and Melbourne, Melbourne and Sydney, and Sydney and Brisbane, with, possibly, a further station at Thursday Island.

Wireless Telegraphy in France.—The "Elektrotechnischer Zeitschrift" states that the French military authorities have recently connected Epinal and Grenoble, the headquarters of the South and Dauphiné divisions of the French army, with Lyons by means of wireless telegraphy. The stations at Lyons and Grenoble are outside the town, but are connected with the military offices in the town by means of telephones and both electrical and optical telegraphs. These stations can also communicate with the Eiffel Tower station in Paris, while Lyons can "ring up" the stations at Marseilles, Toulon and Bordeaux.

Wolverhampton.—The Council have decided to apply for sanction to a loan of £10,000 for extensions of mains.

Worcester.—Twelve additional arc lamps and 57 Osram lamps, to replace 73 gas lamps, are to be provided at a cost of £480. The candle-power will be increased from 3,500 to 13,500, and the annual charge will be £250 against £229 for gas.

Zeehan (Tasmania).—The capital expenditure of the municipal electricity supply department includes £3,500 paid to the Zeehan Electric Light & Power Co. in 1906 for their plant and £3,000 spent in the following two years. The consumers now number 166 compared with 77 in 1906. In April last there were 5,260 (equivalent) 8 c.p. lamps connected (compared with 2,335 in 1906), the units supplied in the last completed year were 63,000 (against 3,800 in 1906). The price of current for lighting has been reduced in the same period from 1s. per unit (less 10 per cent.) to 7d. (less 10 per cent.) and, notwithstanding this reduction, the receipts have increased from £1,500 to £2,723.

Outings.—The Bryant Trading Synd. lamp works staff had their annual outing on July 10. About 200 female employe's travelled to Brighton. Mr. Joseph Metcalfe (managing director), and Mrs. Metcalfe (who distributed the prizes) were present.

The Dublin United Tramways Inchicore works staff had their outing on Saturday. After proceeding to Rathdrum by train, wagonettes took the party to Glendalough through the Vale of Clara.

Sports.—The annual sports of the Croydon Tramways Athletic Club took place on Wednesday last week.

The club has made great progress, largely owing to the exertions of the executive committee and particularly of Mr. C. G. Foster. The most popular events were a 17 mile Marathon race and a tug of war which was won by a West Ham tramways team. The Tramway Band played selections, and amongst the spectators were the mayor, Sir Frederick and Lady Edridge, several other members of the Corporation, and the general manager of the tramways, Mr. T. B. Goodyer.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Kalgoorlie (W. Australia).—The accounts of the municipal electricity department for the first half of the current year show receipts £8,804 (against £8,300 in the corresponding half of last year) and expenses £5,059, leaving gross profit £3,759 (£3,359). Of this £1,138 has been spent on plant, mains, meters, &c., £2,043 paid to general account and £802 carried forward. 485,050 units were generated (against 440,515) and 395,318 (356,645) sold.

Poplar (London).—The accounts of the electricity department for the year ended March, show capital expenditure £290,525 (increase £23,540).

Income was £38,487 (compared with £36,271 in previous year) or £37,810 (£35,310) after deducting discounts, bad debts, &c. Total running and standing costs were £19,468 (£18,390), gross profit £18,343 (£18,390), capital charges £15,125 (£14,218), annual surplus £3,218 (£2,702), total surplus to date £9,294 (£6,077) or a net surplus of £1,704, after writing down £7,591 out of appropriation account. Units generated were 7,164,208 (6,464,497) and units sold 5,845,692 (5,296,040), including private lighting 1,083,523 (1,014,720), power 3,972,099 (3,433,512), public lighting 789,690 (847,808) and bulk supply 380 (nil). The maximum demand was 2,800 kw. (2,600 kw.), the annual cost per kilowatt of maximum demand was £8. 2s. 10d. (£8. 5s. 4d.), and the load factor was 23·83 per cent. (23·25). Coal cost 0·354d. (0·404d.) per unit, and total cost of production was 0·799d. (0·833d.). Public lamps include 343 (344) arcs and 557 (555) incandescents.

The borough electrical engineer and manager (Mr. J. H. Bowden) says, in his report, that it is now possible to compare the actual result of the change over from carbon to metal filament lamps for public lighting. In the year prior to changing over, the cost for current was £5,344, and last year £4,936, a saving of £408. In the latter year lamp renewals cost £497, compared with £162, so that the net saving was £74, without taking into consideration the lamps converted to gas in the interval. There has also been a gain in efficiency of street lighting from an initial 24 c.p. per post (and a steady diminution during use) to 50 c.p. per post without any material reduction during life of lamps.

Sheffield.—The accounts of the electricity department for the year ended March show capital expenditure £945,545 (increase £52,008).

Revenue was £77,728 (against £78,535 in the previous year), working expenses £25,026 (£25,344), gross profit £52,702 (£53,191) interest and loans, &c., £27,449 (£27,139), and sinking fund £22,831 (£21,255), surplus £2,423 (£4,796). 9,029,741 (8,300,748) units were sold. Coal cost 0·21d. (0·27d.) per unit, and other generating expenses were 0·20d. (0·21d.), distribution, rents, rates, taxes, &c., 0·25d. (0·24d.); total 0·66d. (0·72d.).

The report of Mr. S. E. Fedden, the general manager and engineer, states that there was a slight drop in the lighting and heating units, the sales for lighting having decreased 196,175 units = £4,251 of revenue. That decrease was caused to the extent of 113,175 units by the increase in the use of metal filament lamps. The net decrease in total income is £819. 14s. 3d., and total costs have decreased £319, although 728,993 more units have been sold. Mr. Fedden advises that the surplus of £8,752 should remain available for any requirements of the undertaking as, unless there is an improvement in trade and a further increase in sales of electrical energy, he anticipates having to make a call on this surplus next year to meet standing charges.

In moving the adoption of the accounts last week, Councillor BENNETT said if it had not been for the interest and sinking fund on unproductive capital the profit would have been £12,327 instead of £2,423. As an instance of the saving effected by the use of metal filament lamps, he stated that the saving of cost by their use at the town hall during the half-year to June last was 33⅓ per cent., while the new lamps gave at least 100 per cent. more light. Mr. Bennett referred in appreciative terms of the work done by the general manager and staff, and the accounts were adopted.

Wellington (N.Z.).—The revenue of the municipal electricity department last year was £44,321 and the profit £4,272.

West Ham.—The electricity department accounts for the year ended March show capital expenditure £438,558 (increase £19,281), and the capital repaid, and in sinking fund is £93,599 (increase £15,501).

Revenue was £67,202 (compared with £58,624 in the previous year), gross profit £33,365 (£24,713), interest and special charges £14,904 (£16,465), sinking fund contribution £14,607 (£12,918), surplus £3,853 (compared with deficit £4,669). Total works costs were 0·457d. (0·63d.) per unit, of which coal cost 0·25d. (0·32d.), oil, stores, &c., 0·01d. (0·02d.), wages and repairs 0·17d. (0·23d.), rents, rates, taxes and management 0·09d. (0·15d.). Capital charges were 0·457d. (0·63d.). Total charges 0·977d. (1·35d.). The reserve fund stands at £5,886 (£1,548). The capacity of the generating plant is 11,400 kw. (8,400 kw.), the maximum demand was 6,100 kw. (5,500 kw.), and the load factor 29·1 (23·5) per cent. 18,854,202 (13,340,948) units were generated and 15,522,065 (11,299,783) sold, including supplies for private lighting 1,928,528 (2,123,336), power and heating 8,190,453 (4,161,156), public lighting 785,157 (790,180), and traction 4,617,927 (4,225,111). There are 2,245 (1,978) consumers connected to the mains. Current is supplied to 833 (445) motors of an aggregate horse-power of 8,683 (6,224).

The report of Mr. A. H. Seabrook (who was engineer and manager of the undertaking at the time the accounts were made up, and is now con-

sulting electrical engineer to the Corporation) states that the improvement in the accounts is £8,522, mainly due to the increase of the power business from 4,000,000 to 8,000,000 units, and to the fact that the sales department has had a complete year under proper organisation, with successful results. 5,500,006 more units have been generated at an additional cost of £700. An important factor in the difference in the year's results is that in the two previous years the charges had to be borne on capital that had not then become productive. Total expenditure had decreased slightly, although over 4,000,000 more units had been sold. The reduction in cost per unit was nearly 33⅓ per cent. (about the second lowest figure in the country, but not the lowest that Mr. Seabrook thinks will be reached in West Ham within the next two years). It is expected that the surplus for the current year will not be much, if any, less than that of the past year, allowing for the increased assessment. Private lighting receipts have decreased £1,212, while receipts for power have increased nearly £8,200. In view of the impossibility, owing to metal filament lamps, of rapidly increasing the lighting business, Mr. Seabrook reports that he is certain the position of the undertaking would be most serious if it had not the benefit of a much increased power business. The opposition to the Corporation's doing consumers' wiring and supplying motors, lamps, &c., is due to the fact that the electricity undertakers are younger than the gas people, and have not yet overcome prejudice, but there are signs that the policy of doing such work will become as general as in the gas business. The sales department (continues Mr. Seabrook) has made a profit of £500, although it has borne expenses such as canvassers' commission, which should be borne partly, and in some cases wholly, by the general undertaking. The situation is finally summed up by statments that between 1905 and 1909 the output has been quadrupled, the load has been nearly trebled, the number of motors increased sixfold, the horse-power of same 12-fold; capital expenditure has only increased by about one-third, the Silvertown mains are not more than half loaded and a great deal more business can be taken there and also at the generating station without increasing capital charges appreciably. The average charge to consumers has been reduced to less than half (1d. against nearly 2½d.), the charge for power to one-third, total cost of production from nearly 1¼d. to ½d., cost of management, &c., by two-thirds, wages and repairs by half, and coal by half.

Wolverhampton.—The electricity department accounts for the year ended March show capital expenditure £232,763 (increase £19,300).

Income was £36,477 (compared with £30,926 in previous year). Expenses were £19,533 (£15,831), gross profit £16,694 (£14,845), capital charges £13,491 (£11,797), net profit £3,401 (£3,325). 7,799,941 (5,452,731) units were generated, 179,211 (173,858) supplied to public lamps, 4,854,545 (2,797,983) to private consumers by meter, 15,009 (18,840) by contract and 1,506,360 (1,563,776) for traction. The maximum load was 3,660 kw. (2,450 kw.). There are 165,143 (129,559) equivalent 32 watt lamps connected. The report of the committee states that although there is an increase in both gross and net profit there is a slight decrease in percentage of profit to average capital. There has been a marked reduction in consumption among power consumers owing to trade depression. Cost of coal was 20 per cent. higher than in the previous year, and there was an increase of £250 for rents. Notwithstanding the increased cost of coal, cost of generation and distribution per unit has been further reduced.

The accounts of the tramways department show capital expenditure £258,772.

Revenue was £42,614 (compared with £44,432 in previous year), working expenses £25,566 (£26,461), capital charges and income-tax on profits £11,141, net profit £5,908 (£6,762). 9,050,459 (9,440,369) passengers were carried, 962,681 (975,714) car-miles run, and 1,502,068 (1,563,072) units used = 1·56 (1·602) per car-mile. Total revenue was 10·624d. (10·929d.) per car-mile, average fare charged 0·896d. per mile, and average fare per passenger 1·108d. (both as in previous year). £26,591 now stands to the credit of renewals fund. There was a substantial decrease in working costs per mile of the Lorain surface-contact system, these being 6·374d., against 6·509d., and it is claimed that this is below the average of other municipal tramway undertakings of this country.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited for supply of ten 100-number switchboards to the Postmaster General's Department, New South Wales. Tender forms, &c., at the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

Tenders are invited for the supply of telephone material to the Postmaster-General's Department in New South Wales. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Edmonton Guardians invite tenders for supply and installation of a private telephone equipment at the infirmary, consisting of a 100-line switchboard with direct lines to different parts of the buildings and operated by magneto-generator calling and clearing.

Specification from Mr. Stuart Hill, 106, Cannon-street, London, E.C., Tenders by 9 a.m. July 28.

Dublin Corporation invite tenders for (approximately) 12 months' supply of machinery oils for the electricity works, Pigeon House Fort, Dublin. Specification, conditions, &c., from the town clerk, Mr. Henry Campbell, to whom tenders by July 26.

The Electric Lighting committee of Hull Corporation invite tenders for the supply and laying of electric mains, &c., during the period ending March, 1910. Forms of tender and specification may be obtained on depositing one guinea with the city treasurer (Mr. T. G. Milner). Tenders by noon July 29.

Hull Corporation want tenders by 10 a.m. July 28 for supply of electric and gas fittings required for new public hall. Specifications, &c., from Mr. J. R. Hirst, Town Hall, Hull.

Sheffield Education committee want tenders by Aug. 10 for heating and electric lighting of the Training College Hall of Residence for Men. Specifications, &c., from Messrs. Gibbs & Flockton, 15, St. James-row, Sheffield.

Ilford Council require tenders by 4 p.m., July 27, for the construction of permanent way to the entrance and inside of the car shed extensions in Ley-street, Ilford. Specification, from Mr. H. Shaw, Town Hall, Ilford.

Manchester Tramways committee want tenders by 10 a.m., July 27, for the supply of lighting cable. Specifications, from Mr. J. M. McElroy, 55, Piccadilly, Manchester.

Leyton Council want tenders by 7 p.m. July 27 for electric wiring and fittings for Sybourn-street school. Specifications, &c., from Mr. W. Jacques, 2, Fen-court, London, E.C.

Bradford Tramways Department want tenders by noon July 30 for supply of eight automatic point controllers. Specifications, &c., from Mr. C. J. Spencer, 5 and 7, Hall Ings, Bradford.

Keighley Corporation require tenders by Aug. 7 for supply of two 1,000 kw. turbo alternators with condensers, and two water tube boilers. Specifications from the Borough Electrical Engineer.

Pontypridd Council want tenders by noon, July 27, for supply of one 500 kw. steam dynamo. Specifications, &c., from the Clerk.

The Deputy Postmaster-General, Brisbane, requires tenders by noon, Sept. 1, for battery glassware, battery material and chemicals. Specifications, &c., from the Controllers of Stores of the Postmaster-General's Department in the several States of the Commonwealth.

TENDERS RECEIVED AND ACCEPTED.

Southwark (London) Council have received the following tenders:

Erection and maintenance of battery, per annum, for 15 years.

Electrical Power Storage Co. (*accepted*)	£247
Hart Accumulator Co.	395
Chloride Electrical Storage Co.	390
Tudor Accumulator Co.	351
D.P. Battery Co.	289
Premier Accumulator Co.	263

For supplying and fixing four superheaters Southwark Council received three tenders, and the lowest (Heenan & Froude, at £420) was accepted. Babcock & Wilcox tendered at £498 and Davey, Paxman & Co. at £615.

For supply of 110 yds. of 0·3 by 0·3 by 0·125 paper-insulated and lead-covered cable Southwark Council received the following tenders :—

Western Electric Co. (*accepted*)	£56	0	0
British Insulated & Helsby Cables	56	0	0
Johnson & Phillips	56	15	0
Siemens Bros. & Co.	56	12	6

Southwark (London) Council have accepted the tender of J. Marsland & Sons for erection of a battery room at £1,120. There were four tenders, varying from £1,120 to £1,190.

For supply of 130,000 tons of coal ("washed singles") for Greenwich generating station, London County Council received the following tenders :—

			s.	d.	
Wm. Cory & Son (*accepted*)	130,000	tons at	11	0	per ton
John Hudson & Co.	130,000	,,	11	2	,,
Rickett, Cockerell & Co.	40,000 or 20,000	,,	11	5	,,
	70,000	,,	12	7	,,
Myers, Rose & Co.	15 to 20,000	,,	11	1	,,
	20 to 25,000	,,	12	0	,,
Dunham, Fewins & Co.	25,000	,,	11	5	,,
Harrison, Hardman & Co.	20,000	,,	11	6	,,
	30,000	,,	12	9	,,
Philip Speakman & Sons	20,000	,,	12	3	,,
	10,000	,,	11	10	,,
Phillips & Co.	20 to 30,000	,,	12	3	,,
Alfred Blackmore & Co.	30,000	,,	12	9	,,
	20,000	,,	11	9	,,
Cleeves & Co.	130,000	,,	12	10	,,
Harrison, Tidswell & Co.	20,000	,,	13	6	,,
Charrington, Sells, Dale & Co.	20 to 25,000	,,	14	3	,,

Dunedin (N.Z.) Council have accepted the tender of Thos. Cole for supply of 3,300 volt, three-core cable at £876, that of the National Electrical and Engineering Co. for two 25 H.P. motors at £72 each, and that of the United Electric Construction Co. for a 5 H.P. motor at £28.

Bedford Corporation have accepted the tenders of Siemens Bros. & Co. for cables for the ensuing year at the company's schedule prices, Edwin Danks & Co. for a 30 ft. by 8 ft. Lancashire boiler with superheater and pipework at £659. 10s., and W. H. Allen, Son & Co. for condensing plant and pipework at £1,169. 5s.

Stretford Council has accepted the tender of E. Green & Sons for the replacement of the first cold end group of the economiser, consisting of 80 tubes and boxes, for £144. 10s., and for the replacement of any other sections that may be required at £12. 10s. each.

For supply of 260 canopy bends for tramcars London County Council accepted the tender of Hopton & Sons (at 1s. 4d. each, less 2½ per cent.) in place of that of F. & G. Smith, which has been withdrawn.

For wiring the New Cross Fire Station, London County Council received four tenders (varying from £191 to £282), and the lowest (Tilley Bros.) has been accepted.

Bermondsey (London) Council has accepted the tender of Davidson & Co. for exhaust fan at £72, and that of Browning & Co. for forced draught fan at £19. 5s.

Stoke Newington (London) Council have accepted the tender of the Reason Mfg. Co., for demand indicators and of Messrs. Crompton & Co., at £150, for a balancing machine at Edwards-lane station.

Ilford Council have accepted the tender of W. Griffiths & Co. for construction of Ilford-lane tramway at £1,465. 3s., and that of Hammond & Miles for tramcar shed extensions at £1,892. 5s. 3d.

The Victoria (Australia) Railway Department have accepted the tender of the British Insulated & Helsby Cables for 880 yds. of electric light cable at £621 per mile.

Chelsea (London) Council have placed an order with Wright Bros. & Co., for alterations to the electric light installation in the new portion of the Town Hall.

Messrs. Balmer, Lawrie & Co., of Calcutta, recently supplied 111 of their Bengal ceiling electric fans to the East Indian Railway Co.

The Metropolitan Water Board has accepted the tender of Glenfield & Kennedy (at £450) for electrical water level instruments.

Worksop Council have accepted the tender of W. T. Glover & Co. for cables at £354.

Swinton and Pendlebury Council have accepted the tender of Callender's Co. for cable extensions at £181. 7s. 6d.

BUSINESS NOTICES.

Messrs. F. G. Edey & Co., electrical contractors, are removing from the premises on Ludgate-hill, London, which they have occupied for the last 16 years, to 25, Warwick-lane, E.C. Telephone number still 2547 Central.

Messrs. James E. Sayers & Caldwell inform us they have removed to new offices at 190, West George-street, Glasgow.

SPECIAL NOTICE.

NOW READY.—Vol. LXII. of "THE ELECTRICIAN" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

It is announced that the sole control of sales in the Eastern Hemisphere of the "Schureman" switchgear has passed into the hands of the Adams Mfg. Co., of Bedford and London. The "Schureman" switchgear is entirely of the self-acting type, and includes automatic starting switches and controllers for pumps, lifts, air compressors, &c., and for remote control of motors performing any duty whatever.

Messrs. A. & T. Burt (Ltd.), electrical engineers and contractors of New Zealand, have opened an office at Eldon-street House, London, E.C., to execute the buying for their N.Z. houses. The new office is under the charge of the resident director, Mr. Jas. A. Burt.

Sale by Tender.—Messrs. Fuller, Horsey, Sons & Cassell have been instructed to offer for sale by tender in lots, the modern electric power plant at the works of the late Morris Aiming Tube and Ammunition Co. (Ltd.), Dagenham, Essex. Some particulars are given in an advertisement, and further information, with forms of tender, may be obtained from Messrs. Fuller, Horsey, Sons & Cassell, 11, Billiter-square, London, E.C., and tenders must be delivered at their offices by noon of Friday, Aug. 6.

Patents Development.—The proprietors of the following patents are desirous of granting licences or entering into other arrangements to ensure their full development in this country.

No. 1,863/1900 for "Improvements in Coils or Helices for Electrical Purposes." No. 1,864/1900 for "Improvements in and relating to a Method of Winding Coils or Helices for Electrical Purposes." No. 5,257/1900 for "Improvements in Apparatus for Winding or Producing Coils, Bobbins, Helices or the like for Electrical and Other Purposes." Nos. 6,873/1904 and 9,397/1904, both for "Improvements in and relating to 'Clusters' for Incandescence Electric Lamps." Applications to Messrs. W. E. Heys & Son, 51, Deansgate-arcade, Manchester.

No. 18,842/1907, relating to "Means for receiving intelligence communicated by electric waves." Apply to Messrs. Cruikshank & Fairweather (Ltd.), 65-66, Chancery-lane, London, W.C.

Holiday Jaunts.—There are few Englishmen who would not wish to make a pilgrimage to the birthplace of Shakespeare, and realising this fact the Great Central Railway Co. has made the visit an easy one : either from London or the north there is no better means of reaching Shakespeare's land. The railway company issues tickets which include rail journey, drives and luncheon. A postcard to Publicity Department, 216, Marylebone-road, N.W., will secure a copy of the illustrated Shakespearean souvenir which has been specially prepared to inform and interest visitors to Stratford-on-Avon.

CATALOGUES, &c.

THE "FLIP-FLAP"—*Correction.*—Our note under this heading last week contained an error. It was stated that a 100 H.P. motor, driving the "Flip-Flap" at the Imperial International Exhibition, was supplied by the Electric & Ordnance Accessories Co. As a matter of fact the controller for this motor was supplied by the latter company, the motor itself having been supplied by the Lancashire Dynamo & Motor Co.

D.P. BATTERIES.—The latest contribution to storage battery literature is a brochure issued by the D.P. Battery Co., of Bakewell, Derbyshire, which deals with storage battery economy from both the technical and financial points of view and contains several interesting photographs and curves, showing plant in use with D.P. batteries. This pamphlet should be useful.

ERITH STOKERS.—From the Erith Engineering Co. we have received a pamphlet dealing with their patent grateless stokers. This apparatus is fully described and illustrated, and various subsidiary plant designed for use in connection with them is also dealt with. It is interesting to note that this company have supplied the stokers and fan used in connection with steam raising plant at the Port Huron tunnel, where the load varies very greatly.

X-RAY EQUIPMENT.—Messrs. Siemens Bros. & Co.'s well-known catalogue on X-Ray equipment generally has received two additions in the shape of pamphlets dealing with "X-Ray outfits with rotating high-tension rectifiers," and "New protective devices and accessories for X-Ray work." In both cases the apparatus is fully illustrated and described. The technical information takes up most of the

pages, the necessary but more sordid financial data being kept separate.

CURTIS STEAM TURBINES.—The steam turbine is at the present time an important part of electrical engineering economy, and it is interesting to receive from the British Thomson-Houston Co., a list of the Curtis steam turbines which are already installed or in course of construction. From this it appears that the first vertical turbine installed in this country was a 1,500 kw. two-phase machine, erected at the County of London Electric Supply Co.'s City-road station in November, 1905. Other similar sets have been erected at this company's stations in the City-road and at Wandsworth, the last being a 2,500 kw. two-phase machine. Those interested in turbine development should secure a copy of this pamphlet.

"SUN" GLASS WARE.—We have received from the Sun Electrical Co., a catalogue illustrating and describing their glass shades for electrical fittings. In addition to the usual stock patterns, it includes a wide range of novel and artistic designs. The company have in fact done their utmost to cater for all classes and types of fittings used at the present time, or likely to be employed in the future, and we hope that they will obtain the due reward of their enterprise.

ELECTRIC LIFTS.—Mr. C. Herrm. Findeisen, of Chemnitz-Gablenz, sends us a catalogue dealing with the interesting subject of electric lifts for all purposes. All the necessary details are given in English, French, German and Spanish, so that the same pamphlet is available for a numerous clientele.

Mountain & Gibson (Ltd.)—We are informed that at the creditors' meeting on Monday a resolution was passed authorising Mrs. Lemon, a creditor for £2,000, to apply to the Court for the appointment of Mr. A. Whittaker, C.A., 3, York-street, Manchester, to act with Mr. Bowden as joint liquidator together with a committee of inspection. The application will be made on Monday next at the same time as the adjourned hearing of the petition.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

June 5, 1909.

13,177 PAPE. Sparking plugs.
13,220 SIEMENS BROS. & CO., HANDCOCK, DYKES & RAWLINGS. Sheathing of insulated electrical conductors.
13,228 BASTIAN. Incandescence electric lamps.
13,231 ALLGEMEINE ELEKTRICITATS-GES. Brush-holders for dynamo-electric machines. (Date applied for, 6/6/08.)*†
13,234 CLAIRE. Clutches for electric automobiles. (Date applied for, 27/6/08.)*†
13,238 LAURIE-WALKER & NIBLETT. Ploughs for electric tramcars.

June 7, 1909.

13,250 TAYLOR. Charging and discharging secondary batteries or electric accumulators.
13,253 CATTELL & HOOKHAM. Electrolytic meter.
13,295 NATHUSIUS & WESTDEUTSCHE THOMASPHOSPHAT G.M.B.H. Electric furnaces. (Addition to No. 71,88/08.)*

June 8, 1909.

13,391 CLARKE. Incandescent electric lamps of the "Nernst" type.
13,433 ENGEL. Electric fuses.*
13,442 BERRY. Electric switches and switch fuses.
13,443 BERRY & MARKHAM. Protected or armour-clad electric switch fuses.
13,450 DELON. Converting alternating P.D.s into high continuous P.D.s. (Addition to No. 1,070/09. Date applied for, 13/6/08.)*†

June 9, 1909.

13,473 KENT. Mercury or metallic vapour lamps.
13,506 BOULT. (Electrizitäts Akt.-Ges. vorm. Kolben & Co., Germany.) Firing or charging indicators for furnaces.*
13,509 WILSON & WILSON. Spark coils.
13,523 SCHRÖDER. Electric alarm clocks. (Date applied for, 3/2/09. Comprised in No. 2,596/09, dated 3/2/09.)
13,526 MUIRHEAD & SMITH. Magnetos for the purposes of ignition in internal-combustion engines.
13,527 STONEHAM. Electric incandescent lamps.
13,528 GORHAM, DRAKE & D.P. BATTERY CO. Resuscitating electric accumulator plates.
13,532 STOKER. Electrical accumulators.
13,560 MIDGLEY & VANDERVELL. Dynamo-electric machines.
13,573 MARKS. (John Lewis Milton, U.S.) Generation of currents.*
13,576 HARVEY & BASS. Covering for electric cables and other like articles.*

June 10, 1909.

13,590 DONOVAN. Electric starting and regulating switches.
13,612 KEMBLE. Joining of metal to porcelain or other non-conducting materials.
13,655 B.T.-H. CO. & RICHARDSON. Switchboards.
13,661 SCHWEIGER. Electric contacts.*

June 11, 1909.

13,701 TAYLOR. Charging and discharging secondary batteries or electric accumulators.
13,728 SCHUBR. Arc lamps.
13,734 LAKE. (F. Bissel Co., U.S.) Controlling mechanism for electric motors. (Date applied for, 12/1/09. Comprised in No. 758/09.)*
13,749 & 13,750 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*
13,762 & 13,763 PECK. Alternating electric current distribution systems. (Date applied for, 15/7/08. Comprised in No. 15,047, dated 15/7/08.)
13,771 ADAMS-RANDALL. Telephones.
13,786 LINKE. Fixing electric conductor wires on insulators.*
13,798 ALLGEMEINE ELEKTRICITATS GES. Power transmission systems. (Date applied for, 12/6/08. Addition to No. 11,339/09.)*†

COMPANIES' MEETINGS AND REPORTS.

National Telephone Company (Ltd.)

The forty-fourth ordinary general meeting of the company was held at Hamilton House, Victoria Embankment, yesterday, Mr. GEORGE FRANKLIN in the chair.

The SECRETARY (Mr. Albert Anns) having read the notice convening the meeting and the auditors' report,

The PRESIDENT said: Turning to the accounts you will see that for the June half of 1909 the income in respect of the business is £1,546,837, as compared with £1,452,569 in the corresponding half of last year. That gives us an increase of income of £94,268. This increase is less than in several preceding half-years, and indicates a check in the rate of progress, largely due to depression in trade, and to some extent to the necessity which the company is now under of making its capital expenditure coincide with the needs of the remainder of its licensed period. The Post Office Royalties have increased from £139,531 to £148,951, an increase of £9,419, with regard to which there is hardly a word to be said excepting the chronic complaint always made at these meetings since I can remember them, of an unjust charge imposed upon the company, and imposed upon the telephone industry—because that is what it is, an unjust charge imposed on the telephone industry without sufficient justification. (Hear, hear.) The net income is therefore, you will see, £1,397,886, as compared with £1,313,037 an increase of £84,848, after deducting the Royalties.

The working expenses amount to £893,767, as compared with £828,969, an increase of £64,798. Apart from the ordinary expenditure which is due to the growth of the business, and which must keep step with it, we have special items of expenditure, as, for example, the increase in rates, to which I referred at the last half-yearly meeting, and the increase again at this half-yearly meeting is £5,843. That increase is due on the one hand to the cupidity of local authorities in regard to their assessment, and on the other hand, with regard to their expenditure, which some of us consider is extravagant, especially when it is borne in mind that a company like this, paying scores of thousands a year in rates, has absolutely no voice or representation in the expenditure to which they are compelled to contribute. Then we have this half-year's extra outlay in maintenance and renewal of lines and instruments, including replacements, £10,148. One item which goes to swell our expenses is the item of rent and maintenance of Post Office wires. This amounts to £42,679, and may be compared with £27,619 a year ago. This is a substantial increase, and it is due to the fact that we have to pay rent and some contribution for capital which the Post Office have laid out, which capital is practically lines, wires, and so forth leased to the company. The bearing of it will be seen when we turn to the percentage of working expenses, because you will notice that it is really in the nature, to a large extent, of a capital charge, for if the money had been provided by the shareholders, it would have been taken away in the form of interest, and it would not have come in the form of a working expense. The only point in it for the moment is that we may say our working expenses have increased from 63·13 to 63·93 per cent. You will bear in mind that both these sums, the amounts paid to the Post Office, are included in these working expenses, whereas, strictly speaking, they are not working expenses, at least, not the whole of them, but only rather a capital charge. If now we look at the net result for the half-year, you will see that the amount is £504,118, as compared with £484,068, giving us a net increase of £20,050, of which £12,954 is absorbed by the debenture and other interests, which have increased from £121,652 to £134,607. The preference and other dividends remain as before, and the contribution to your reserve fund has increased from £140,000 to £150,000. The balance carried forward of £11,100 compares really with £10,676, which was the estimated balance we were carrying forward at this time last year, but which you will notice has been corrected by the results in the December half-year, and when it was absolutely ascertained, which was some time after our meeting, instead of being £10,676, that balance amounted to £14,104. The rentals for unexpired terms pursue their upward course, as one would expect, and now amount to £1,366,283, as compared with £1,314,591, an increase of £51,692. That, at all events, is an indication that the business, although nearing the termination of the licence, still continues its upward growth, because this £1,366,283 represents revenue which has been collected or debited from subscribers, and will come into the current half-year or into the half-year following it.

If now we turn to the capital account you will see we begin with the amounts expended during the last six months, £313,393. That compares with £496,584 in the corresponding half-year, a reduction of £183,191. This points to the restriction in capital expenditure now going on, and which may, perhaps, be best illustrated by looking at the figures for four half years. In December, 1907, the amount on lines and instruments was £545,752; in June, 1908, £496,583; in December, 1908, £361,079, and in June, 1909, £313,393. This reduction may from the shareholders' point of view be considered satisfactory, and is due to the necessity of spending only such capital as will be reproductive within the period of our licence. At the last half-yearly meeting, I referred at considerable length to this subject, and I stated that the company had offered to the Postmaster-General to favourably consider any proposals for the provision of plant for 1912 and subsequent years which might ensure the company against loss in providing for Post Office requirements. I think I may say that this offer, in part and only in a small part, meets with the approval of the Postmaster-General. I can only say that the position which the Board took when they made their offer to the

Postmaster-General still obtains. Of course, this is always provided that such capital, and the full cost of such capital, is to be borne by the Postmaster-General, and that no further burden is cast upon the shareholders of the company. (Hear, hear.) If we follow on the capital account, we see that land and buildings have absorbed £808,747, as compared with £685,310 a year ago, and that we now have a total expenditure of £15,526,179.

The total expenditure upon construction plant amounts to £14,717,432. The number of stations to-day—that is the real test of the size of the concern—is 489,747, compared with 463,864 a year ago, so that we have an increase on the year of 25,878 stations; and if we divide our capital expenditure upon lines and instruments by the number of stations, we find that every station stands in our books at the modest cost of £30. 1s. per station.

Now, you may say, "How has that capital been provided?" If you turn to the credit side of the account, you will notice £7,500 000 has been raised in stocks, preferred and deferred, and preference shares, and that £3,983,593 has been raised in debenture stock. That amount has increased during the past year by about £262,000, and the balance which represents over-expended capital—that is, money of a capital nature which the Company have expended in excess of the monies the Company have raised in the form of capital—amounts to £4,042,586. As to stock of materials last half-year, I had to report a satisfactory decrease, and this half-year we have another decrease. The amount is now £325,229, as compared with £365,929. The remaining assets are pretty well normal, with the exception of loans on securities and cash in hand, which are some £69,000 more than they were at this period of last year, and also the creditor and debtor balances. On looking to the balance-sheet, what strikes us on the debit side is reserve fund account, £3,076,381, and if we add to that the £150,000 which is to be to-day transferred to it, we shall have a reserve fund of £3,226,381. The balance-sheet will show you that this large sum of money is invested in the business. This telephone business is always requiring the expenditure of new capital.

The chairman proceeded to refer to the litigation between the Company and the Post Office regarding the position of (A) and (B) lines in relation to the question of royalties. The proceedings showed in the Court of Appeal that the Company were right in their view, because the Court of Appeal upheld the Company's contention, but the appeal to the House of Lords by the Postmaster-General reversed that decision, and decided entirely in favour of the Postmaster-General. We went into this litigation with our eyes open and half-year by half-year provided in our accounts, out of profits, for the royalty which might be claimed ultimately. In this way, therefore, the accounts for this current half-year are not in any way adversely affected, nor will they be in future half-years by this adverse decision.

The shareholders may have noticed an important statement made by the Postmaster-General in the discussion of the Post Office Estimates to the effect that an earlier purchase of the Company's property and plant than that provided for by the purchase agreement of 1905 was from the public point of view advisable. I can only say that following upon that statement in the House of Commons, there have been certain *pourparlers* between the Post Office and the Company, but the Company await definitive proposals, which proposals will be carefully considered by the directors in the light of their obligations under the agreement of 1905 and in the light of their duty to the shareholders. The chairman proceeded to describe as pure fiction certain reflections upon the efficiency and uptodateness of the Company's plant and service. The Company's plant will be found to be in accordance with the specification required by the Government in 1905, when we entered into our agreement, and it seems to me that, as far as we can judge, the Company's plant was never in more efficient condition than it is to-day, and certainly there never was a time when we were spending more upon our plant in maintenance than the Company are doing to day. The effect of such obviously unfair and inaccurate statements was shown by a rise of $1\frac{1}{2}$ in the price of the company's deferred shares on the stock exchange. We have during the year installed 14 new central battery exchanges in entirely new premises, providing for the needs of such places as Hillhead (Glasgow), Greenock, Manchester City, Manchester, Rusholme, Cambridge, Dalston, Bradford, Birmingham and Gerrard (London), and at the present moment there are buildings and switchboard apparatus in hand for some 16 other places, and provision is being made for the equipment of 25,000 direct exchange lines. This is our reply to the statements made in Parliament. With regard to any proposals which may be made, we maintain an open mind. If they are found to be in the interests of the Company we shall not fail to come to you and recommend them to your notice.

I now move the adoption of the report and accounts and the declaration of the dividends set out therein.

The VICE-PRESIDENT (Mr. S. H. Sands) seconded the motion, which was carried unanimously; and resolutions were afterwards passed re-electing the retiring directors and auditors, and according a hearty vote of thanks to the chairman, the directors, and the staff.

United River Plate Telephone Co. (Ltd.)

The 23rd ordinary general meeting was held on Tuesday, Sir Irving Courtenay presiding.

The SECRETARY (Mr. David Smith) read the notice calling the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, the steady growth and development of the Argentine Republic which has been a feature of recent years continues, and is reflected in every department of our business, resulting in an increase both in gross income and net profit. During the past year we have added considerably to the number of our subscribers, both in Buenos Ayres and the provinces. We have opened new exchanges in Dolores, General Paz, General Belgrano, Nueva Roma, Lobos, Balcarce and Canuelas, all important centres. We have also started work on the extension of our main southern line from General Belgrano to Azul, a line which is, we hope, destined eventually to be carried to Bahia Blanca, and to become one of our most important trunk routes. Further, we have, in response to strong and influential demands, authorised the extension of another section of our southern line from Dolores to Mar del Plata, the Brighton of Argentina. There is, besides, a scheme on foot to make this one of the centres of the export trade. Our trunk lines, giving our subscribers facilities for communicating with the capital and with other towns, have been an important feature in our progress, and toll line receipts from this inter-city traffic are growing most satisfactorily.

During the year we have continued our work of extending our subways in Buenos Ayres and reconstructing our overhead circuits for common battery working. The three new exchanges in that city on the common battery system give great satisfaction to our engineers and to the general public, and we are now busily engaged in altering our Avenida building, our principal exchange in Buenos Ayres, to receive a new common battery board which we hope to have working within the next few months. In the beginning of the present year Sir John Gavey visited Buenos Ayres, and he reports that the new boards already installed have resulted in an appreciable improvement in the service. Besides our subway work in Buenos Ayres we have also done a considerable amount of similar work in Rosario, Cordoba and Bahia Blanca.

As to the accounts. Our capital is increased by £100,000, the amount of the issue made in April, 1908. Sundry credit balances are considerably larger, partly owing to the large amount of work in hand, and to the general expansion of the business. Subscriptions paid in advance have increased by about £3,000, a satisfactory feature. The reserves remain at the same figures. We propose, however, this year, to increase the reserve by £25,000. The Directors feel very strongly, and have no doubt the shareholders will agree, that, in view of the continual expansion of the Company, it is necessary to build up the reserve. Turning to the assets, we have expended £119,590 on capital account. Last year we wrote £25,000 off the special replacement account, but this year it has again increased to £35,138, and as the work of conversion is still proceeding we propose this year to write off £32,000 from this account, which will give us a fairly clean slate. We have increased our real estate by £4,500, representing land for the new exchanges with the buildings erected thereon, as well as some additions to our existing buildings. Our securities are considerably increased, part of the last issue having found a temporary resting place in this account. With the calls for construction work to which a Company like ours is liable, the directors feel that a reasonably large sum should always be kept in this account, available for immediate use. Our investments have been carefully chosen and well spread, and they represent a market price in excess of the figure at which they stand in the balance-sheet. Our stock of materials is some £600 under last year's figure, and cash in bank and bills receivable are about £5,000 less. Profit and loss shows an increase in receipts and expenditure in the Argentine of £36,300 and £23,000 respectively. The cumulative result is that there is an increase in net profit for the year of about £12,700, and I venture to think you will find these results satisfactory. We owe them largely to the skill and energy put into the business by our staff, and as our staff are forming a provident fund in Argentina, towards which they will themselves subscribe for the purpose of mutual help in sickness or misfortune, the directors believe the shareholders will be glad to follow the excellent example set by other public companies, and make a donation of £2,000 out of the profits towards such a laudable object. We have to deplore the loss of our valued colleague, Mr. Le Rossignol, and also of Dr. Ramon Santamarina, a member of the consultative committee in Argentina. We have been fortunate enough to secure in his place his brother, Senor Antonio Santamarina. To provide for the increasing wants of our business it will be necessary to make a new issue of capital in the autumn of £150,000. It is too early to enter fully into particulars, but I have no doubt the terms will be acceptable to the shareholders. The directors recommend a final dividend of 5 per cent. on the ordinary shares (making 8 per cent. for the year, tax free), and I now move the adoption of the report and accounts.

Mr. FREDERICK GREEN seconded the motion, which, after a few remarks, was carried unanimously.

The retiring director, Mr. George Keith, and the retiring auditors, Messrs. Welton, Jones & Co., were then re-elected.

The CHAIRMAN then said: I wish to propose a resolution which I feel sure will meet with your most cordial acceptance. It is that a hearty vote of thanks be accorded to our consultative committee in the Argentine as well as to the manager and staff there, and also to Mr. David Smith, our excellent secretary, and the staff in London. I have already expressed our full appreciation of the services of all those who are connected with the company in the Argentine in the anxious times they have gone through during the past year, and I do not think I need say more.

Sir JOHN GAVEY seconded the motion and said: I had the pleasure of inspecting our works in the Argentine Republic in the course of last winter, and I was strongly impressed with the devotion to the company's interests and with the energy in administering its affairs which I observed both on the part of the consultative committee and of the very energetic officers who carry out our work in the Republic. We owe them a very great debt of gratitude. With regard to the services of our energetic secretary and his staff in London, I am sure we fully appreciate them.

The resolution was carried unanimously, and a very hearty vote of thanks to the chairman and directors was proposed by Mr. Gamble and seconded by Mr. Kingsbury. After acknowledgment by the chairman the proceedings terminated.

CENTRAL LONDON RAILWAY CO.—Subject to audit, the directors have declared the following dividends for the half-year to June 30: On the undivided ordinary stock, 3 per cent. per annum; on the preferred ordinary stock, 4 per cent. per annum; on the deferred ordinary, 2 per cent. per annum is provided and carried forward, together with £39,000. The distribution on both stocks was at the same rates last year, when £29,125 was carried forward.

CHATHAM & DISTRICT LIGHT RAILWAYS CO.—The directors' report and accounts for the half-year ended June 30, show receipts £20,363. 1s. 5d. expenses £12,820. 12s. 5d. After deducting rent of Rochester Corporation lines £1,871. 16s. and debenture interest £1,234, and adding balance brought forward, 1908, (£233. 5s. 3d.) there is a balance of £4,669. 18s. 3d. The directors recommend that £2,940 be applied to payment of the preference dividend and that £1,729. 18s. 3d. be carried to revenue new account.

CROMPTON & CO. (LTD.)—The directors' report for the year ended March 31 states that the depression in trade and the resulting keen competition, has rendered the obtaining of remunerative orders very difficult, and a certain amount of work has had to be undertaken at a very small margin over cost. Net profit is £10,051. 10s. 4d. (compared with £31,320. 10s. for the previous year). After providing for debenture interest and other charges, there remained, with the sum brought forward, an available balance of £7,827. 15s. The directors propose to set aside £1,500 for doubtful debts and contingencies and to carry the balance forward. The lamps connected to the mains of the Electric Supply Corpn. undertakings during the year ended December last increased approximately 20 per cent. The guarantee as to the earnings of the Electric Supply Corpn., which expires in December next, will not, so far as the Directors can foresee, necessitate any further increase in the company's interest in the guaranteeing company.

The dulness of trade continues, although there are some indications of improvement. The directors have in view some important orders which, it is hoped, will be secured at satisfactory prices. During the year a patent has been obtained for a new auto-converter, invented at the company's works. Orders for these machines are now being executed, and it is anticipated that the invention, for which there is a large field, will prove of considerable importance to the company's business. With a view to obtaining fresh capital until such time as the company can profitably reduce its holdings in other concerns, an offer of short term notes was made to the shareholders in February last, and the directors are now offering elsewhere the balance unapplied for. It is proposed, in future, to close the accounts of the company's foreign branches at Dec. 31 in each year, instead of March 31 and this course has the approval of the auditors.

DIRECT UNITED STATES CABLE CO. (LTD.)—The revenue for the half-year ended June 30 (after deducting out-payments) amounted to £56,444. 18s. 1d., compared with £51,367. 11s. 5d. for the corresponding period of 1908, an increase of £5,077. 6s. 8d. Working and other expenses for the same period (including income-tax) amounted to £25,035. 17s. 3d., leaving a balance of £31,409. 0s. 10d. as net profit, making, with £4,506. 4s. 2d. brought forward, £35,915. 5s. For the corresponding period of 1908, the working expenses and other payments amounted to £24,932. Three quarterly interim dividends of 4s. each per share, amounting to £36,426, have been declared and paid during the financial year, and a final dividend of 4s. per share is now proposed, together with a bonus of 1s. per share (both tax free), making, with the three interim dividends, 4¼ per cent. for the year, a total distribution of £51,603. 10s. After transferring £5,000 to reserve, the balance of £3,595. 15s. is proposed to be carried forward. The reserve fund account has been debited with £13,857. 6s. for cost of cable maintenance, and after being credited with interest on the investments, profit on sale of securities, and amount transferred from revenue, the balance now amounts to £510,267. 0s. 11d.

EDMUNDSONS' ELECTRICITY CORPN. (LTD.)—At the annual meeting on Thursday last Mr. P. D. Tuckett said the gross profit was down by £5,234, the main cause being the reduced capital expenditure of the sub-companies. The net profit was only a bare margin over the amount of debenture interest. The conditions of the past year had been peculiarly adverse to all similar businesses and their progress in the future was not likely to be other than slow. He doubted whether the very moderate cost of electric light under existing conditions was as fully realised as it deserved to be.

GENERAL ELECTRIC CO. (LTD.)—At the meeting on Monday the chairman (Mr. G. Byng) said they had made a larger profit this year than last. They had written off more for depreciation at their works and had placed to the credit of reserve a larger sum (over £16,000). The margin of security of the preference shareholders had thereby been materially strengthened and had more than doubled since the company was incorporated nine years ago. In spite of such undoubted security he was sorry to see their preference shares quoted at a discount. The income from their investments did not vary much; it had resulted in a return of about 10 per cent. The pressure of competition at home forced them to seek orders more and more abroad. Unfortunately, Customs duties were against them. After having spent money in pushing their manufactures, the duties were suddenly raised against them. From a purely technical point of view all their works had done well. Their engineering staff at Witton had especially distinguished itself. They had installed a larger number of big plants. They had proved very successful and had greatly enhanced the reputation of their Witton works, strengthening their position in the foremost rank of electrical engineering firms. Their carbon works were largely occupied with making flame arc carbons. Theirs was the only factory in England where such carbons were made. They had succeeded in competing with continental firms. For that great credit was due to the energy and skill of the manager and staff of that factory. All their batteries, porous pots and dry cells were now made at Witton. They had added a large welding plant to their tube works, and their art metal works at Sherlock-street, Birmingham, were making heating stoves and radiators, in addition to electric light fittings. They had considerably extended their telephone factory at Peel Works, and he was pleased to record that the telephone equipments produced at those works had been adopted by the Home and Colonial Governments, and were considered an advance upon those made by the most prominent manufacturers in America and on the Continent. The sale of Osram lamps had been large, and experience had proved that the marvellous economy and durability claimed for that invention were entirely justified. No invention since the advent of electric lighting had produced an equal effect. Generally speaking, they could not be dissatisfied with the year's working. The foundations of their company were good, and also, he believed, its management, but they suffered, as almost everybody did, from a general trade depression. They had seven large factories and every one of them could give an increased output without any material increase of capital or of general expenses beyond the payment of more wages.

MADRAS ELECTRIC SUPPLY CORPN. (LTD.)—The directors' report for the year ended Dec. 31 states that the contractors have not yet completed their work, but the buildings and equipment of the main generating station, the sub-station at Mylapore and the tramway sub-station are practically finished. The construction of the main generating station had been so far completed on April 3 that the supply of electricity to the public was commenced from the permanent plant, and it is hoped shortly to supply current to the tramways company, who are to take a minimum of 1,000,000 units per annum. Agreements for the supply to the Port Trust and to the Government buildings have been drafted and are now being considered. The grant of new licences for the supply of current to Fort St. George and the Port Trust is expected shortly. In anticipation that there will be a large demand for electric fans, to take the place of punkahs, which are used for the whole year in Madras, the directors sent out a considerable number to sell or hire out. The temporary oil engine plant is being dismantled. The supply to the public commenced with 5,200 equivalent 8 c.p. lamps connected to the mains, and many applications from other consumers have since been received. The company has recently received a dividend at the rate of 5 per cent. per annum (including ½ per cent. out of surplus profits) on its investment in the 4½ per cent. preferred ordinary shares of the Madras Electric Tramways (1904), Ltd.

METROPOLITAN RAILWAY CO.—The directors' report for the half-year to June 30 states that the total receipts were £379,487 and the expenses £193,243, leaving a profit of £186,243. Compared with the corresponding half-year of 1908, the receipts show an increase of £22,700 and the expenses a decrease of £6,536. The expenditure is at the rate of 56·25 per cent. of the total traffic receipts, compared with 60·36 per cent. After providing for the interest upon the debenture stocks and other fixed charges and for electrical depreciation, the balance is £137,075, which will permit of the payment of the dividends upon the preference stocks and leave £32,564. The directors recommend a dividend upon the ordinary stock for the past half-year at the rate of £1 per cent. per annum and to carry forward £3,904. The development of the passenger traffic resulting from the improved train services and through bookings with the tube railways has been well maintained, while the new express parcels service which was brought into operation at the beginning of the year has also been very successful, and has attracted a large amount of new business. The electrical plant and machinery have worked very satisfactorily throughout the half-year, and the current is still produced at a low rate per unit. The installation of automatic signalling on the Inner Circle is now practically completed, and has resulted in greatly improved punctuality in the running of the trains.

MEXICAN LIGHT & POWER CO. (LTD.)—The report for 1908 states that the actual and prospective demands for power in the centres of consumption supplied had increased beyond expectations, and to meet those demands it had been decided to double the capacity of the present hydro-electric plant at Necaxa during the next three years, and to bring into the Necaxa Basin, by a series of diverting and storage dams, canals and tunnels, the waters of the Lower Tenango, Nexapa and Catepuxtla rivers. The advent of cheap electric power to Mexico City and its suburbs and to El Oro and vicinity had so reduced the operating costs of all industrial enterprises located in those places that existing industries had extended their operations, and many new undertakings had been and were about to be established. In some cases during the past year it has been deemed advisable to supply electric energy to customers by the operation of the steam plants during the dry season at a considerable loss, pending the completion of the hydraulic works of the company. The directors have authorised the construction of such new and additional works as are necessary to meet future requirements. The gross earnings for 1908 were $2,938,474 gold, and the operating and maintenance expenses $1,080,570 gold. Out of the earnings of the past year 3½ per cent. has been paid in dividends on the ordinary shares, and on Dec. 31 last a balance of $910,823 gold was carried forward.

MEXICO TRAMWAYS CO.—The net revenue for 1908, after paying expenses and fixed charges, was $459,649, which, added to $151,701 brought forward, made $611,350. Four quarterly dividends, each at the rate of 4 per cent. per annum, were paid, leaving $371,350 to be

carried forward. $1,027,294 has been spent on capital account, extensions, improvments and the general equipment of the tramways.

NATIONAL TELEWRITER CO. (LTD.) The statutory meeting was held on Thursday last week, when Sir W. P. Treloar, who presided, said the number of shareholders was 550, and the list showed that a widespread interest was taken in the telewriter. Undoubtedly, the instrument was destined to effect a revolution in our methods of communication. Its use, either alone or in conjunction with the telephone, was permitted by the Postmaster-General throughout the kingdom. Their licence provided that the company might erect exchanges. The telewriter was not intended to supersede or to supplant the telephone, but to act as a complement to it. The licence also provided for the transmission in writing or drawing of parliamentary, sporting, Stock Exchange, and general news, and it allowed a telewriter being supplied on all private lines rented from the Post Office. An important provision was that which permitted the company to carry on its business with a comparatively small outlay of capital—that was, that the Postmaster-General would provide all wires and wayleaves required for the exchanges throughout the kingdom. Complete arrangements had been made with the National Telephone Co. The licence was for 21 years, and the Post Office had the right to purchase their undertakings on the same terms as the National Telephone Co.'s business. The instrument was earning rentals at many establishments in London, and a large number of inquiries had been received from all parts of the United Kingdom. The company had ordered a large supply of instruments, and hoped soon to have an exchange in the City. They would soon be at work, but they hoped the shareholders would not be impatient.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)—The profits for the first six months of the current year amount to £47,759. After including balance from last year and deducting interest on loans, debentures, &c., there remains £41,704. The directors have decided to pay an interim dividend on the preference shares of $2\frac{1}{2}$ per cent., absorbing £17,187. 10s. The balance (£24,516. 10s.), though subject to deductions for depreciation and a sum to be carried forward, would permit the declaration of a small interim dividend on the ordinary shares, but in view of the critical position of the coal trade, and the possible stoppage of and damage to other trades which may follow therefrom, the directors do not think it prudent to deal with the balance before the end of the year.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—At the annual general meeting on Friday, Mr. H. Birchenough, C.M.G., who presided, said that owing to the fact that they had, during the past year, been mainly occupied in construction work, and only supplied current from the old stations, a profit and loss account was not submitted. After paying interest on debentures allotted in part purchase of the Rand central station, and providing for general expenses and depreciation of stores, furniture, &c., the account showed a surplus of £48,177, compared with £36,685 last year. Their temporary contract for the bulk supply of electricity to the City of Johannesburg expired in the middle of the year. The board had thought it wiser not to pay any interim dividend upon the preference shares for the first six months of this year. In the long run the preference shareholders would not suffer, as their dividends were cumulative. Their business had developed from one of medium size and importance into one of the largest electrical power businesses in the world, with an assured and permanent connection. The company acquired from Mr. Harper a conditional agreement made by him with the Rand Mines, under which 15 mining companies would contract to take the whole of their power requirements. This agreement was originally for 12 years, but they were successful in negotiating an extension of the contract from 12 to 20 years. The annual power requirements of those mines were estimated at 270,000,000 units. Negotiations had also been successfully carried out for the prolongation of the contract with the Consolidated Gold Fields of South Africa from 10 years to 12 years, and important contracts had been entered into with other mining groups, including the Johannesburg Consolidated Investment Co. An agreement was negotiated and entered into with the German banks for the subscription of £900,000 5 per cent. debentures, and £900,000 preference shares issued in London. The capital now consisted of £1,000,000 ordinary shares, £1,700,000 preference shares, and £1,700,000 debentures. The Rand Mines Power Supply Co. had been formed to operate the Eckstein contract, and supply power in bulk to the Victoria Falls & Transvaal Power Co. It had a capital of £1,500,000, including borrowed capital of £1,000,000. The whole of the 500,000 £1 shares of that company were being subscribed by their company, which would also advance the borrowed capital.

They had before them, however, the prospect of immediate and dangerous competition. If a powerful competing company had been established, it would undoubtedly have led to a severe rate war. Thanks to the success of the negotiations he had referred to, cut-throat competition had been avoided, and the result would be that their undertaking, which a year ago had a revenue of £160,000, with scope for increase up to £200,000, would have a revenue of £800,000 a year as soon as the necessary machinery was ready for commercial use. Subject to approval the board had fixed the remuneration of Lord Winchester, as chairman and member of the executive committee, at £3,000 a year.

Sir Charles Metcalfe said he had just returned from visiting the works in South Africa, and everything was working well and smoothly. They had now something like 12,000 kw. in active work, and by that date next year they would have more than double. The question of the transmission of power from the Victoria Falls, which was what they originally thought of, was rendered enormously difficult, owing to the hostile attitude of the people in the Transvaal, who were having their coal used by the various companies, and also of the railway companies, who derived a great deal of their income from the carriage of coal. This company had to meet that hostility by deferring the long transmission, though it would give him the greatest gratification to carry it out.

The report and accounts were adopted.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

BRITISH RADIO-TELEGRAPH & TELEPHONE CO. (LTD.) (104,024.)—Reg. July 13, capital £15,000 in £1 shares, to adopt an agreement with J. G. Balsillie, and to carry on the business of manufacturers of and dealers in radio-telegraphic and telephonic instruments and installations, electric and general engineers, &c. Private company.

FIFE TRAMWAY LIGHT & POWER CO. (LTD.) (7,188.)—Reg. in Edinburgh on July 3, capital £200,000 in £1 shares, to acquire all or part of the share capital of the Dunfermline & District Tramways Co. and the Fife Electric Power Co., to construct or acquire light or other railways, electric or other tramways and electric lighting and power supply works, &c.

MORTGAGES AND CHARGES.

ELECTRO-MECHANICAL BRAKE CO. (LTD.)—Mortgage or charge on certain patents for inventions relating to an electro-mechanical brake dated June 7, 1909, to secure not more than £1,500. Holder, G. Law, Jun. Also mortgage on certain book debts dated June 9, 1909, to secure £140. Holders, Metropolitan Bank of England and Wales.

CITY NOTES.

MEMORANDA (July 22).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{1}{2}$d. per oz. Consols $84\frac{1}{4}$—$84\frac{3}{8}$ for money and for account. Consols Pay Day, Aug. 5; Stock and Shares Continuation Days, July 27 and Aug. 10; Ticket Days, July 28 and Aug. 11; Pay Days, July 29 and Aug. 12; Mining Shares Carry Over Day, July 26.

Prices of Metals (London).—*Copper*, cash, $58\frac{3}{4}$; three months $59\frac{1}{2}$. *Lead*, English, $12\frac{7}{8}$—$13\frac{1}{4}$; foreign, cash, $12\frac{9}{16}$—$12\frac{11}{16}$; three months, $12\frac{7}{8}$—13. *Spelter*, cash, 22—$22\frac{1}{8}$. *Tin*, English, 130—132; foreign, cash, $132\frac{1}{8}$; three months, $132\frac{5}{8}$—$133\frac{5}{8}$. *Iron*, Cleveland, cash, 48/6, and three months, 49/$2\frac{1}{2}$. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

AMERICAN TELEPHONE & TELEGRAPH CO.—The net earnings for the past six months, after payment of interest and dividends, were $2,462,000 compared with $2,543,000 for the corresponding period of 1908.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have decided, after placing £5,000 to renewal fund, to declare an interim dividend for the quarter ended June 30 of 15s. per cent. on the ordinary stock and £1 10s. per cent on the preferred stock (less tax) payable July 31, £24,414 is carried forward.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend of 2s. per share on the ordinary shares for the past half-year.

MATHER & PLATT (LTD.)—The directors have declared an interim dividend on the ordinary shares of 5 per cent. (tax free) for the half-year ended June 30, being at the rate of 10 per cent. per annum, the same as in 1908.

MONTREAL LIGHT, HEAT & POWER CO.—The directors have declared a dividend of $1\frac{3}{4}$ per cent. on the paid-up capital stock, being at the rate of 7 per cent. per annum, for the quarter ending July 31.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The directore have declared an interim dividend on the preference shares at the rat of 7 per cent., and on the ordinary shares at the rate of 10 per cent. for the half-year ended June 30. The share transfer books will be closed rom July 24 to Aug. 6 inclusive.

The amount of electricity sold by the Company, during the half-year ended June 30, is returned at 4,826,663 units, estimated to produce £60,697, against 4,802,560 units, which produced £61,635, for the corresponding period of last year.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Aug. 5 a special settling day in a further issue of 39,070 £5 fully-paid ordinary and 39,070 £5 fully-paid 7 per cent. cumulative preference shares of the *British Aluminium Co. (Ltd.)*, and have granted quotations to 640,000 £5 fully-paid 5 per cent. cumulative first preference shares, 500,000 £5 fully-paid 5 per cent. cumulative second preference shares and £1,733,380 $4\frac{1}{2}$ per cent. debenture stock (in lieu of first, second and third preference shares now quoted) of the *Anglo-Argentine Tramways Co. (Ltd.)*.

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—The transfer books will be closed from July 19 to 27, inclusive, preparatory to the payment of an interim dividend of 12s. per share.

VICKERS, SONS & MAXIM (LTD.)—The directors have declared an interim dividend of $2\frac{1}{2}$ per cent. (less tax) on the preferred 5 per cent. stock and 5 per cent. preference shares, and 1s. per share (tax free) on the ordinary shares for the half-year ended June 30.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 14	1,453	+ 114	6	9,117	− 112
Airdrie	,, 9	221	+ 2	27	5,863	− 126
Anglo-Argentine	,, 15	35,323	+ 969	28	1,010,509	+ 61,280
Ayr Corporation	,, 17	467	+ 10	9	2,929	− 151
Baker St. & Waterloo Ry.	,, 17	3,105	− 45	2	6,470	+ 230
Barnsley	,, 9	166	− 14	27	1,478	− 196
Barrow	,, 2	258	− 9	27	5,899	− 456
Bath Electric Trams, Ltd.	,, 14	897	+ 35	23	20,192	+ 619
Birmingham Corporation	,, 17	6,300	− 65	16	103,927	+ 3,182
Birmingham & Mid.	,, 2	841	− 21	26	21,303	+ 22
Blackburn Corporation	,, 14	1,103	− 21	16	18,207	− 519
Blackpool and Fleetwood	,, 17	974	+ 45	2	2,062	+ 203
Bolton Corporation	,, 18	2,435	+ 3	16	37,537	− 531
Bombay	June 17	R37,595	− R2,877	23	R916,962	+ R53,940
Bournemouth Corporation	July 14	1,651	− 53	15	21,878	+ 19
Bradford Corporation	...	...	...	...	...	...
Brighton Corporation	,, 18	1,037	+ 71	16	14,881	+ 805
Bristol Trams & Carriage	,, 16	5,759	+ 229	8	46,416	− 367
Burnley Corporation	,, 17	1,256	− 195	16	20,527	+ 25
Burton Corporation	,, 18	275	− 56	16	4,184	− 132
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	,, 17	R52,246	+ R6,293	2	R195,062	+ R11,954
Camborne-Redruth	,, 17	119	− 4	29	3,523	− 82
Cardiff Corporation	,, 10	2,227	− 39	15	31,652	− 912
Cavehill	,, 9	90	− 6	27	2,095	− 258
Central London Railway	,, 17	5,294	− 2,264	2	10,902	− 3,841
Charing C., Euston & H'stead	,, 17	3,850	+ 570	2	7,840	+ 1,255
Chatham & Dist. Lt. Rys.	,, 15	875	+ 107	23	21,631	+ 1,151
City & South London Rly.	,, 18	3,035	+ 331	2	6,273	+ 383
City of Birmingham	,, 9	4,386	+ 1,510	27	75,476	+ 482
Colchester Corporation	,, 14	201	− 19	2	399	− 61
Cork Electric Trams Co.	,, 15	537	+ 7	28	11,634	− 931
Croydon Corporation	,, 16	1,455	+ 44	15	23,112	+ 63
Devonport & Dist. Trams	,, 9	344	− 111	27	9,817	− 2,237
Dover Corporation	,, 17	235	+ 9	16	3,163	− 346
Dublin & Lucan Railway	,, 16	159	+ 22	‡2	347	+ 9
Dublin United	,, 16	5,682	+ 247	‡2	13,002	− 86
Dudley-Stourbridge	,, 9	833	− 14	27	20,958	− 632
Dundee Corporation	,, 14	1,112	− 31	†9	10,173	− 419
East Ham Council	,, 17	1,026	+ 186	§15	15,816	+ 2,305
Exeter Corporation	,, 16	337	+ 5	16	5,521	+ 565
Gateshead & Dist. Trams	,, 9	997	− 28	27	25,657	− 322
Glasgow Corporation	,, 17	16,962	− 325	‡17	117,591	− 2,715
Glossop Trams	...	...	...	...	...	...
Gravesend—Northfleet	,, 9	239	+ 5	27	5,200	− 219
Great Northern & City Rly.	,, 17	1,325	+ 43	2	2,691	− 38
Gt. Northern, Piccadilly, &c	,, 17	5,470	+ 25	2	11,105	+ 230
Greenock & Port Glasgow	,, 9	479	− 31	27	14,020	+ 124
Hartlepool Tramways	,, 9	276	+ 20	27	5,922	− 149
Hastings Elec. Trams Co.	,, 15	1,166	+ 121	2	2,271	+ 91
Hong Kong	,, 17	$7,653	− $1,724	2	$15,847	− $2,591
Huddersfield Corpn.	,, 17	1,625	+ 76	15	35,854	+ 564
Hull Corporation	,, 17	2,481	− 95	15	33,482	+ 329
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 14	135	− 18	15	2,003	− 167
Ipswich Corporation	,, 17	460	+ 14	16	6,150	− 14
Isle of Thanet Co.	,, 17	1,016	+ 83	§33	15,587	+ 208
Jarrow	,, 9	125	+ 13	27	3,055	+ 254
Keighley Corporation	,, 15	150	+ 8	15	2,823	+ 65
Kidderminster & District	,, 9	137	− 15	27	2,600	− 147
Kilmarnock Corporation	,, 17	155	− 4	9	1,346	− 75
Lanarkshire Trams Co.	,, 15	1,335	+ 100	28	34,501	− 1,700
Lancashire United	,, 14	1,317	+ 1	28	36,615	+ 218
Leamington	,, 9	222	+ 28	27	4,331	+ 170
Leeds Corporation	,, 16	7,290	− 2,485	15	99,849	+ 134
Leicester Corporation	,, 17	2,161	− 129	2	4,406	− 196
Leith Corporation	,, 10	707	+ 103	8	6,023	+ 419
Lincoln Corporation	,, 17	127	+ 12	16	1,983	+ 85
Liverpool Corporation	,, 10	11,766	+ 618	‖27	289,207	− 2,997
Liverpool Overhead Rly.	,, 18	1,434	− 41	‡3	4,416	− 34
Llandudno & Colwyn Bay Ry	,, 16	1,592	+ 7	33	6,448	+ 1,618
*London County Council	,, 3	36,273	− 915	§13	485,934	+ 18,396
London United	,, 19	6,631	− 337	‖31	164,724	− 15,594
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	...	...	...	...	...	...
Manchester Corporation	,, 17	15,218	− 281	16	257,119	− 625
Mersey Railway	,, 17	1,980	+ 101	2	3,913	+ 203
Merthyr	,, 9	233	+ 17	27	5,672	+ 38
Metropolitan Dist. Railway	,, 17	10,136	+ 606	2	20,484	+ 1,532
Metropolitan Elec. Trams	,, 9	7,304	+ 1,031	27	160,591	+ 12,957
Middleton	,, 9	374	− 13	26	8,903	− 694
Nelson Corporation	,, 17	143	...	§15	2,131	− 81
Newcastle-on-Tyne Corp.	,, 17	3,743	+ 36	15	61,565	− 1,330
Newport (Mon.)	,, 17	637	− 32	16	10,552	− 291
Northampton Corporation	,, 16	496	+ 5	§16	7,487	+ 113
Oldham, Ashton & Hyde	,, 9	690	− 15	27	14,929	− 1,017
Oldham Corporation	,, 18	1,904	− 140	16	31,425	− 1,957
Perth (N.B.) Corporation	,, 14	118	+ 6	§4	1,335	− 42
Perth (W.A.) Elec. Trams	,, 16	1,380	− 45	27	40,104	+ 92
Peterborough	,, 9	233	− 14	26	3,041	− 267
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 9	1,892	+ 139	27	47,733	− 1,101
Preston Corporation	,, 7	778	+ 2	1	778	+ 2
Rotherham Corporation	,, 15	533	− 37	15	9,165	− 268
Rothesay	,, 9	435	+ 6	27	3,716	− 96
Salford Corporation	...	...	...	...	...	...
Sheerness	,, 9	52	− 10	27	1,261	− 198
Sheffield Corporation	,, 18	5,718	+ 190	§16	92,773	− 1,112
Singapore Trams	,, 17	$3,360	+ $380	2	$13,933	+ $649
South Metropolitan	,, 9	904	+ 31	27	20,101	− 345
South Staffs	,, 9	918	+ 57	27	22,305	− 1,267
Southend Corporation	,, 14	586	+ 72	15	7,295	+ 1,015
Southport Tramways	,, 9	372	− 4	27	7,294	− 210
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 17	837	+ 17	§15	12,101	− 412
Sunderland Corporation	,, 18	1,220	+ 59	16	18,073	− 668
Sunderland District	,, 14	441	− 22	37	16,525	− 682
Swansea Trams	,, 9	1,025	+ 10	27	24,866	+ 448
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 7	41	+ 2	27	987	− 76
Tynemouth and District	,, 9	353	+ 105	27	5,237	− 14
Tyneside Trams Co.	,, 14	415	+ 39	2	903	+ 72
Wallasey District Council	,, 17	1,099	+ 24	§15	14,712	+ 510
Walsall Corpn.	,, 17	511	− 39	23	14,149	− 1,105
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	,, 8	2,463	+ 223	14	33,787	+ 1,955
Weston-super-Mare	,, 8	266	− 10	27	2,603	+ 129
Wolverhampton Co.	,, 9	417	− 92	27	11,020	− 1,237
Wolverhampton Corpn.	,, 14	884	− 38	2	1,656	− 1,998
*Worcester	,, 8	325	+ 2	27	7,074	− 120
Wrexham	,, 9	103	− 3	27	2,566	− 115
Yorkshire W.R. Trams	,, 18	1,184	− 67	29	33,575	...
Yorkshire Woollen District	,, 9	923	+ 51	27	23,825	− 523

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name	Price Wed. July 21	Rate % Yield-ed.	Dividend Due.	Business Week to July 21 High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½–10½	6 1 9	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝–10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼–10¾	5 11 6	Feb, Aug	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99–103	4 7 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½–4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93–96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8–8½	5 17 0	March	..	8
5	3/6	Do. 7 per Cent. Pref.	8–8½	4 2 6	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97–100	4 0 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4–4½	5 16 0	Feb, Aug	4⅜	4¼
5	2/3	Do. 4½ per Cent. Pref.	4½–4¾	4 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96–99	4 1 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99½–101½	4 9 6	..	99½	99
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅞–4⅛	5 5 0	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3⅞–4⅛	4 9 3	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101–103	4 7 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord.	10¾–11	5 10 0	Feb, Aug	11	10¾
10	6/0	Do. 6 per Cent. Cum. Pref.	12–13	4 12 3	Jan, July	12½	12¼
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121–124	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99–102	4 8 9	Jan, July	..	—
5	..	County of Durham Elec. P. D. Ord.	1¾–2	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3½–3¾	3 17 6	April, Oct	..	—
10	6/0	County of London Elec. Supply Ord.	8⅜–8⅝	5 15 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞–11⅛	5 8 0	Mar, Sept	11	11
St.	4½%	Do. 4½% Deb. Stock (red.)	103–106	4 5 0	Jan, July	104	..
St	4½%	Do. Second Deb. Stock	100–103	4 7 6	May, Nov	101	101
5	3/6	Folkestone Electricity Supply Co. Ord.	4½–5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	98–101	4 9 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7½–7¾	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord.	6½–7¼	6 2 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝–6⅞	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97–100	4 0 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98–101	3 19 0	April, Oct	..	..
St.	4½%	†Kent Elec. Power Co.	83–87	5 3 6	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞–2⅛	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅜–5⅝	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93–97	4 2 6	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅛–4⅜	5 13 0	April, Oct	4½	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞–5	4 10 0	Jan, July	4⅞	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105–108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½–86½	4 1 0	Jan, July	83½	83½
10	4½%	Midland Elec. Corp. for P. D. 1st Mort. Db.	94–97	4 12 6	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4¼–5	4 2 1	Feb, Aug	..	..
10	4½%	Do. 4½ per Cent. Deb.	84–88	5 5 11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4⅝–5	2 10 5	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾–5	5 1 3	Feb, Aug	—	..
10	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97–99	4 1 8	Jan, July	—	..
10	50/	North Metro. Elec. Power Sup. 5 Morts	99–101	4 19 0			
1	3%	Northern Counties Elec. Sup.	—		Mar, Aug	—	..
10	4½%	Do. 4½ per Cent. Deb.	81–91	5 0 0	Jan, July	—	..
1	6/0	†Notting Hill Electric Ord.	11½–12½	5 14 6	March	—	..
1	4/6	Oxford Electric Ord.	5–5½	5 8 0	March	—	—
St	4%	†Do. 4 per Cent. Deb. Stock	93–95	4 4 0	Jan, July	..	..
1	5/0	St. James' & Pall Mall Elec. Ord.	8¾–9¼	5 8 0	Feb, Aug	—	..
1	3/6	Do. 7 per Cent. Pref.	7–7½	4 13 6	Feb, Aug	7⅛	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84–86	3 19 6	Jan, July	85	..
1	..	Smithfield Markets Electric Sup. Ord.	9/16–13/16	..	Feb	..	..
1	4/0	South London Electric Supply Ord.	2¼–3⅛	6 8 0	April	..	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	100½–102½	4 17 6	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	5/16–7/16	4 14 0	..	—	—
1	0 8⅜	Do. 7 per Cent. Cum. Pref.	1 1/16–1 3/16	5 7 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100–103	4 7 6	April, Oct	—	—
5	2/6	Urban Electric Supply Ord.	½–1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1¾–2¼	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	80–84	5 7 3	April, Oct	..	—
5	5/0	Westminster Elec. Sup. Ord.	8⅝–9⅛	5 10 0	Mar, Sept	..	—
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4⅝–5¼	4 8 0	Jan, July	5	—
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	†Baker St. & Waterloo 4% Perp. Db. St	95–96	4 2 0	Jan, July	95	97
1	..	Bath Elec. Trams Pref. Ord.	¼–⅜	..	April	..	..
	0/6	Do. 5 per Cent. Cum. Pref.	1/16–1/8	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87–91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88–91	4 19 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	7¾–9¼	7 1 0	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	7¾–8¼	4 11 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99½–100½	3 19 7	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅛–⅜	..	June, Dec	¼	½
10	8/0	Do. 6 per Cent. Cum. Pref.	2¼–2¾	10 18 0	Feb, Aug	2⅝	2⅝
St.	5%	Do. 5 per Cent. Perpetual Debs.	86–90	5 11 0	April, Oct	85⅜	87
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	66–70	6 9 0	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	61–63	5 11 0	Feb, Aug	61½	..
St.	4%	Do. 4 per Cent. Pref. Stock	83–85	4 14 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	43–45	5 11 0	Feb	..	..
100	4%	†Do. 4 per Cent. Debs.	100–102	4 18 0	Jan, July	102	101½
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	91–93	4 6 0	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼–5¼	4 15 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs	97–101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31½–33½	4 13 0	Feb, Aug	32½	31¾
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	110–112	4 9 0	Feb, Aug	111½	..
St.	5%	Do. (1895)	103–105	4 11 9	Feb, Aug	108	107½
St.	5%	Do. (1901)	103–105	4 15 3	Feb, Aug	..	—
St.	5%	Do. (1903)	93–96	5 4 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	99–101	3 19 0	May, Nov	101	—
10	6/0	Dublin United Trams. 6 per Cent. Pref.	13–14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾–1	..	Feb, Aug	—	..
10	..	G. Northern, Picc. & Brompton 4% G. Pf	8–8½	..	Feb, Aug	.	—
St.	4%	Do. 4 per Cent. Deb. Stock	93–95	4 4 0	Jan, July	95	93½
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1⅛–1⅞	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	75–80	5 12 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	1–1½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5–6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	83–84	5 7 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58–63	6 7 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9⅜–11⅛	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½–90½	6 10 6	Jan, July	..	.
10	..	Liverpool Overhead Railway Ord.	⅛–1⅛	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	5–6	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82–84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2–2½	..	Jan, July	2	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	65–68	5 18 0	Jan, July	67½	65
St.	—	Mersey Con. Ord. Stock	1–2	—	Feb, Aug.	—	..
1	10⅜	Metropolitan Elec. Tramways Ord.	⅜–½	—	..	..	..
1	—	Do. Deferred	1/32–3/32	..	April..	1/16	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3¼–3½	5 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95–97	4 12 9	Jan, July	95	95½
St.	½%	Metropolitan Railway Consolidated	40¼–40¾	1 4 6	Feb, Aug	41¼	39¾
St.	3%	Do. Surplus Lands Stocks	67–69	4 7 0	Feb, Aug	68¼	67½
St.	3½%	Do. 3½ per Cent. Preference	89–91	3 17 0	Feb, Aug	90½	90½
St	3½%	Do. 3½ per Cent. "A" Preference	83–85	4 2 6	Feb, Aug	84½	84¼
St.	3½%	Do. 3½ per Cent. Convertible Pref.	83–84	4 3 6	Feb, Aug	84	83⅛
St.	3½%	†Do. 3½ per Cent. Debenture Stock	92–94	3 14 6	Jan, July	93	92½

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., July 21.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to July 21 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½	†Met Rly. 3½ per Cent. "A" Deb. Stock	91—93	3 15 8	Jan, July	91½	91½
St.	..	Metropolitan District Railway Ord.	17¼—18	—	Feb, Aug	17¾	17⅞
St.	..	Do. Extension Pref. (5 per Cent.)	45—47	..	Feb, Aug	46	44½
St	3½	Do. Asserted Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	65—67	5 4 0	Feb, Aug	66¾	..
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	76—78	3 17 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	101—104	3 16 0	Jan, July	..	..
St.	1¾	Do. Guar. Stock 4 per Cent.	93—96	4 3 6	Mar, Sept	95½	95
St	6	Do. 6 per Cent. Perp. Deb. Stock	159—161	4 5 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	93—95	4 4 0	Jan, July	94½	93½
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—½	—	May	..	—
1	..	Potteries Electric Traction Ord.	1/16—3/16	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	¼—½	6 0 0	Feb, Aug	...	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86—89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70—74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	82—86	5 16 0	Jan, July	..	..
..	...	UndergdF.Rys.Lon.6% In.bds.with coup.8	37—39	..	June, Dec	37½	..
..	5	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	102½
—	4½	Do. 4½% Bonds with coup. 8	87—89	5 1 0	..	88⅝	88½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	83—87	5 3 6	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅜—½	..	..	—	..
1	1/4½	Do. 6% Cum. Pf.	¾—⅞	6 17 0	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.	4¼—4⅜	4 11 9	April, Oct	4 11/32	4 5/16
1	0/7½	Do. Pref.	1⅜—1½	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅜—7⅞	6 9 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	6¼—6⅝	4 10 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103—106	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91—96	4 13 8	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	7/16—9/16	..	Feb, Aug	7/32	—
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97—99	6 1 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38—42	9 10 0	Jan, July	..	..
St.	4½%	BrushE.Eng Co.4½% Perp. 1st Deb. Stock	43—45	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27—31	14 10 0	Jan, July	..	—
5	10/0	Callender's Cable Con. Ord.	9¾—10½	7 3 0	Jan, July	10⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅝—6½	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	104—106	4 6 0	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	1⅞—2	6 6 0	May, Nov	1 15/16	1⅞
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103—106	4 4 0	Feb. Aug	..	..
1	0/1	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	6 11 9	March ..	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1 5/16—1 7/16	5 14 0	April, Oct	..	..
1	0/8¾	Consolidated Electrical Co.	[illegible]	6 4 0	August ...	7/16	..
1	1/0	Consolidated Signal Co.	1⅛—1¼	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	½—1	15 0 0	Jan, July	1	15/16
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	91—94	5 6 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1¼	8 0 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	4 16 9	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99—102	4 8 0	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	[illegible]	5 0 0	Feb, Aug	..	—
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	[illegible]—63	6 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84—87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	†Do. 4½ per cent. 1st Mort. Deb. (red.)	59—62	7 5 0	Jan, July	..	..
2	..	Electric Construction Co.	7/16—11/16	..	Jan, July	½	—
2	2/9½	Do. 7 per Cent. Cum. Pref.	1 7/16—1 11/16	8 0	July	..	..
St.	4%	†Do. 4 per Cent. Perp. 1st Mort. Debs.	63—67	5 19 0	Jan, July	62½	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71—77	6 10 0	...	..	...
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛—7½	6 13 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85—88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	12¼—12½	6 3 0	Feb, Aug	[illegible]	[illegible]
5	2/3	Do. 4½ per Cent. Pref.	5—5½	4 3 6	Feb, Aug	..	—
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105—107	4 4 0	Mar, Sept	..	..
10	5/6	India Rubber, Gut. Per., &c., Wrks.	14½—15½	6 10 0	Feb, Aug	..	..
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—11	..	..	10⅝	..
100	4%	Do. 4 per Cent. Debs. (red.)	99—101	3 19 0	April, Oct	—	—
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	[illegible]	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	81—84	5 7 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1½	—	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5—5½	—	..	..	—
12	24/0	Telegraph Construction & Maintenance	32½—35	5 8 6	Mar, July	34⅛	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99—101	3 19 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	[illegible]	5 9 3	—	[illegible]	[illegible]
1	1/6	Do. 5 per Cent. non-Cum. Preference	[illegible]	3 12 9	—	[illegible]	[illegible]
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109—112	4 9 3	..	[illegible]	.
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	101½—[illegible]	3 17 6	June, Dec	[illegible]	[illegible]
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104—106	4 5 0	June, Dec	[illegible]	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105—107	4 13 0	..	..	—
1	6	†J.G. White & Co. 6% Cm. Pref.	9—10	8 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	3¼—3½	9 4 0	Apr, Oct	—	—
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	82—86	4 18 0	May, Nov	78¼	78½
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3¼	—	June, Dec	..	—
100	5%	Do. 5 per Cent. Debs. (red.)	92—95	5 5 6	June, Dec	..	..
St.	15/0	Anglo-American	68—70	5 8 0	F,My,Ag,N	[illegible]	..
St.	30/0	Do. Preferred	101—102	5 17 0	F,My,Ag,N	[illegible]	100½
St.	5/0	Do. Deferred	16¼—17¼	2 8 9	F,My,Ag,N	17⅛	16⅞
St	4%	Commercial Cable 4 per Cent. Deb. Stk.	89—91	4 8 0	Jn,Ap,Jy,O	88½	..
10	6/0	Cuba Submarine Ord.	8½—9½	6 15 0	Feb, Aug	[illegible]	—
10	10/0	Do. Preference 10 per Cent.	17—18	5 11 0	Feb, Aug	17⅛	17½
5	2/0	Direct Spanish Ord.	2⅞—3⅜	5 18 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	[illegible]	5 12 9	April, Oct	—	..
St	4½%	Do. 4½ per Cent. Deb.	99—101	4 9 0	Jan, July	..	..
20	4/0	Direct United States Cable	[illegible]	6 8 0	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99—101	4 9 0	June, Dec	..	..
St	25/0	†Eastern Ordinary	125—126	6 9 6	Ja,My,Jy,O	[illegible]	125
St	17/6	†Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,Jy,O	[illegible]	85
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—[illegible]	3 15 0	May, Nov	106	.
St	1/6	†Eastern Extension	11½—11¾	6 18 6	Ja,Ap,Jy,O	[illegible]	11½
100	4%	Do. 4 per Cent. Deb. Stock	[illegible]	3 14 6	Feb, Aug	[illegible]	..
	4%	Eastern & S.Af. 4% Mauritius Sub. Debs.	100—102	3 18 0	May, Nov	100	..
	1/0	G.N. (of Copenhagen), with Coupon 76	[illegible]	6 2 6	Jan, July	.	—
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99—101	4 9 0	June, Dec	99½	..
..	[illegible]	Indo-European [illegible]	61½—62½	5 16 9	May, Nov	[illegible]	..
100	$1	Mackay Companies Common	80—84	4 16 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	74—78	5 1 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April	.	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99—101	3 19 0	June, Dec	—	—
	1/3	West Coast of America	1⅛—1⅜	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	99—101	3 19 0	Jan, July	..	..
10	..	West India & Panama	½—⅝	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	[illegible]	6 17 0	May, Nov	...	—
10	[illegible]	Do. 6% 2nd Pref.	8—9	6 15 6	May, Nov	—	—
100	5%	Do. 5 per Cent. Debs.	[illegible]—102½	4 17 6	Jan, July	—	..
10	3/0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	[illegible]	[illegible]
St	4%	Do. 4 per Cent. Deb. Stock (red.)	101½—103½	3 16 6	June, Dec	—	—
...	4%	Western Union Telegh. $1 000 4% Bonds	93—96	4 6 0	..	..	—

Share	Last Dividend	Name	Price Wed., July 21.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to July 21 Highest	Lowest
		TELEPHONES.					
100	$8	Amer. Telephn. & Telegh. Cap. St.	143½—144½	5 13 9	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97—99	4 1 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	102½—104½	4 15 6	Mar, Sept	..	—
5	3/0	Chili Telephone	[illegible]	4 14 9	August ..	—	—
1	0/7½	Monte Video Telephone Ord.	[illegible]—1	6 0 0	Nov	..	—
1	0/6	Do. 5 per Cent. Pref.	13/16—15/16	5 7 0	May, Nov	..	.
St.	6%	National Co. Pref. Stock	108½—110	5 9 0	Feb, Aug	109½	109
St.	6%	Do. Def. Stock	[illegible]	4 14 0	Feb, Aug	[illegible]	[illegible]
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¾—11	5 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10¾—11	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅝—5⅞	4 5 0	Feb, Aug	[illegible]	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97—99	3 11 0	June, Dec	98	.
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99—101	4 19 0	Jan, July	99¾	99
1	1/0	Oriental	1 5/16—1 7/16	5 7 6	April, Oct	[illegible]	
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	5 4 0	April, Oct	[illegible]	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	[illegible]	4 11 6	Jan, July	[illegible]	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99—101	4 9 0	Jan, July	.	..
5	3/0	United River Plate	6⅞—7⅛	5 12 0	July	7⅛	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5—5⅜	4 13 0	June, Dec	[illegible]	
St.	4½%	Do. 4½ Deb. St. Red.	102—103½	4 7 0	Jan, July	102½	..
		FINANCIAL INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3—3½	8 11 6	Jan, July	..	..
10	5/6	Globe Telegraph & Trust	10½—10¾	6 7 0	SpDcMrJu	10⅝	[illegible]
10	3/0	Do. 6 per Cent. Pref.	13½—13¾	4 7 0	SpDcMrJu	13⅝	[illegible]
10	6%	Submarine Cables Trust (Cert.)	130—133	4 10 3	April, Oct	130	.
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	3/0	Anglo-Argentine 6% Cum. 1st Pref.	..	4 18 0	April, Oct	..	
5	5/0	Do. 10% Non-cum. 2nd Pref.	[illegible]	5 5 9	Jan, July	[illegible]	[illegible]
St.	4%	Do. 4% Deb. Stock	[illegible]	4 7 0	June, Dec	[illegible]	
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	101—103	4 17 6	Jan, July	6⅛	6
5	3/6	Brisbane Electric Trams. Invest. Ord.	6⅛—6⅝	4 14 0	May	5⅝	.
5	2/6	Do. 5 per Cent. Cum. Pref.	5—5¼	4 15 0	May, Nov	[illegible]	
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100½—104½	4 4 0	Jan, July	.	
St.	8%	British Columbia El.Ry.Df. Ord.	143—147	5 9 0	Mar, Sept	..	
St.	6%	Do. Pref. Ord. Stock	123—126	4 15 0	May, Nov	125	
St.	5%	†Do. 5% Cum. Perp. Pref. Stock	107—110	4 11 0	Jan, July	108½	[illegible]
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102—104	4 6 6	April, Oct	..	
100	4½%	†Do. Vancouver Power Debs.	101—104	4 7 0	Jan, July	102¼	[illegible]
St.	4½%	Do. 4½% Perp. Con. Deb. St.	101½—103½	4 7 0	—	[illegible]	[illegible]
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99—101	4 19 0	Mar, Sept	[illegible]	
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	93—100	6 0 0	Feb, Aug	..	
5	2/0	Calcutta Tramways (1 to 137,610)	4½—4⅞	4 2 0	Mar, Sept	[illegible]	4
100	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5	5 0 0	Jan, July	..	
1	4½%	Do. 4½% 1s. Deb. Stock (red.)	97—100	4 10 0	Jan, July	98½	
St.	—	Cape Electric Tram Shares	⅛—⅜	..	..	..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 11/16—5 15/16	4 4 0	F,My,A,N	..	
St.	4%	Do. 4 per Cent. Deb. Stock	98—101	3 19 0	June, Dec	..	
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98—101	4 19 0	May, Nov	—	
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80—83	6 0 9	June, Dec	..	
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91—94	5 6 6	Feb, Aug	91½	
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..	
100	5%	Do. 5 per Cent. "A" Deb. Stock	90—93	5 7 6	Jan, July	91½	
5	6%	Do. 6 per Cent. "B" Ditto	64—68	8 13 0	Jan, July	.	
5	1/0	Lisbon Elec. Trams. Ord.	[illegible]	4 14 0	July	..	
100	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	5 1 0	Jan, July		
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	94—96	5 2 0	Jan, July	94½	
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	[illegible]	5 2 0	Jan, July	..	
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	94—96	5 3 6	Feb, Aug		
100	$1½	Mexico Trams Co. Com. St.	129½—131½	3 16 0	..	132½	[illegible]
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	[illegible]	5 6 0	..	[illegible]	
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103—105	4 6 0	Feb, Aug	..	
St.	4½%	Do. do. (Nos. 1 to 4,600)	102—104	4 6 6	..	103½	
1	0/6	Perth Elec. Trams Ord.	[illegible]	8 0 0	May	..	
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—	
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6⅜—6¾	5 4 8	..	..	
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99—101	4 9 0	..	..	
100	..	Rio Janeiro Tram, Lt. & P. Co.	89—91	..	..	91½	[illegible]
..	5%	Do. 30 yr. Gold Bnds.	92—94	5 6 6	..	[illegible]	[illegible]
100	5%	Do. 10 yr. Mt. Bnds	[illegible]	5 17 0	..	[illegible]	
—	[illegible]	Sao Paulo Tramway, Light & Power Co. $100 Stock	[illegible]	6 10 0	..	[illegible]	
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	97½—98½	5 0 6	June, Dec	[illegible]	9
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	100—102	4 12 0	Feb, Aug	..	
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5⅝	5 11 0	Mar, Sept	..	
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	[illegible]	
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93½—95½	4 18 6	Jan, July	94	
5	4/9	Calcutta Elec. Supply Ord.	[illegible]	6 8 0	April, Oct	[illegible]	
100	$1½	Canadian Gen. Elec. Co. Com. St.	122—124	5 16 0	..	[illegible]	
100	$3½	Do. 7% Cm. Pf. Stock	117—119	5 16 0	..	[illegible]	11
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99—103	4 17 6	Jan, July	..	
500	5%	Elect. Development Co of Ontario	85—87	5 16 0	—	[illegible]	
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	..	..	Feb, Aug	..	
St.	5%	Do. 5 per Cent. Deb Stock	...	5 8 0	Jan, July	—	
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87—90	5 11 0	Jan, July	..	
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	
10s	[illegible]	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	[illegible]	
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	6 18 3	April, Oct	[illegible]	
St.	5%	Madras E.S. Corp. 5 per Cent. Constn. Deb. St	76—80	6 5 0	April, Oct	..	
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	[illegible]	5 10 0	..	[illegible]	
St.	$1	Mexican Lt & Power Co. Com. St.	70—74	6 2 0	—	[illegible]	
500	5%	Do. 5% 1st Mort. Gold Bnds.	[illegible]	5 12 0	..	[illegible]	
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	130—134	4 9 6	F,My,A,N	..	
1	1/7½	River Plate Electricity Co. Ord.	[illegible]	5 11 0	April	..	
1	[illegible]	Do. 6 per Cent. non-Cum. Pref.	[illegible]	5 1 6	May	[illegible]	
St.	5%	Do. 5 per Cent. Deb. Stock	102—105	4 15 0	Jan, July	[illegible]	
5	8/0	Rosario Elec. Co. 6% Pref. (1-20,000)	[illegible]	5 7 6	April, Oct	..	
100	$1	†Shawinigan Water & Power Co. Ca	92—94	4 7 3	—	[illegible]	
..	5%	Do. 5 per Cent. Bds.	104—106	4 14 3	Jan, July	..	
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	96½—98½	4 11 6	—	[illegible]	
..	6d.	Victoria Falls Power Co. Pref.	[illegible]	5 14 0	Jan, July	[illegible]	

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote the

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.

Electrician No. 1627.
Indust. Suppt. No. 38.

JULY 23, 1909.

Gratis to Subscribers.

De Omnibus Motorum.

AT the present time it is certainly hard for anyone connected with the electrical industry to feel very optimistic about the future; concern for the present is too dominating a thought. But looking at things closely, as perforce we must, does not allow us to see them in their true perspective; and it is only by the consideration of certain questions as a whole and over a long period that the truth can be discovered.

To many it would seem that the electrical industry is practically stagnant at the present time; but this is, in truth, far from being the case. Not only are great advances being made in the discovery of more economical methods of production and arrangement of apparatus; but the slackness in many works allows a review of equipment and the means employed in the production to be carried out with good results; and the employment of electricity in driving factories is becoming more and more extended, an advance which is certainly a good sign.

And much more remains to be done in this direction. It is estimated that the total horse-power of the driving machinery employed in factories in this country amounts to about 4,000,000 H.P., but of this only 500,000 H.P., or 12·5 per cent., is electrical. It will thus be seen that, far from being in the position of Alexander the Great, the electrical industry has still a large field for its operations in this direction alone, and that the time is yet far off when we shall be able to fold our hands and contemplate with satisfaction a totally electrified country. But is this time so far off? It all depends. Many opposing factors have to be overcome. Not the least among these is the inertia displayed by many manufacturers to the new dispensation. Except it be taken as an example of British conservatism, it is hard to see why this should be the case.

If a factory is on a public supply mains, the capital cost required for the transformation from an inefficient steam engine to an efficient electric motor, to do away with flapping belts and clanging shafting, to substitute individual drive and ease of control for a central drive and exceedingly hard control, is by no means heavy. And when, as in many cases, the supply authority hires out the necessary motors and attendant apparatus, it is very small.

There is, besides, very little difference in the factors to be considered when the necessary electrical energy has perforce to be generated on the manufacturer's own premises; a state of things which we hope will not exist much longer, confidently expecting, as we do, the advent of that day when not only London streets, but country lanes also will be "flushed with electricity."

The British manufacturer is, however, primarily a business man who does not see his way to spending capital, however little, unless some adequate return may be expected therefrom. And who can blame him! But he also takes advantage of another state of things. The electric drive at the present time suffers from a superfluity of systems, and the manufacturer, while desiring to use the best, cannot get sufficient, or, what is worse, gets contradictory advice from those he consults on the subject. Not having expert knowledge, he naturally becomes confused; puts down a system which is unsuited for his works, continues to use his old plant, or, worst alternative of the three, employs suction gas. Now, against suction gas, as suction gas, we have not a word to say: as a cheap and

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easy means, in certain cases, for driving a dynamo it has much to recommend it; but what we think about its employment for the direct driving of machinery—the less said the better.

It, therefore, appears that what supply engineers have to do at the present time is to persuade manufacturers that the electric drive will be cheaper than the methods they are already employing and also to advise on the best means of utilising this system of driving in each particular case, in order that the most satisfactory results may be obtained. This latter duty may call for some self-denial on the part of the engineer. For instance, if his method of supplying energy be on the single-phase system it might become necessary to advise the manufacturer to put down his own plant, or better, to instal a motor-generator, in order to obtain the kind of current most suited to his needs. The supply engineer should also, in many cases he already does, see that the manufacturers' installation is carried out in a proper way in order that there may not be trouble under the new Home Office Regulations; a little *contretemps* that, if it occurs, is scarcely likely to prejudice the user in favour of the electric drive.

Once the manufacturer has installed the electric drive, and has had some experience of its great advantages, he will prove the best of canvassers—the satisfied consumer! The adoption of the electric drive should, therefore, advance in geometrical progression, and that it is advancing at by no means a snail's pace can be gathered from THE ELECTRICIAN annual tables, which show that the horse-power of motors connected increased from 357,000 H.P. in January, 1908, to 443,000 H.P. in the corresponding month of 1909. With the last issue of the INDUSTRIAL SUPPLEMENT we published a set of tables dealing more particularly with the question of electric power. A comparison of the figures published last month with those published in the same tables in January last show that the horse-power of motors connected has increased to a satisfactory extent. These figures are unfortunately by no means complete, as certain undertakings, notably Manchester, are unable for various reasons to supply us with data; but they serve to show which way the wind is blowing and that the trend is ever upward. Small amounts of horse-power, if the expression may be allowed, are being added every day, and as examples of higher things, we may instance the recent connection of over 1,000 H.P. to the Brighton Corporation mains for driving the London, Brighton & South Coast Railway's locomotive shops, and a very similar sized plant installed in a steel works in Bolton which has also just been connected to the supply mains in that town.

There is certainly no lack of missionary work for us to do. And with us lays the onus of realising within as short a time as possible that "electric city," and that electric country, too, in which smoke stacks will be few and far between, perhaps non-existent altogether; where the electric drive will be universally employed in factories; electricity for lighting and heating purposes in all houses; and the present much too serious pollution of the atmosphere will be mitigated.

Oerlikon Electric Hydraulic Riveter.

SUCH work as riveting, where a very heavy load is thrown on for a short time, imposes a great strain upon a motor if direct driving be employed, and, in fact, requires that the motor used should be very generously designed. For this work, on this account, hydraulic power

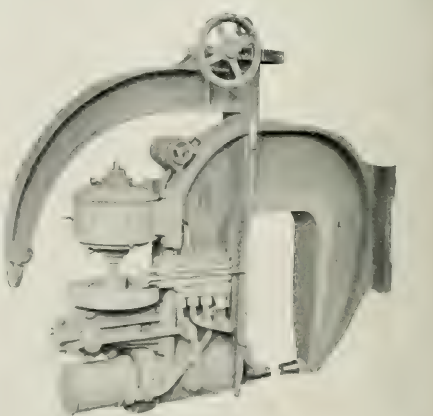

Fig. 1.—Oerlikon Electric Hydraulic Riveter.

has been found suitable, but, on the other hand, the transmission difficulties in this case are great. The ease with which electric power can be transmitted is, of course, well known, and it is interesting to note that this property has

been combined with the advantages of hydraulic working in the Oerlikon hydraulic riveter which is described below.

In this machine an attempt has been made to utilise the good points of both systems. The general appearance of the new riveter is shown in Fig. 1. As may be seen, it is possible to sling it from two points, and it can, therefore, work at any angle either horizontally or vertically. The frame is a steel casting with a gap having a depth of 30 in. and a width of 16 in. The lower snap is fixed, the other being operated by a piston working in a cylinder mounted on the frame. The necessary power for working this riveter is supplied by a 6 H.P. motor running at 1,420 revs. per min. and driving a reciprocating pump through worm reducing gear and connecting rods. A starting resistance for the motor is also fixed to the frame. The pump used on this machine is of the differential piston type fitted with a bronze bushed cylinder, and makes 170 strokes per minute, the length of the stroke being $1\frac{1}{2}$ in. The pump acts upon a mixture consisting of water containing about 40 to 45 per cent. of glycerine. Such a mixture would not freeze during any ordinary cold winter, so that any danger of the equipment bursting in a frost is thereby avoided. The capacity of the pump is equal to a circulation of about 2 gallons per minute. The cylinder of this equipment is built for a maximum riveting pressure of 90,000 lb., and the machine is designed to deal with rivets up to $\frac{7}{8}$ in. in diameter. The piston, which is 6·3 in. in diameter and which has a stroke of $2\frac{3}{4}$ in., is packed by

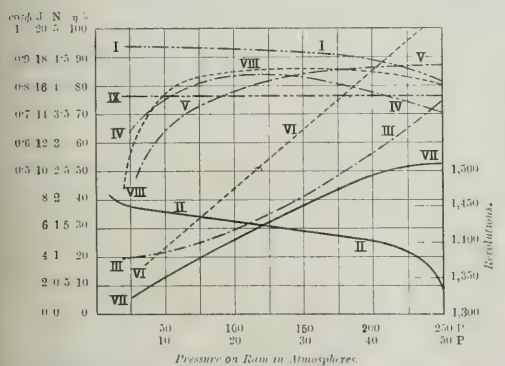

Fig. 2.

rings, and is prevented from turning by vertical guides. The snap is set forward and eccentrically of the centre line by $2\frac{3}{4}$ in., so that rivets may be closed when close to the flanges. The ram has a downward speed of 16·5 in. per minute, which is increased to 70 in. on the return stroke.

The pump on its upward stroke draws liquid from the reservoir above the riveting chamber. This liquid is on the downward stroke forced into the valve chest and, if the hand lever be in its central position, simply passes round the stems of the two valves back to the reservoir. The ram therefore remains at rest. With the lever in the lower position the liquid passes round the first valve stem and enters the upper part of the cylinder, so that the ram descends. The ram is raised for admitting the mixture to the lower side of the piston.

The operation of the machine is shown in Fig. 2, in which curve I. is the percentage of the theoretical piston speed obtained at various working pressures, the falling off being due to the slight slip past the valves; curve II. gives the relationship between the speed of the motor and pressures; curve III. shows the current taken by the three-phase motor when running on a 240-volt circuit and a frequency of 50; curve IV. indicates the efficiency of the motor at various loads, curve V. the power factor of the motor at various loads and curve VI. the output of the motor in brake-horse-power for various closing pressures; curve VII. shows the effective work in horse-power done by the machine, curve VIII. the efficiency of the worm-gear and curve IX. the losses due to the friction of the water. The vertical scale marked J represents amperes and that marked N horse-power.

This machine is very compact, and though its weight is 2,750 lb. it possesses, it is claimed, many advantages which more than act as a set-off. During a 10 hours' run 1,000 $\frac{3}{4}$ in. rivets have been placed and finished by three men under ordinary working conditions. It is further claimed that this machine is portable and easily handled, requires no piping, can be easily adjusted to suit any special work and is ready for immediate use.

The Oerlikon electro-hydraulic riveter, stationary type, possesses similar advantages to those mentioned in connection with the portable type of riveter and in principle it is built exactly on the same lines. It is specially adapted for use in boiler and tube works and in heavy railway and bridge work and shipbuilding work. In this case also the idea of centralising of the riveting installation (adopted with pure hydraulic and pneumatic riveters), so excellent on paper, very often works out at a disadvantage insofar as leakages or breaking in the main pipework or the pumping installation throws the whole series of riveters out of commission, and these accidents frequently occur when shops are most crowded and work most pressing. The independent action of the Oerlikon electro-hydraulic stationary riveter obviates all these inconveniences.

We have to thank Mr. G. Wuthrich, manager and engineer of the Oerlikon Company's British and Colonial department, of Norfolk-street, Strand, for the information contained in this article.

A New Controller.

THE control of electrical circuits and machinery being a matter of the highest importance, it is interesting to watch the progress made in this direction towards the ideal, and we are, therefore, pleased to be able to give some details of a controller recently introduced by Messrs. Wellman-Seaver & Head which possesses several points of interest. This controller is illustrated in Fig. 2. Its frame is of cast iron and of strong mechanical design, while lugs are cast at the base and at the back for bolting the controller in position for vertical or horizontal operation. The lower bearing for the drum spindle is cast in the base of the frame, a steel ball bearing taking the weight of the drum, the upper bearing being in the top cover. A sheet steel case, covering the front and sides of the controller, is clamped to the frame by means of hinges and hinge bolts, the slight loosening of which allows the case to be swung back, disclosing the interior of the controller, and enabling adjustment or inspection of the working parts.

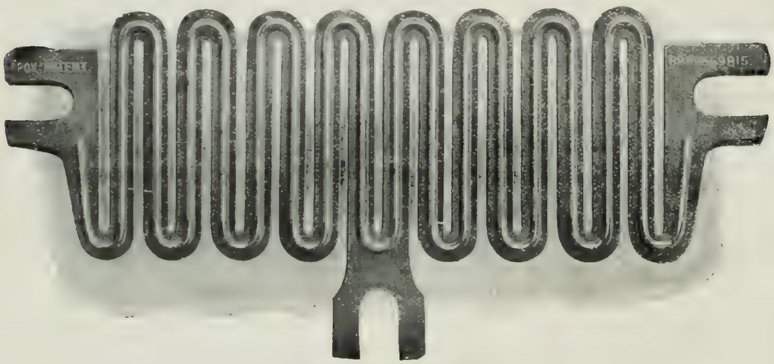

Fig. 1. Stamped Steel Resistance Grid.

The drum body is cast in sections, three or four of which make up the complete drum. The sections themselves are cast in two pieces having lugs which are clamped on to the spindle by B.A. screws with spring washers, which make it impossible to slack back. The drum segments are made up of hard drawn copper, of ample thickness to allow for wear, and are firmly screwed to the drum casting. The entire drum is insulated from the spindle by means of a heavy tube of insulating material.

A series coil, the core of which forms part of the base of the frame casting, is used to saturate a heavy cast-iron arm running from top to bottom of the drum, and closely covering all points of contact, thus allowing an efficent blow-out to be obtained. This arm is pivoted at each end to the frame casting, and locks against the frame. Attached to the arm are suitable arc shields of fireproof insulating material. Easy access to fingers and drum is obtained by unlocking the blow-out arm and swinging it back on its hinges.

A steel bar, well insulated with a tube of insulating material, is bolted to lugs cast at the top and base of the frame. Upon the support, finger blocks with terminals are clamped opposite their respective drum segments. The fingers consisting of a phosphor bronze spring, a brass finger, and a hard drawn copper tip which is easily renewable; a flexible copper shunt being fixed between finger and finger-block in order to prevent heating of the spring. Adjustment is effected by means of a nut which can be turned by hand, and which so locks itself that it is impossible for the setting of the fingers to become altered, after once having been adjusted. The finger tips are very easily renewed, without the necessity of taking off the fingers.

The entire interior of the controller is treated with several coats of non-inflammable insulating paint. Spindle and finger post are encased in thick insulating tubes, so that any leakage to earth from fingers or drum is impossible, even under the most abnormal working conditions. Cables are brought into the controller through a hole in the bottom of the frame casting, and ample air-gap is provided between all live stationary and working parts to prevent arcing.

All insulation, arc deflectors, &c., are of non-hygroscopic material, the entire controller being fire and damp-proof. When the handle is in the "off" position, both poles are broken, and the motor is entirely isolated from the mains.

Another interesting piece of apparatus for controller work of which some details have already appeared in THE ELECTRICIAN, is the stamped steel resistance grid shown in Fig. 1. It is a mild steel stamping with a deep corrugation running along its whole length. Stamped grids have been put on the market before but they were not corrugated and sagged badly, and owing to their having had to be supported in a special manner, they were not suitable for fixing into frames as were the ordinary cast grid type. These stamped grids it is claimed entirely take the place of the old cast grid type as they are not liable to sag and are mounted in exactly the same manner. The following are the important advantages of this resistance grid:—Trouble has been caused by the old cast-iron grids through breakage. These grids are absolutely unbreakable and therefore are suitable for positions where they are subject to jars of any description.

The weight of a stamped grid having a resistance of 0·03 of an ohm with 50 amperes carrying capacity is 5 oz., while that of a similar cast-iron grid is $1\frac{1}{4}$ lb. This shows a large saving in freight for export purposes, and generally makes the resistance banks much lighter and easier to handle. The grids owing to their large radiating surface can also be packed much closer together and thus occupy less space. The ends are perfectly smooth, thus ensuring that there is no trouble with unsatisfactory contact. The structure is perfectly homogeneous throughout, and there is no likelihood of breakdowns through blow holes, or other defects, which are found in castings. For export, where there is a possibility of rough usage, and wherever reliability and lightness is an advantage, the makers are confident that these grids are the best on the market. They can be supplied in mild steel or in any resistance material, thus, if necessary, giving very high resistance. They can be supplied in plain steel, copper plated or sherardised finish.

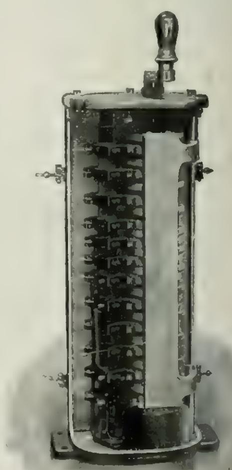

Fig. 2.—Controller.

Ferranti Switchgear for Mines . . . .

In our last issue we referred to Messrs. Ferranti switchgear for fuse on board ship, pointing out the various difficulties present in this class of work and the way in which they had been overcome. Another branch of industrial work which requires that special switchgear shall be designed for it is mining. Care must be taken that any flashing of the switch parts does not explode the "fire-damp," while hardiness is another essential feature in order that equipment may stand the continued racket of mining work without damage.

Messrs. Ferranti have designed swithgear, which we illustrate herewith, specially to work under these conditions. The switches in this case are of the automatic oil type capable of dealing with three-phase currents up to 3,000 amperes per phase. The ammeters and trip coils are worked by low-tension current supplied from current transformers so that all sparking except under the surface of oil is prevented. All the fittings are fixed in gas-tight enclosures, while the gear is protected from water dripping by a sloping roof. Easy access to the gear is provided. All sweating sockets have been avoided, suitable clamps of ample area being employed. The whole forms an eminently suitable piece of apparatus.

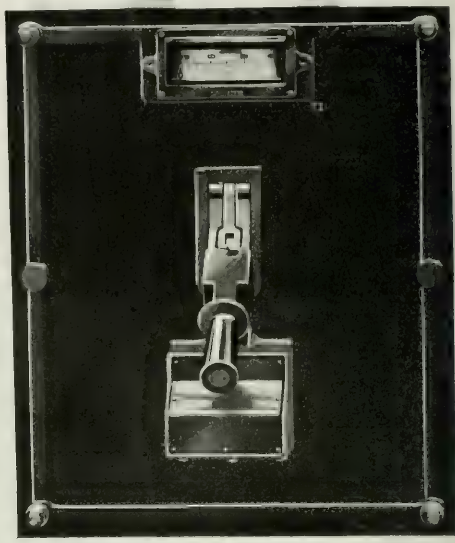

Fig. 2.—Front View of Two-phase H.T. Switch.

A demand having lately arisen for compact high-tension switchgear a problem which comes up for solution is to obtain this compactness without loss of cheapness. High-tension trip coils, which have been proposed, possess grave objections and it will be admitted that the ideal arrangement is to connect the leads direct to sockets on the top of the main switch insulators to simplify all live parts and to protect them by oil.

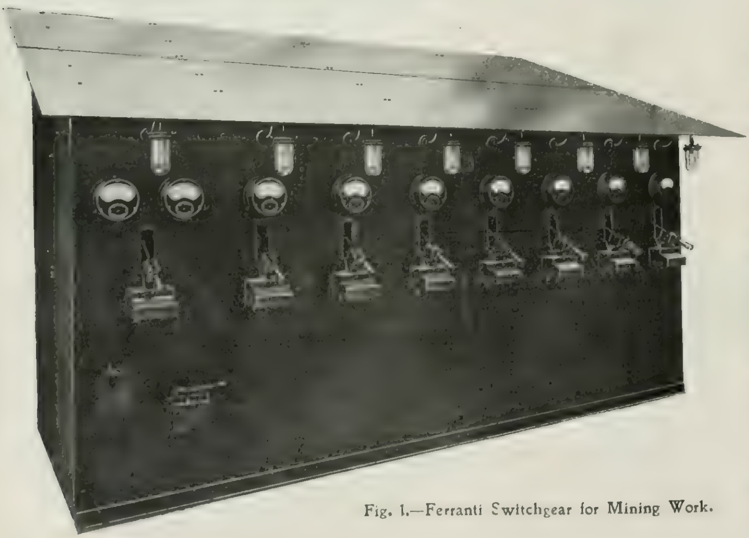

Fig. 1.—Ferranti Switchgear for Mining Work.

Figs. 2 and 4 show how Messrs. Ferranti have solved these problems. They illustrate a two-phase 300 amperes 6,600 volt switch with low-tension tripping arrangement in each phase and low-tension ammeter. The trip coils and ammeter are fed by special transformers forming integral portions of the switch, having no primary winding at all. Thus while the advantages of low-tension tripping are secured, no extra link such as the primary if a transformer is introduced into the high-tension circuit. This arrangement is only possible by the use of the patent power reduction free-handle tripping mechanism recently

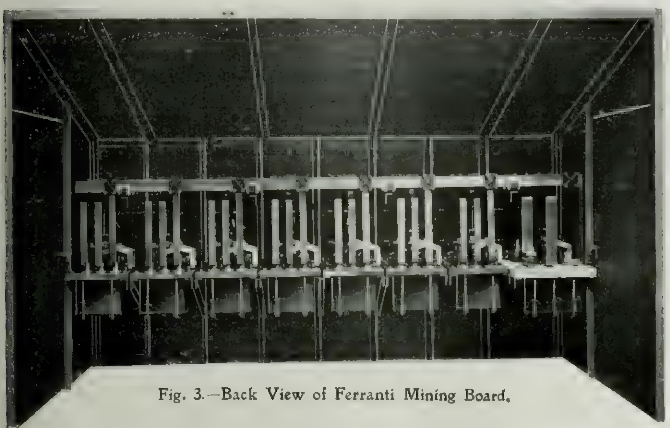

Fig. 3.—Back View of Ferranti Mining Board.

introduced by Messrs. Ferranti. We show in Figs. 1 and 3 side and front views of the complete compact panel suitable for wall mounting. The bottom and sides of the panel can be removed in one piece, and this provides ready access to the switch tanks or otherwise. The whole switch, though

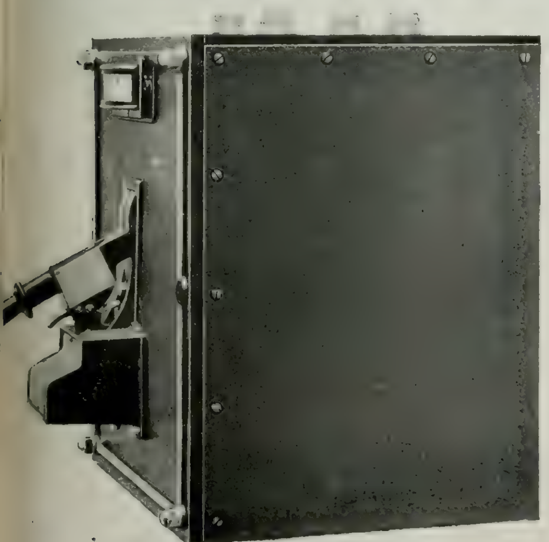

Fig. 4.—Side View of Ferranti H.T. Switch.

confined to a small space, is liberally and amply designed, and special attention has been given to the tanks and their supports with a view to their resisting excessive internal pressure when the switch opens on short-circuit.

Works of the British Electric Calibrated Fuse Co. . . . .

An essential part—it might, in fact, be called the most essential part—of an electric circuit is the switch, while the fuse is almost as important. Many attempts have been made of late to combine these two fittings into one apparatus, an arrangement which possesses certain distinct advantages. Nor is it hard to see how these advantages arise. With a switch-fuse, as the combined equipment is called, it is impossible to replace the fuse while the switch is on—an operation which is often attempted with more or less undesirable results to the experimenter, when the two parts are separate—while the utility of neither the switch nor the fuse is decreased by making them one.

It is, therefore, not surprising that several firms should have designed switch-fuses as protecting devices for electrical circuits. Among these firms may be named the British Electric Calibrated Fuse Co., whose works at Harpenden we had the pleasure of inspecting the other day. This firm have long been known as "Fuse Specialists," and, having inspected their works and seen the care which is taken to turn out a reliable article, we are of the opinion that they justify the name.

Harpenden is at the present time one of those places where the benefits of the electric drive are not recognised

as they should be, and in that part of the town where the fuse works are situated no public supply is available. A suction gas plant of the National type has, therefore, been laid down, and this supplies power to an 80 H.P. Fielding & Platt gas enigne, by which the shops are driven and the works are lighted. One of the shops is driven direct from the engine shafting, while another, which is situate some

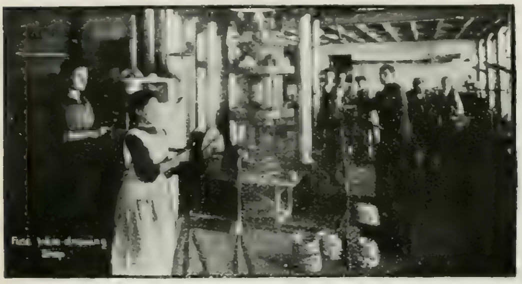

Fig. 1.

distance away from the main works, is motor-driven, current being supplied from a General Electric generator. This engine also drives a compressing plant used in connection with the press for making fuse wire.

Fuse wire drawing and manufacture is one of the specialities of the firm, and we give in Fig. 1 an illustration of the shop in which these operations are carried out. The metal of which the wire is to be made is fed in a molten condition into the container of the hydraulic press, shown on the left of the illustration. The metal, when in a pasty condition, is forced through dies of any desired size and is wound directly on to reels. The firm purchase their metal in the rough and mix it together in the proportions required for the particular type of fuse wire ordered.

The British Electric Calibrated Fuse Co. are the makers of the well-known "Weekes" fuse, whose useful features require no explanation. In the machine shop shown in Fig. 2 the various metal caps and fittings for these fuses are stamped out and prepared for assembly. Every operation is the result of much hard thinking, and various

Fig. 2.

methods used seem to be all that can be desired from the economical point of view. It is quite a trite remark to say that "many a mickle makes a muckle," and practically everybody believes it. But if there are still some unbelievers, they should visit the Harpenden works and study the manner in which the smallest detail of the fuses is taken into account and fitted into its proper place in the various processes, with beneficial results to the article in process of manufacture—and, incidentally, to the balance-sheet at the end of the year.

The "Weekes" fuse is, it will be remembered, a very simple piece of work. It consists essentially of a fibre tube through which the fuse wire is threaded. This tube is then filled with a special compound and rammed tight with asbestos wool. Two brass caps are spun on, to which the fuse wires are soldered. To assemble a fuse complete requires 32 different operations, so that the work is more apparently than really simple. The work people are, however, kept to one particular operation, in which they are able to attain great skill, so that the total output per day is very large. A view of the assembling shop is shown in Fig. 3.

No modern works can be complete without its stores, and the Harpenden undertaking is certainly not lacking in this respect. Here the stores consist, as is usual, of two distinct parts. Into one of these is fed the raw material, which is then taken and worked up in the wire-drawing or machine shop. These finished parts are again returned to store and are drawn upon as required for use in the assembling shop.

We understand that the demand for the "Weekes" fuses is very large. The reliability of the fuse is evident

Fig. 3.

from the way in which it stands the Admiralty test, from whom they receive large orders. This latter is more than usually severe, as the fuse is required to stand 10 per cent. overload continuously and to blow at 25 per cent. overload, the limits being thus very circumscribed.

This company have recently taken up the manufacture of a switch-fuse, the principal details of which were given in The Electrician for May 7, 1909. As will be remembered, its features are that the fuse can only be replaced when the switch is off; wire cannot be used instead of the standard fuse; the switch blades are the fuse blades; and it is only necessary to slack back one screw to replace the fuse.

We have already mentioned the care that is taken at the works of the British Electric Calibrated Fuse Co. to determine and keep down the cost of each operation. This laudable endeavour is carried out by means of a very complete system of cost keeping and work cards. An incoming job is booked up and cards are then issued, containing full details of the work, to the assembling and machine shop. Each man is provided with a card, which is, however, kept in charge of and filled up by the foreman's clerk, on which the time taken by him on a job and the wages due on that account are ent..ed. A premium system is employed whereby any sav..ng in time over the standard time

set down for a piece of work is credited to the workman. The details from these cards are carried to a cost card, one of which is issued for each order, the material being entered on one side and the wages on the other. Stores are dealt with in a similar way, with the consequence that an eye can easily be kept on the cost of any particular piece of work.

Heywood's Cranes.

IT can be said without fear of contradiction that in the average engineering workshop the apparatus of most general utility is the crane. And if this crane be electrically driven its superiority over those of the ordinary hand-worked variety is startlingly evident to everyone of experience in these matters. These opinions, in which we ourselves most heartily concur, are held by Messrs. S. H. Heywood & Co., of Reddish, whose operations in the domain of electric cranes are well known to our readers.

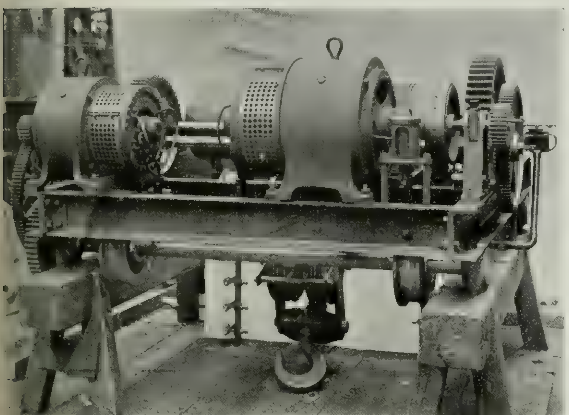

Fig. 1.—Heywood Standard Crab.

Their standard cranes are carried on cross girders of the built-up or steel-joist type, according to the weight and span, while the runners are of cast steel in the small sizes and of cast iron with steel ties in the larger sizes. The crab framework is built up entirely of steel, while the shafts are also of steel the bearings being bushed with gunmetal. The winding drums are grooved for use with steel ropes, and the bottom blocks are fitted with ball bearings. Over-winding and overlowering gears, as well as solenoid brakes, are fitted in all cases, so that accidents are practically avoided. One, two or three motors are fitted, and the crane can be operated from either the cage or floor level, whichever is found most convenient. A standard type of crab designed for hoisting running at 10 ft. per minute and traversing at 100 ft. per minute, is illustrated in Fig. 1. This gives a good idea of the general appearance and general arrangement of the apparatus on a Heywood travelling crane.

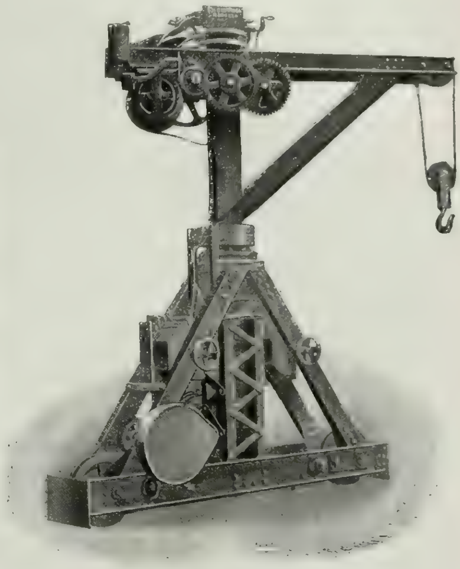

Fig. 2.—3-Ton Walking Crane.

Another useful piece of apparatus for shop work is shown in Fig. 2. It is a 3-ton travelling, or walking, jib crane, designed for use in cramped shops where overhead gear is impossible. It hoists 3 tons at 10 ft. per minute and travels at 150 ft. per minute.

The activities of Messrs. Heywood are not merely confined to making the apparatus described above. Their manufactures, in fact, range over a wide field. We have already described traversers made by them for locomotive work, and of such work they make a speciality. It may, moreover, be said that all hoisting machinery receives their attention.

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Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

A Simple Coaling Apparatus. Much well-thought out equipment has been designed and built for the purpose of supplying ships with coal when they are lying out in the roads, or even on the high seas. Such equipment would, of course, be highly necessary in time of war, and its portability and freedom from complication are, therefore, matters worthy of the closest consideration. In these directions, at any rate, we shall not be far wrong in assigning the palm to the new electric pulley block recently brought out by Messrs. Siemens Bros. Dynamo Works, and which we describe on another page of this issue. While expressing great admiration for the ingenuity displayed in the design of some of the special coaling ships now in use, we fear that a shot, chance or otherwise, from an enemy's ship would soon put them out of action, and we ask: Could anything be simpler or more suitable for the work than this new pulley block? In the first place it is a self-contained unit. Any number may be employed "in parallel," and simultaneously, on one ship, while the temporary dislocation of one will not affect the working of the others. Further, the block itself is compact—a great advantage in ship work—while the only accessory gear necessary is a derrick, easily constructed from a few spars, of which the ship's carpenter always possesses a varied assortment. With such an arrangement each ship is able to possess within herself her own coaling machinery, which can be quickly rigged up when and where desired, and as quickly stowed away. Taking six barges for each ship with four electric pulley blocks to each barge, we are informed that the coal taken in per hour, assuming the height of lift to be 23 ft., will amount to 720 tons. The aggregate weight of the four blocks is 5 tons, to which must be added the weight of the cables and other electric apparatus, which should not be a very serious matter. Only 24 men would be required to work such an installation, so that the crew, if divided into shifts, would be saved much fatigue. In our opinion this apparatus marks a distinct step forward in the employment of the electric drive for marine work, and its good qualities should ensure it an immediate and lasting success.

Shop Lighting Fittings. At the present time, when much discussion is taking place on the relative advantages of gas and electricity for lighting work, any advance made by one or other of these agents is a matter of some moment. Even if we allow, for the sake of argument, that gas is in some way superior to electricity for this purpose, there is at any rate one particular application in which electricity more than holds its own. This is shop lighting. A very favourite method of illuminating shop windows is by suspending outside the establishment powerful lights, which are shaded on the road side, but which throw an exceedingly bright light on the goods displayed; for this work the flame arc is specially suitable. Another, and even better, method is to light the window from the inside, ordinary incandescent, or, rather, metallic filament, lamps being used for the purpose. In spite of the advances that have recently been made in the study of the science of illumination, it is distressing to see how little the knowledge thus acquired has filtered through to the ordinary consumer or been put into practical use by him. Only too often is a shop window lighted in such a way that the lamps glare into the eyes of the prospective customer and prevent the wares displayed being properly seen. The fact that this method is not infrequently used by the smaller optician is not without a touch of humour.

This state of things is, however, gradually being changed. Shop window fittings which illuminate the window, while at the same time shielding the lamp from the direct view of the man-in-the-street, are being designed and brought more and more into use. In our issue of May 28th we described some fittings of this kind which have recently been put on the market by the Reason Manufacturing Co., of Brighton. They are worthy of notice, as the lamp is enclosed in a silvered reflector, which causes the light to be thrown down exactly where it is wanted. The present glare in our streets at night predicates a nation of moles, as the strain on the eye cannot but cause some destruction of that organ. Means to prevent this should be quickly undertaken and are just as much, and even more, worthy of governmental attention than some of the matters now under consideration. To walk along one of the principal streets in comfort at the present time really requires a pair of blue spectacles, though there should be no need for this if the illumination were carried out in a scientific way.

Electric Drive in Railway Shops. The increasing introduction of the electric drive into the repair and other shops of our great railways is, if nothing else, a distinct testimonial to the reliability of this method of transmitting power. It may be taken for granted that had there been any advantage in using steam, or had the advantage on the electrical side been only minute, the motor would not have had much chance. It is, therefore, interesting to consider in what particular ways the electric drive is able to "cut out" its older rivals, the problem of

the driving of the railway machine shops being specially discussed. From the very nature of the work it follows that the jobs received, especially in the repair shops, are of a varied character. On the other hand, it may happen that a very large number of one particular class of job has to be dealt with, while of another class there are no representatives. Certain machines are, therefore, fully loaded, while others remain idle. In such cases as this the group drive, made possible by the employment of the electric motor, offers many advantages over the conditions when one engine was used for driving all the shops. Machines not in use need not be run; neither need long lengths of shafting be unnecessarily kept in motion, while, owing to the greater subdivision, it is obvious that belt and shafting losses are much reduced. Further, the ease with which any machine or groups of machines can be immediately started up is not without its importance in railway shops. There are unfortunately such things as accidents, and the speed with which the whole shop can be started when motors are used is a factor worth considering. It is, therefore, not on the whole surprising that so many of our railways should be converting their shops to the electric drive, while it is to be hoped their good example will be speedily followed by others.

The Magnet in War. At the present time, when war's alarms are filling the columns of many of our contemporaries, and people are wondering whether the Territorial army is at last to have a chance of doing something more than walk about the streets in uniform, it is interesting to note that electrical appliances are to be a distinct factor in the next naval war. It is quite in accordance with the eternal fitness of things that the apparatus which will thus bring electrical science to the front is of German origin. Its simplicity is undoubted; it is, in fact, proposed to fix powerful electromagnets at the entrances of harbours and rivers. These magnets are to be connected with the nearest power station and "the enormous attractive force thus obtained" will then be utilised in throwing out of action the machinery on the enemy's ships or even, if they be of small size, in drawing the ships on to the rocks. The idea is, as we have said above, simple, but it nevertheless has its disadvantages. Station engineers of seaport towns will recognise such magnets as a welcome addition to their mains, though we cannot help thinking that the load factor will be rather low. It would not be necessary to draw a ship on to the rocks more than once a day, even in these troublous times. On the other hand, a magnet sufficiently strong to do any damage to a "Dreadnought" would probably be large enough to block effectively the mouth of any harbour, and would thus form good enough protection without any magnetisation of its coils being necessary. While congratulating the inventor on his ingenuity we fear that large structural alterations to most harbour mouths, or a new sort of magnetic material will be necessary before the idea can have any great practical vogue. Meanwhile, we must confess we shall continue to pin our faith to the older though perhaps more barbarous, methods of protection.

Electric Drive in Railway Machine Shops. . . . .

It cannot be denied that one of the most important parts of railway organisation, and one which enables the service to be worked both punctually and to the satisfaction of the passengers, is the machinery repair shop. Steam locomotives and rolling stock, owing to the arduous nature of the work which they have to do, are very apt to require frequent repairing, and in order that this may be done in as rapid and economical a way as possible it is necessary that the most modern equipment should be installed in the shops provided for this purpose.

It is, therefore, not surprising to learn that the electric motor is being very generally used for driving the various tools, cranes and transporters for this work. Many shops are so driven in this country, and we are constantly hearing of others being added to their number.

Whatever criticisms we may make on our American cousins in other branches of engineering work, there is no doubt they are pre-eminent in that part relating to machine tools and their driving. It will, therefore, be of interest to give a short description of the shops of the Richmond, Fredericksburg & Potamac Railway at Richmond, Virginia, and we are able to illustrate them with blocks kindly lent us by the editor of the "Railway Engineer."

These shops represent yet another case of conversion from steam to electric power. A three-phase 200 volt system is used with a frequency of 60, constant-speed induction motors being employed for driving the various machinery. The original electrification was begun about six years ago, a 75 kw. generator driven by a belt being then installed for lighting purposes. This experiment was so successful that about a year later a 125 kw. generator was erected for supplying power to the machine shop. This is still being used and is driven by a direct-coupled steam engine. The erection of a new planing mill necessitated the replacement of the 75 kw. generator by one double the size for driving the wood-working machinery. This latter engine is also direct connected to a 250 h.p. engine. These generators are excited from a 17·5 kw. machine, which delivers direct current at 125 volts. The larger of the two generator units mentioned above and the exciter are shown in Fig. 1. Steam is supplied to them from two locomotive type boilers at a pressure of 125 lb.

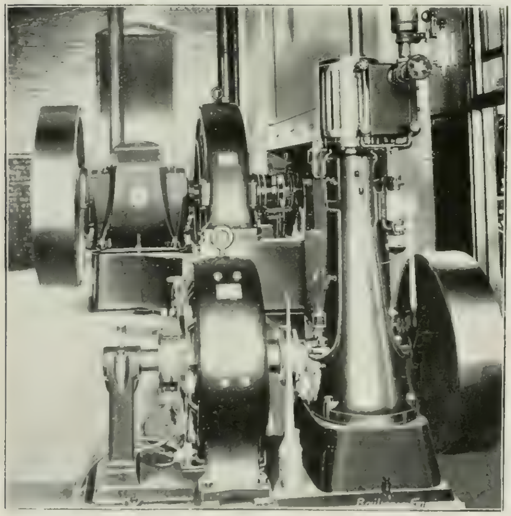


Fig. 1. 125kw. Steam Generator.

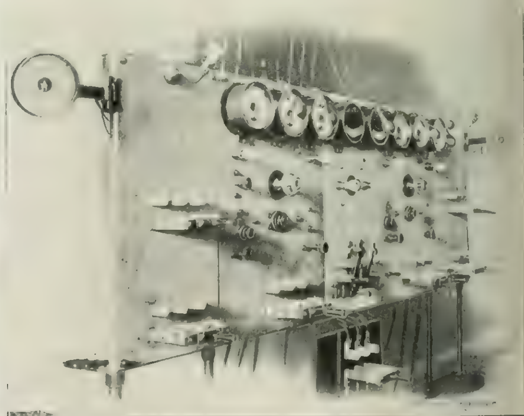


Fig. 2.—Main Switchboard.

The entire electrical equipment was installed under the supervision of Mr. W. F. Kapp, and it is interesting to note, and satisfactory at the same time, that since the adoption of the electric drive no interference whatever with the works operations has been experienced by a failure of any of the

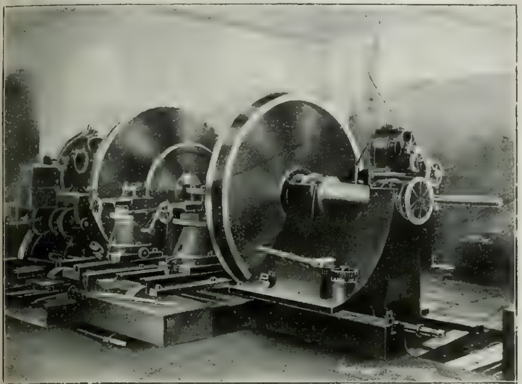


Fig. 3.—90 in. Driving Wheel Lathe.

power plant or motors. Slight interruptions have, it is true, occurred through the blowing of the fuse, but this has been practically always due to one of the motors being started too quickly, and not to any inherent fault in the plant itself. Fig. 2 shows the switchboard used in these shops. There are two generating panels, one exciter panel and two feeder

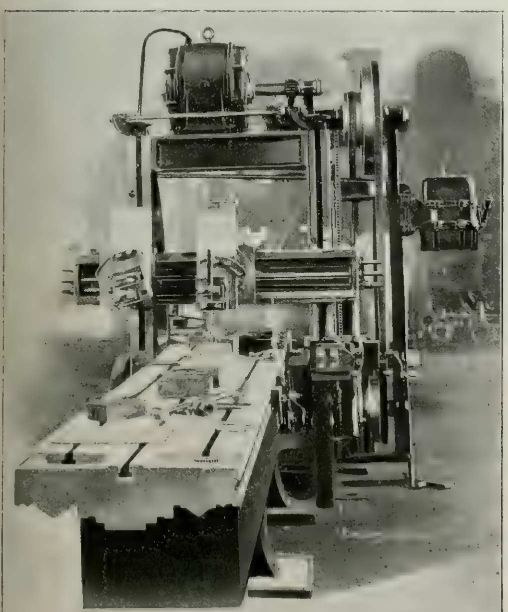


Fig. 4.—36 in. Planing Machine.

panels, all of blue Vermont marble. Ammeters are provided in each phase of the generator panel. There is also a voltmeter for each generator, and a voltmeter and ammeter on the exciter panel. The lighting and power circuits are kept separate throughout, though the switchboard is so arranged that either set of circuits can be supplied from either or both generators as required.

The machine shop equipment is, as will be seen from our illustrations, excellently well arranged, both with regard to machines, motors and natural lighting facilities. The

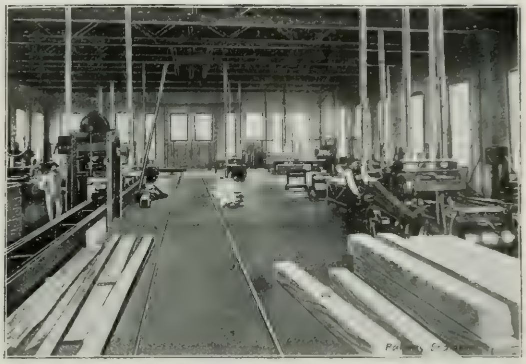


Fig. 5.—Planing Mill.

practically entire absence of belts naturally assists in obtaining this latter advantage. We illustrate herewith several of the individually driven machine tools, which clearly indicate the convenience of the motor drive and the general cleanliness of the shop.

The total motor horse-power installed in these shops is 281 H.P. This includes 68 H.P. in the machine shop, the largest motor there installed being one of 20 H.P., which we

illustrate in Fig. 3. A 24 in. shaping machine driven by a $7\frac{1}{2}$ H.P. motor and a boring mill driven by a 5 H.P. motor are shown in Figs. 6 and 7 respectively. There are three groups of machines in this shop, which are driven off 15, 10 and $7\frac{1}{2}$ H.P. motors respectively. The blacksmith's shop contains 10 H.P. and 3 H.P. motors, the latter driving a 30 in. fan and the former a $1\frac{1}{2}$ in. bolt header, 24 in. drill

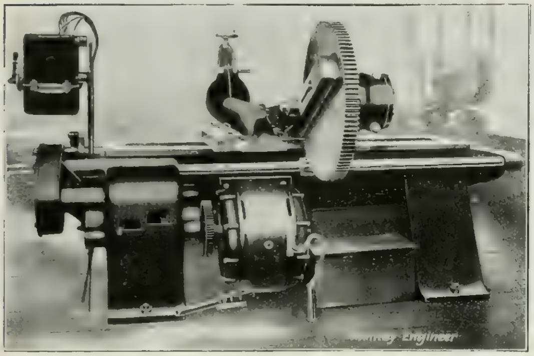


Fig. 6.—24-in. Shaping Machine.

press and a 4 in. pipe threader. The tool room is equipped with two grinding machines driven by a 3 H.P. motor. In the wheel shop are a group of machines connected to a 40 H.P. motor. This group is made up of two 44 in. boring mills, a double-head axle lathe, 250 ton wheel press, 24 in. tool-grinding machine and a 200 tube tumbling machine. In the wood-working mills are various saws and tenoning

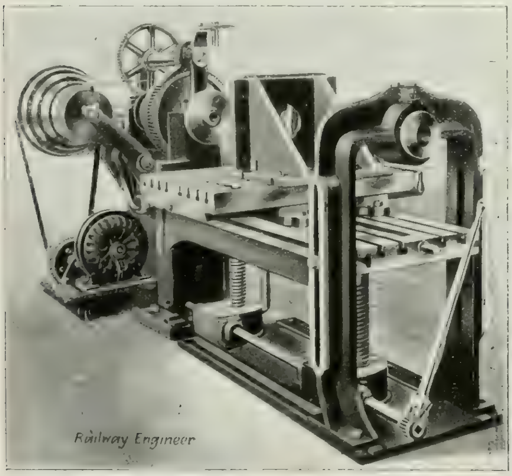


Fig. 7.—Boring Mill.

machines, while the 12 ft. by 30 in. universal planing machine, which we illustrate in Fig. 5, is also erected in these shops. In the machine shops the line shafting driving the various groups is run at the high speed of 400 revs. per min., but there has been no trouble in consequence of this. The planing mill shown in Fig. 5 is interesting from the way in which the motors are mounted. When the shop was extended the ground had to be filled up level, but it was decided not to fill in the space immediately beneath the building, but to leave this portion as a basement, utilising the space to mount the motors and such shafting as was necessary to operate the various machines. The motors are suspended from the lower side of the floor beams, and are connected to the machines which they drive by means of a flexible chain. The planing mill is, therefore, practically free from obstruction, the only motors above the floor being those on the traversing bed planer and that driving the fans for drawing away the shavings. This latter motor is fixed in the roof, and the blast and exhaust pipes drop direct from the trusses to the machines which they serve. The refuse from the machines is collected by means of a 50 in. fan and driven to the boiler room, where it is consumed with the help of a second 50 in. fan. Both fans are driven by a 40 H.P. induction motor.

Besides the motors which we have described above, and which are used for driving the various machines, a 10 H.P. induction motor is installed for driving a lift and a Sturtevant fan in the punch shop, which is used in connection with the overhead system, and is driven by a 10 H.P. motor. The heating of the paint shop is effected by a 50 in. fan and heater coils, which are erected in the roof trusses, the fan being operated by a $7\frac{1}{2}$ H.P. motor.

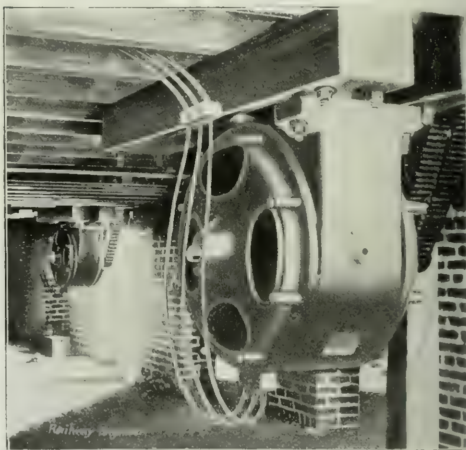


Fig. 8.—Method of supporting Motors in Planing Shop.

In connection with the installation of a 40 H.P. motor, which drives two boring mills and the double head axle lathe in the wheel mounting shop, the original intention was to drive all the machines from this one motor, but circumstances allowed the re-grouping of the tool shop, so this motor became available for its present work. It has ample capacity available, and other tools may be coupled to it when an extension of this department becomes necessary.

The subject of driving railway shops by motors should be of great interest to electrical engineers. This somewhat new departure can only be looked upon as a testimonial to this class of machines, for its reliability has thus made itself felt even in places where steam has heretofore been king.

J. & P. Enclosed Lamps.

MESSRS. Johnson & Phillips' "Orb" patent enclosed lamp, which has been designed by Mr. J. Brockie, and previously referred to in THE ELECTRICIAN, is one of the most interesting and up to date arc lamps. It is of the shuntless type (for ordinary parallel or series burning), a single coil being utilised for striking and regulating the arc, while an ingenious form of clutch is also employed. The latter is placed beneath the base plate and is protected by a removable cup which also forms a seating for the globe, the correct degree of enclosure necessary to obtain the maximum candle-power and life being thereby maintained. By unscrewing the cup the clutch may be inspected without removing the case. The globe is held in position by a spring holder with a hook and eye attachment and is particulary easy to remove for trimming. The lamp may be supplied with or without a dashpot. The latter pattern is specially suitable for use in dusty or steamy positions such as grinding and buffing shops, cement works, saw mills, laundries and factory work generally.

Fig. 1.—"Orb" Lamp.

Fig. 2.—"Satelite" Lamp.

In operation the lamp strikes up without pumping and the regulation is absolute; there being no tendency to get

out of balance even with three lamps running in series on 250 volts. Differential solenoids (shunt and series) may be fitted to the "Orb" lamp if desired and are recommended for long-series working.

The above particulars refer primarily to direct-current lamps, but this firm also manufacture a similar lamp for alternating-current working which burns in series without either shunt or safety coils and is absolutely noiseless in operation. For the interior lighting of shops, &c., this point is, of course, of considerable importance. The cover of the "Orb" lamp is very ornate and is supplied in various finishes, including a special vitrified cream enamel with gold lines for drapers' and milliners' shops, &c. The design is registered.

A companion to the "Orb" lamp is the "Satelite"—a low current single enclosed lamp—not a midget, but a substantially constructed small lamp, generally similar to the larger pattern.

The illustrations show the "Orb" with reflector (Fig 1), and the "Satelite" without reflector (Fig. 2).

Kelvin Electrical Instruments.

It is not surprising, considering the wide range of the late Lord Kelvin's tastes, to find that he was intimately connected with a firm of manufacturers. This would synchronise with his proverbial thoroughness in all things. The methods by which he aided the progress of the electrical industry are, of course, well known to our readers, and his ideas and designs as regards instruments are still being carried out by Messrs. Kelvin & James White, of Glasgow.

In electrical instruments, as our knowledge of the various phenomena increases, many improvements can be made. This knowledge has been applied to Messrs. Kelvin & James White's S.R. moving-coil instruments, which have recently been re-designed and greatly improved. A notable feature is that these instruments are now air-tight, a property which is found to be very advantageous for practically all working conditions. Another improvement is the fitting of the external zero adjusting device to this type of instrument.

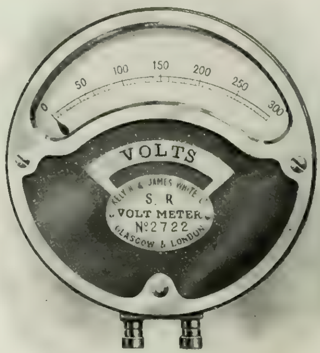


Fig. 1.—6-in. S.R. Voltmeter.

This is naturally a great convenience, and should be highly appreciated by all station engineers. These instruments are made in the round, thistle and edgewise patterns, the scale being either 6 in. or 9 in. long in the first and last of these, and 9 in., 12 in. or 18 in. long in the second.

Another interesting instrument made by this firm is the

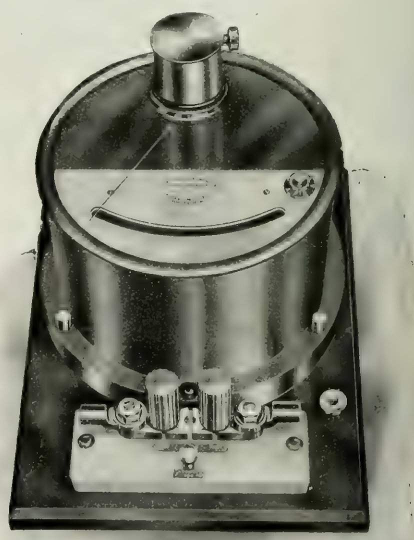


Fig. 2.—H.S. Wattmeter.

"E.D." voltmeter, which is constructed on the electro-dynamometer principle, and is designed specially for use on alternating-current circuits. It is dead beat in action, and it is claimed that its temperature error is negligible. These voltmeters are made in either switchboard or portable

types. The former of these is manufactured in two patterns; the round pattern has a 6 in. scale and the thistle pattern a 12 in. scale. The portable instrument has a 6 in. scale, and is light and eminently suitable for the work it has to do—in fact, portable instruments are a speciality of Messrs. Kelvin & James White, and are manufactured by

Fig. 3.—M.M. Testing Set.

them for both alternating and continuous-current circuits. In this connection it is well to draw attention to their combined portable ammeter and voltmeter, a handy set for general purposes and testing work. By it both current and pressures varying over a very wide range, can be measured accurately. In connection with testing work, the workshop Wheatstone bridge, which is a very compact and handy testing instrument, may be mentioned.

Fig. 4.—Multicellular Voltmeter with Multiplier.

Another important piece of apparatus for general testing purposes is the Kelvin indicating wattmeter, which is specially recommended. It is of the electrodynamometer type, and can, therefore, be used on either alternating or continuous current. An arrangement is fitted whereby the coils can be put into either series or parallel, thereby enabling a wide range, combined with extreme accuracy, to be obtained. As regards insulation testing, a set well known to cable manufacturers and station engineers is made by Messrs. Kelvin & James White. As a combined and thoroughly reliable instrument this is claimed to be a piece of apparatus of particular merit.

A high-tension electrostatic voltmeter made by Messrs. Kelvin & James White will be found extremely convenient for pressure tests on cables and other similar work. These instruments are light, compact and very portable, while the range covered is a large one. This type of instrument is embodied with certain slight modifications in the volt balance supplied by this firm which is made with a range up to 100,000 volts.

A further interesting instrument is the Kelvin feeder log, really a combined recording voltmeter and ammeter. These instruments are being extensively adopted for station use They are dead beat in action and have a large working force, thus giving perfectly satisfactory record under such trying conditions as are present when there is a rapidly fluctuating load. A particular point about these instruments is the fact that the operation of winding the clock cannot be forgotten, as the action of withdrawing the drum to change the chart automatically re-winds the clock for the next run. This movement is such that the clock drum passes out to a position where the paper can be easily changed without any damage to the pen.

An instrument in the design of which the late Lord Kelvin applied a great deal of ingenuity was the Kelvin multicellular electrostatic voltmeter, and this has been greatly improved within late years. The scale is now 6 in. long, thus giving wide open spaces between the divisions. A feature of the instrument is that it reads equally correct on direct or alternating-current circuits at any frequency. This instrument can be supplied with multiplier, which extends its range considerably. It is dead beat in action, and both horizontal scale and vertical scale types are made, the former being the portable and the latter the switchboard pattern.

Siemens Electric Pulley Block.

THE peculiar conditions under which a battleship works necessitate that it should often be coaled at sea, and such a requirement predicates that a special apparatus must be designed in order that this operation may be carried on with ease and safety. Several arrangements have been suggested to secure these conditions, and one of the most interesting is the electric pulley block illustrated and described in this article, which is made by Messrs. Siemens Bros. Dynamo Works, Ltd. The inception of this self-contained electric pulley block originated in a desire to simplify the existing methods of coaling battleships, and the objects kept in view in designing the present appliance were ease of transport and small dimensions, so that when not in use it could be stowed away and leave the decks free for action.

Perhaps quite the simplest method of slinging anything from a boat on to the deck of a ship is to use a rope which is laid over a guide pulley fixed to a boom, and this is the essence of the Siemens arrangement, with the slight difference that the electric pulley block, instead of one of the ordinary type, is slung from the boom.

An electric pulley block of this kind and ready for work is shown in Fig. 1. Its hoisting capacity varies between 220 lb. and 265 lb. at a speed of 400 ft. per minute, while its own weight is 480 lb. The current consumption of the motor is 25 amperes at 100 volts, and the equipment is

capable of hoisting from 20 to 30 tons per hour through a height of from 20 ft. to 23 ft. One such block is only suitable for dealing with one basket at a time, though, of course, any number of blocks may be provided in accordance with the number of coaling points on the barge. If each pulley block is fixed to a light boom with a derricking motion, as shown in Fig. 1, it can be worked independently of the others, and in such a manner as always to remain vertically above its coaling point, and the equipment, being self-contained, can be examined without interference with the rest of the apparatus. As will be seen from the illustration, the pulley block is provided with two broad flanges which are cast on to the frame, so that it can be rolled along the deck with ease and without damage to the flooring. It can be easily raised to its working position and as easily moved and stowed away. Such an apparatus is naturally not confined to ship working, but can just as easily be used for a number of land installations, such as unloading material from railway trucks, conveying coal into the bunkers of a boiler house and much other similar work where space and cheapness are desiderata.

Fig. 1.—Siemens Electric Pulley Block.

The various parts of this electric pulley block are shown in Figs. 2 to 7. The driving motor is fixed inside the rope pulley, and the latter is fitted on the magnet frame of the motor and rotates with it. In order to utilise the well-known principle that the weight of a motor for a given output diminishes with increasing speed, both the motor armature and the motor field are arranged to rotate, but in opposite directions, the relative speed being 900 revs. per min. The rope pulley has a peripheral speed of from 5 ft. to 6 ft. per second, and careful experiments have shown that $1\frac{1}{2}$ turns of dry hemp rope give sufficient adhesion for all purposes. The pulley block is provided with sheet iron covers which protect the rope, but which it is recommended should be removed in dry weather. Rope of diameter not exceeding $\frac{3}{4}$ in. should be used, in which case there is room on the pulley for three turns side by side. The current is brought up to the motor by means of a flexible cable and the motor is started by a simple switch, no starting resistance being necessary. The field is compound wound, so that there is no likelihood of injury to the motor at starting.

The method of operation is as follows: When the load has been hooked to one end of the rope a pull of a few pounds on the other end is sufficient to raise the load; but

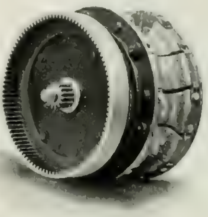


Fig. 2.

Fig. 3.

if the pull on the free end is relaxed the rope slips on the drum and the load remains suspended, while if the rope is paid out the load sinks. The empty hook is lowered by means of the following special arrangement. The rope pulley is not rigidly fixed to the field system of the motor but through a friction clutch. It is provided with 12 rollers mounted on ball bearings, which enable it to rotate with very little friction on the outer circumference of two hardened steel rings fixed to the rotating field system. The frame of the rope drum has six rectangular openings in which slide six brake blocks which have very little lateral play, but can move radially. Springs are interposed

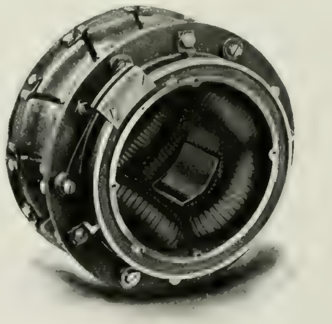


Fig. 4.

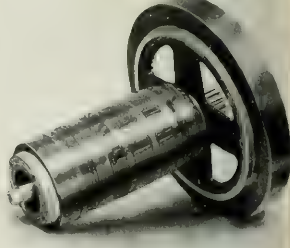


Fig 5.

between the brake blocks and the rope pulley, so that the blocks move inward when the pull on the rope is larger than the opposing pressure of the spring, but move outwards when the rope pull is smaller. The brake blocks are fitted with bronze shoes which come into contact with the inclined inner surfaces of the steel rings as soon as the pull on the rope exceeds a certain value. When this occurs the rope pulley is coupled to the rotating field system of the motor. When the load has been hooked on, the pull on the rope causes the brake blocks to move into contact with the steel rings so that the rope pulley rotates with the field system of the motor. After the load has been deposited, the springs overcome the small pull due to the empty hook, and the brake blocks are disengaged from the steel rings. The rope pulley can then rotate back-

wards when the rope is paid out at the free end. Three guide rollers are provided at each side of the rope pulley to prevent the latter from moving sideways. These rollers, as well as those described above, are visible in Fig. 2. The pulley block is suspended from the boom by two ropes, as shown in Fig. 1, and can easily be hauled into position without the aid of a winch.

As mentioned above, current is supplied through a flexible cable, a plug and a socket being fixed on the block. From the pins of the plug the current flows to two slip-rings mounted inside the end shields of the motor, and is then collected by brushes which are fixed to and rotate with the field-magnet frame.

The current then divides between the two slip-ring brushes, part flowing directly through the shunt winding, and the larger portion through the commutator, armature

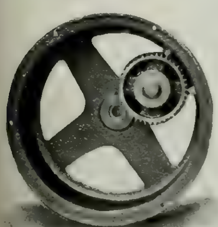


Fig. 6.

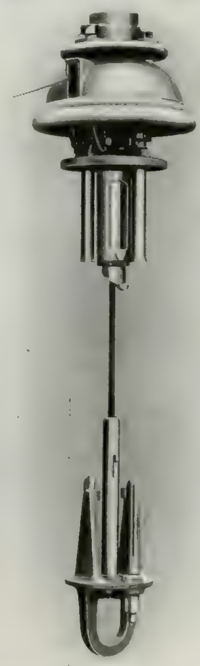
Fig. 7.

and series winding. To ensure safety in working, a brake consisting of a hard steel ring fixed to the field system and a projection fixed to the motor frame are provided.

Enough has been said to show that the problems present in designing an apparatus for ship work has been fully solved by Messrs. Siemens. The sailor is not by nature a gentle animal or a skilled mechanic, and both these facts have been recognised. The pulley block is strongly built, there is a minimum number of parts to go wrong, and very little attention is needed.

J. & P. Contact Gear.

AN interesting piece of apparatus made by Messrs. Johnson & Phillips, of Charlton and London, is the "Bell" arc lamp raising and lowering gear. This comprises a self-sustaining automatic contact device and a self-locking winch, intended primarily for facilitating the trimming and cleaning of arc lamps in exposed, or more or less inaccessible, positions, *i.e.* streets, railway stations, docks, yards, &c. The contact gear is simply constructed and contains no pawls or springs. The lamp is suspended from a strong malleable iron hanger and its weight is carried



"Bell" Contact Gear with Casing and Hood removed.

by substantial lugs. Electrical spigot and socket self-cleaning contacts of ample size are employed, insulated in the best manner with steatite cones, only one size of insulator being used. The action of the gear is claimed to be absolutely reliable, and the lamp always returns to its original position. Reversal of polarity is thus impossible.

In operating the gear the lamp is lifted by the winch as far as it will go for both raising and lowering, the definite stop action being part of the system. It is interesting to

hear that one of these gears was recently coupled to a crank driven by the shop shafting and run continously for a period equivalent to about twenty years' ordinary use. At the end of the test the gear showed no signs of wear, nor did it once fail to engage or release. The self-locking winch is a strong piece of mechanism and its component parts are simple in design and few in number. The drum is direct-driven, one turn of the handle giving one revolution of the barrel. Friction is practically eliminated, so that it is easy to operate. Should the handle be detached the lamp cannot descend, so that maximum safety is obtained. The winch is usually supplied with ordinary wall lugs, but special fixings for use in arc lamp pillars can also be supplied. The figure illustrates the "Bell" contact gear with casing and hood removed.

Electrically-driven Gas Exhausters.

THE Bryan Donkin Co., Ltd., of Chesterfield, have had much experience in the design and manufacture of gas exhausters. The evolution of these machines has been steady since 1866, when the machine then used, and designed by Beale, possessed the disadvantage that the friction losses were very high. By abolishing the guiding rings this difficulty was to a great extent overcome. The guiding of the motion of the slide was brought to the centre of the machine by the use of a block running on a pin fixed to one of the end plates. By this arrangement the slides could be cast in one piece, and very much larger wearing surfaces provided by the block than with the old rings. In addition, the relative velocity of the guiding surfaces for a given diameter of shell is only one-tenth of that of the rings in the old type, and the internal friction has thus been reduced with a consequent saving in power.

The exhauster cylinder is bored to the exact oval shape described by the slightly eccentric movement of the slides or blades. As, however, this movement of the blades is entirely guided by the central block in conjunction with the axle, no wear whatever can take place on the cylinder. The only pressure on the cylinder as the blades pass round is that due to the springs under the packing strips or nose-pieces. An essential feature which distinguishes this type of exhauster from others is that the slides pass through fixed slots in the rotating axle; in most other types the slides pass through slotted rollers working in bored recesses in the axle, and as considerable pressure is exerted on the outer diameter of the rollers which are very difficult to lubricate, very considerable wear takes place owing to their grinding action. As a consequence, much larger wearing surfaces can be provided in the latest Beale type, and in addition the number of surfaces on which wear can take place is reduced. It is owing to these distinguishing features that the Bryan Donkin exhausters can run for such long periods without requiring any repairs. For pumping gas against high pressures, machines of this type are found in practice to be far the most efficient and durable. This is owing to the same feature—viz., that the slides pass through fixed slots

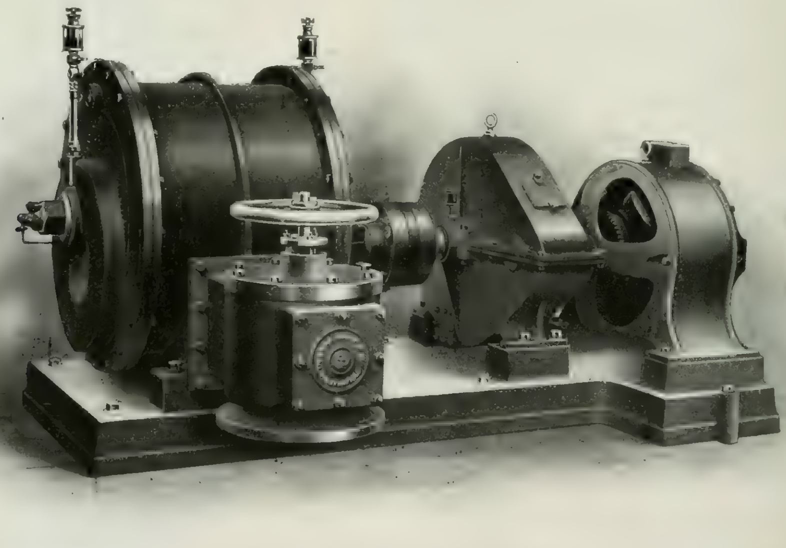


Fig. 1.—Standard Electrically-driven Gas Exhauster.

in the axle, so that the heavy pressure on the exposed surface of the slide is directly taken by the axle which forms the driving member of the machine, and at the same time adequate wearing surface can be provided for the increased loads involved.

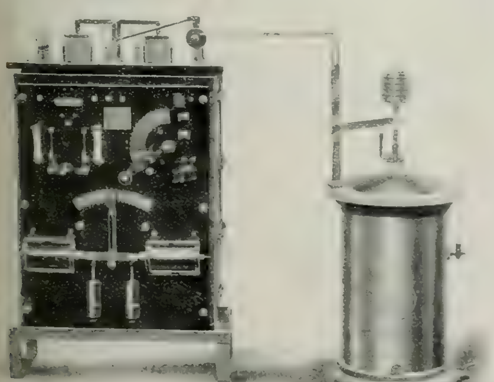


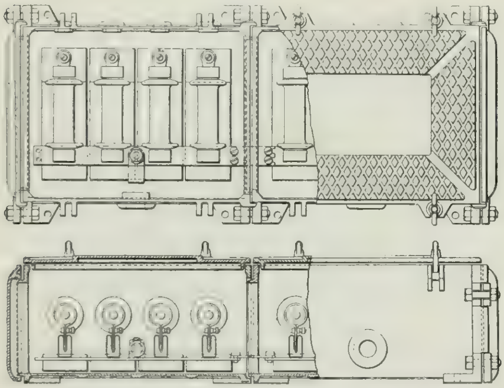
Fig. 2.—Control Equipment for Electrically-driven Gas Exhauster.

An electrically-driven exhauster of the above type is shown in Fig. 1. In connection with these machines a special system of control has been designed suitable for working with either shunt or compound-wound motors and with the control in the armature or field circuit. This arrangement is illustrated in Fig. 2, and in this particular case the control is in the armature circuit, the speed of the motor being varied from 500 to 850 revs. per min. The motor is coupled direct to the gas exhauster through worm gearing, the whole being mounted on a cast-iron bedplate. The controller consists of two parts—viz., the gas-operated regulator and the electric switchgear. The gas regulator consists of a tank partially filled with water in which floats a bell. The top of the bell is connected to the outside lever by a rod passing through a stuffing box. A pipe is connected from the inlet side of the exhauster to the inside of the bell, and as the vacuum in the inlet pipe varies, due to the variation in the rate at which gas is made by the retorts, so the position of the bell varies. The lever on the top of the gas regulator is connected to a two-way oil break switch on the top panel of the switchgear. This oil-break switch controls the two solenoids on the front panel which operate the regulating switch. In addition the front panel also contains a double-pole main switch and fuses and a starter with no-voltage and overload releases. In starting up, the connecting rod between the gas regulator and the two-way switch is lifted up, and the plant run up and adjusted by hand until the proper vacuum is attained The connecting rod is then dropped on its pin, and the plant works automatically, increasing in speed as the vacuum decreases and vice versa.

It will thus be seen that an arrangement is obtained whereby practically all continuous attention of the plant becomes unnecessary. Human aid has to be requisitioned for starting, but after that the equipment is automatic. This is a point worth bearing in mind.

Hope's Unit System for Ironclad Fuse Boxes.

OF recent years ironclad distribution fuse boxes have been almost universally adopted for power work, and this in spite of the difficulty that almost always arises from "spare ways." Spare ways have, in fact, to be provided on almost all boards for possible future requirements, and even when provision is made for these it often happens that one particular board requires several extra ways, whilst other boards remain with spare ways unused for years. Spare ways are an expensive matter, a common practice being to allow 25 per cent. extra ways as spares on the whole job, and it is claimed that the Hope's patent unit system, shown herewith, overcomes the difficulties inseparable from the usual arrangements.



Hope's Unit Ironclad Switchboard.
Scale 1 : 8.

In this system the cases are of cast iron, built up in such a way as to allow of either end being removed, and an extra case unit being added, the box remaining perfectly watertight and gastight. The one end of the case is a "male" and the other a "female" end. Extra sections of case can therefore be added at either end. Four strong set screws hold the case or the end plates, as the case may be, together. Additions can, therefore, be made in a few moments. All parts are "jig" made throughout and that all extension pieces are guaranteed to bind together without filing or any fitting whatsoever. With regard to the interiors, each fuse way is a separate unit complete in itself, the fixing of the bases and the coupling-up of the same to the 'bus-bars being effected from the front of the board. Extensions can be made and extra fuse ways coupled up whilst the board is "live," the adding of additional fuse units only requiring the fixing of two screws in each. All bases are of black china of a special quality. The insulation test of any complete board is guaranteed to be at least 50 megohms.

The materials and workmanship are of the same quality as in the Hope standard boards.

The following special features in connection with these boards are specially noteworthy. The unit system boards are made single-pole only. Two boards must be allowed, therefore, for double-pole and three for triple-pole, and, owing to simplicity in manufacture, the prices are no more than for the usual solid boards.

Ercole Marelli's Fans.

AT this time of year, in countries more fortunate than our own in regard to summer weather, the employment of some kind of fan is practically a necessity, and in this connection the electric drive finds a useful application, for it cannot be denied that in private residences, hotels, offices and similar places no other means for operating the fan need be seriously considered.

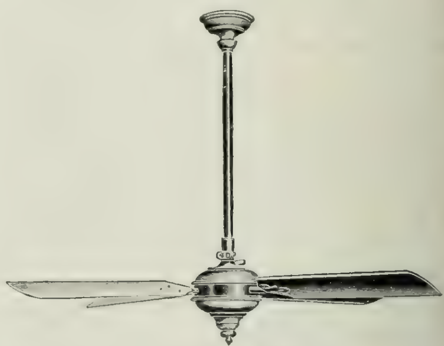


Fig. 1.—"Maestrale" Fan.

A firm which has for many years made a speciality of fan work is Ercole Marelli & Co., of Milan, whose London offices are at 26, Garlick-hill, Queen Victoria-street, E.C. This firm have, in fact, specialised in the manufacture of electric fans and small motors, though large motors up to 100 H.P. and every variety of blowers, exhaust fans and ventilating plant are also manufactured. Messrs. Ercole Marelli's fans are manufactured in a number of types which are appropriately named after the different winds, as for instance, the "Borea" desk fan for both alternating and direct current. These fans are made in three standard sizes for voltages between 100 and 250 volts and for standard frequencies of 40 to 60, but can be supplied for higher or lower voltages and frequencies. Somewhat similar fans, made in three sizes, 10 in., 12 in. and 16 in. respectively, can be fixed to either a desk, or bracket, these positions being made possible by a specially arranged trunnion and clamping screws. Other specialities

are porthole exhaust fans, fitted with automatic shutters which open or close as the fan is started and stopped. Then there are self-rotating ceiling fans, which have the effect of transmitting the air in all directions as, besides the blade rotating, the fan itself moves round.

Special attention must be called to the Maestrale ceiling fan, which we illustrate in Fig. 1. This fan is specially wound for use in tropical climates, a precaution which is, in fact, taken with all Messrs. Ercole Marelli's fan equipments. The motor used is of the single-phase induction type, and the fan proved a great success last year. With this fan is also supplied a special speed regulator which gives a speed reduction of about 50 per cent., a most unusual figure to obtain with an inductor motor. Mention may also be made of a 10 in. fan specially designed for working on batteries.

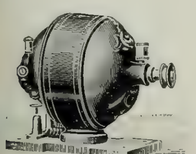


Fig. 2.—Marelli Standard Motor.

As regards the motor side of Messrs. Ercole Marelli's business, they make a speciality of machines varying in output between $\frac{1}{50}$ H.P. and $\frac{1}{8}$ H.P. both for direct and single-phase alternating current, and $\frac{1}{20}$ H.P. and $\frac{1}{10}$ H.P. motors for three-phase work are also made. The $\frac{1}{50}$ H.P. motors are designed for a very wide range of voltage, varying from those suitable for working from 4 to 6 volt batteries to those wound for a pressure of 250 volts. A direct-current motor of this type is shown in Fig. 2.

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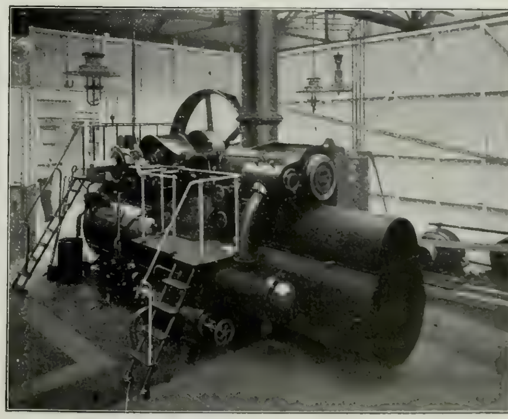
The Wolf Locomobile.

In our last issue it will be remembered we gave a fully detailed description of this interesting piece of apparatus by whose use a coal consumption of just over 1 lb. per horse-power hour can be obtained. We regret, however, that in this description two of the foot lines to the blocks were misplaced, and we reproduce one illustration herewith in order that our readers may see it as it ought to be. The figure shows a 130 H.P. Wolf tandem compound condensing locomobile, which is working at a



130 H.P. Wolf Tandem Compound Condensing Locomobile in Works Central Station at Acton Green.

central station at Acton Green, and was wrongly described as a 500 H.P. superheated steam compound condensing locomobile, working in a German central station, this latter being shown as working at Acton. The Acton locomobile is fitted with the feed water heater, jet condenser, removable furnace tubes and superheater, and is capable of giving 130 H.P. continuously and as much as 150 H.P. for short periods. With this class of machine Messrs. Wolt guarantee a coal consumption of 1·17 lb. to 1·33 lb. per horse-power hour and a steam consumption of 9·21 lb. to 10·6 lb. per brake horse-power per hour. This locomobile is a complete and compact plant, with the engine set on the top of the boiler, and is entirely self-contained.

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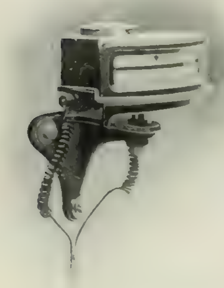

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NOTES.

Single-phase Results on the Midland.

SINCE the conversion of the Heysham Morecambe branch of the Midland Railway to single-phase working 15 months ago, engineers have awaited anxiously the publication of some results, but very little has been made known. Mr. R. M. DEELEY has now broken the silence somewhat by communicating a few figures, which will be found in another column. These relate to test runs, and show a consumption of 99·3 watt hours per ton-mile. Unfortunately the conditions are not typical of suburban service, but Mr. DEELEY gives figures showing that 83·83 watt hours per ton-mile might be expected under these conditions if the gear ratios and wheel dimensions were altered. It is difficult to draw comparisons, but Mr. DEELEY expresses the opinion that the result, if only from the energy point of view, is favourable to single-phase as compared with continuous-current. As to weight—a point on which much stress is often laid—the single-phase equipment is about one-third heavier than the corresponding continuous-current equipment, but when the whole train is taken into consideration this additional weight amounts to only about 7½ per cent. It appears that this difference would be considerably reduced if the rolling stock were made for through running, and in the case of locomotives used for goods and mineral traffic any such additional weight would be an advantage for adhesion. Thus the excess weight in the case of the Midland Railway does not seem important, while from the point of view of economy and simplicity of plant the advantages of the single-phase system are very marked under certain conditions.

The City & South London Railway.

WE are pleased to notice that the directors of the City & South London Railway Co. were able to report, at the general meeting of the company held this week, a more encouraging state of affairs; the improved position may be gathered from the fact that the half-yearly traffic returns showed larger gross receipts and more passengers than at any previous stage of the company's operations. There is no doubt that the arrangements for through-booking with other tubes are much appreciated, and the proposed subway to connect, at the Bank, with the stations of the Central London Railway and the Waterloo & City Railway should also prove beneficial to the company's traffic; whilst the convenience of the tube stations at Euston and King's Cross has not yet been realised by a large number of likely passengers, although the bookings to these stations are slowly increasing. In view of the satisfactory progress which has been shown by most Tubes as the result of co-operation, it is to be regretted that this principle cannot be extended, but at present the indications are that rate cutting is to continue between the competing forms of locomotion. The question of reducing fares is therefore being considered by the City & South London Railway Co., and the problem of co-operation is rendered more difficult where, as in this case, the chief competitor for the traffic is a municipal tramway, on which, of course, a small financial loss is not necessarily regarded as of serious moment.

Electric Locomotives.

AT the present time both electric locomotives and motor coaches are extensively employed, and it is unlikely that either type will oust the other entirely from favour. Elec-

tric locomotives offer many advantages, and, of course, are practically essential where electric traction is only adopted on certain sections of a given route. Such cases frequently occur where steep gradients are encountered, steam locomotives then being taxed to their utmost capacity, and also in the case of tunnels through which a frequent service has to be maintained, bringing with it difficulties in the way of ventilation. The second case often includes the first, not merely in mountainous country, but also in tunnelling under rivers, and several electrification schemes of this character have been completed in the United States during the last few years. Elsewhere in the present issue will be found particulars of the most recent of such schemes—namely, that under the Detroit river—and this case is particularly interesting in view of the large size of the electric locomotives, which are of the continuous current type.

Four motors, each of 300 H.P. rating, are installed on each locomotive, and a total starting tractive effort of 50,000 lb. to 60,000 lb. is obtained, whilst the maximum speed will be 35 miles per hour on the level and about 10 miles per hour on the 2 per cent. up-gradients. A feature of the control is the number of resistance steps—namely, nine with the motors in series, eight in series-parallel and seven with the motors in parallel. This is doubtless due to the large weight of the trains and the necessity for even and gradual acceleration on the gradients. It is also interesting to notice that the motors are of the interpole type, and that forced ventilation has been adopted—a combination which is evidently coming into favour. The motors are suspended on the axles, so that the centre of gravity is maintained low, but this is not of great importance, since any curves will be negotiated at a low speed. In calling attention to the important developments which have recently taken place in the design of electric locomotives, we need only remind our readers that we have described within the last few weeks single-phase electric locomotives manufactured both by Siemens-Schuckertwerke and by the General Electric Co., of America, in which the motors were mounted on the top of the frame and side rods were adopted. Standardisation in the design of electric locomotives has evidently not yet been reached.

Magnetism at Low Temperatures.

A considerable amount of work has been done to determine the effect of high temperatures on the magnetic properties of certain substances, and investigations of a similar nature, but concerned with the other end of the scale, have been undertaken by Dewar and Fleming. Bearing on this latter part of the subject are some interesting experiments performed by Messrs. Gray and Higgins, an account of which will be found on another page. Instead of magnetising the specimens at normal atmospheric temperatures and then reducing the temperature, they magnetised the specimens to saturation at the temperature of liquid air and then gradually warmed them. This process produced effects varying considerably from those of Dewar and Fleming. The behaviour of manganese steel is worthy of note, but the authors do not refer to very feeble paramagnetic or to diamagnetic substances. Research in this direction would be of considerable interest.

Institution of Municipal Engineers.—The first annual general meeting of this Institution will be held at Durham on Saturday, August 7th. A Paper on "The Design and Requirements of Electric Power Works," read by Mr. H. Boot at the meeting on April 24th last, will be discussed, and other Papers of a non-electrical nature will also be dealt with.

British Association.—In addition to the Papers already down for reading before Section G (Engineering) and announced in our last issue, the following will also form part of the proceedings: "Losses from High-tension Overhead Lines due to Brush Discharge," by Mr. E. A. Watson, and "On the Calculation of the Charging Current in Three-core Cables and Overhead Transmission Lines supplied with Three-phase Currents," by Dr. E. W. Marchant.

Depreciation of Electricity and Tramway Undertakings.—The agreement announced in our last issue, p. 596, in regard to allowances for depreciation in the case of income tax assessment of electricity and tramway undertakings, does not receive the support of the Incorporated Municipal Electrical Association. Mr. H. Faraday Proctor, the honorary secretary of the Association, has drawn our attention to this fact, and points out that the Incorporated Municipal Electrical Association has taken great exception to the depreciation allowances proposed, which are considered quite inadequate. The attitude of the Association is referred to in the annual report of the Council given in our issue of July 2, p. 472.

Reduction in Press Telegram Rates.—In regard to the announcement made by the Telegraph Administrations transmitting telegraph traffic "via Eastern" and "via Indo" which appeared in The Electrician for July 16, p. 534, it is announced that the British, Indian and Colonial Governments are prepared to bear their rateable share of reductions in tariffs for press messages, and that the following reduced rates will come into effect on August 1st:—

India and Burma 9d. per word, Ceylon 9½d. per word, Australia, Tasmania and New Zealand 9d. per word, Cape Colony, Natal, Orange River Colony, and the Transvaal 9d. per word, Southern Rhodesia 9½d., Northern Rhodesia and Nyassaland 10¼d., Beira Railway Offices (via the Cape), 9¾d., and Portuguese Zambesi 10¾d.

Electric Furnaces in Canada.—We understand that Sir Wilfrid Laurier has received a communication from the British Minister to Sweden giving particulars of the establishment of an electric smelting plant at Trollhätten Falls. These works bring the number of commercial plants now in existence up to three, two in Sweden and one in Norway. They have three furnaces, each of 2,500 E.H.P., and a capacity of 7,500 tons. The cost of electric energy will be 30s. per H.P. per annum for the first 10 years, rising to £2 in the second 10 years. The ore treated carries a percentage of phosphorus ranging from 0·4 to 1·9. The iron deposits of Ontario and Quebec, and particularly in the valley of the Ottawa and Gatineau, present this very peculiarity. Dr. Haanel is therefore extremely sanguine as to the possibility of the establishment of an iron industry in Central Canada as the result of the Swedish experiments.

The Electrical Production of Steel.—At a recent meeting of the Verband Oesterreichische Ingenieure in Vienna, Mr. Engelhardt gave some details on this subject, which we reproduce from "L'Industrie Electrique." In March, 1909, there were in Europe, working or under construction, the following furnaces for the production of steel by electricity:—

	System.			
	Kjellin.	Héroult.	Girod.	Stassano.
Total input per annum, tons	47,250	32,800	28,000	17,000
Largest furnace, tons	8·5	5	8	5
No. of furnaces	18	12	8	12

The energy consumed is between 2,000 and 3,000 kw.-hours per ton for the production of iron or steel from the ore, and from 900 to 1,500 kw.-hours for the production of steel from cold cast iron. For the purification of steel it is only 250 kw.-hours, while to melt the charge sufficiently to pour it only 50 kw.-hours per ton are necessary. The direct production of iron and steel by this means from the ores can only be employed economically where coal is very expensive and where large water powers are available, as in Sweden or Canada.

Cable Interruptions.	Date of Interruption.
Tangier—Cadiz	May 19, 1909
Tourane—Amoy	June 17, 1909
Assam—Perim	July 8, 1909

Electric Traction on Mont Blanc.—A communication from Geneva states that the first section of the Mont Blanc electric railway, running as far as Col Vaza, a height of 5,495 ft., was opened on Sunday last. The first train conveyed a number of French engineers and local authorities. The journey takes about an hour, the distance being 4½ miles. There are no tunnels and the steepest gradient is 1 in 5.

Large Hydro-Electric Station in California. The work commenced by the Great Western Power Co. in 1906 of driving a tunnel from the bank of the Feather River, where it forms a horseshoe, about 20 miles north of Oroville in Butte County, California, has been completed. The neck of the bend is about 3 miles across, and there is a difference of 500 ft. in the levels of the two positions. The tunnel to carry the water to the generating machinery has been cut for 3 miles through a mountain, and has been lined with concrete and finished smooth. In that distance there is a fall of 75 ft., but from the lower end of the tunnel to the point where the power house is situated there is a fall of 540 ft. The plant is to consist of eight electric generators, each of 18,000 H.P.; four of these have been installed, and a sum of about £2,000,000 has been expended. This station, which will form one of the largest electric generating installations in the world, will be capable of producing 144,000 H.P. continuously.

The Post Office and Marconi Wireless Stations.—On Thursday last week Mr. Sydney Buxton made a statement at Hull indicating that the Post Office Department were in negotiation for the purchase of the wireless telegraph stations of the Marconi Wireless Telegraph Co. The Postmaster-General said :—

As a matter of public policy I have come to the conclusion that it is desirable that at any rate the principal wireless telegraph stations for communicating with ships should not remain in private hands, but should be in the hands of the Government. In order that all interests concerned may be impartially considered, and that no private monopoly should be allowed to grow up, no licences for such stations have been given or promised for over three years from the present time, and therefore the Government should be able to take the service into its own hands in 1912. I think it will be desirable to anticipate that date and take over the stations at once, if it is found possible, as I hope it will be, to make an arrangement which shall be acceptable to the Marconi Company and the other interests concerned.

This was an important announcement, and the next day a representative of "The Times" interviewed Mr. Marconi with reference to the statement of the Postmaster-General. Mr. Marconi said that :—

While it was true negotiations had been begun by the Post Office with a view to acquiring the Marconi land stations in this country for communicating with ships, the offer made was so inadequate that it had not been accepted by the directors of the Marconi Company, who had, in fact, decided on Thursday last that it was not an offer that could be entertained. Mr. Marconi added that, while it is true that the licences have only three years to run, as stated by the Postmaster-General, it would perhaps have been better to explain that they were originally granted for eight years. As the service has been perfectly satisfactory from a public point of view, it seemed somewhat unfair to suggest that the licences to the Marconi shore stations might be terminated at the end of the period for which they were granted. There was no monopoly such as the Postmaster-General suggested beyond that obtained by good and efficient working and by the patent rights to which every inventor is entitled. The Marconi Company had fitted shore stations for the Post Office for the purpose of communicating with ships, with which stations the Post Office had expressed every satisfaction.

A New Surface-Contact System.—The question of surface-contact systems of electric traction is one that has been receiving a good deal of attention lately. It is not, therefore, surprising that many new arrangements for obtaining a satisfactory solution of the problem have been proposed, with the idea of overcoming certain disadvantages from which many of the present inventions suffer. This being the case Mr. David Suchostawer has recently been working on a surface-contact invention, which, it is claimed, possesses well-defined advantages over the older arrangements. On Monday last we were present at a demonstration of this system and were then able to form some idea of its capabilities under working conditions. The car is provided with a flexible contact skate, which extends over a length of track sufficient to cover three of the studs, which are spaced as usual along the line. Above the skate, and magnetising it is a long pole, ⊓⊓-section, electromagnet, the middle limb of which carries the winding. The outer limbs are designed to carry the magnet flux through the outer cylindrical shells of the stud boxes, and thus intensify the field between the middle limb of the magnet and the top of any stud that happens to be below it. This magnet is supplied with current from a battery of accumulators carried on the car. When a stud is magnetised it attracts an iron collar within the box. The upward movement of this collar switches in the main circuit, the switch working with a scissors mechanism and making contact on a metal block connected to a cable. On the experimental track this system, which certainly possesses many points of interest, worked well, but although we understand the present arrangement is the result of exhaustive experiments, it seems to us impossible to say whether it fulfills all the many exigencies which will be met with in actual operation.

Electrical Matters in the City of London.—The report on the works executed by the Public Health Department of the Corporation of London during the year 1908 has just been issued, and contains some details of the street lighting in the City. The number of arc lamps employed is 450; 398 of these are of the open type, 34 are Oliver flame arcs and 18 are Reason enclosed arcs. The payment for open arcs is at the rate of £26 per annum, for flame arcs (mostly experimental) £17. 10s. and for enclosed arcs £12. 10s. The number of defective electric lamps reported by the police during the year was 71, the amount of resultant fines deducted from the account of the City of London Electric Lighting Co. being £15. 18s. 7d. The number of gas lamps in use at the end of 1908 was £2,730, a decrease of 35 during the year, due to the removal of the lamp columns in Fleet-street and in a few side streets. Of the total, 117 are high-pressure gas lamps. During the year 2,081 gas lamps were reported as defective, 1,728 being of the ordinary type and 353 high-pressure lamps. It is worth noting that the percentage of defective high-pressure gas lamps was no less than about 20 times the percentage of defective arc lamps. The additional cost of street lighting due to fog or unusual darkness was £146. 19s. 2d. for the electric lamps and £236. 4s. 9d. for gas lamps. The largest type of high-pressure gas lamp employed burns 100 cubic ft. of gas per hour, excluding the pilot burner, and costs for 4,300 hours' burning per annum £58. 14s. 8d., £53. 0s. 4d. of this being for gas at 2s. 5d. per 1,000 cubic ft., £2 for lighting, &c., £1. 10s. for repairs, and £2. 4s. 4d. for mantles. Mr. F. Sumner, the city engineer, says in the report: "Since March 26, 1903, it has been a condition that all overhead clocks fixed after that date shall be synchronised according to Greenwich mean time. This condition appears to me very necessary, as one cannot help thinking it would be an inestimable boon to the many thousands of persons frequenting the City if the Corporation compelled all owners of clocks overhanging the public way to keep them synchronised. At present it is a rarity to find two unsynchronised clocks alike." We regret to notice that during the year the following clocks, erected before the Corporation regulation came into force, have ceased to be synchronised: 1, Adelaide-place; T. Cook & Sons (Ludgate Circus); General Electric Co. (Queen Victoria-street). It is worth noting that none of the 29 church clocks in the city are synchronised, and only 28 of the 86 private clocks, compared with 23 out of 80 during 1907. The report also deals with overhead wires. Since 1899 25 miles of derelict wire have been removed, 276 yds. being the length removed during the past year. All owners of overhead wires are required to identify them by having a perforated zinc label attached; the system has proved of great advantage. The number of private owners of lines is 137, and 23 lines belong to companies; 733,828 spans now cross public thoroughfares, compared with 733,200 last year, and 260,000 in 1899. There has been a net increase of about 755¾ miles of wires of the National Telephone Co. and 22 miles of other companies and private owners. It is interesting to notice that 5,602 defects were notified during 1908, compared with 2,795 in 1907, and 1,854 in 1906. Owing to the acids formed in the smoky city atmosphere, the corrosion of exposed metal proceeds far more rapidly than is generally supposed, and the galvanising applied as a protection to pole-stays and cable suspending wires does not last long.

AUXILIARY POLES FOR DIRECT-CURRENT MACHINES.*

BY J. N. DODD.

Summary.—The author discusses the electrical design and testing of auxiliary pole machines from the practical point of view, giving the methods he has devised for the purpose. His method of testing is to adjust the auxiliary coils until the voltage between two points on the commutator under a brush is zero.

Although this advance in design is generally considered a recent step, auxiliary poles were patented by Mather, an American, in the year 1885, or possibly earlier, and they were adopted by Mr. F. J. Sprague in the motors used in his experiments on the Manhattan Elevated Railroad during the years 1885 and 1886.

The author first describes briefly the general principles of commutation, and shows that, if at full load the armature flux can be annulled, and in particular that part of the flux which passes through the coils when under commutation, commutation would be equally good at full load as at no load. The armature flux, as stated above, is identical with the flux of armature self-induction, as defined and calculated from ordinary practical formulæ, and is the resultant, as shown in Fig. 1, of the two sets of magnetic lines passing through each armature tooth in opposite directions. If there is placed over the commutated coils a pole of magnetic material, the flux of armature self-induction will be increased, due to the increased permeability of the path. If this pole is excited with a coil of the same magnetomotive force as the armature, but opposed to it, this additional flux will be annulled, but the original flux, the flux of armature self-induction, will be left unchanged. There must be added to the auxiliary coil a sufficient magnetomotive force so that the flux, which in Fig. 1 emerges from the top of the teeth and lies across the slots in the commutation zone, may be supplied from the auxiliary pole instead of from the armature, and, in addition, a sufficient number of lines must enter the armature to equal the self-induction of the armature end connections.

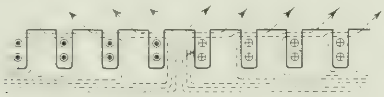


FIG. 1.

Electrical Design.—The first step in the design of an auxiliary pole is to calculate the voltage of armature self-induction. This is usually not a difficult matter, for there are in use a number of good formulæ for what is called, with some looseness, the "sparking constant." This is usually equal to, or from it can easily be derived, the volts per bar of self-induction. The factors contained in such a formula should embrace :—the frequency of commutation, the current in the commutated coils, what is known as the slot constant, and an allowance for the self-induction of the armature end connections. The volts per bar of armature self-induction have the same value as the instantaneous voltage which must be induced in the commutated coils by the auxiliary pole. Knowing the instantaneous voltage and the peripheral speed of the armature, the flux-density necessary over the pole-face can be calculated.

It is not necessary, and is often undesirable, to make the pole and the pole-tip of the same size. The pole must be of sufficient size to carry the flux of armature self-induction, while the pole-face or tip must be wide enough to cover the zone of commutation—that is, the pole-tip must cover the extreme positions occupied by any of the armature coils at the time they are commutated. Whether or not it is advisable to make the pole-tip wider than this is a point open for discussion. Against the wider pole-face are the important arguments of space required, increased magnetic leakage and decreased ventilation. Moreover, the auxiliary pole must supply, not a given flux, but a given flux-density per inch of periphery over the commutated zone. Consequently, for a given air-gap density, the total auxiliary pole flux is proportional to the pole-face, and with a given pole-core the wider the pole-face the sooner will saturation of the pole be reached. Against these arguments it may be stated that if a wide pole-face is an advantage, it usually costs very little to make the auxiliary pole of ample size, and no electrical troubles are experienced if the pole-face is wider than necessary.

Figs. 2, 3 and 4 show the effect of auxiliary poles on the full load distribution curves. Fig. 2 is the distribution curve of a direct-current machine at full load, with brush at the no-load neutral position, showing the distorted field. Fig. 3 gives the distribution curve of the same machine with auxiliary poles of the necessary width and correct strength. Fig. 4 gives the distribution curve of the same machine with auxiliary poles slightly wider than necessary. It will be noted that in both Figs. 2 and 3 the coil emerges from under the brush into an active field, but in Fig. 4 the field is very weak, and it reverses almost immediately—that is, if a spark should form under the brush there is less probability of its being carried beyond the brush if conditions are as shown in Fig. 4 than if they are as shown in Fig. 3. From this point of view a wide pole-tip is of more advantage than a tip of exactly the width of the brush.

From these three figures can be noted the particular difference between a motor and a generator. For a generator, the motion of the commutator is toward the right, for a motor it is toward the left. In a generator the coil emerges from under the brush into an active field, which rapidly dies out and reverses. In a motor the coil enters a field which rapidly grows stronger, and does not die out until the coil has almost reached the succeeding brush. The general conclusions from this are : First, there is a greater tendency to flash over in a motor than in a generator ; second, a wide pole-tip is of special advantage in a motor, on account of its effect in introducing a definite space between the brush and the active field. At the same time it must be said that the disadvantages of a wide pole, in respect to leakage and ventilation and space, are most evident in certain motor designs ; for example, railway motors.

Prof. Arnold has given the correct width of pole-tip as $Br+T-b$, where T=distance between slot centres, Br=thickness of brush reduced to armature diameter, and b=thickness of commutator bar reduced to armature diameter. A slightly different form is

$$\text{Thickness of brush}\cdot\frac{\text{Arm. dia.}}{\text{Comm. dia.}}+\frac{\text{Arm. circum.}}{\text{No. of slots}}-\frac{\text{Arm. Circum.}}{\text{No. of bars}}$$

The auxiliary pole prevents sparking by providing a magnetic flux which neutralises that part of the armature flux passing through the commutated coils. It should do this at every load up to the specified overload, without any adjustment of the auxiliary coil winding : in other words, the flux passing through the auxiliary pole

FIG. 2.

FIG. 3.

FIG. 4.

should be proportional to the load, or the pole must be unsaturated up to the specified overload limits. Now the flux of armature self-induction varies directly with the armature current—*i.e.*, according to a straight line which is fixed for any machine. The current passing through the auxiliary coil is a certain proportion of the armature current. It is, therefore, possible to plot the curve of auxiliary-pole saturation in terms of armature current and auxiliary-pole flux. For any machine this curve is not constant, but can be changed by changing the proportion of armature current passing through the auxiliary coil, thus altering all the abscissæ of the curve in the same proportion. If for a certain adjustment of the auxiliary pole the two curves of armature induction and auxiliary-pole flux are plotted, the vertical distance between these two curves at any load measures the flux cut by the armature coils at that point, and is, therefore, a measure of the sparking tendency of the machine. To ensure sparkless commutation this vertical distance should be zero for any load up to the maximum overload specified, and to obtain this the proportion of current passing through the auxiliary coil must be adjusted until the two curves coincide.

Two cases occur where this coincidence is impossible. (1) Not enough turns on auxiliary coil. This can be remedied either by reducing the air-gap or by increasing the number of turns on the coil. If the length of the auxiliary pole-tip measured parallel to the shaft is less than the length of the armature core, the desired result may be obtained by increasing the pole-tip length. It is useless to increase the size of the pole-tip measured along the circumference. (2) Auxiliary pole saturated at maximum load. In this case the only real remedy is obtained by supplying a larger set of poles.

This second case is the one usually met with in practice. The usual conception is that the flux which is to be supplied by the auxiliary poles is an almost negligible quantity. The minimum pole area permissible is given by the formula

$$A_p = \frac{A_t}{B}\cdot B_t\left(1+\frac{L}{100}\right)$$

* Abstract of a Paper read before the American Institute of Electrical Engineers.

where A_p = area of cross-section of pole, A_t = pole-tip area, B_t = magnetic density in air, B_p = maximum magnetic density permissible in pole-core, and L = per cent. leakage.

The air-gap should be the minimum permissible from mechanical considerations. The magnetic resistance of the auxiliary-pole circuit can be calculated by the same formulas as used for any magnetic circuit. In view of the fact that the iron sections are unsaturated, it will be sufficient to calculate the magnetic resistance or the ampere-turns for the gap alone. The total ampere-turns in the auxiliary coil is the sum of the ampere-turns thus calculated and the armature ampere-turns.

An example is worked out in the Paper to show the application of the above principles.

Testing of the Auxiliary Poles.—The method of testing these poles and adjusting for their correct strength is presented here for the first time, and its simplicity makes it a matter of great importance to the designing engineer. For adjusting the coils it is not satisfactory to depend on the visual method of adjusting; that is, adjusting the coils till there is no sparking apparent to the eye. Such a method is not accurate, and if there are no facilities available for testing at full load it gives no indication within wide limits of how the poles must be adjusted at a low load. Moreover, it gives no idea of the magnet curve.

Whatever method of testing for the adjustment is used it should satisfy the following requirements: (1) It should be an exact method, and not approximate; (2) it should be to a certain extent quantitative; (3) it should be a method which is easily understood by shop men and road men; (4) it should employ instruments easily obtainable by both the above classes of men; (5) if the poles or coils must be changed, it should give precise information on the changes that must be made; (6) it should be definite in its indication of trouble.

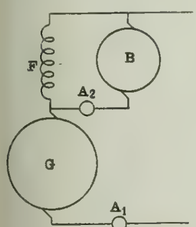


FIG. 5.

A method of testing which the author has found extremely satisfactory is one depending on the principle pointed out in the first part of the Paper—namely, to adjust the auxiliary coils until the volts per bar under the brush are zero. In any particular case, in the absence of facilities for making full-load tests, it will be a sufficient test to adjust the auxiliary coils at the maximum current attainable, until the voltage between two points on the commutator under the brush, as obtained by two voltmeter points resting on the commutator, a bar's thickness apart, registers zero. It is immaterial whether the machine is tested as motor or generator at full voltage or at low voltage, at full speed or at low speed. It is, of course, assumed in the above that the results of calculation and of experiments with other similar machines make it certain that the cross-section of the auxiliary pole is ample to carry the flux of armature self-induction at the extreme overloads to which it will be subjected.

The following simple rule will prove useful: If in a generator under test the voltage of a bar under the trailing half of the positive brush is higher than the voltage of the preceding bar, the pole is too weak, and more current is needed in the auxiliary coil. If the voltage of this bar is lower than that of the preceding bar it indicates that the pole is too strong; that is, that the field of the forward pole has been shifted back into the commutating zone. When the two bars have the same voltage—that is, when the volts per bar are is zero—the pole is of the correct strength.

Measurements can be made with a direct-current voltmeter with a maximum reading of 3 to 5 volts. It should be noted that this voltage should be measured under the centre of the brush or between bars equi-distant from the centre. If the voltage is measured between bars on the same side of the centre, or if on opposite sides at unequal distances from the centre, a correction must be introduced to allow for the Ir drop due to the fact that current is collected equally from all bars, and, therefore, each coil carries current. For measuring this voltage an alternating-current voltmeter must not be used, as it measures the root mean square of this fluctuating Ir drop instead of the average.

This method also provides a test for the correct shape of the auxiliary pole tip and the proportion of the air-gap at various points. According to the author's experience, a different value in the voltage between bars under the various parts of the brushes, usually accompanies a high density in the body of the pole. As an example of the accuracy of this method of adjusting a high-capacity machine at low currents, the author might mention a machine adjusted by him for no volts per bar under a load of 200 amperes. With the same adjustment the machine was able to carry 10,000 amperes very satisfactorily. The method of adjusting described can be relied upon only when it is certain that the pole is of sufficient size to carry the maximum flux of armature induction without approaching saturation.

As previously pointed out, with zero volts per bar under the brush the auxiliary pole flux is exactly equal to the armature flux. The armature flux varies directly as the armature current. Therefore, if a series of readings are taken of armature current, and the corresponding auxiliary pole current necessary for zero volts per bar, a curve plotted from these readings is the saturation curve of the auxiliary pole. Such a curve is of great value for checking original calculations, and of particular value when it is necessary to supply new coils or poles, or both. It shows the exact point at which even a slight degree of saturation is apparent, and therefore the correct size of the new poles, and the exact number of turns necessary on the coils at low loads, and therefore on the new coils at all loads. It will be noted that this method of adjustment depends only on the current carried by the armature, and not in any way on what may be termed the stability factor, or the ratio of the armature ampere-turns to the main field ampere-turns.

A simple method of taking this saturation curve is shown in Fig. 5. G and F represent the armature and the auxiliary field of the machine under test. B is a low-voltage separately excited booster, connected directly across the auxiliary field of the machine. A_1 and A_2 are ammeters; A_2 may be a zero centre ammeter, but since not more than one reversal of current is made this is not necessary. The method of testing is apparent from inspection. The rising curve should be taken; that is, the pole should be adjusted for increasing loads. It will be found that for the lowest load taken an accurate adjustment to zero volts is desirable. For succeeding loads the exact curve can be determined by interpolation from a series of more or less exact readings. A slight experience makes it possible to take the saturation curve of the auxiliary pole with very little less trouble than is experienced in taking the same curve for the main poles.

The following points are of interest, although not touched on in the main body of the Paper. The shape of the pole-tip which the writer has found as useful as any other is a tip with a perfectly plane face, designed to help to support the auxiliary coil, the edges shaped to reduce magnetic leakage as much as possible. It may be a solid bar of soft steel, as heating of the face from eddy currents does not seem a common source of trouble.

A low magnetic density in the magnetic yoke should be employed, but the importance of this point can be easily over-estimated. In the majority of direct-current machines the density in the yoke is low, and the addition of the slight flux of the auxiliary pole will cause very little change in the necessary magnetomotive force. Moreover, the combination of the auxiliary pole flux and the main pole flux in the yoke is such as to still further minimise this effect of density in the magnetic yoke. Since, instead of increasing the magnetic density from one auxiliary pole to the next, the density is increased only from the auxiliary pole to the edge of the next succeeding main pole, and is decreased by the same amount for the same distance through the rest of the path, so that the necessary magnetomotive force is very little changed.

For a shunt to the auxiliary coil an inductive resistance should be used having the same time constant as the coils, otherwise the operation will be unsatisfactory on variable loads.

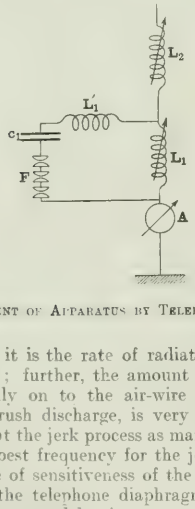
THE NEW TELEFUNKEN METHOD OF WIRELESS TELEGRAPHY.

BY W. H. ECCLES, D.SC.

In a lecture delivered at Cologne nearly two months ago, Count Arco described a number of improvements that have been made in the wireless telegraph methods and apparatus of the Gesellschaft für Drahtlose Telegraphie. An abstract of the lecture appeared in THE ELECTRICIAN of June 18th (p. 370) and a preliminary announcement, also by Count Arco, appeared in THE ELECTRICIAN of April 30th (p. 89). The changes discussed in these communications form so great a contrast with the former methods of the Telefunken Company that a leisurely examination into the merits, scientific and practical, of the recent alterations seems needed at the present moment. Such discussion is the more necessary in view of the rather paradoxical aspect of some of the Telefunken improvements—to

mention only one point, the introduction of a heavily damped (or "quenched") spark into a circuit closely coupled to the air-wire, at first sight seems contrary to that reduction of primary damping and coupling which has up to now been universally accepted to be the direction of real progress. This *volte face* must, of course, be critically looked into before full confidence can be placed in the new methods.

The system is based on Wien's well-known method of exciting oscillations in a slightly damped circuit by impulsive action from another oscillatory circuit which is opened immediately after the blow is delivered. The opening of the exciter or primary circuit is accomplished by quenching its spark. The result is that oscillations of single frequency and small damping are set up in the secondary circuit. The actual arrangement of apparatus used by the Telefunken Company is shown in the figure. Direct and rather close coupling of primary and secondary is used. The high-tension winding of a transformer is connected to the spark-gap in the ordinary way, and therefore the passage of a spark sets the system into electrical oscillation. The spark-gap consists of a series of cooled parallel metal plates, and produces very rapid damping in the spark circuit, that is to say, quenches the spark. In consequence, the action of the primary is of the nature of a short-lived jerk whose termination is marked by the opening of the branch circuit; and then the aerial system is left alone to execute electrical oscillations of its own period and damping. In other words, a fraction of the primary energy is thrown suddenly upon the air-wire and left to dissipate itself—chiefly, it is hoped, as radiation. Now,



Arrangement of Apparatus by Telefunken Co.

in aural reception it is the rate of radiation of energy, the *power*, that counts; further, the amount of energy that can be pushed suddenly on to the air-wire without provoking heavy losses by brush discharge, is very small: hence it is imperative to repeat the jerk process as many times per second as possible. The best frequency for the jerks is fixed principally by the range of sensitiveness of the human ear and by the properties of the telephone diaphragm; but taking the 1,000 per second suggested by Arco as a rough figure for the frequency, the problem arises of making this number of serviceable sparks per second. It is a merit of the new Telefunken methods that the same complex spark-gap that is used to damp the primary oscillations quickly, suffices at the same time to make a thousand sparks per second possible without heating the metal surfaces to the arcing point. The rapid series of sparks is produced by the use of a specially designed alternator which supplies current of the standard frequency to the low-tension windings of the transformer. Much of the present paragraph applies also to the Lepel method of exciting the aerial, since it also is based on Wien's shock-excitation principle. Mr. Lepel uses the fact that the direct-current discharge across a very short cooled gap which is shunted by an oscillatory circuit of relatively very large capacity becomes broken into a sustained series of exceedingly frequent spurts. The frequency of these spurts is much above the limit of audition; and therefore the broken discharge, or its effects at the receiver, must be cut up to yield acoustic requencies. It seems possible that these ultra-acoustic interruptions of the discharge in the Lepel apparatus occur also at the peaks of the voltage curves of the Telefunken transformer; and then the essential difference between the Lepel and Telefunken methods is that Mr. Lepel uses a low voltage and single gap, whereas the Telefunken Company use a high voltage and a series of gaps. However, as Count Arco appears to deny this virtual identity and to insist that only one spark occurs at each alternation of voltage in the Telefunken generator, it is convenient (and unimportant in the argument) to accept his statement.

The principal advantages claimed for the new Telefunken method are: (*a*) High overall efficiency, (*b*) small damping in the radiated waves, (*c*) singleness of wave, (*d*) musical tones in the telephone at the receiving end. We have to look into the means of attaining, and the degree of perfection of, these improvements.

(*a*) The overall efficiency of a sending set ought to be measured by comparing the energy detached as radiation with that delivered from the source of electrical energy. There is not at present any means of measuring the radiated energy directly. Numerical estimates of efficiency must therefore be received with caution, especially if they appear boastful. But since the principal energy losses are easily enumerated it is easy to say in what directions improvement in overall efficiency is to be sought. The chief losses in a coupled sender arise from brush or glow discharges in the primary and secondary circuits, from ohmic resistance in the earth, in primary and secondary conductors and in the primary spark, and, in the case of badly designed plant, from eddy and circulating current losses in various conductors. The loss from silent discharges may be enormous, and is irremediable (and uncomputable) where high voltages exist on the air-wires. The ohmic losses in most stations are considerable both in primary and secondary; while the loss at the spark-gap is obviously always great. Any way of reducing these losses makes the radiated energy a greater proportion of the whole energy undergoing transformation and thus increases the overall efficiency. The Telefunken engineers have worked along these lines with great success. In the first place they have reduced the aerial voltages, and they have made up for the consequent decrease of radiation per spark by increasing the number of sparks per second. For instance, if the spark frequency be increased from the old fashioned 50 per second to 1,250 per second the same antenna will radiate at least at the same rate, with an aerial voltage one-fifth as great as before. The decrease in the loss from silent discharge might be reduced by the application of this principle from a very large figure to a small one. This improvement is not, however, the prerogative of the Telefunken engineers; in fact, they have been rather slower than Fessenden and Marconi in applying the principle. Marconi especially, by the use of the rotating disc discharger, has utilised the principle very successfully.

In the second place the Telefunken engineers have reduced the losses in all conductors conveying large oscillatory currents. They have done this by carrying to an extreme the process of stranding the conductors. For instance, Count Arco mentioned in his lecture that the aerial coils were wound of stranded cables composed of more than 3,000 wires of diameter corresponding to our S.W.G. 46, thus reducing the resistance offered to the aerial currents to 3 ohms. Fessenden, also, some years ago, claimed to have made a like reduction—how, is not known. Fessenden and Marconi have both used liberal sizes in tube and sheet copper and in cased cord—a less compact method than the German.

In the third place the Telefunken Company claim to have reduced the spark-gap losses by using the sparker of copper and mica sheets with the air-wire connections shown in the figure. It will be seen from this figure that since the spark in the gap F is quickly quenched the oscillations along the air-wire do not pass through the spark-gap. In the usual disposition of the coupled circuit method, and also in the antique "plain air-wire" method, the spark-gap is always in the path of somewhat prolonged oscillations. It may be remarked

here that the new Telefunken sender might be regarded as consisting of a wire leading to an elevated capacity—the original Marconi aerial—excited by jerks and allowed to radiate in its own period just as was the ancient aerial, but with the spark-gap removed from the path of the oscillations. This relapse of the Telefunken Company towards a method that savours strongly of the plain aerial method condemned by the International Convention is perhaps justified by the shifting of the spark-gap. But it is not easy to decide whether a heavily-damped spark-gap in the branch circuit is actually a more economical device than a properly designed spark-gap placed in the air-wire of an elevated capacity system. The point will be tested before long, I hope, by unbiassed observers. At first sight, since the wastage in a spark-gap is roughly inversely proportional to the damping factor, the heavily damped spark-gap is apparently more economical than one made as slightly damped as possible. But this deduction is made on the supposition that the initial currents in the two contrasted gaps are equal. Now, in the method of the diagram, if oscillations of stated amplitude are to be excited by shock in the air-wire, the current through the heavily-damped gap in the branch circuit will probably have to be initially greater than would be the current through a gap placed in the air-wires in the old-fashioned way; and thus it may come to pass that a comparatively small saving, if any, is effected by the shock excitation method. The physics of the spark is so complicated a matter that mere calculation can offer nothing towards a sound decision. It is more difficult, again, to compare the method of shock excitation of the air-wires with the method of excitation by a loosely-coupled closed reservoir circuit containing an ordinary spark-gap, and the comparison ought not to be attempted without adequate data. The comparison is made still more difficult if it be remembered that it would be possible in the modern disc method of making the primary spark, to arrange the peripheral speed of the disc so as to destroy the spark at the most favourable moment and thus to pass all the energy from the primary circuit to the air-wires without jerk. On the whole we have to conclude that the advantages claimed for the shock method over methods of established value, as regards economy of energy, are not yet proven.

(*b*) The second improvement claimed for the new method is that the emitted waves have smaller damping than is the case with other methods, and hence that sharper tuning is possible. This is in the main correct. The damping will clearly be somewhat smaller than that found with the simple elevated capacity or the Lodge-Muirhead "aerial carpets," even when these are improved by proper reduction of ohmic and brush losses, and also by that employment of multiple enclosed spark-gaps of minimum resistance which has been practised for some years by the Lodge-Muirhead syndicate and others. This increase of selectiveness is a true advantage whenever it happens that exceedingly sharp tuning is absolutely necessary—a rare event. But, here again, comparison with the tuned coupled sender becomes necessary. The structure of the air-wire system is a matter of importance in this connection. If the capacity of the air-wires exceeds a certain lower limit and the radiative power is less than a certain upper limit we can conclude at once that the shock-excitation method will give waves less damped than those got by the coupled-circuit method; but if the conditions are otherwise it will on the contrary give a wave more highly damped than the wave from the coupled sender. This is for small sets. When we come to large powers, the quenched spark method must be compared with the coupled-sender operated by the rotating disc. And with the latter it should be possible to generate waves of very small damping factor; unfortunately, Dr. Marconi has published almost nothing on these matters. We conclude that in respect of sharpness of tuning, the quenched spark can be expected to be better than the coupled sender for small powers, only when air-wires above a certain capacity are used; and in respect of large powers there is no strong argument or evidence available to favour either method.

(*c*) The third improvement claimed for the Telefunken sender is that a single wave is generated. This is presented, of course, as an improvement over the coupled sender, not over the ancient simple elevated capacity and spark-gap. I think that only slight stress is intended to be laid on this advantage. The "see what you save" argument is a weak one; firstly, because it is probable that coupled circuits can be constructed, if required, so as to concentrate the main part of the energy into one prolonged wave train of single frequency, and, secondly, because a few per cent. saving in current consumption is not worth considering in commonplace everyday wireless telegraphy.

(*d*) The fourth improvement is in Arco's own words "perhaps the greatest advantage of the new singing spark." Dots and dashes are received by the operator in a clear musical tone distinctive of the station he wishes to read and very different from the noise of atmospheric disturbances. Count Arco proceeds: "It may be said that for the first time since the invention of wireless telegraphy a system has been obtained which enables telegraphic work to be carried on through the heaviest atmospheric disturbances." This statement is not correct. Musical-toned signals have been produced and used habitually and extremely successfully by others. Fessenden has wailed across parts of the North Atlantic for years, and Marconi's disc has been singing through atmospheric disturbances for quite a long time. Our own Admiralty has long been employing quick alternating current and transformers, just as the Telefunken Company do now. Perhaps the Telefunken people, though somewhat tardy in arriving at this stage of development, have now succeeded in producing shriller notes than their predecessors, notes nearer the optimum for their *own* telephone receivers. The copper-mica spark-gap will assuredly make easier the production of high notes by alternating current and transformer, because the strong cooling prevents the formation of an arc. The special design of their alternating-current generator contributes to this success. This generator, it may be recalled, is wound to produce an alternating current of the frequency of the desired note and of very peaky wave form, the voltage being stepped up to 70,000 by a transformer. The idea of such a generator is not novel—for instance, Villard designed such machines in 1907—but the Telefunken Company have carried the design much nearer perfection. Nevertheless, the fundamental objection to the use of such a generator in wireless telegraphy still remains. This objection is that the unavoidable irregularity of a load consisting of dots and dashes makes constancy of acoustic frequency almost impossible without a big reserve of power or ample flywheel provision. Fessenden also has encountered this difficulty, I believe. In fact, the only conceivable mechanical way to attain absolutely constant acoustic frequency, and yet employ minimum electrical generating units, is to cut up the low voltage or high-voltage current by means of a commutator or similar device driven and governed independently of the machine supplying signalling energy.

To summarise: The foregoing analysis of the claims of the new Telefunken apparatus shows that the genuine improvements contributed to the technology of wireless telegraphy consist of the extreme stranding of the conductors carrying heavy oscillatory currents, and the employment of more frequent sparks than are usually used by the originators of the singing spark. The stranding reduces ohmic losses and the quicker spark-rate reduces losses by discharge from the aerial wires. These things accomplished, we find, then, that an elevated capacity can emit little-damped waves conveying considerable total energy per second. (This, by the way, should be very encouraging to the Lodge-Muirhead Syndicate.) These improvements taken by themselves are amply sufficient to account for the inferiority of the old Telefunken apparatus as compared with the new, without invoking the copper-mica plate spark-gap or any of the numerous devices that might replace it. Finally, its seems inevitable that in the effort to increase the power of emission to greater values the Telefunken Company will be obliged to reinstate the coupled reservoir-circuit which they have lately taken such pains to eliminate, unless they are prepared to erect gigantic radiating antennæ.

LARGE CONTINUOUS-CURRENT LOCOMOTIVES.*

The General Electric Co., of America, have recently supplied the equipment for what is stated to be the most powerful continuous-current locomotive—at any rate, as regards tractive effort—yet designed. This locomotive is one of six which are to be operated in the new tunnel under the Detroit river, in connection with the Michigan Central Railroad. The length of track to be electrically operated is about 6 miles, and the maximum gradient, which is adjacent to the two approaches to the tunnel, is about 2 per cent., and extends for 0·4 mile in each case.

The locomotives are designed for hauling both freight and passenger traffic through the tunnel, and also for switching service at the termini. The specifications provide for a capacity sufficient to haul a 1,800 ton train on a 2 per cent. gradient at a speed of not less than 10 miles per hour, with two locomotives in multiple unit, and the motors are to be capable of repeating trips with this weight of train continuously with a lay-over of 15 minutes at each end.

The locomotives are of the articulated four-axle type, weigh 200,000 lb. each, and are equipped with four G.E.-209 motors. The truck side frames are heavy steel castings of a truss pattern, and are heavier than required from considerations of strength, so as to obtain the necessary weight on the driving wheels. The end frames and bolsters are castings of heavy box girder types, rigidly bolted to the side frames, and fitted in such a manner as to relieve the bolts of shear. Draft gear, buffers and all truck frame members are calculated for buffing stresses of 500,000 lb., and hauling stresses in proportion.

The spring suspension is of the locomotive type, the weight being carried on semi-elliptical springs resting on the journal box saddles. The system of equalisation by which these springs are connected together is interesting. The "A" end of the running gear—that is, say, the forward truck—is side equalised, the two springs on each side being connected together through an equaliser beam. This equalises the distribution of weight between the two wheels on one side, giving to this truck a two-point support and leaving it in a condition of unstable equilibrium as regards tilting stresses—that is, stresses tending to tip the truck forward or backward. The "B" end of the running gear—or, say, the rear truck of the locomotive—is cross equalised, the two springs on the rear axle being connected together through an equaliser beam. The other two springs on this truck are independent and are connected directly to the truck frame. This results in a three-point suspension on the rear truck, leaving it in a condition of stable equilibrium, capable of resisting stresses in any direction, whether rolling or tilting. The two trucks are coupled together by a massive hinge so designed as to enable the rear truck to resist any tilting tendency of the forward truck; so that this hinge combines the two trucks into a single articulated running gear, having lateral flexibility with vertical rigidity. The braking equipment is arranged so that the action is mechanically independent on each truck.

As mentioned above, the motor equipment consists of four standard General Electric motors of the commutating pole type, each having a rating of approximately 300 H.P. At its one-hour rating the motor will develop a torque of 4,050 lb. at 1 ft. radius. The gearing between motor and axle has a 4·37 reduction, and the driving wheels are 48 in. in diameter. With this reduction, each motor will develop a tractive effort of 9,000 lb. at the rail head, which gives a total tractive effort for the four motors of 36,000 lb. at 12 miles per hour. The motors have an overload capacity sufficient to skid the driving wheels, and the locomotive can develop at the slipping point of the wheels an instantaneous tractive effort of 50,000 lb. to 60,000 lb. The maximum speed of the locomotive, running light upon a level track, is about 35 miles per hour. There are two gears and pinions per motor, one at either end of the armature shaft. This construction was used on account of the unusually heavy torque and the excessive overloads that the motors will be called upon to carry.

The motors are designed for forced ventilation. Air is delivered into the motor frames at the end furthest from the commutator, passes between the field coils and around the armature, and finally escapes through suitable discharge openings over the commutator. The blower used for this purpose has a capacity of 2,000 cubic ft. of air per minute at 2½ in. water pressure, and is driven by a direct-current series motor.

The Sprague-General Electric multiple unit control is used, with two master controllers in the main cab and the contactors in the auxiliary cab. Multiple unit connections have been supplied, so that three locomotives may be operated in multiple unit if necessary. The problem of starting and accelerating a train of from 1,000 to 1,500 tons, which may consist of 40 or 50 cars, is a rather delicate one. Such a train is not a rigid mass, but a long elastic body, and any inequality in the starting torque results in waves of jerking and buffing strains which are very likely to reach abnormal values in some parts of the train. Consequently, the control of this locomotive was designed especially to produce a uniform increase of speed and torque during the period of acceleration. The control combinations are arranged so that the motors may be operated four in series, two in series and two in parallel, or four in parallel. There are nine resistance steps in series, eight in series parallel and seven in the parallel position. This, it is stated, gives a very smooth acceleration, the value of which in starting a long and heavy train will readily be appreciated.

The locomotive is equipped with third-rail shoes to take current from an inverted third rail. It is also fitted with an overhead trolley which can be raised or lowered by a foot operated valve in front of the motorman.

* This description is based on articles which have appeared in the American technical press.

A BIFILAR VIBRATION GALVANOMETER.*

BY W. DUDDELL.

Summary.—A new type of vibration galvanometer and a series of tests made upon it are here described. The features of the instrument, which is practically a Duddell Oscillograph, comprise simplicity, the small mass of the moving parts, the wide range of frequency for which it can be tuned, high sensibility, negligible self-induction and comparatively small back E.M.F.

Vibration galvanometers, like ordinary galvanometers, may be broadly divided into two classes—those in which the moving part consists of a piece of iron or steel and the current to be measured flows round fixed coils as in the case of the Thomson galvanometer; those in which the current to be measured flows round a moving coil placed in a fixed magnetic field on the siphon recorder principle. The vibration galvanometers of Max Wien and Rubens belong to the first class, while Mr. Campbell's moving-coil vibration galvanometer belongs to the second, and so does the new bifilar instrument described below. Generally speaking, when one requires to build a sensitive instrument having a short periodic time it is necessary to reduce as far as possible the mass of the moving parts in order to combine high sensibility with short period. Further, in the case of a vibration galvanometer, it is also necessary to keep the damping forces as small as possible, as the sensibility to alternating currents depends very greatly on the magnification one can obtain by bringing the instrument into tune or resonance with the alternating current to be measured. These considerations have led me to construct a vibration galvanometer in which the mass of the moving parts is reduced to a minimum, the moving coil being reduced to the two wires forming its two sides, similar to a bifilar oscillograph, but with this difference: Whereas the bifilar oscillograph is designed so as to make the damping aperiodic, the bifilar vibration galvanometer is designed so as to keep the damping as small as possible.

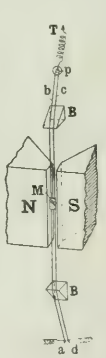


Fig. 1.

The design of the instrument† is shown in Fig. 1, in which *a, b, c, d* is a fine bronze wire passing over a pulley, *p*, and stretched tight by means of a spring, the tension on the spring being capable of variation by a milled head. The wires carry a mirror, M, in the centre, and are placed in a strong magnetic field between the poles N and S of a magnet. The wires pass over two bridge pieces (B B), which limit the length of the wires that is free to vibrate. These two bridge pieces can be moved nearer together or further apart by means of a right and left-handed screw as required. The current to be measured passes up one wire and down the other, causing one wire to tend to move forward and the other back in the magnetic field, and so tilts the mirror M through a small angle. The periodic time of the wires depends on their mass, length and tension, as well as upon the moment of inertia of the mirror. In a completed instrument the moment of inertia of the mirror and the mass of the wires are fixed, but their length and tension can be altered in order to adjust the periodic time. It is seen from curves in the Paper, showing the relationship between the free length of the wires, the frequency of the free vibration and different tensions, that the total range of frequency obtain-

* Abstract of a Paper read before the Physical Society. A brief account of the discussion appeared in THE ELECTRICIAN, June 4, 1909, p. 302.

† Messrs. Nalder Bros are manufacturing the instruments.

able with the instrument is very large—namely, from about 90∼ per second up to 1,900∼, though the wires are rather too loose below 100∼ per second.

As the damping in the instrument is very small, the resonance is very sharp. Fig. 2 shows the amplitude of the deflection where an alternating current, having a constant root mean square value, is passed through the instrument, set for 595∼ per second, the frequency of the alternating current being varied.

To measure the sensibility of the instrument the following method was used: A current, generally 0·1 ampere, from a small high-frequency alternator having a very nearly sinusoidal wave-form, was passed through a small non-inductive resistance and an accurate

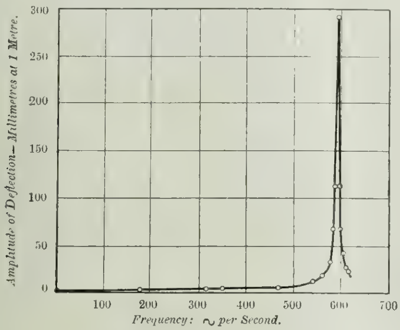


FIG. 2.

dynamometer. The vibration galvanometer in series with a high non-inductive resistance (25,000 ohms) was connected as a shunt to the terminals of the small resistance in the main circuit. The current of 0·1 ampere flowing through the main resistance produced a small known difference of potential applied to the galvanometer circuit, from which the current through the galvanometer could be calculated.

With an instrument giving a very sharp resonance there is some difficulty in determining the exact value of the maximum amplitude, a fact which prevents such consistent results being obtained as would otherwise be the case. When the instrument is tuned so as to be in resonance with the alternating current to be measured, the amplitude of the vibration is practically proportional to the root mean

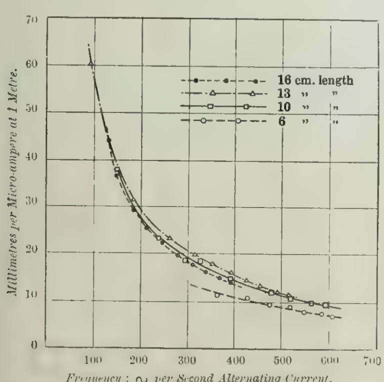


FIG. 3.

square current, hence it is permissible to quote the sensibility in millimetres of amplitude at a metre, per root mean square microampere. This method has, therefore, been adopted.

In Fig. 3 the relationship between the sensibility of the instrument in millimetres of amplitude per root mean square microampere, and the frequency of the alternating current is given. The different curves refer to different free lengths of the wires. One interesting point of this figure is that where it is possible to tune this vibration galvanometer to a given frequency, using various combinations of length and tension, the sensibility so obtained is very nearly the same so long as the wires are longer than the pole-pieces. The practical result of this is that if at any given length of wire or tension one can tune the instrument to suit the frequency of the alternating current, then no further adjustments need be made in the hope of finding a better combination of length and tension for the purpose.

With each adjustment of the instrument in Fig. 3 to suit the various frequencies the sensibility of the instrument was tested with direct current as an ordinary galvanometer. The tests show that whilst the sensibility to alternating current decreases very nearly inversely as the frequency for which the instrument is adjusted, for direct current the sensibility decreases approximately inversely as the square of the frequency. A new curve can then be obtained (Fig. 4), which I have called the magnification, which shows for a given adjustment of the instrument how much more sensitive it is to an alternating current of the proper frequency than to a direct current. The highest value obtained in the curves is about 460. Had the vibration galvanometer been aperiodic and of sufficiently short period to follow the alternating current, then the alternating current sensibility would have been only $2\sqrt{2}=2·82$ times the direct-current sensibility.

The practical applications of the vibration galvanometer nearly all involve using the instrument in some form of bridge or null method for determining when a small difference of potential vanishes, that is to say, the instrument is generally used as a sensitive detector for small alternating voltages. The resistance of the instrument used in these tests is 136 ohms, but owing to the back E.M.F. of the instrument its sensibility as a voltmeter must not be calculated on

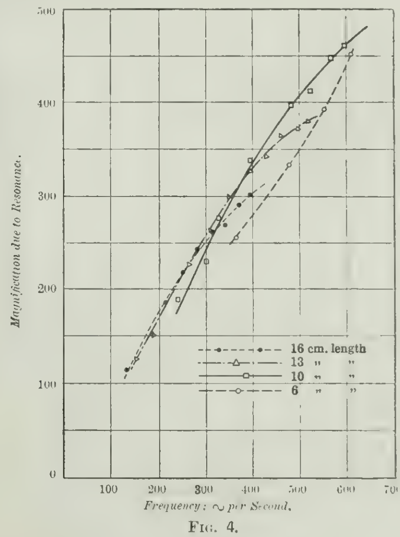


FIG. 4.

the basis of this figure. This resistance could be easily reduced by employing a more conducting material than hard phosphor-bronze for the wires. There would be no objection to doing this except that the upper limit of the frequency to which the instrument could be tuned, without risk of breaking the wires, would be somewhat reduced.

The author then describes some tests to determine the back E.M.F. of the instrument. The very large amount that the apparent resistance of the instrument is increased by its back E.M.F., over 200 ohms in one case, shows how very important it is to try to keep this back E.M.F. as low as possible, and how little can be gained by reducing the real resistance of the wires themselves. The fact that the back E.M.F. of the instrument is practically proportional to the deflection, and hence to the current through it, and so appears, as far as the outside circuit is concerned, like an addition to the resistance of the instrument, indicates that no arrangement of condensers is likely to improve matters as one might at first expect. It is seen that there is some advantage in using the wires as short as possible when measuring small P.D.s in a low-resistance circuit.

All the sensibilities so far given for the vibration galvanometer correspond to the use of a permanent magnet for the field. The instrument has, however, been tried in an oscillograph electromagnet, and the current sensibility was found to be increased threefold. This corresponds at a 100 frequency to a sensibility of not less than 160 mm. per microampere; as a small fraction of a millimetre movement of the spot is noticeable, we may reckon that at a 100 fre-

quency with this instrument we can detect a current as low as 2 or 3×10^{-9} ampere.

The advantages of the bifilar galvanometer may be summarised as follows: Simplicity, ease in tuning, wide range of frequency for which it can be tuned, high sensibility, negligible self-induction, comparatively small back E.M.F. Its main defect is the small size of mirror that it is necessary to use on the instrument. With a carefully adjusted optical arrangement, and using a small 4 volt metal filament lamp, one can work with comfort at a scale distance of a metre in a room which is not too well lighted.

MODERN SUBMARINE TELEGRAPHY.

BY S. G. BROWN.

We briefly abstracted in THE ELECTRICIAN for March 19 the Paper read by Mr. S. G. Brown before the Royal Institution on March 12th entitled "Modern Submarine Telegraphy." The Paper has an interest for many of our readers, and we are therefore pleased to have the opportunity of making fuller reference to it. It must be remembered that the audiences at the Royal Institution are largely non-technical, and that, consequently, the lecturer had to introduce his subject by some of the elementary facts which govern the operation of submarine cables for telegraphic work. After a brief introduction Mr. Brown proceeded:—

This lecture relates to modern submarine telegraphy, and, therefore, I shall omit the historical part of the subject and start with the cable itself as we deal with it now.

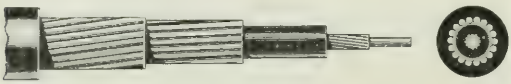


FIG. 1.—ATLANTIC 1894 CABLE.

When dealing with the electrical properties of a cable the core only is considered, and for all practical purposes it may be taken that the return conductor to the current is the water immediately outside the gutta-percha with which the wire or core is covered. A core of any given length has a certain time rate of signalling—that is to say, when a voltage is applied at one end the effective current that as a consequence flows in the wire does not arrive at the distant end instantaneously, but takes time to grow. The time rate of signalling is inversely proportional to the product of the resistance of the wire and the electrostatic capacity of the core. This is termed the "K.R.," or capacity-resistance law, a law first pointed out by Lord Kelvin.

It follows from this law that if you double the length of any given kind of cable you reduce its speed for signalling to one quarter. The time rate is inversely proportional to the resistance multiplied by the capacity. If you make a certain sized core (size of gutta-percha) with a large copper, up to a certain point you decrease the resistance and increase the capacity, but there is a critical value giving the minimum K.R. This critical limit, or the point when the size of the copper is reached to give the lowest K.R., is when the diameter of the copper is to the diameter of the core as 1 : 1·65.

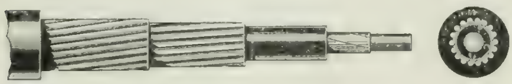


FIG. 2.—IDEAL CABLE.

There is another advantage in keeping the resistance low for any K.R. The time constant only determines the time when the current at the far end reaches a certain percentage of the possible maximum after the application of the voltage at the sending end. Of course, the amount of current after any given time is determined again by the voltage of the sending battery, and is inversely as the resistance of the cable. For instance, if two cables were constructed of equal K.R., but one had a larger copper of half the resistance of the other, with equal sending batteries, the one with the lower resistance would deliver twice the current at the receiving end at the ends of equal times, and could, therefore, be made to work at a faster rate. It should also be a cheaper cable, because copper is less expensive than gutta-percha.

Against these electrical advantages should be placed several mechanical disadvantages: the reduction of the thickness of the insulation might result in a greater liability to faults developing after the cable was laid. With such a heavy wire, which would naturally have to be well stranded to reduce the stiffness, the liability of the decentralisation during manufacture would be greater than with existing cores. These mechanical difficulties could, I feel sure, be overcome, say, by greater care being taken in the manufacture, or by substitution for the present yielding gutta-percha dry cotton or similar material well impregnated with gutta-percha compound. I take an Atlantic cable laid in 1894, as having the greatest size of copper for size of core. I take this core to illustrate the improvement that might result by increasing the copper up to the largest size electrically permissible:—

1894 Atlantic Cable (FIG. 1).

Diameter of core	0·466 in.
" copper	0·202 in.
Resistance per nautical mile	= 1·684 ohms.
Capacity " "	= 0·420 mfd.

The cable is 1.852 nautical miles long, its K.R. is 2·41, and its speed of working under the capacity block system of duplex about 205 letters per minute.

The Ideal Core (FIG 2).

Diameter of core	0·466 in.
" copper	0·282 in.
Resistance per nautical mile	= 0·864 ohm.
Capacity " "	= 0·700 mfd.
K.R. for 1.852 nautical miles	= 2·06

Speed of working with same duplex system about 240 letters per minute, and the current received with this speed would be twice as

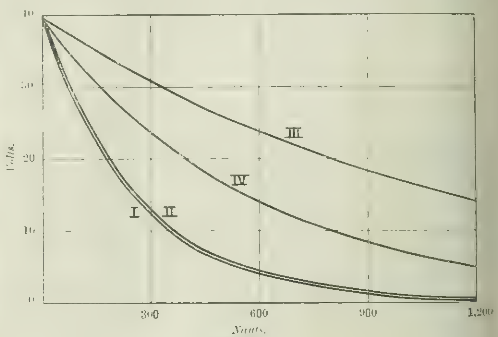


FIG. 3.

strong as in the actual cable, so that a still greater speed than that given would result; perhaps a speed of 260 letters per minute; a sending battery of 40 volts to be used on both cables.

The copper conductor offers resistance to the electric currents that flow along it. This resistance by itself would not, with sufficiently sensitive receiving instruments, affect the speed of signalling; it produces what is termed "attenuation," or a weakening of the signalling current. There is also a lateral storage of electricity along

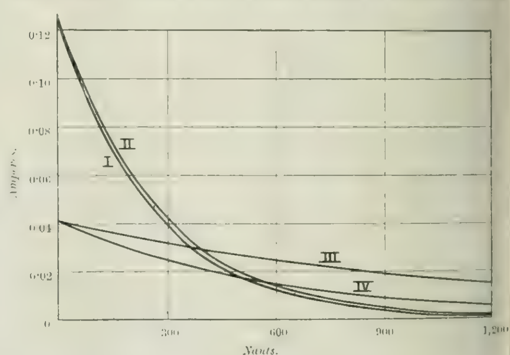


FIG. 4.

the outside of the copper, due to the capacity of the insulating material to absorb a charge of electricity; this property is termed the electrostatic capacity of the core.

To allow this to be more fully understood I shall take mechanical analogies:—

Resistance in electricity is equivalent to friction in mechanics, capacity to elasticity of a spring, and self-induction to inertia.

The core of a submarine cable is similar to that of a pipe charged with water—the force of the water creates resistance. In the case of our submarine cable, the less the capacity and the less the resistance the less the time constant or the quicker the rate of signalling. I may say that the current usually received would be 1,000 times greater if we had no capacity but only the resistance to deal with.

Nauts (x)	I.		II.		III.		IV.	
	Volts.	Amps.	Volts.	Amps.	Volts.	Amps.	Volts.	Amps.
0	40·0	0·1264	40·0	0·1264	40·0	0·0408	40·0	0·041
300	12·25	0·039	12·7	0·042	31·0	0·0316	23·7	0·0244
600	3·8	0·0125	4·4	0·0137	23·9	0·0244	14·2	0·0147
900	1·1	0·005	1·5	0·0055	18·5	0·0189	8·3	0·0088
1,200	0·35	0·0012	0·48	0·00155	14·2	0·0146	5·1	0·0051
1,500	0·15	0·00065	0·2	0·00083	11·0	0·0112	3·04	0·0031
1,825	0·0453	0·00014	30·0418	0·000132	8·32	0·0085	1·71	0·00175
Total lag behind V_0	371	371	392	347	1,717°	1,714°	1,714	1,714

Except in Case I. (near its end), the lag in every case is proportional to x. Frequency, 6·36 per second.

Submarine Telegraph Cable.—r = 1·684 ohms per naut, k = 0·42 mfd. per naut. The current received by recorder would be 82 times this if we had no capacity.

At x nauts from sending end these are the volts and amperes :—

I. There is a recorder with 317 ohms resistance at the end of 1,825 naut cable.

II. Infinite cable.

III. Infinite cable, 0·4 henrys per naut ; no leakance. Not much distortion.

IV. Infinite cable, 0·4 henrys per naut ; leakance, $1·768 \times 10^{-6}$ mhos per naut to give *no* distortion.

(*See also* Figs. 3 and 4)

As stated, the cable has resistance, the current therefore suffers attenuation. It also possesses capacity; the signalling currents through it therefore suffer distortion. Before dealing with this distortion I must refer you to Fig. 5. You will notice that the signals, arranged to form the alphabet in the cable code are of varying lengths, being one, two, three, four and five times the length of the individual or shortest signal. Sending and receiving on this principle is electrically equivalent to working the cable with varying electrical frequencies of six, three, two, &c., complete periods per second. The lower the frequency the less the capacity affects the current, so that the higher frequencies of six and three a second are more attenuated than those of two and less. The signals that form the letters in the alphabet are differentially attenuated ; the quicker signals, such as those forming a C, are much weaker when they arrive to operate the receiving instrument than the slower signals that form the letters M, O, and so on for the other and longer signals.

Submarine cable signalling of the present day affords us an electrical illustration of that fable of "the tortoise and the hare," or the principle of "more haste, less speed." As the slower signals get through the cable with more vigour than is necessary, the ingenuity of experimenters is to retard them, and to assist as much as possible the quicker ones, so that all the signals, whatever their period, shall arrive with exactly the same strength. Cromwell Varley, in 1862, patented a system for the reduction of distortion on cables by inserting condensers of suitable capacity in series with the conductor at each end of the cable.

The reason for the abolition of distortion is obvious : The condenser absorbs the signals of slow frequency, while the cable transmits them. The condenser allows the signals of high frequency to pass through it although the cable has attenuated them. It is, therefore, possible so to arrange the condensers at each end of the line that the condensers and the cable together will more or less correct one another and the distortion be reduced. Unfortunately, the absorption of a series condenser is relative, and is inversely proportional to the frequency : it absorbs more of the slow than the quick signals. At the same time it does absorb some of the quick, and so far as that is concerned it is harmful ; it diminishes distortion, but at the same time adds to the attenuation.

Now "distortion" means something more than the differential transmission of various electrical frequencies—it also means the "phase relation" of the current to the voltage ; and this "phase relation" varies with the various frequencies. By "phase relation" we mean the position of the current with regard to the voltage producing it. To understand what "phase relation" means let us take the analogy of a pendulum in motion. The force keeping the pendulum swinging is a maximum at the end of each swing, while the greatest velocity resulting from this force is at the middle of the swing. Obviously, the times of greatest speed and greatest force are not coincident ; the one is out of phase with the other by what mathematicians would determine, in the case of the pendulum, as 90 deg., or a quarter period. Now the current leads the voltage at the sending end of the cable by 45 deg. If a series condenser is introduced to diminish distortion it still further increases the lead and reduces the effective power into the cable. The effective power can only be a maximum when the current and voltage are exactly in step, or, in other words, when there is no "phase relation."

A receiving condenser is also harmful for the same reason as a sending condenser. By abolishing the sending condenser and replacing the receiving one by a magnetic shunt placed across the suspended coil of the siphon recorder or relay in 1898 the speed and accuracy of signalling were materially increased. A magnetic shunt, as employed on the cables, consists of an insulated copper wire, wound round a closed circuited iron core. The resistance of the shunt is about 30 ohms, its inductance varies up to a maximum of from 20 to 40 henrys, and its weight from 1 cwt. to 3 cwt. In the case of a siphon recorder used as the receiver, the shunt short-circuits the suspended coil and the series condenser is abolished. In the case of a cable relay the series condenser is usually retained, so as to ensure that earth currents are effectually stopped, but the condenser is made large. A shunt inductance has a similar time action on the incoming current to that of a series condenser, but with this improvement, it helps to reduce the phase distortion of current with voltage rather than accentuate it, as is the case with the condenser.

Having obtained the best value of the shunt alone, the following curious effect was discovered : that adding a condenser as an additional shunt, the size of the signals on the recorder became larger and more distinct. The mathematical reason for this is as follows : that for any particular frequency—say the highest frequency of the cable signalling—the shunts of inductance and capacity, when properly proportioned, act as a shunt of infinite resistance. For frequencies much below this it is as if we had no condenser at all. For frequencies much above this it is as if we had no inductance, but only a condenser.

To reduce still further the harmful effect of phase displacement series inductances have lately been introduced at the ends of cables,

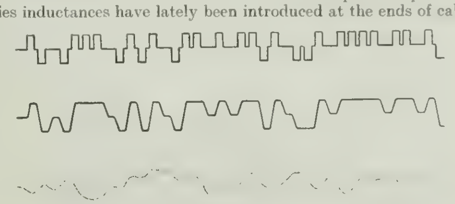


Fig. 5.

particularly at the sending end. By placing an inductive coil of low resistance in series with the battery, at the apex of the duplex bridge, not only has the speed of signalling been increased, but the effect of what is known as "jar" on the duplex balance has also been greatly reduced.

Before proceeding to describe the instruments that work the cables, I will say a few words about "duplexing." All cables are now duplexed that is to say, are arranged so that messages can be sent and received at the same time at each end simultaneously. The first cables were duplexed by Stearns, and later ones by Muirhead and Taylor. Duplex reduces the speed of simplex, or of working one way only, by some 20 per cent., but the total carrying power of the cable, irrespective of direction, is raised by some 70 per cent., and duplex is for this reason valuable, and repays the trouble in maintaining the balance. Cables are duplexed by arranging an artificial or imitation cable, which is an exact electrical copy of the real, in parallel with the actual cable. The current from the sending battery flows through two equal arms of capacity, or inductance, of a Wheatstone bridge arrangement, and into the real and artificial cables. The inductive or magnetic bridge is the best to employ, because it gives, in practice, higher speeds than any other form of bridge. The receiving instrument is joined to the commencement of the cables, and is thus not interfered with by the sending currents, because there is no tendency for the current to flow one way or the other, the real and artificial cables having exactly the same electrical properties and acting on the sending current in the same way. But the current that is received flows only from the real cable, and is not balanced by any from the artificial, so that the receiving instrument is worked by it.

When duplex is properly adjusted it is said to be in balance, from its similarity to the adjustment of an ordinary balance used for weighing goods. Take the ordinary balance as an illustration of the electrical one. Let one scale pan represent the cable, the other the artificial. If equal weights are placed in each pan the beam will not turn, but the beam will turn if, while equal weights are or are not in the pan, a small weight is added or placed on one pan.

In the cable "duplex" the receiving instrument will not be affected by the sending current, because the voltage is always the same on each side of the instrument, but will turn to indicate a signal when a voltage is received or is added to or subtracted from the voltage already on the cable side, due to a voltage being applied to the cable at the far end.

In Fig. 6 is shown the simplest diagram of a cable "duplex," and Fig. 7 illustrates its mechanical equivalent. The lettering is similarly related.

RR are the two resistances, or the arms of the balance.

S is the receiver or indicator, which shows a difference of voltage or weight.

B is the battery voltage, or weights in the pan.

C and AL are cable and artificial line respectively, or the two pans of the balance.

If the battery B sends equal currents into cable and artificial line, as it should do if there is a perfect balance, no current will flow through S, and thus the receiver S is unaffected by the sending voltage. Or if the pans of the balance have equal weights (B) placed on them, the indicator S will not move. On the contrary, if a voltage is received from the cable C, this voltage is added to or subtracted from whatever voltage may be in C at the time, due to the sending battery, and thus there will be a difference of potential across S, and the receiving instrument will be worked from currents sent from the far end of the cable and from these currents only. In the mechanical analogy a small weight, W, is added to or taken from one of two equal weights in the pans C and AL, and the beam will be tilted and will be moved by this weight only, however the weights BB are varied.

The voltage of the battery, as applied to the sending end of a cable, is very much greater than that received from the cable to work the instrument, say, in the relation of 40 volts to $\frac{1}{20}$ volt in the case of a moderately long cable, or as 800 is to 1, and the sending and received currents resulting from the same follow a similar proportion. In the mechanical illustration I have, therefore, indicated the weights B and W as squares having areas of this proportion to give a visual indication of what this means in the balance. The proportion I have given is only the relation of the sending voltage to that received. If the balance were out to this proportion, the sending voltage would affect the receiver with disturbances equal in size to those due to the receiving voltage; the duplex would then be very badly indeed out of balance. To receive properly the sending voltage must produce no movement of the receiver whatever—that is to say, any disturbance due to this cause must certainly be under one-tenth of that due to the arrival current.

Taking the figures I have given, we see that the balance must be obtained and maintained, so that, applying 40 volts to the cable and artificial line, the two currents dividing must not vary more than what will produce $\frac{1}{200}$ volt—that is, must be balanced to an accuracy of 8,000 to 1.

If, after the duplex has been established, the artificial varies in its electrical properties as much as one-eight thousandth of its value, the balance would require adjustment so as to keep it useful for receiving. The sensitiveness under these conditions may be considered as equivalent to the sensitiveness of an ordinary metal balance that with 8 grammes in each pan must turn accurately with 1 milligramme.

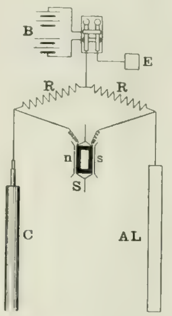


Fig. 6.

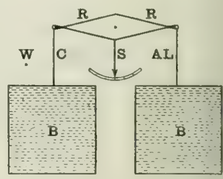


Fig. 7.

It is now found necessary to maintain still more perfect balances for my new method of "high-speed working of cables." In fact, a balance that must be maintained to within the proportion of 72,000 to 1. To do this the very greatest care has to be directed to questions of insulation and temperature correction, and special appliances are supplied to obtain this high degree of accuracy. In fact, the future of "high speed working of cables" is locked up very much with this question of more delicate and accurate balances, for if still more perfect balances could be obtained still higher working speeds of cables would immediately be possible.

(*To be continued.*)

THE ELECTRIC POWER SUPPLY OF CHICAGO.

(*Continued from page 587.*)

In the alternating-current distribution from sub-stations to consumers the Commonwealth Edison Company meets all kinds of conditions, from those of a large city to those of the smallest town. The general practice is to use one lighting transformer for each 660 ft. block. In most of the territory an interconnected secondary network, fed by a number of transformers, is impracticable, because of local conditions. To interconnect the secondaries from one block to another would require about 25 per cent. increase in copper, and it is not considered that the advantages in the majority of cases would justify this expense. There are, however, a few places where secondaries are interconnected and fed by several transformers. In such cases there are placed in the secondaries midway between transformers fuses which will blow and isolate any transformer in case of trouble. These fuses are common open-link fuses mounted on a slate block placed in a wooden box. The fuses are rated at about one-half the output of the neighbouring transformers.

The great majority of the pole lines are run in alleys, and, in some cases where there are no alleys, along rear property lines by permission of the owners. Poles are generally placed 125 ft. apart. The transformer ratio is such that 115 and 230 volts pressure on three-wire systems is delivered on the secondary with 2,080 volts pressure across the primary. The neutral wire of all secondary lighting circuits is earthed, and one point of each three-phase motor circuit is earthed.

The earthing of transformers and lightning arresters is accomplished by driving a $\frac{3}{4}$ in. galvanised iron pipe 10 ft. into the ground. A pipe cap is placed over the end of the pipe before it is driven, this cap performing the double function of protecting the end of the pipe during driving and making the electrical connection between the end of the pipe and the earth wire. The earth wires are of No. 6 or No. 4 copper, and they are protected in moulding partly for mechanical reasons and partly to avoid shocks to persons who may come in contact with them, should the earth connection be accidentally broken.

Where the arc-lamp load on the secondary becomes larger than the incandescent load, a separate arc-lamp transformer and secondary service main are installed, unless there are less than five arc lamps. This method is used because of the voltage drop in secondaries and transformers caused by arc-lamp load.

Motors are also placed on eparate transformers from the slighting load, except where the motor load is a very small fraction of the lamp load on a transformer. Motors rated at 5 H.P. or less are required to be single phase, as the company will not go to the expense of installing three-phase service with two transformers for such small motors. The company will supply energy to any single-phase motor in which the starting current is not over three times the full-load running current. The same restriction is made on three-phase motors.

In residential districts transformer rating equal to 15 to 20 per cent. of the connected load is installed. The higher ratio applies to secondaries supplying energy to a large number of small consumers. The transformer rating used in determining these transformer ratios is based on an eight-hour full load. It is considered that transformers can operate with entire safety at from 25 to 33 per cent. overload for one or two hours per night. In manufacturing and mercantile districts the transformers installed are rated at 75 per cent. of the connected load. The transformer rating on motor installations of over 25 H.P. is usually 50 per cent. of the connected load. On installations of from 100 H.P. to 300 H.P. it is 70 to 80 per cent. of the connected load.

Transformers having a total rating of 38,000 kw. are connected to the 60 cycle distributing system. The connected alternating-current load totalled last year 71,000 kw., of which 50,000 kw. was for incandescent lamps, 2,500 kw. for arc lamps and 18,500 kw. for motors. The average transformer rating was, therefore, 53·5 per cent. of the connected load for all classes of business.

The same kind of transformers are used for lamps and motors, the only difference being in the method of connecting the secondaries. The smallest transformer used is rated at 1 kw. No transformers larger than 50 kw. are used. If more output is needed than this, additional transformers are installed. The reason for this limit is partly the unwieldiness of large transformers, but mainly the fact that there are so few places where transformers of over 50 kw. are needed that it is not thought wise to keep the larger sizes in stock. The oil is replenished in transformer cases yearly.

Transformers for three-phase motors are joined with their primaries in Y connection between the neutral and outside wires of the circuit. This connection impresses the regular 2,080 volt primary E.M.F. upon them and gives a secondary E.M.F. of 230 volts. The 230 volt secondaries are connected in " delta " for the motors. The middle point of one of these delta-connected secondaries is earthed.

Fig. 13 illustrates the method by which new territory having both motor and lamp loads is built up. From a sub-station located, for example, at A, four wires are run to a distributing centre at B. From this centre single-phase lighting feeders branch off in three directions. These feeders use the common neutral from the sub-station at A to B. Aside from this, each of these feeders is independent of the others, voltage regulation being inserted in each feeder at the sub-station to maintain the proper voltage at feeder ends. If there is a demand for motor service along any one of these single-phase feeders, as, for example, at C, an additional wire is connected to the other phases at

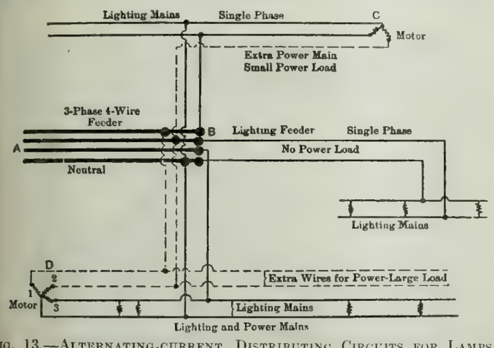


FIG. 13.—ALTERNATING-CURRENT DISTRIBUTING CIRCUITS FOR LAMPS AND MOTORS.

the distributing centre B, as indicated by the dotted line. These wires are of smaller diameter than the single-phase lighting feeder. If larger loads develop two more phase wires are put in for motors, as at D. The neutral and single-phase lighting feeders already up are used for one phase of the motor circuit and the two additional smaller wires furnish the other two-phase leads. This arrangement utilises one of the great advantages of the three-phase four-wire system for this miscellaneous class of work. Each single-phase lighting feeder can be regulated independently as to voltage for lighting purposes, and at the same time used to supply energy to one leg of the three-phase motor circuit. All of the 2,080 volt distribution system is laid out on the principle indicated in Fig. 13.

About one-half of the main feeders are laid underground. Most of the mains are erected overhead in alleys. In fact, about 90 per cent. of the overhead work is located in alleys. The feeders average about 1½ miles in length, the short length being due to the frequent location of sub-stations, local conditions, rather than reasons of electrical distribution having required the placing of sub-stations at such intervals. In a few cases where alleys have not been available, and underground work was necessary, transformers have been used in manholes. This construction is avoided as much as possible, however.

All primary mains are connected according to the " tree " method, and there are no closed loops, because in most cases there is little advantage to be gained by such loops; moreover, they are likely to cause accidents to linesmen who think that a line is dead when it has been opened at one place, but is being fed with energy from the other end. No fuses are placed at branches except in a few places where there is a current of only 10 to 15 amperes. Large fuses on poles have been found unreliable. Disconnecting boxes, however, are provided at branches, so that a branch circuit can be disconnected for repairs.

When passing from overhead to underground circuits, the lead-covered underground cables are brought up the pole in iron pipe and terminate in porcelain potheads, these potheads also serving as disconnecting switches. The shell of the pothead, which is of porcelain, is placed over the end of the cable and poured full of " Mineral-lac " compound. The overhead line terminates in a brass plug with a porcelain cap, which slips over the pothead. The insulators for the primary wires are of common double-petticoated glass. Lightning arresters are placed about 1,500 ft. apart. Three kinds are in use—old and new style General Electric and Garton-Daniels. All are placed in wooden boxes. Figs. 14 and 15 show typical transformer installations at large motor customers in manufacturing districts.

OPERATION OF THE SYSTEM.

The routine and emergency operation of a large electrical distributing system with enormous rotary-converter and motor-generator sub-stations connected to generating stations of enormous output, presents operating problems entirely unknown in smaller systems. When the 9,000 volt 25 cycle transmission system began to assume large proportions, the necessity of having all switching operations pertaining to that system under supervision from a central office became apparent. The generating plants supply energy to the sub-stations through 9,000 volt transmission lines running directly from the generating plant to the sub-station. To supplement these lines there are also some tie lines connecting the sub-stations for

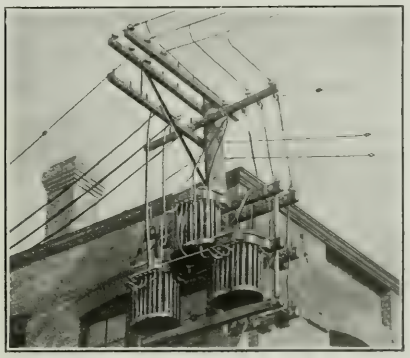


FIG. 14.—POWER TRANSFORMERS AT A FACTORY.

emergency use. The necessity for central supervision is further emphasised by the fact that in normal operation two separate electrical systems are maintained, part of the generators used feeding energy into " A " system and part into " B " system. These systems are, of course, not operated in parallel, but their separate frequencies are maintained so nearly the same that they can easily be joined in parallel at any time on short notice. However, with 'bus bars in the same sub-station receiving energy from separate sources the chances for throwing these two systems together when not desired would be great if the sub-station operators were allowed to perform the high-tension switching without central supervision. All companies having such large systems maintain a central supervision of this kind, called by various names. The term " load dispatcher " (Fig. 16) was selected by this company as indicating the responsibility of the man who has charge of the electrical operation of the system, this responsibility corresponding to that of the train dispatcher on a railroad, without whose authority no trains can move.

In a quiet room at the company's headquarters, there will always be found on duty one, two or three load dispatchers, the number being varied according to the time of day. From this room direct telephone communication can be had with all of the generating and sub-stations. Occupying the side wall is a large diagram of the 25 cycle 9,000 volt transmission system. This diagram shows all the transmission lines, high-tension oil switches and station 'bus bars connected with the system, and is placed there for the use of the dispatchers in keeping a record of switching operations. On this diagram switches are indicated by holes for pegs. When a switch is closed a peg is inserted in the hole. Copper-coloured plugs are used on the " A " system and green plugs on the " B " system. In

most cases the absence of a peg from a hole indicates that the switch is open, but in order to remind the load dispatcher of danger points, red pegs are used where the closing of a switch would connect the A and B systems together. The red pegs serve as warnings to the dispatcher not to order any of those switches closed. White pegs are also used as warnings in connection with certain 'bus bars in the Fisk-street station which operate motor-driven exciter units, in order that the supply of current may not accidentally be cut off from these exciter motors without previous provision for exciting current.

In general, the load dispatcher gives orders for the opening and closing of all switches in the 9,000 25 cycle system, but there are some important exceptions to this rule. For example, in case a sub-station which is supplied with energy over two transmission lines has the circuits suddenly opened, the sub-station operator will immediately synchronise and connect the converters to the other line if he is able to obtain energy over it. To provide for such emergencies, all lines to a sub-station are normally kept " alive " up to the switch connecting the transmission line to the sub-station 'bus bars.

In case of a short-circuit on the system causing the rotary converters supplying energy to the down-town direct-current network to be thrown out of step, and consequently disconnected from the 25 cycle system through the opening of overload switches, the emergency storage batteries immediately discharge into the system, as they are kept floating on the line. Battery attendants have orders immediately to connect in enough end cells to hold the E.M.F. on

FIG. 15.—POWER TRANSFORMERS ON A PLATFORM.

the system as near normal as possible. The batteries may be discharged up to as high as three times the regular one-hour rate. The rotary converters are run up to synchronising speed from the direct-current end and again connected to the system. In the alternating-current sub-stations, of course, no such reserve exists.

The sub-station operator is instructed to get the machinery into operation from any remaining good line as quickly as possible without calling the load dispatcher, and notify the dispatcher afterward. An operator noting some disturbance not serious enough to throw the machines out of step must not call the dispatcher until five minutes have elapsed, because if all sub-station operators were to call the dispatcher at each time of slight disturbance confusion would result. The Fisk-street station operator in the ordinary routine of connecting and disconnecting units to conform to the load, is allowed to connect units to the 'bus bars and notify the dispatcher subsequently. In case of a disturbance on either the " A " or " B " systems, one of the first procedures of the operator at the Fisk-street station is to parallel the two systems, so that the undisturbed system may help out the one in trouble.

The large diagram on the wall in the dispatchers' office indicates merely the 25 cycle 'bus bars, switches and lines. There are between 500 and 600 oil switches on this system. The elementary 'bus bar diagrams of the various sub-stations are kept in the form of drawings under a glass plate on the dispatcher's desk, where it is in plain sight as he answers the telephone. The telephone switchboard which gives the dispatcher communication with the entire system is divided so that two dispatchers can work at once. The E.M.F. at two sub-stations is indicated by voltmeters in front of the dispatchers, one of these sub-stations being on the " A " system and the other on the " B " system. Two voltmeters also show the feeder E.M.F. at two points in the down-town direct-current network. The dispatchers also have in convenient reach complete necessary data on routes of feeders, feeder tunnels, &c.

Although the street and elevated railway sub-stations are not owned by the Commonwealth Edison Company, their operators are subject to orders of the load dispatcher as far as high-tension switching is concerned. There are in all 41 sub-stations under the dispatcher's orders. To prevent misunderstandings, all orders are repeated back to the dispatcher after being received. An order from the dispatcher is required before any alteration or construction work is done around stations.

During the peak load three dispatchers are on duty. At all other hours two are on duty, except after midnight until morning, when one of these two is allowed to sleep in the building, where he is within immediate call of the one on duty. The dispatchers work in three shifts, a total of five dispatchers being required. Each dispatcher is off regular duty two days out of every eight. One of these days is for rest and recreation, the other day is for visiting stations and sub-stations, getting acquainted with conditions in each sub-station and becoming familiar with the men and methods of operation. Load dispatchers are promoted from the ranks of chief sub-station operators, and so have had a very complete operating experience.

Sub-station operators are very carefully picked and trained, the training and discipline of these men having reached a high state of perfection. Of the applicants for the position of operator only about 5 per cent. have qualifications which cause them to be considered. An applicant, to be considered, must have at least a high-school education, and, in addition, must have completed either correspondence school work or taken evening courses in electricity. Very few

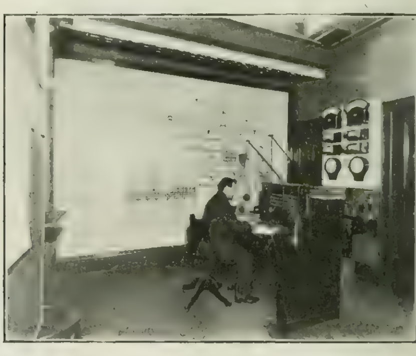


FIG. 16.—A LOAD DISPATCHER'S OFFICE.

experienced sub-station operators apply for positions. The company has to train most of its operators from the beginning. In the 33 sub-stations belonging to the company about 150 men are employed, of which 80 are certified operators who are in responsible charge.

The company maintains under separate management three departments for testing. The meter department sets, removes and tests consumers' meters. For the regular testing and calibrating of the hundreds of switchboard instruments and watt-hour meters a separate department is maintained in connection with the company's laboratories. The laboratories constitute a department of engineering testing for the purpose of carrying on electrical and photometric tests of various kinds on matters upon which the company needs information. The frequency of test of consumers' meters is somewhat in proportion to the size of the meter and the amount of money involved in the monthly bill. The classification adopted for commutator meters was as follows: Annual tests for meters of from 5 to 10 ampere rating. Semi-annual tests for meters of from 15 to 50 ampere rating. Quarterly tests for meters of 75 ampere rating and above. Induction meters on alternating circuits, it is found, can safely be allowed to run much longer without test. Single-phase meters rated at 50 amperes or less are allowed to run from one to two years between tests. Those rated at over 50 amperes and polyphase meters are tested every six months.

The load factor of the entire system has been steadily increasing, and for the year ended June, 1907, was 39·6 per cent., as compared with 35·6 per cent. in 1906 and 33 per cent. in 1905.

(To be concluded.)

THE MERCHANT VENTURERS' TECHNICAL COLLEGE, BRISTOL.

ELECTRICAL EQUIPMENT OF THE NEW BUILDING.

Introduction.

The condition of technical education in Bristol has become more interesting quite recently owing to the fact that His Majesty the King has just granted a charter for the founding of a new University in that city. The institution which up to the present has taken upon its shoulders the burden of technically educating the young people in the neighbourhood of Bristol is the Merchant Venturers' Technical College; and the progress of this institution has been by no means uneventful. It was founded in 1856, and taken over in 1885 by the Society of Merchant Venturers, a guild of old-established date, which was, perhaps, most active at the time when John Cabot set forth from the Avon to discover America. In parentheses, it may be remarked that in the West of England, and in Bristol especially, this adventurer is given the credit for work which in other, and perhaps less enlightened, portions of the globe is usually ascribed to Christopher Columbus.

The Merchant Venturers' Technical College was founded, as mentioned above, to provide a scientific, commercial and technical education for the youth of Bristol. A building was erected in Unity-street, and there the work of the college was carried on for some years. In fact, the various operations pursued the even tenor of their way—although we may suppose some progress was made to keep step with the times—until October 9, 1906, when the building was practically destroyed by fire.

After the siege of Paris in 1870, Haussmann was deputed to rebuild those parts of the city which had been destroyed either by external or internal enemies. The result is, as is well known, the beautiful Paris of to-day; and there can be no doubt that the bombardment by the Prussians and the vagaries of the Communists proved in many ways a blessing. The same result may be said to apply to technical colleges. For many of our older institutions, among which may be included the Merchant Venturers' Technical College, were no doubt equipped in accordance with what was best in technical apparatus at the time of erection, yet the fact remains that after a very few years engineering equipment is apt to become out of date, and, were it not for economical reasons, a wholesale destruction would be by no means the worst way out of the difficulty, as often such apparatus is more a hindrance than a help from the teaching point of view. The fire at the College, therefore, made the erection of a new building equipped with more modern apparatus possible, and we shall hope to show in what follows that the work has been done quite satisfactorily and in a wholly modern way. Unfortunately, a number of manuscripts were destroyed in the fire, and their loss was, of course, irreparable. A great part of the engineering machinery, including some of a fairly modern type, was, however, untouched, and has been transferred to the new building.

Soon after the fire the Bristol Education committee placed the Castle school at the disposal of the College authorities, and this was as soon as possible adapted for technical work, while the engineering workshop and the electrical engineers' laboratory were temporarily installed in the Rosemary-street branch which at that time contained the experimental boiler, engines and dynamos.

It was soon decided to rebuild the College on the same site, and, owing to the fact that it was proposed to employ its engineering sections for the work of the Faculty of Engineering in the proposed University of Bristol, great care was taken in the design of the various buildings and laboratories. The work was started in December, 1907, and is now practically complete. It was opened by Lord Reay on June 24th.

Lighting.

The College is lighted by electricity, which is supplied from the mains of Bristol Corporation, the supply being alternating current and on the three-wire system at a voltage of 2×105. The current passes through a three-pole quick-break switch fuse, which is placed in the electrical engineering laboratory immediately over the supply authorities' fuses and meters. Connection is then made by a three-core armoured cable to the main switchboard in the adjacent entrance hall. This switchboard was supplied by Messrs. Morris & Lister, of Coventry, and is illustrated in Fig. 1. The control of the electric lighting is vested in the hands of the professor of Electrical Engineering, who thus is able to give the installation an adequate and easy supervision.

The main switchboard is fitted with three-pole linked switches with fuses on the outer poles only. For lighting purposes the college is divided into six circuits, and from this board are also supplied three other circuits, which will be employed for experimental purposes. All the sub-mains from

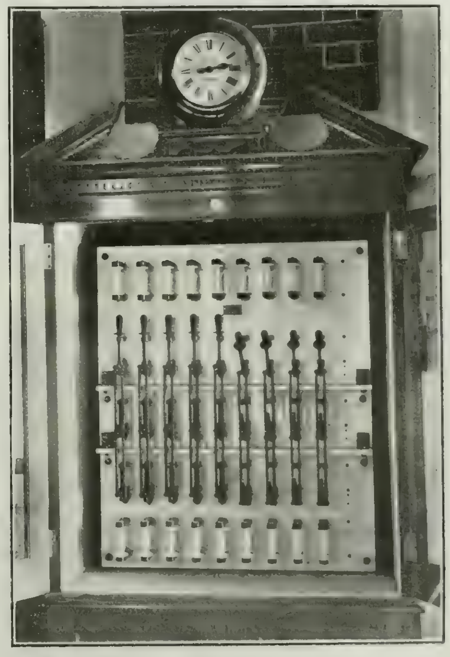


Fig. 1. Main Lighting Switchboard.

this board are three wire, in order that the balance may be as good as possible. Four-pole distributing switchboards are placed on each floor, and from these two-wire circuits supplying current at 105 volts are taken to the various rooms by tubes laid in channels sunk in the floors. The larger rooms have their lights supplied from two or more circuits. These circuits are so arranged that they come off on opposite sides of the three-wire system, so that, in case of a fuse blowing, it is extremely unlikely that all the lights will be simultaneously extinguished. The general arrangement of the wiring is as follows: The distributors from the fuse boards are, as mentioned above, carried in tubing sunk in the floor of the rooms which they are to serve. Channels have been left in the concrete floors for this purpose, and these are covered by planks screwed down flush with the wood block flooring. At suitable places these tubes are brought up about 1 ft. above floor level and run into wood casing, so that in the rooms themselves the wiring is effected in casing; and, owing to the structural details of the building,

surface work is used practically throughout. This arrangement will, doubtless, be of interest to engineers at the present time, and there is no doubt that in this particular instance it makes an excellent job. Great care has been taken to obtain good joinery work, and the lay-out of the casing has been so arranged that a certain amount of ceiling decoration is thus obtained, with quite a pleasing effect. Siemens highest-grade wires and cables have been used throughout, and Simplex

Fig. 2.—View of Chemical Laboratory, showing Method of Fixing Tubing.

tubing is used for carrying the wires through the various floors. Metallic filament lamps have been used everywhere, about 600 being employed altogether. Great care has been taken so to arrange the lamps, which are suspended at a greater distance from the floor than is usually the case, that direct glare in the eyes of the students is avoided when they glance up at the blackboard or from their work. A personal test of these lighting arrangements showed us that this result has been

Fig. 3.—Great Hall, showing Lighting.

satisfactorily obtained; and while the lighting will, we think, be quite sufficient for all purposes, there is a "quietness" about it which is too uncommon at the present time.

There is scarcely any need in this article to deal with the lighting installation in any great detail. The usual difficulties have been met with, and also certain unusual pieces of work have occurred owing to the girder type of construction which is used throughout the building; but these have been satisfactorily overcome, and the results should now be contemplated with equanimity by all concerned. An example of how one of these difficulties has been overcome is shown in Fig. 2. It illustrates the chemical laboratory. Here, owing to the top lights, ordinary arrangements were impossible, so that the "Simplex" was run across from wall to wall and supported by special ties.

In general, the lights are controlled from switches in the room itself, which are placed at convenient points on the walls or on the lecture tables, but in some of the laboratories ceiling switches with hanging cords are fitted near to the lights which they control. In the great hall, however, owing to the fact that this room is sometimes used for popular lectures, where it may be necessary to turn out the lights when using a lantern, a special controlling arrangement has been adopted. The main lights are supplied from a distribution board of their own, which is controlled by a solenoid switch. In this way the lights can be put on or off by any one of three tumbler switches placed at two points on the platform and on the gallery rail beside the lantern, thus allowing all the lights in the

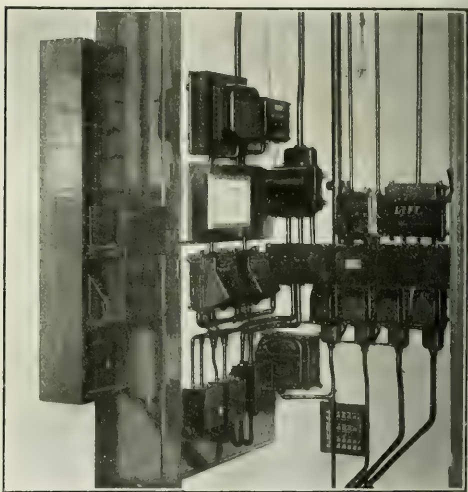


Fig. 4.—Main Power Switchboard.

hall to be under the control of one person during the lecture. A general view of lighting arrangements in this hall is shown in Fig. 3.

Power.

The Bristol Corporation have separate circuits throughout the city for the supply of direct current for power and alternating for lighting respectively, the pressure in the former case being 500 volts. The Corporation fuses and meters for this supply are placed in special brickwork cubicles next to those for the lighting in the electrical engineering laboratory. Owing to the fact that the building is intended to be used for educational purposes, the opportunity has been taken to employ a rather varied collection of switches and equipment generally for controlling the various circuits, in order to give the students an idea of the many ways in which the same thing can be done. This idea has been followed in constructing the power switchboard (Fig. 4), which is fitted with a collection of iron-clad quick-break switch fuses, and is fixed on the wall in the electrical engineering laboratory. These switches have been supplied by Messrs. Parmiter, Hope & Sugden, Berry, Skinner & Co., Electrical & Ordnance Accessories, and Engineering Instruments.

The switches are of the ironclad type, and connections between them are run in conduit, which is screwed into all the iron cases, thus making a continuous earthed circuit. From this

board are supplied the power circuits in the electrical engineering laboratory, engineering workshop, motor car shop, hydraulic laboratory, and for the lift motor and controlling gear and the photo-printing apparatus; the lanterns in the drawing office and the engineering lecture room, and a distribution board for supplying fans for ventilating the chemical department are also supplied from this board. Three Blackman fans of 54 in.,

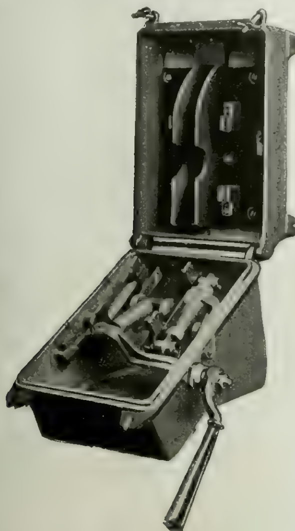


Fig. 5.—Switch Fuse (open).

48 in. and 36 in. diameter respectively are also supplied from this board, and are used for the general ventilation of the building. These fans are started and controlled from a board in the electrical engineering laboratory, so that tests can easily be made on them by the students. In the workshops the electric drive has been used throughout, and the arrangements adopted are those which are now becoming standard. The lift is of the Otis type, and is automatically controlled by means of this firm's well-known push-button arrangement.

Fig. 6.—Switch Fuse (closed).

All the gear is placed above the lift in a special chamber at the top of the building. From the above description it will be seen that there is a good deal of apparatus for the students to experiment on without the resources of the laboratories themselves being over-taxed, or even used at all.

As mentioned above, a number of the power fuseboards, and also some new spring-on switch fuses, have been supplied by Messrs. Parmiter, Hope & Sugden. A special feature of these spring-on switch fuses is their quick make and break, and they are supplied with a special locking key so that they can be locked either in the "on" or "off" position. This piece of apparatus is illustrated in Figs. 5 and 6.

Telephones.

A very complete system of telephones has been installed throughout the building, so that effective communication between the Principal, staff and various departments is ensured. After a careful consideration of the various systems, Parsons-Sloper secret intercommunication telephones were chosen for use in the college, chiefly owing to the fact that conversation can thereby be effected by direct calling without

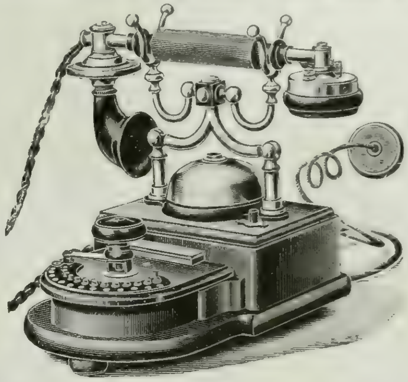


Fig. 7.—Standard Pattern Table Telephone for Secret Circuit Intercommunication.

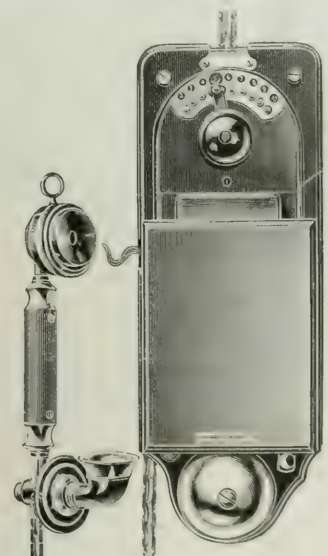


Fig. 8.—Standard Pattern Wall Telephone for Secret Circuit Intercommunication.

the delay of passing through an exchange. At the same time there is, it is claimed, no cross talk when several couples are speaking, the conversations being secret. Ten instruments have been provided in the college, each fitted with a 15-way switch, so that any station can select any of the nine others. Five studs are at present kept vacant to allow for future extensions. The instruments are connected

by a 17-way cable, both the wall and table type being fitted respectively, according to the room in which they are used. The designs adopted are shown in the accompanying figures. A feature of this system will be appreciated by busy people: Immediately on ringing up and before speaking takes place the calling operator knows if the instrument is already engaged, if the attendant at that instrument is absent, and the moment the latter comes to the telephone to speak. This characteristic, which is said to be peculiar of the Parsons-Sloper instruments, rids telephony of one of its most irritating features—that is when a reply is not immediately received of waiting for an answer and not knowing the reason for such wait. Two instruments of the type used in the College are shown in Figs. 7 and 8.

TIME DISTRIBUTION.

In a place like the Merchant Venturers' Technical College it is essential that the correct time should be known throughout the building, in order that the daily programme of work may be carried out expeditiously and as punctually as possible. The time of the institution is controlled by an installation of "B.P." electric impulse clocks, which are entirely automatic in their working and require neither winding nor individual attention. The installation consists of a time transmitter, or master clock, which transmits half-minute impulses to a series of secondary dials installed in various parts of the building. There are 32 clocks in all, which are provided with dials varying in size from 8 in. to 21 in. in diameter. One of the 12 in. clocks is provided with contacts for ringing a bell at regular

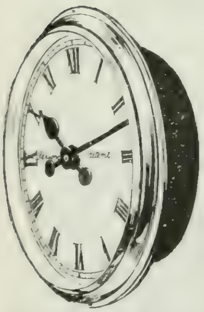


FIG. 9.—PANEL CLOCK IN ALL-METAL CASE FOR DROPPING INTO EXISTING PANELS.

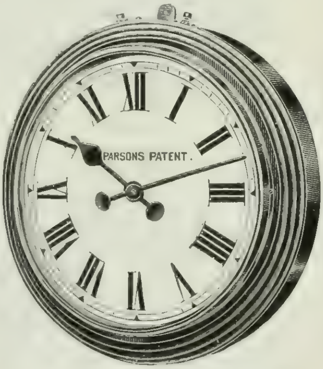


FIG. 10.—WALL CLOCK IN AIRTIGHT WOODEN CASE.

periods for signalling intervals, and a special movement operates a bell-ringing arrangement for regulating the classes, with which we shall deal later on. An arrangement whereby the bells can be rung every 10 minutes to give the signals required for engine trials is also fitted to one of the clocks. In some cases special clocks have been designed. One of these, which is the clock installed in the governor's room, is shown in Fig. 9. The dome shaped metal back is damp proof and protects the movement. This clock is very useful, as it readily fits into any pattern of panelling or woodwork, and in this particular case is placed in an ornamental fumed oak wood case designed by the architect. It has a silvered dial and brass bevel of bold design, the hands and dial being protected by a bevelled plate glass. Fig. 10 illustrates one of the many 12 in. clocks installed throughout the building. These clocks are of light oak and match the surrounding woodwork. A specially artistic clock has been designed for use in the lecture hall. It is 21 in. in diameter, and is of iron enamelled dead black, with raised gilded chapters and minutes, the hands also being gilded. The dial used is the same as was on the clock in the old building, and has been adapted for electric working.

The complete clock installation is driven by the accumulators installed in the building for experimental purposes, so that the necessity for a separate battery is avoided. Excess voltage is absorbed by a resistance fitted in the transmitter case, which is shown in Fig. 11. In this instrument the movement is fitted with a jewelled escapement, and the pendulum, which beats true seconds, is compensated for changes of temperature, and is fitted with a micrometer rating, so that fine adjustment can be obtained. This transmitter is installed under the professor's care in the electrical engineering laboratory, and is fitted with separate mercurial seconds contacts for occasional demonstration purposes and for laboratory use. The case is fitted with glass sides, so that the working arrangements are visible to the students. The vibrations of the pendulum are maintained solely by gravity, the function of the electric current being simply to lift the gravity lever to its potential position after an impulse has been given to the pendulum.

FIG. 11.—JEWELLED TRANSMITTER WITH SECONDS PENDULUM.

This arrangement is due solely to the patentees, Messrs. Gent & Co., of Leicester, who supplied the whole of the clock equipment in the college, as well as the telephones described above.

In connection with the time distribution, a machine has been designed by Prof. Robertson for ringing the college time signal class bells when required. It consists of two drums one of which is driven by the half-minute impulses from the master-clock, and which goes once round in four hours, while the other makes one revolution in a week. These drums drive special rings, in which are cut notches. The effect of these notches is to make electrical contacts when the slider drops into them. The first drum settles by the position of its notches at which minutes during any four hours the bell is to be rung. The second drum, whose contacts are in series with the first, determines the intervals of four hours during which that programme is to come into play throughout the week. At present only three contacts on each drum are in use, one each for morning, afternoon and evening bells. In order to cut down the time of ringing

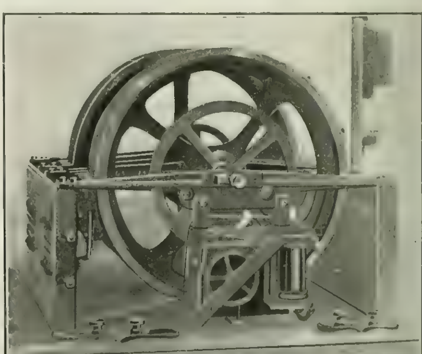


FIG. 12. TIME DISTRIBUTION MACHINE.

to less than the 30 seconds during which the drums stand still, a third contact has been put in series with the battery, and is worked by Gent's "Waiting Train" movement. This arrangement is shown in Fig. 12

(To be concluded.)

LOW TEMPERATURE EXPERIMENTS IN MAGNETISM.*

BY G. GRAY, B.SC., AND H. HIGGINS, M.A.

Summary.—A description is here given of experiments carried out on steel wire, special hard steel and manganese steel by alternate cooling with liquid air and warming. The experiments resemble those of Dewar and Fleming, except that the specimens were magnetised at the temperature of liquid air; and the results are very striking.

The alterations brought about in the magnetic moments of magnets composed of various metals and alloys by alternate cooling and warming between ordinary room temperature and that of liquid air have been very fully investigated by Dewar and Fleming.† It was found by these experimenters that, in the case of most of the metals examined, the effect of the first cooling upon the magnet—which had previously been magnetised to saturation in the field of an electromagnet—was to bring about a very considerable reduction in its magnetic moment. On allowing the magnet to warm to room temperature its magnetic moment still further diminished. On cooling once more to the liquid air temperature the magnetic moment increased, and from and after this stage it was found that the magnetic moment of the magnet when cold exceeded that of the magnet when at room temperature by a definite amount. The changes brought about by the treatment were found to be much greater in the annealed than in the quenched condition of the material. In a few cases, notably that of the chromium steels, the effect of the first cooling was to increase the magnetic moment; in other cases the treatment caused very little alteration in the magnetic moments of the specimens.

The authors of the present Paper repeated the above procedure, but started with a specimen magnetised to saturation at the temperature of liquid air. The results obtained differ from those observed by Dewar and Fleming in that the reversible condition is arrived at after the first warming up of the specimen from $-190°C.$ to room temperature, and the percentage change in magnetic moment then brought about by cooling from room temperature to that of liquid air is much greater than is the case for a specimen which has been magnetised initially at room temperature.

In the case of a specimen of steel wire, after being magnetised at room temperature the effect of the first cooling was to bring about a diminution in its magnetic moment of 45 per cent. On warming it to room temperature the magnetic moment still further diminished by about 11 per cent. On cooling the specimen once more the magnetic moment increased by about 9 per cent., after which stage the effect of the cooling always resulted in an increase in the magnetic moment of about this amount. Starting with the specimen magnetised when at $-190°C.$, the effect of the first warming was to bring about a diminution in the magnetic moment of about 44 per cent. After this stage had been reached, cooling to $-190°C.$ caused an increase in the magnetic moment of nearly 12·5 per cent.

With the specimen in an annealed condition, and magnetised at room temperature, the effect of the first cooling was to reduce the magnetic moment by about 40 per cent. On warming to room temperature the magnetic moment further diminished by 20 per cent., after which stage the effect of cooling the specimen was to increase the moment by about 5 per cent. With the specimen magnetised at $-190°C.$, the effect of the first warming was to diminish the magnetic moment by about 65 per cent., after which each cooling resulted in an increase in the magnetic moment of nearly 10 per cent.

With the specimen in quenched condition and magnetised at room temperature the effect of the first cooling was to diminish the magnetic moment by about 2·5 per cent., and on warming to room temperature a further reduction of 3·5 per cent. took place. Further cooling always resulted in an increase in the magnetic moment of nearly 1 per cent. Whilst with the specimen magnetised at $-190°C.$ the effect of allowing it to warm to room temperature was to diminish its magnetic moment by 16 per cent. The magnet was now in a condition in which its magnetic moment at $-190°C.$ exceeded its magnetic moment at room temperature by about 1·5 per cent.

The results obtained on testing a specimen of special hard steel resemble the results obtained for steel wire, but after the reversible state has been arrived at the magnitudes of the changes brought about by the cooling are much more marked in the case of the specimen when magnetised at $-190°C.$ than when magnetised at room temperature.

The results obtained for manganese steel in the annealed condition are very remarkable. On magnetising the specimen at the temperature of the room its magnetic moment was found to be 250 C.G.S. units. On cooling the specimen to $-190°C.$ its magnetic moment diminished to 93 C.G.S. units, and on allowing it to warm to room temperature the magnetic moment fell to 59 C.G.S. units. From and after this time the effect of cooling the specimen to $-190°C.$ was to bring about an increase in the magnetic moment of about 9 per cent. Starting with the specimen magnetised when at the temperature of liquid air, the initial magnetic moment was 590 C.G.S. units. On warming to room temperature, the magnetic moment fell to 387 C.G.S. units, and the effect of cooling once more to $-190°C.$ was to bring about an increase in the magnetic moment of about 13 per cent.

The specimen was now remagnetised at room temperature, and the procedure repeated. The results obtained differed very greatly from those yielded by the freshly annealed specimen. The initial magnetic moment was now 557 C.G.S. units. On cooling the specimen to $-190°C.$ its magnetic moment diminished to 416 C.G.S. units. Warming to room temperature resulted in the magnetic moment still further diminishing to 406 C.G.S. units, and after this stage any subsequent cooling resulted in a small increase taking place in the magnetic moment. Quenching produces very little change in the properties of this steel. The properties of this steel for low and moderate fields have been investigated by A. D. Ross and one of the authors. In the annealed condition the material is, comparatively speaking, feebly magnetic. Cooling to the temperature of liquid air results in the permeability being greatly increased, and on warming to room temperature a further large improvement in magnetic quality is brought about.

On placing a specimen of manganese steel (12 per cent. MN) in the field of the electromagnet a weak magnet was obtained. No appreciable change in its magnetic moment or in the magnetic quality of the material was brought about by the cooling in liquid air.

* Abstract of a Paper read before the Royal Society of Edinburgh.

† *Proc.* Roy. Soc., Vol. LX., p. 57.

THE ELECTRICAL OPERATION OF TEXTILE FACTORIES.*

BY H. W. WILSON.

Summary.—The author here reviews the arguments for and against the use of electrical transmission as the method of conveying power to the various departments of a textile factory, and gives tables showing the horse-power required for driving the various machines.

A number of conditions affect the relative importance of the various considerations. Thus, the factory may be (1) a spinning mill, (2) a weaving shed, (3) a bleaching, finishing or dyeing works, (4) a combination of any two sections. Also the particular case may be (1) a totally new factory, (2) an existing works requiring additions, (3) an old mill requiring partial or entire re-equipment. Again, in an electrically-driven factory, the energy may either be produced by the mill's own plant or purchased from an outside source of supply. It is impossible to lay down a list of advantages which will apply with equal force to all cases. Stated briefly, however, the main advantage claimed by the advocates of the electric drive and generally admitted by the owners of electrically-driven textile factories is that electrical driving permits of an improvement in the quantity and quality of the output of practically all textile machines. The importance of this point can hardly be exaggerated. If it is once admitted that the claim of the electric drive's advocates in this respect is substantially true, the question of capital cost of equipment and running cost sink into relative insignificance.

To amplify the claims put forward by those in favour of electrical driving, they may be generally stated as follows: (1) The mill and engine house can be placed each in its most convenient position, without regard to their relative situations. (2) The internal arrangements of the mill as regards shafting, gearing, belt and rope drives, &c., are much simplified, and the cost reduced. The flexibility as to extensions is, of course, obvious. (3) The grouping of the machines is much less arbitrary than in an ordinary mill, as the motors and light shafting required can be placed where most convenient. (4) The reduction of the chance of a breakdown which would stop the whole mill. (5) The ease with which sections of the machinery can be either stopped or run overtime (where conditions permit) without waste of power. (6) The reduction in the maintenance and depreciation charges. (7) The reduction in the capital cost per loom or per spindle of the whole factory when once a given size is exceeded. This is partly due to reduction in the weight and cost of the buildings. (8) The possibility of obtaining records of the work done in the different sections of the factory, otherwise impossible, and the keeping of a constant check upon them. (9) The greater steadiness of

* Abstract of a Paper read this week at the Liverpool meeting of the Institution of Mechanical Engineers.

drive which can be obtained with a consequent permissible higher average speed and increased output. As stated above, this last claim is by far the most important one, and it has been proved to all reasonable satisfaction in many cases that electrically-driven spindles in a mill can be run at a higher average speed on the same counts than mechanically-driven ones, with a correspondingly higher production. In one fairly well-known case in Lancashire, with two mills under the same management and of about the same size and working under the same general conditions, the results obtained from the electrically-driven factory have been distinctly superior to those from the mechanically-driven one. To such a marked extent was the improvement in quality of yarn noticeable that the output of the electrically-driven mill fetched a distinctly better price than that from the other factory, the increase being stated at about 2½ per cent.

It is exceedingly difficult to get absolutely reliable statistics concerning the improvement in output and quality obtained by mills in this country which have adopted electrical driving, but it may be taken as a conservative estimate that the increase in production is on the average at least 5 per cent., and we will leave out of consideration any improvement in value, as stated above.

The author then shows that an increase in output of 5 per cent. would mean a reduction in cost per pound on the whole output of 0·6 per cent., and even allowing for a considerable increase in the cost of power, which the author does not admit, there is a margin of 0·35 per cent. extra profit on the whole turnover, which means a considerable amount in a year.

As to the objection of increased capital cost caused by the installation of an electrical transmission system, this has been argued almost to death, but it may be said that, taking a new spinning factory as a basis, and assuming that if electrically operated the structure would be brightened and modified to suit the altered conditions, then below 80,000 mill spindles the mechanical transmission system is the cheaper, between 80,000 and 100,000 the costs are about equal, and above 100,000 the electrical system is the cheaper. The efficiency of the electrical transmission system would be about 82 to 83 per cent., or about the same as a well laid-out modern mechanical transmission system.

In the case of an old factory requiring re-equipment, it frequently happens that, owing to the inconvenient arrangement of the existing buildings, the electric drive offers distinct advantages both as regards initial capital outlay and efficiency. The intermediate case, however, of a fairly modern factory with a good mechanical transmission system requiring extensions above the capacity of the engine is a very interesting and promising one. Under such circumstances as these the use of the exhaust steam turbine has many advantages, and, as will be shown, this almost of necessity involves, either wholly or partially, the electrical driving of the factory.

The author takes a concrete case. A spinning mill mechanically driven but electrically lighted has a main engine of the compound vertical type developing 1,000 I.H.P., with a steam consumption of about 13 lb. per indicated horse-power-hour. The lighting dynamos are driven by the main engine, and in the winter, when fully loaded, require a trifle over 100 H.P. It is required to make some extensions in the factory involving an additional load of about 200 H.P. It was first suggested that a generating set of 150 kw. (225 I.H.P.) should be installed at once, and later on a second set of the same capacity when other extensions became necessary. The first set would supply the lighting and also about 100 H.P. of motors in the preparation section, and thus relieve the main engine. A small set such as this, with a standard quick-revolution engine, however, would use at least 16 lb. of steam per indicated horse-power-hour, and it has since been suggested that an exhaust steam turbine might be a better solution of the difficulty. As plenty of condensing water is available the question was investigated, and it has been found possible to alter slightly the valve setting of the main engine, obtain about 850 I.H.P. from it non-condensing and 500 I.H.P. from an exhaust steam turbine utilising the steam from the engine. In this manner it would be possible to obtain some 1,350 I.H.P. for a steam consumption of about 10·5 lb. per indicated horse-power-hour. The saving in fuel over the other arrangement suggested is very considerable, being approximately 30 per cent.

There are, however, several features in this case which require to be specially met, and the most important and obvious of these is the fact that the load on the turbine generator is to be a variable one—at all events, as far as regards the lighting. This is a feature of difficulty, inasmuch as the load on the main engine is fairly constant and the amount of steam passed by it fairly regular. In order to meet the conditions it is necessary either to use a portion of the steam from the main engine for other purposes at times of light load on the turbine, or else to make such an arrangement as will permit of the variation in load affecting both engine and turbine in the same proportions, and thus automatically regulating the supply of steam to the combined machines. The simplest method of doing this is to rope drive a small generator of, say, 100 kw. capacity from the engine and to run this generator in parallel with the turbo-generator. This involves, again, the driving of a larger portion of the mill electrically than was originally intended, but the large fuel economy justifies this, apart altogether from every other consideration. This brief statement of a comparatively common case shows how in existing factories the introduction of the electric drive may reduce working costs, apart altogether from every other advantage.

As to the advisability or otherwise of a textile factory taking its supply of power from an outside source, the result of the author's observations is that a Lancashire factory of, say, 1,500 I.H.P. capacity can produce energy at 0·2d. per indicated horse-power-hour, or 0·3d. per kilowatt-hour, allowing for interest and depreciation. This is on a basis of being able to purchase good slack with a calorific value of 11,000 B.Th.U. at 8s. per ton delivered. It has been found generally practicable to induce fairly large factories to purchase power at about 0·4d. per unit, the power being metered on the low-tension side of the mill switchboard before reaching the motors.

The main differences of opinion among engineers designing the lay-out of electrically-equipped mills arise over the question of group or individual driving. The author is in favour of the individual driving of ring spinning frames and the group driving of all other machines, but keeping the groups fairly small. The mere substitution, as in some factories, of a large motor for the rope pulley on a line shaft can hardly be regarded as the final step in the adaptation of an electrical installation to suit textile manufacturing needs. A point needing attention is the heating effect of the motors. It is now the best practice to build motors for a ring spinning room with hollow frames, and to bring cooling air from some external source round the frames, thus preventing the discharge of heat to the room.

Electrical manufacturers generally do not appear to realise that the actual powers required need very careful investigation before the machines are actually installed, and it is by no means a safe rule to assume that the horse-power is so much per 100 spindles of the mill, as this may lead to considerable error. The author gives several tables showing the horse-power required for the various machines installed in a small mule-spinning mill, with an estimate of the time each machine is standing idle for doffing; also the sizes of motors installed in two mills where group driving is employed. In one, six pairs of mules required a 130 H.P. motor and 120 looms 50 H.P., whilst in the other 63 ring frames, 2½ in. gauge, 6 in. lift, total spindles 34,864 and 32 mules, 1¼ in. gauge, total spindles 41,216, required motors aggregating 850 H.P. in 200 H.P. and 150 H.P. units, the total horse-power in the mill being 1,250.

THE CONDITIONS WHICH DETERMINE THE COMPOSITION OF ELECTRO-DEPOSITED ALLOYS.*

COPPER-ZINC ALLOYS.

BY SAMUEL FIELD.

Summary.—The conditions under which brass is deposited from a mixed solution of copper and zinc cyanides are investigated. The alloy is deposited quantitatively, but the deposits are not good physically. Any condition tending to raise the E.M.F. increases the percentage of zinc in the deposit. Anodes dissolve freely if the solution is warm.

Mixed electrolytes offer many points of interest to the electrochemist, some of a more theoretical interest, and others of a more practical importance. The following experiments were made in order to determine the influence of varying conditions on the composition of electro-deposited copper-zinc alloys :—

Preliminary Notes.—To deposit two metals together we must electrolyse compounds having approximately the same heat of formation, and requiring therefore about the same E.M.F. to maintain steady deposition of the metals. Thus a mixture of copper and zinc sulphates in the presence of sulphuric acid yields, as is well known, pure copper with a low E.M.F., the copper ions being discharged more readily than those of zinc. In cyanide solutions, however, both copper and zinc ions occur only in small quantities, and are more easily discharged together, the main bulk of the substance occurring as $K^{\cdot}$ and $Cu(CN)_2'$ and $K^{\cdot}$ and $Zn(CN)_4''$ ions respectively. The cyanides therefore possess a distinct advantage as

* Abstract of a Paper read before the Faraday Society, June 29. A brief summary appeared in our issue of July 9.

electrolytes for the deposition of the mixed metals, though at the same time they do not present ideal conditions. As the ions are more easily discharged together, it may at once be anticipated that slight changes of E.M.F. will induce decided changes of composition and colour, and this would account, therefore, for the difficulty experienced in maintaining deposition of uniform shades of colour. Cyanide solutions are also advantageous in that striking changes of current density may be made without so readily producing pulverulent deposits. A distinct disadvantage, however, is the fact that the materials produced by the anodic oxidation are ordinarily insoluble, and hence care needs to be exercised in order to keep the anodes from becoming covered with non-conducting layers of single cyanides. Another disadvantage is that cyanide solutions are prone to so much change of composition in aqueous solutions with the formation of various compounds that any inefficiency at the anode or cathode is not at once shown by the appearance of an equivalent quantity of oxygen or hydrogen, such as would at once be observed in a nickel-plating solution. Again, cyanide solutions in the presence of air exert a decided solvent action on most metals, and in the course of the experiments allowance should be made for a loss at the cathode, and an added loss at the anode through this cause. Before using the mixed solution of copper and zinc cyanides a few preliminary experiments with the metals separately were made to obtain some definite knowledge of the conditions necessary for producing quantitatively correct deposits.

Quantitative Deposition of Copper from Cyanide Solution.—There are many methods available for the preparation of cyanide solutions, but the one adopted was that of dissolving precipitated carbonate in potassium cyanide solution. Solutions containing ammonia had already been found to give very poor quantitative results.

By saturating a cyanide solution with copper carbonate a solution was obtained containing about 50 grammes copper per litre. Experiments were then made to determine the best conditions for producing quantitative deposits. A copper voltameter was connected in the circuit, the anode was of best soft-rolled copper and the solution was sometimes kept in motion. The following results may be summarised: –

I. At ordinary temperatures and with a stationary solution—

(*a*) The cathode efficiency is good, ranging between 80 and 90 per cent.

(*b*) The anode efficiencies are very poor, ranging roughly about 15 to 30 per cent. This would be expected owing to the formation of insoluble copper cyanide which is liable to reduce the current almost to zero. This does not form so readily if the temperature is raised, and not at all if there is free cyanide.

II. At ordinary temperature and with a moving electrolyte :—

1. The cathode efficiency is improved, varying between 90 per cent. and 95 per cent.

2. At the anode a striking improvement is observed.

III. Using a warm solution (40 to 50 per cent.) without stirring. The results obtained in this manner are similar to those shown under (2).

IV. Using a warm solution (40 to 50 per cent.) with agitation :—

(*a*) With regard to the cathode efficiency these conditions undoubtedly produce the best results. Here a cathode efficiency of 95 to 98 per cent. was readily obtained.

(*b*) The anodes under these conditions showed frequently more than 100 per cent. efficiency, and seldom less. Most usually the anode acquired, in spite of the absence of free cyanide, a beautifully clean and somewhat polished surface, and thus behaved almost ideally.

The combined action of air and the electrolyte exert a marked solvent action upon both plates, for which due allowance should be made.

Composition of Zinc and Copper Cyanides.—Previous to preparing the brassing solution we examined the two salts quantitatively. The formulæ appear to be $3 \cdot CuCN . KCN + 5KCN$ and $Zn(CN)_2 2KCN$.

Preparation of Brassing Solution.—The solution was then made up as follows: –

Copper potassium cyanide	100 grammes.
Zinc potassium cyanide	100 grammes.
Water up to	1,200 c.c.

To get rid of excess cyanide the solution was heated, and a mixture of zinc and copper carbonates well agitated in it, afterwards filtering off the excess of carbonates.

Preparation of Deposits.—The solution contained in a glass cell was usually maintained at a temperature of 50-60°C. by passing steam through a glass spiral contained in the solution. Unless otherwise stated, agitation was employed in every experiment, this being necessary for efficient anodic solution. Deposits were prepared on a platinum gauze cathode. For anodes, zinc and copper plates of equal areas were employed.

Experiments on Deposition of Brass.—Set A showed that :

(*a*) Zinc anode efficiency steadily decreases with an increase of current density.

(*b*) The two anode efficiencies may either total more than 100, due to solvent action of the agitated electrolyte in conjunction with air; or less than 100, owing to an inefficient anode reaction. Or these effects may to some extent balance one another, and so leave the total at approximately 100.

(i.) The percentage of zinc in the deposit steadily increases with an increase of current density.

Concerning the whole of the deposits it may be said that while they are obtained almost quantitatively, yet they are by no means physically good, and variations of colour sometimes occurred on one deposit, leading one to the conclusion that good deposits both quantitatively and physically are most difficult to obtain.

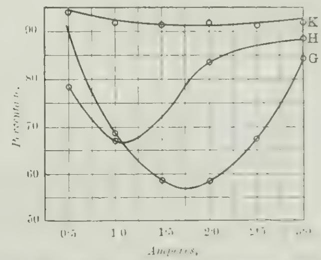
(ii.) The potential difference in each case was low.

(iii.) As the solution of zinc and copper at the anode and their deposition at the cathode follow very different laws there must be a continual change of composition in the electrolyte.

(iv.) The zinc anodes in all cases became coated with copper by simple immersion.

Increase in the zinc cyanide caused a larger percentage of zinc in the deposit.

Effect of Dilution—Dilution with an equal volume of water produced a marked difference. Thus there was considerable difficulty in maintaining a proper anodic reaction at high current densities. Zinc is more readily obtained from weak solutions, this being due to a generally higher F.M.F. as compared with those necessary in



EFFECT OF FREE CYANIDE ON COMPOSITION OF DEPOSIT.

G=9 grs. per litre. H=16 grs. per litre. K=35 grs. per litre.

stronger solutions. In fact, any change in the conditions—such as (*a*) density, (*b*) proportion of constituents, (*c*) rate of agitation, (*d*) current density, (*e*) temperature, and (*f*) variation of free cyanide present—must be expected to impress a change in the colour and composition by reason of the alteration of E.M.F. necessitated to maintain a constant current density.

Influence of Temperature.—The chief results of varying the temperature are as follows :—(1) Quantitative deposition only occurs or is approximated to in warm solutions. (2) At lower temperatures hydrogen is evolved in considerable quantity. (3) The character of the deposit is improved in the colder solution, being much brighter in the presence of hydrogen. (4) Most of these results may be directly traceable to the variation of E.M.F., which follows a normal course. (5) The percentage of copper shows a rapid increase, with rise in temperature, due to its being more easily discharged than zinc at lower potentials.

Effect of Free Cyanide.—The influence of free cyanide is by no means so pronounced as that of free acid in a sulphate solution. Its value seems to be chiefly as a means of removing the insoluble materials formed at the anode, rather than in improving the conductance by adding ions. It also is well known that the quality of the deposit is considerably enhanced by the presence of free cyanide. Burning is attributed to the inclusion of small particles of basic salts. The presence of solvents for these basic substances prevents their deposition, and so improves the deposit. Potassium cyanide, being an excellent solvent for copper compounds, serves this purpose, so that by its addition conditions are obtained which are more nearly conformed to those of a workshop solution.

The largest addition of cyanide showed ease of deposition of copper (*see* Fig.), ease of solution of the zinc, and a large amount of hydrogen deposited.

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PHYSIOLOGICAL EFFECTS IN ILLUMINATION.

Those who have the improvement of illumination at heart, not merely from the artistic point of view, but from that of optical hygienics, will have noticed a very unfortunate, not to say a retrograde, movement since the advent of the metal filament lamp. A few years ago carbon lamps, although generally used with clear globes, were more often than not surrounded with shades which prevented the filament from coming easily into the field of view. As soon as the economic possibilities of the new lamps were appreciated, these carbon lamps were in many cases replaced by metal filament lamps, the shades being left unchanged. The earlier types of metal lamps were made with more or less obscured bulbs; it is noticeable, however, that lamps with clear globes are now used more frequently, and as these are fitted in the old shades, which were made for very much smaller lamps, the result is that the metal filament is left generally quite unobscured. The effect on a sensitive eye is painful, and in any case must be bad, considering the high intrinsic brightness of the metal filament as compared with the carbon. It might have been thought that the frosted type of lamp would have been adopted pretty generally, but contractor and consumer alike seem to pay no attention to this point, and we suppose they will continue this course until optical troubles arise. This is the more inexcusable

because a little loss of efficiency is unimportant, and the general effect of using frosted bulbs with metal lamps is to give the sensation of higher illumination, which, after all, is the condition at which we should aim.

The importance of correct illumination has been emphasised recently by an investigation carried out by Prof. S. W. ASHE and published in the "Electrical World." This work was concerned with visual acuity under varying conditions—a subject which is by no means easy of investigation because the eye itself must be used as the measuring instrument, and is subject to variations in sensibility, not merely in different observers, but in the same observer from time to time. Last year Messrs. A. BROCA and F. LAPORTE went into this question and concluded that such widely different sources of light as the carbon glow lamp and the mercury arc gave the same visual acuity when giving the same illumination. Owing to the physiological properties of the eye, the authors recommend that the intensity of illumination under ordinary working conditions should be from 20 lux to 40 lux.

Prof. ASHE, on the other hand, employing a reading test, obtained curves for red, green, blue and white light (carbon glow lamp) which, although liable to shift slightly from day to day, depending upon the physical condition of the observer, showed marked differences in visual acuity depending on the colour.

As regards light in the field of vision, Messrs. BROCA and LAPORTE came to the conclusion that the luminous sources should be removed as much as possible from the field of peripheral vision. The contraction was found to depend more on the brightness of the luminous source than on its distance. Consequently, high intrinsic brightness should be avoided, and if indirect illumination by reflection can be adopted the result is far better. It was found, however, that the contraction of the pupil caused by peripheral vision of the lamps is the more harmful to visual acuity as the illumination in reading is the more feeble, and that considerable fatigue may result. On the other hand, it is less important when the intensity rises between 20 lux and 40 lux. It is curious that the mercury arc, which has the most feeble intrinsic brightness among the lamps tested, causes a marked contraction of the pupil, and, consequently, this source of light is not quite so advantageous as might have been expected. Generally speaking, so long as the luminous source is not directly in the field of vision, the question as to which source should be used is a matter of indifference from the hygienic standpoint. These results are in general borne out also by Prof. ASHE. It was found that the pupil contracts to a greater extent for green than for the approximately white light of the carbon filament. Prof. ASHE makes the somewhat striking observation that the presence of a foreign lamp in the field of vision decreases one's ability to read by approximately 30 per cent. for an ordinary 16 c.p. carbon lamp. With the higher candle-powers, to which we are getting more and more accustomed, the effect would probably be still more marked.

Points such as these are of the greatest importance, and we hope that contractors and others responsible for illumination will not only bear them in mind, but will bring them before the public.

REVIEWS.

Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electrical Installations of Electric Light, Power, Traction, and Industrial Electrical Machinery. By RANKIN KENNEDY. Vols. I. and II. (London: Caxton Publishing Co. Pp. viii. + 251. 7s. 6d. net.

The fact that a second edition of this five volume work has been called for within a few years is evidence that it has found favour with a fairly wide circle, and this is probably to be attributed to its popular style, and to its appeal to those who like to experiment for themselves in their own homes. The book has certainly been much improved since its first appearance, but the introductory chapter, which has evidently been added to the first volume with the object of bringing it up to date, is a most unfortunate one, and would prejudice all but careless readers against the whole book, as it plunges into a most extraordinary *mélange* of the properties of electric currents, of dielectrics and condensers, of oscillatory discharges, permanent and electromagnets, inductance, vacuum tubes and electrons; with calculations which must be hopelessly confusing to a beginner who has to be taught Ohm's law in succeeding chapters. The language is also frequently loose and misleading; but on the other hand the writer's practical experience and originality show themselves in many useful remarks. He explodes, for instance, the fallacy still prevalent in certain quarters that the winding of the magnets of instruments in parallel reduces their time constant, and he argues for the basing of our unit of current on the natural unit, the electron.

Chapter I. is practically a repetition of the first chapter of the first edition, in which the author describes the construction of simple apparatus, and the proving of fundamental laws and making of measurements by its aid. But for the looseness of the style this could be cordially recommended, though it is somewhat disconcerting to be told immediately after the prefatory chapter on electrons that the question, "What is electricity cannot be answered." The remainder of the volume deals with electrical measuring instruments, and supply meters which are fairly well handled. A cardboard dissected model of a Kelvin balance is provided, and may prove of value, but one wonders at the liberal display of dark green paint which adorns the plates. On a turbo-dynamo set this looks fairly natural, but on a galvanometer case, battery jar, or switch it is unconvincing, or suggests severe corrosion.

Vol. II. continues the subject of supply meters, the descriptions being often good, though there is little attempt at scientific classification. We do not see why a description of the Duddell oscillograph should be sandwiched in between prepayment and two-rate meters. Permanent magnets are next dealt with in a fairly practical manner, although directions for hardening and tempering are given without the least reference to the recalescence point of the steel; but although magnetic testing was dealt with in the first volume there is nowhere any clear statement of the meanings of the units and terms used in electromagnetism.

The bulk of this volume is devoted to dynamos and motors. Magneto machines, which are evidently a speciality of the author's are very completely described, and his own ideas are frequently visible in ingenious devices in conjunction with dynamos and motors, namely, the monocoil inductor magnet, the self starting and synchronising motor, &c.

In dealing with homopolar machines the author repeats the assurance given in the first edition that he has obtained a practical solution of the high-voltage machine, but it still awaits practical proof. In the meantime the only method of obtaining the higher voltage from such a machine which he shows is by the use of a number of insulated bars, sliding one after another under brushes in series, which would probably have most of the present commutation difficulties with a few new ones as well. Dynamo design is carried out by the aid of certain rules of the author's, but heating and reactance are

scarcely mentioned. The author objects to vector diagrams and rotating fields in conjunction with induction motors, but he does not give the least idea as to how the power factor or performance of such motors can be predicted. It is surely unfortunate to encourage the tendency to sneer at theory in this way, without at the same time doing something to improve it. This is best shown in a reference to magnetic theories, where he criticises the use of the term magnetic moment of a magnet and states that this idea led to the employment of very long magnets in the dynamos of an early noted inventor, which were afterwards improved upon by another inventor by halving their length. We were always under the impression that this was due to a better knowledge of the theory of electromagnetism, on the part of the improver. A good dissected diagram of a three-phase motor is given as a frontispiece.

Die Atmospharische Elektrizitat. By A. H. MACHE and E. v. SCHWEIDLER. Part 30 of "Die Wissenschaft." (Brunswick: F. Vieweg & Sohn. Pp. xi—236. M. 6.

Through the extension of our knowledge of the electrical processes in gases and the discovery of radio-active substances, there has been during the last 10 years a great development of researches on atmospheric electricity. Facts relating to the electrical conductivity of the air, and to the presence of radio-active substances in the earth's crust and in the air, have thrown much light on many conclusions which were previously of an empirical character, and have contributed to the design of new methods of observation. The ion hypothesis has also been very fruitful in its application to the processes in the electric field of the atmosphere.

The book under review contains a very valuable summary of the work that has been done on atmospheric electricity, and, as everything is viewed in the light of modern theory, it will be found interesting, not only to skilled meteorologists, but to students of electricity in general.

The earlier portion of the book deals specially with the electrical field of the atmosphere, which may be explained under ordinary conditions by assuming a negative charge on the earth and a positive charge permeating the air. Explanations are given of the methods of measuring the rate of fall of potential, both when the observer is on the earth and when in a balloon; and various electrometers are described. Then follow records of measurements which have been made in various parts of the earth from the polar regions to the tropics. (The patriotic Britisher may note with pride the honourable position which the Kew observations occupy in the series of records.) The measurements are studied under the heads: (*a*) Absolute value, (*b*) yearly period, (*c*) daily period, (*d*) the connection between fall of potential and meteorological factors, (*e*) the influence of the sun and moon upon the fall of potential, (*f*) the disturbances of the normal electric field of the atmosphere, (*g*) alterations of the normal fall of potential and of its daily behaviour with increase of height—balloon observations.

Succeeding parts of the book deal with the electrical conductivity of the air, with ions and how to count them, with the production of ions, with electrical currents, with lightning and the remarkable phenomena of polar regions, and with various theories of electricity. The book concludes with a seven-page index of the literature on subjects of direct importance in the study of atmospheric electricity.

SINGLE-PHASE ELECTRIC TRACTION ON THE MIDLAND RAILWAY.

In the early days of electric traction the advantages of the single-phase system were fully recognised by engineers, but the low starting torque of the only motors available made its actual application practically impossible. The numerous disadvantages of the early single-phase motors have, however, as is well known, been to a great extent overcome during the past few years, so that advantage may now be taken of high-tension single-phase current for railway working, and this has in fact been done in many cases both in America and on the Continent.

Some years ago Mr. R. M. Deeley, locomotive superintendent of the Midland Railway, taking into account the advantages and disadvantages of the opposing systems of electric traction, recommended the directors of that railway to introduce single-phase electric traction on the branch between Lancaster and Heysham, in order that the suitability of this system for railway working generally might be demonstrated. We have already described in these columns the equipment of this line, and we are now enabled, through the kindness of Mr. Deeley, to give some test figures which have recently been obtained, showing its operation.

This section of the Midland Railway was, of course, originally worked by steam locomotives but the single-phase service has now been running quite successfully for 15 months. The results of some tests given below will be interesting as it has been contended in certain quarters that such tests, both as regards starting torque and weight, would show that greater advantages were possessed by the continuous-current system, which would also be better as regards acceleration. These results compared with the recently-published results obtained on the L. & Y., a line worked by continuous current, will show how far these contentions are borne out.

The tests were made on the level lengths between Lancaster and Heysham. The train weighed 51½ tons and was worked over a distance of 1,760 yds., starting from rest. This distance was covered in 119 seconds, the mean-speed being 30·25 miles per hour.

Table I. gives the leading particulars of the train used.

Table I.—*Train for 26 M.P.H. Schedule, including one 20 second station stop per mile.*

	Tons.	Passengers.
Two motor cars (Siemens, revised weights)	72	144
One trailer car	18	54
Total	90	198
Weight of 198 passengers	12·5	
Total	102·5 tons.	

Total horse-power 4 by 210 840·0
Horse-power per ton of train 9·33 (without passengers)
" " " = 8·2 (with ")
Test train 51½ tons. 420 H.P. Horse-power per ton 8·15.

In Table II. the mean results of 12 tests, six in each direction, taken on different days, are shown. The total energy consumption was measured by a meter on the high-tension circuit, and the figures thus obtained agreed with the sum of the watt-hours registered by the low-tension meters.

Table II.

Driving wheels	43·5 in. diameter
Gear ratio	88 30
R.M.S. current	445 amps., or 11 over continuous capacity of motor
Watt-hours per ton-mile, L.T.	92·80
Main transformer C^2R loss	= 1·20
" " iron loss	2·35
Auxiliary transformer losses	0·25
Vacuum pump	1·59
Blower	1·00
Control	= 0·11
Total watt-hours per ton-mile	= 99·30
Average acceleration	25 M.P.H. in 22 secs.
Maximum "	= 1·3 M.P.H. per sec.
" "	= 1·91 ft. per sec. per sec.

Table III.

Driving wheels	40 in. diameter
Gear ratio	3·7/1
R.M.S. current	360 amperes
" "	10 under continuous capacity of motor
Watt-hours per ton-mile, L.T.	= 77·50
Main transformer C^2R loss	1·03
" " iron loss	= 2·35
Auxiliary transformer losses	= 0·25
Vacuum pump	1·59
Blower	1·00
Control	0·11
Total watt-hours per ton-mile	= 83·83
Average acceleration	19 M.P.H. in 13 secs.
Maximum "	1·8 M.P.H. per sec.
" "	2·65 ft. per sec. per sec.

Though the horse-power rating of the motors per ton of loaded train was only 8·15 H.P., the acceleration obtained and the energy consumption compare favourably with the results obtained on lines worked by continuous current.

Diagrams of energy consumption were taken by properly calibrated testing instruments of the indicating type, the curves being obtained from records photographed on to a mechanically-driven drum.

To obtain the best results possible with the given speeds and distance, which are regarded as typical of the requirements of urban and suburban services, somewhat altered gear ratios and wheel dimensions would have to be adopted.

In Table III., the figures have been altered to show what the effect of such a change of motor purchase would be.

Here the accelerations with the single-phase system appear to be better than those usually obtained with continuous systems and similar horse-power of the motors. The single-phase motors were not worked above their rated capacity in any way, and the watt hours per ton-mile at the collector bow came out at 83·83. The only comparative figure, and this is not quite a comparative one, is the 112 quoted by Mr. Aspinall for mixed trains, including shunting work.

With regard to the weight of the single-phase equipment this itself is about one-third heavier than the corresponding continuous-current equipment, but on a train such as the one under consideration the additional weight amounts to only about 7½ per cent. of the total weight of the train. For through services the disproportion, Mr. Deeley thinks, would be considerably reduced, and if electric locomotives were used for goods and mineral trains, all the additional weight would be required for adhesion purposes. The question of weight, however, ceases to be of consequence when the advantages of single-phase systems are considered from the point of view of economy and simplicity of plant.

HIGH-VOLTAGE TRANSFORMERS AND PROTECTIVE AND CONTROLLING APPARATUS FOR OUTDOOR INSTALLATION.*

BY K. C. RANDALL.

Summary.—The design and construction of transformers for outdoor use are here discussed, and a comparison is made of the cost of outdoor and indoor installations.

With the exception of arc lamps and series incandescent lamps, transformers have been about the only apparatus in high-tension service not protected by buildings. Thus far, about 50 k.v.a. has been the limiting capacity found in outdoor service, but there are a few exceptions. Transformers for outdoor service may be built for any requirements that the ordinary indoor type of oil-insulated unit will satisfy. As to capacity, the limit of approximately 500 k.v.a. will apply to the self-cooled type, depending somewhat on voltage and frequency. As with the self-cooled indoor transformers, the case is the principal problem. It is difficult to obtain the radiating surface required for cooling very large transformers and still retain a simple mechanical construction. Oil-insulated water-cooled outdoor transformers can be built for any capacity irrespective of voltage and frequency.

The first problem apparent in the development of outdoor transformers concerned the terminals: how to make them reliable in all kinds of weather and service. The next problem was satisfactorily to weatherproof the case. This much of the problem has been worked out, and now outdoor transformers up to 500 k.v.a. capacity have been built, and units for potentials up to 60,000 volts are in service. The downward projecting lead which issues from an overhanging pocket near the top of the transformer case is a quite satisfactory construction for moderate potentials. 10,000 volts or more can better be carried by upward projecting terminals, this arrangement being particularly attractive for convenience in wiring. About the same practice for placing outlet terminals serves for both indoor and outdoor transformers, so far as the general arrangement and convenience are concerned. The essential requirements of outdoor terminals are that they retain their insulation characteristics and that they do not deteriorate by exposure to the elements. Outdoor terminals are larger and require much more room than those for indoor service.

For a self-cooled 300 k.v.a. 33,000 volt outdoor transformer illustrated in the Paper the case is corrugated sheet iron with welded vertical seams. The bottom and top are cast on the corrugated shell. The resulting construction is strong, oil-tight, and is not subject to damage by the elements. The cover, also of cast iron, has a considerable overhang or eave to guard the joint between it and the top of the case, and is fitted with the outlet terminals and a small inspection door. All joints are protected by an overhang and are designed for making tight with gaskets.

Outdoor water-cooled units employ the same general construction as the self-cooled type except that the cases will usually be of boiler iron, and cooling coils with connections must be provided. Weatherproofing outdoor transformer cases is doubtless best done by making the joints vacuum-tight. The "breathing" of wet air is the most important source of trouble, because it is the hardest to eliminate. Well-made gasketed joints, with deep, overhanging eaves and carefully sealed-in outlets give good results.

Whether outdoor apparatus is really desirable involves a great many points even after it is proved satisfactory in the individual piece. Some of the more important considerations are: location and climate; cost of building and ground for indoor station; cost of corresponding ground for outdoor station; capacity of station; high-tension and low-tension voltages; number of high-tension and low-tension circuits; method of operation and control; method of cooling; attendance and supervision; instruments and their housing; and the cost of indoor versus outdoor apparatus.

A 20 k.v.a. 2,200 to 220 volt transformer immediately suggests a pole installation. But if the figures are multiplied by 10, a 200 k.v.a. 22,000 to 2,200-volt transformer suggests indoor service. If these figures are multiplied by three, a 600 k.v.a. 66,000 to 6,600-volt transformer certainly has always demanded housing. The large clearance required for exposed high-tension wiring and disconnecting switches, the expensive construction demanded for enclosed high-tension wiring and switch structures, the cells or compartments often used for transformers, the space for protective apparatus—all these operate to make the high-tension station costly as compared with the low-tension station. If all high-tension apparatus were placed outside, some kind of a structure would still be required in most cases for housing the instruments, the high-tension control apparatus and the low-tension switchboard. If attendance were contemplated, some additional facilities might also be required. When housing is needed for part of the apparatus, perhaps a large part, the expected advantage of placing the remaining apparatus outdoors may not become important, or may even not exist at all. In order to obtain a comparison, the cost of the the station grounds and indoor apparatus must be balanced not only against the smaller building, but also against all the ground required for the outdoor apparatus, the outdoor apparatus itself, and the instruments and the indoor control apparatus.

If the high-tension circuits are many, and switching is contemplated, the outdoor arrangement appears attractive. If the low-tension plan calls for the control of the several circuits, the indoor arrangement looks desirable, as but little additional indoor space over that required for the instruments and high-tension control panels may be necessary for the low-tension switchboard. Furthermore, indoor low-tension switches and wiring, especially if remote control be not used, should be cheaper. Finally, when there has been provided a house that covers all but the high-tension pieces, it may be found that a small additional cost would have housed everything. Evidently no rule can be set down, as every case will require individual solution.

Typical designs of 33,000-volt and 60,000-volt indoor and outdoor transformer stations are given in the Paper. As an example of the growth toward outdoor stations, there may be cited the Lockport station of the Niagara, Lockport & Ontario Power Co.

Cost.—Outdoor transformers, like the indoor type, increase in cost as the operating voltage is raised, and decrease in cost as the frequency of operation is increased. It is common to prefer a few large transformers rather than several small units. Estimates, based on existing installations, for two equivalent indoor and outdoor 2,000 k.v.a. 25,000-volt 60-cycle stations are given in the Paper. The total cost of the indoor station is approximately £3,150 and of the outdoor station £2,390, *i.e.*, a saving of 30 per cent. Another example for a 3,000 k.v.a. 22,000 to 3,000-volt 25-cycle motor-generator sub-station shows for the indoor station: Building (110 ft. by 38 ft.) £4,400, switchboard £4,000, transformers £3,000, motor-generator sets £9,600 and exciters £900; total £21,900. Also with the high-tension apparatus outdoors on concrete foundations, and a building 110 ft. by 19 ft., the cost is: Building £1,500, switchboard £4,050, transformers made weather-proof £3,200, motor-generator sets £9,600 and exciters £900; total £19,250, the saving being 13 per cent.

A self-contained sub-station made up of transformers, circuit-breakers and choke coils has been proposed. Such an arrangement, if three-phase, would require but three high-tension leads and would dispose of 12 other leads otherwise required by switches and the choke coils. If the choke coils were omitted, six leads are still saved. For capacities up to approximately 250 k.v.a. this arrangement may be found attractive. Such units should be protected by fuses or other circuit-interrupting devices on the high-tension side, as a failure outside of the switch could not be relieved by it. Disconnecting switches should also be used.

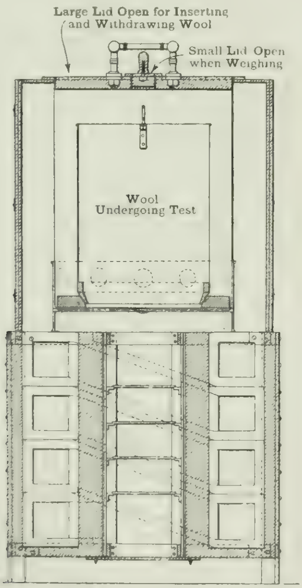
* Abstract of a Paper read before the American Institute of Electrical Engineers.

A construction which permits of shipment in the case with oil is an improvement in transformer design which has been received with quite general favour, as the installation problem is much simplified. The usual unpacking, reassembling, and drying out, if necessary, is reduced simply to removing the blind flanges from the terminal openings and replacing the terminals in order to be ready for operation. Transformers arranged for shipment in their cases with oil, if made weather-proof, need never enter a building after leaving the factory, unless repairs or inspection should demand it.

Conclusions.—The advantage of outdoor apparatus lies in cheapening the installation due to a saving in building; there is also less life and property hazard. The disadvantages are absence of protection from weather when inspecting, overhauling or making repairs, and exposure to molestors. The problem, as a whole, was, first the transformer; second, the switch; and, third, the protective apparatus. All of these have been worked out and some experience obtained. The problem now is to decide when outdoor apparatus is warranted. This is a question of the station rather than the apparatus, and is subject to the individual conditions of each case.

ELECTRICITY IN THE TEXTILE INDUSTRY.

Most modern textile mills are now fitted up with electrical plant, but the application of electricity is generally restricted to lighting and motive power. These, however, by no means exhaust the possibilities, and thus an electric conditioning oven has recently been



CROSS-SECTION OF ELECTRIC CONDITIONING OVEN.

designed by Mr. H. Ellis and Mr. C. E. Allsopp, of the Bradford Corporation Electricity Department. Besides appearance and weight, the strength of a cloth is always taken into account. This is done by straining various samples of equal length and width between two jaws. Such a test should only be carried out after the cloth has first been conditioned, as there are many cloths which have a lower breaking point when wet than dry. The conditioning oven then ensures that the fibre or cloth is free from moisture, or at any rate that the percentage of moisture remaining is such as to to be a negligible quantity when considering weight or strength.

The construction of these ovens differs slightly owing to the heating medium, which up to the present has been confined to gas or steam. The steam oven is used only where a supply of steam is available for power or heating purposes, but where steam is not available, gas is used. The efficiency of the gas-heated oven is naturally low, as the air passing through the wool must not be in contact with the flame or fumes. It is usually passed over a series of large copper plates on its way to the conditioning tank; this means then that by far the greater percentage of heat units passes away to the atmosphere. In most modern gas-heated ovens the hot air is driven through the wool by means of a fan or blower at a pressure such as will ensure that all moisture is removed. Obviously, if electric heating was applied in the same way the expense would prohibit its use, but owing to the fact that the air comes in direct contact with the heating element in the new design, the efficiency is very considerably increased.

Referring to the cross section of the oven shown herewith, the rectangular-shaped box on the centre line contains a number of woven wire resistance mats arranged horizontally one over another. Surrounding this, and insulated from it by slag wool, is a chamber (also insulated on its outer edge) which is really a spiral surrounding the heater. In this spiral, which is square, is a 3 in. by 3 in. tube also in the form of a spiral. These tubes form the economiser of the apparatus. Air is blown through the smaller tube by a fan, entering at the top, into the bottom of the heater, then up through the wire mats into the space at the top. From this point, by means of a series of ports, the air may be directed either through the wool, which is contained in the conditioning tin, or by-passed into the annular space surrounding the oven, and thence down into the larger tube of the economiser. This latter method is adopted when the weighing operation takes place, as it would obviously be impossible to weigh the material with a pressure of air under the tin; furthermore, it is not advisable to switch the current off, as even while weighing takes place it is necessary to maintain the air temperature in the oven as normal as possible, otherwise the fabric would absorb moisture from the atmosphere, and so give a wrong result.

The material rests in the tin on gauze or perforated zinc of small mesh, and the usual quantity used for conditioning is $\frac{1}{2}$ lb. This sample is taken from the inside of a bale indiscriminately, and the percentage of moisture in the sample represents the percentage of moisture in that particular bale. Directly above the tin there is a sensitive scale, and it is customary to keep the scale balanced throughout the tests by adding weights on the wool side to make up for the loss of weight due to evaporation.

The whole apparatus is designed in a manner which ensures the highest possible efficiency, and that the result aimed at has been attained can be proved by noting the temperature of the air at the outlet. Although the temperature of the oven is maintained at 220°F. throughout the test, the outlet temperature is but a few degrees above that of the inlet. This proves the value of the economiser, which, it will be noted, is similar in principle to a feed water heater. A motor consuming about 60 watts suffices to drive the necessary amount of air through the oven; whilst the heaters consume only 1 unit per hour, so that the cost for current is small, and is, in fact, stated to be less than that of gas in the most modern type of gas-heated ovens. Where a supply of electricity is not available, it is a simple matter to run a small dynamo off the line shafting, to which also the fan could be coupled; since in such a case the dynamo would merely replace the motor. The extra cost, therefore, of such an arrangement would be small.

One great advantage that this oven has over the gas-heated oven is that it is ready for use in five minutes, whereas it takes from 30 to 45 minutes to warm up the other thoroughly, owing to the fact that a large mass of copper or other metal has to be heated up before the air blast can be applied. Many other advantages are claimed for the electric oven; among these are: (1) It is compact. (2) It may be removed from place to place and used with a plug and flexible wire. (3) The temperature regulation is perfect, and may be controlled either by regulating the amount of air, or by switching the current on or off. (4) It may be used on alternating or direct current. The apparatus is likely to interest central station engineers, particularly those in the woollen and worsted districts.

CORRESPONDENCE.

THE PHOTOMETRY OF DIFFERENTLY COLOURED LIGHTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 16th I notice an article by Mr. Lancelot Wild in connection with the photometry of differently coloured lights and the difference between tests made with the flicker photometer and other types.

I have already pointed out the difficulty of comparing lights of different colours ("Bulletin" de la Société Internationale des Electriciens, November, 1904, pp. 617-652, and also at the meeting of the International Photometric Commission in

Zurich, July, 1907. The reports presented to the Commission were published in THE ELECTRICIAN, October 18, 1907, p. 6).

Among other tests published in my note to the Société des Electriciens, I may refer to the following, made when comparing a Nernst lamp and an ordinary carbon lamp: (1) With the same photometer, when the distance of both lamps from the screen was varied, the relative value of one lamp to the other varied 20 per cent. (2) With the same distance, and with the flicker photometer, the relative value also varied 20 per cent. according to the method of using the photometer: (*a*) with the disc moving at about 10 to 15 revolutions per second and the photometer really acting as a flicker photometer, (*b*) with the disc at rest, and the photometer acting without flicker, like any photometer of the equality of brightness type.

I agree, therefore, with Mr. Wild's conclusions in regard to the flicker photometer; but I think the difficulty pointed out by him is only one among many others met with by all who try to compare lights of different colours.—I am, &c.,

P. LAURIOL,

Chief Engineer of the Lighting Department of Paris.

Paris, July 21.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest Mr. Lancelot Wild's article upon "The Photometry of Differently Coloured Lights" in your issue of July 16th. So far as I understand it, the results of Mr. Wild's experiments are that when testing the tungsten lamp against a carbon filament lamp the flicker photometers gave results (scale readings) varying only from 1·71 to 1·735, while when the same comparisons were made with other forms of photometer heads the results varied from 1·7 to 2·05.

I take Mr. Wild's argument to be that if one is using a carbon filament lamp as a standard and testing a tungsten lamp one can get a higher value for the tungsten lamp with photometer heads of the Bunsen, prism or Lummer type, and he argues from this that, therefore, one should use photometer heads of this description. It appears to me to be the logical sequence to this argument that, if one is using the tungsten lamp as a standard, in order to get the value of a carbon filament lamp, the reverse procedure should be adopted.

Photometrical values will, indeed, have a new terror if one is allowed to adopt whichever form of photometer head he prefers, however uncertain its readings may be, so long as that photometer head gives a high result to the particular lamp being tested. I can follow Mr. Wild's figures very readily, but I do not see anything at all in the nature of a proof that for testing tungsten lamps the flicker photometers will have to be discarded in favour of the Bunsen disc. Those of us who have studied the question know perfectly well that photometer heads constructed on the contrast or equality of brightness principle will give different results from the flicker photometer, and this is on account of the colour difficulty.

Mr. Wild does not seem to have advanced any sound argument in support of the conclusion to which he comes, however flattering that conclusion may be to the photometrical value of tungsten lamps.—I am, &c.,

Victoria-street, S.W., July 26. JACQUES ABADY.

THE "C.M.B." AUTO-CONVERTER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I thank Messrs. Macfarlane and Burge for their courteous reply in your issue of July 23rd to my letter published on July 16th; at the same time I cannot pass the statements therein made.

The function of a transformer is to convert power at one pressure to another higher or lower pressure and incidentally one may require to regulate the secondary pressure. These two requirements should not be confused. For the simple function of pressure reduction an advantage is claimed for the "C.M.B." machine compared with the double commutator type. What are the facts? Taking the example given in the original article, Messrs. Macfarlane and Burge state that for a reduction ratio of 4 : 1, the division of both field and armature will be approximately in the ratio of 2 : 1. This is perfectly correct. If any ratio $V : v$ be assumed then, neglecting the inefficiency of the machine, the division in the ratio $\sqrt{V} : \sqrt{v}$ will give most normal design throughout. The $C \times R$ pressure drop in the two sections of the armature will, therefore, be in the ratio $\sqrt{v} : \sqrt{V}$, and the resistance or "copper" losses in the ratio $v^2 : V^2$, since the currents are in the ratio $v : V$ and the resistances $\sqrt{V} : \sqrt{v}$.

In the example, therefore, the voltage drop on the low-pressure side would be double instead of ¼th that on the high-pressure side, and the losses in the ratio 1 : 8. The above argument assumes that the currents are in the exact inverse ratio of the pressures. Owing to the facts that the "C.M.B." machine is an auto-transformer and that the high-pressure winding has always to carry the current to supply the armature losses, there is no doubt that in practice this ratio will be reduced to something like 1 : 6.

A similar argument will show that the losses in the field magnets are also very unequal. (It should not be forgotten here that the "C.M.B." machine has twice as many magnetic paths in parallel as the double commutator machine, and, therefore, the product of copper value into value of energy consumed in any time will be $\sqrt{2}$ times as great.)

For greatest efficiency and economy of material, a transformer should have approximately equal losses in primary and secondary sections, and there is little doubt that in practice the loss on either side of a double commutator machine will not greatly exceed the figure representing unity in the above ratio of 1 : 6 for the "C.M.B." machine.

If one takes the statement of 80 per cent. efficiency for a 3 kw. "C.M.B." machine given in the original article, and subtract the odd 17 per cent., by which the "C.M.B." machine is said to excel, we obtain 63 per cent. as being Messrs. Macfarlane and Burge's estimate of the maximum efficiency obtainable from a 3 kw. machine of the double commutator type. Looking up a few tests I find that the nearest example to this is a 5 kw. machine 480/65 volts, which gave on test (made by the customers) 88 per cent.

The remark that "the whole of the conductors" (presumably armature) "are common to either motor or generator fields," is surely incorrect. In the sense that the machine is an auto-transformer it is true that the motor conductors are common, but not the generator. In the double-wound machine all the conductors are certainly common, since there is only one field, *and all the copper is fully utilised and never overloaded.* If special regulation be required it is true that some of the generator conductors only cut the auxiliary field. This will certainly detract from the efficiency, but the arrangement, with the widest degree of regulation, will not be so bad as that of the "C.M.B." machine, which practically corresponds to two entirely separate machines, mechanically coupled and connected auto-transformer fashion.

The risk of breakdown between sections in a double-wound armature is not so great as that occurring between individual turns of a single winding. Nevertheless, the ring-wound armature is undoubtedly superior to the drum-wound in this respect. When the difficulty of winding and expensive construction of a ring wound armature are considered, together with the extreme care required to avoid breakdown to earth, however, no manufacturer would think of using this type in place of the drum-wound with its simple construction and former coils, unless driven to it by the awkwardness of the design.

Again, Messrs. Macfarlane & Burge may easily refer to standard authors, to find that the ring-wound armature coil possesses much higher inductance, and therefore reactance voltage than the drum wound, for the simple reason that the turns of the coil enclose a magnetic path which is entirely through iron. Couple this with the much higher number of turns per segment carrying the large low-pressure current and a higher peripheral speed on the commutator, and it will be seen what an exceedingly difficult commutation problem is presented.

To deal with the whole of the points fully would encroach too far on your valuable space, which is already overtaxed

but, in conclusion, I would say that I am prepared to design a machine for any considerable voltage reduction, of the double commutator type, which shall be cheaper to make and more efficient than the "C.M.B." machine. Further, I ask if this machine can be made having a reduction ratio of 480/10 volts for the purpose of charging ignition cells, this being a type of machine I have been called upon several times to design. Finally, will Messrs. Macfarlane and Burge kindly accept my apologies for this severe criticism, which is given in quite a technical spirit. There is no doubt that the "C.M.B." machine as sold is a perfect article, but I must differ with the designers with regard to the economic applicability of the principle involved.—I am, &c.,

East London College, July 24. LEONARD MURPHY.

INTERESTING TYPES OF ELECTRIC MOTORS.

As long as electric motors were in their infancy they presented the most various designs, from which standard types have gradually been evolved, so that any difference between the exterior of a three-phase induction motor fitted with a slip ring rotor and a continuous-current motor is scarcely discernible; and, further, the electric motors designed and placed upon the market by the various manufacturers can scarcely be distinguished from one another by any special features. On the other hand, however, there has been a tendency to adapt the electric motor as far as possible to the conditions under which it will have to run. The Felten & Guilleaume-Lahmeyerwerke A.-G., of Frankfort-on-Main, have developed quite a number of motors, of which the more interesting types are illustrated and described below. In these the various methods of erection are attained by means of specially designed motor frames.

FIG. 1.—DRIP-PROOF VERTICAL MOTOR.

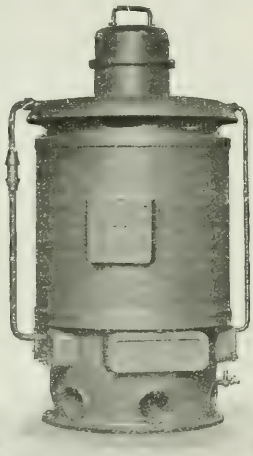


FIG. 2.—THREE-PHASE DRIP-PROOF INDUCTION MOTOR.

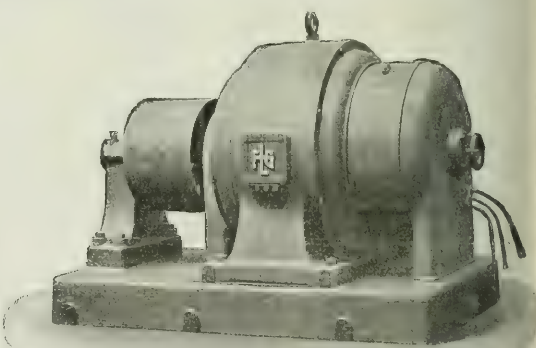


FIG. 3.—MOTOR WITH FORCED VENTILATION.

The standard so-called open-type motor is, under ordinary conditions, always applicable, and therefore the one most universally adopted. It possesses the advantage that the motor is most effectively cooled, owing to the open and accessible position of the windings and the free ventilation. It frequently happens, however, that the motors are required to work in places where they are liable to be injured by falling bodies or objects—for example, in buildings under construction. The motors may be adapted for these unfavourable working conditions by protecting them with a covering of expanded metal or perforated sheet iron, which is placed over the bearing shield of the slip-ring or commutator side as the case may be. The three-phase squirrel-cage motor, however, does not require a protecting device of this description, as all its parts are already sufficiently well protected by reason of its peculiar form of construction.

If the motors are to be employed in places where they are exposed to the continual influence of dripping water—as, for example, in mines, or when building large tunnels—they must naturally be adapted to the special conditions. In the three-phase Lahmeyer induction motor of this construction, designated the drip-proof type, four ventilating openings are provided in each of the end brackets, but are shielded in such a manner that dripping water cannot find an entrance into the interior of the motor. Ventilation is naturally impaired, but this is improved by means of a fan mounted on the shaft of the motor. Air is drawn in from the one side, and after passing through the interior of the motor, is expelled on the other side. In the case of three-phase motors fitted with slip-ring rotor and continuous-current motors, the protecting cover fitted to the slip ring or commutator side of the motor, as the case may be, is only provided with two ventilating openings. For vertical motors (Fig. 1) the protection against dripping water consists of a drip-proof hood. Air is drawn in through the ventilating hole seen at the bottom of the motor frame, and after passing through special ventilating ducts provided in the stator and the rotor, is expelled through the liberally rated openings under the drip-proof hood, thus bringing either the slip-rings or the commutator into intimate contact with the outside atmosphere.

When designed as vertical motors, three-phase motors fitted with squirrel-cage rotors are usually given the preference, and, owing to their simple design, they are particularly adapted for driving sinking pumps, the chief field for large vertical motors. Fig. 2 shows a three-phase drip-proof induction motor of the squirrel cage type having an output of 185 H.P. at 500 volts and 1,500 revs. per min. It may be mentioned that motors so protected may also be set to work in the open air without further protection from the weather.

If the motors are to be employed in very damp situations, or in mills, cement works, textile factories, chemical works, &c., the totally-enclosed type must be chosen. This differs from the drip-proof type inasmuch as the ventilating openings are dispensed with: A cap of compressed sheet metal is fastened over the end bracket at the slip-ring or commutator end, and the other end is closed by a metal disc, by which means the interior of the motor is entirely closed off from the influences of the surrounding atmosphere. On this account the ventilation is considerably impaired, and the output of the machine is about 30-50 per cent. less than in an open-type machine of the same size.

For electrically-operated cranes, particularly those erected in the open air, totally-enclosed motors are generally used. To overcome the objection of reduced output in enclosed motors the Felten & Guilleaume-Lahmeyerwerke have developed a system for the employment of forced ventilation. The motor frame is completely enclosed with the exception of two openings, one at the pulley end and the other at the commutator or slip-ring end (Fig. 3). The former serves for the ingress and the latter for the egress of the air, which is impelled through the machine by a fan mounted on the armature shaft. In this way the motors may be rated as equivalent to open-type machines, and will develop an equal output. In order to give the machines sufficient stability they are mounted on strong bed-plates, as shown in Fig. 3, in which there are openings connecting the air conduits with the motor housing, assuming that the air supply is taken from below. With a belt drive the machine, together with this bed-plate, is mounted on slide rails, which are so constructed that the connection between the motor and the underground channels is always airtight. Fig. 4 shows this arrangement.

When used for driving sinking pumps it may happen that the motor has periodically to work below the water level. In this case it is not possible to make use of the ordinary totally enclosed type, and an absolutely watertight design must be adopted. With this

construction the two totally-enclosed end brackets are screwed tightly to the motor housing with the interposition of rubber washers. A watertight closing cover on the commutator or slip-ring side, as shown in Fig. 5, is also necessary with continuous or three-phase current motors fitted with slip-ring rotors, in order that the commutator or slip-rings may be periodically examined. In consequence of the absence of all sliding contacts, motors with short-circuited rotors are even more suited to this class of work than those of the slip-ring type. When designed for large outputs they, of course, require special starting devices, mostly starting transformers; the special connections to the rotor necessary for motors of the slip-ring type are, however, totally dispensed with.

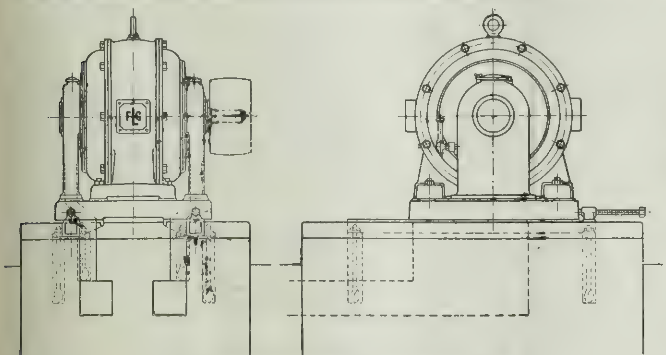


Fig. 4.—Arrangement for Forced Ventilation.

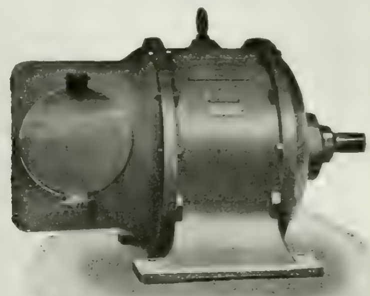


Fig. 5.—Watertight Motor.

What has already been said about the reduced output of the ordinary totally-enclosed motors in connection with impaired ventilation holds good in a still greater degree for the watertight type of motor, if effective means for artificial cooling—viz., by cooling water—are not provided. The water-cooled watertight motor of the short-circuited rotor type, illustrated in Fig. 6, which serves for driving a sinking pump, develops a continuous output of 95 H.P. at 2,880 revs. per min. and 2,000 volts. The overall dimensions of this motor are particularly small, the outside diameter being only 29½ in. and the height 62½ in. The pipes seen on the left-hand side of Fig. 6 serve to conduct the water for cooling the stator frame, the top suspension and top guide bearing and the lower guide bearing; these pipes are directly connected to the lowest pressure step of the centrifugal sinking pump to which the motor is direct coupled. The three pipes seen on the right-hand side of the motor serve to discharge the cooling water.

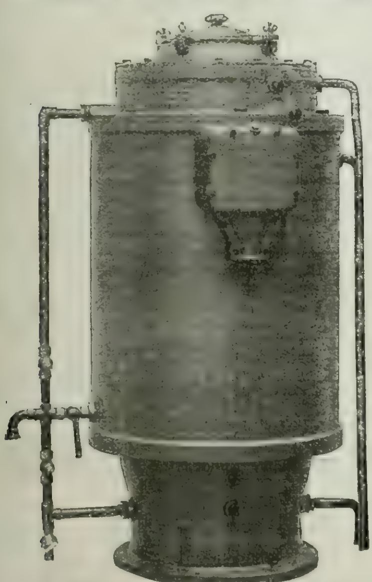


Fig. 6.—Water-cooled Watertight Motor.

In conclusion, one more special type may be described—viz., a motor for fiery mines. Machines constructed with gas-tight housings which were first tried did not prove entirely satisfactory; the total absence of ventilation caused them to be unduly large and absolute gas-tightness was extremely difficult to maintain. The result was that the explosive gases were gradually drawn into the motor housing, and with the slightest sparking an explosion occurred and fractured the motor shell. A further series of tests were undertaken, eventually resulting in the so-called "plate" protection. This consists of a number of hollow, circular or rectangular brass, or other non-rusting metal sheets, built up one above the other, with narrow air spaces between. Through the slots formed in this way the explosion gases in the interior of the motor, which have perhaps become ignited from any cause, will escape and become cooled in their passage by contact with the iron plates, so that an ignition of the firedamp outside the motor cannot possibly occur, after the manner of the Davy safety lamp. This principle, which is used on British and foreign machines, and has proved to be the most satisfactory from every point of view, has been adopted by the Felten & Guilleaume-Lahmeyerwerke for their ventilated flame-proof type of motors.

The plate protection may be utilised in various ways; it can, for example, be confined to the flame-proof covering of the slip-rings in the case of three-phase motors. There is, however, still the danger of an explosion caused by sparks from the stator winding. Should it be deemed advisable to avoid even this, the plate protection for the stator housing is then, as may be seen in Fig. 7, built up of a number of iron plates arranged one above the other with air spaces between them, whilst the rotor is protected by means of two similar devices, one being fitted in each of the end brackets. A fan mounted on the motor shaft draws air in through the apertures in the two end brackets, and the air after passing through the motor is expelled through the aperture above the stator housing. When continuous-current motors are employed in mines—only exceptional cases—the flame-proof protection can be fitted in an exactly similar way.

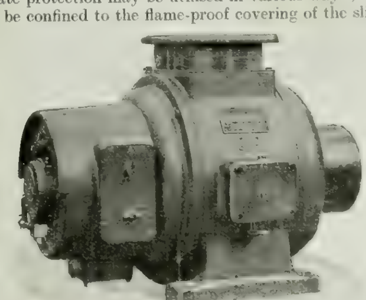


Fig. 7.—Plate-protected Explosion-proof Motor.

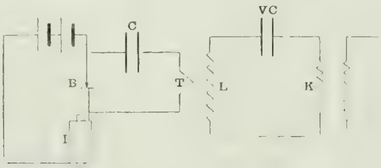
From the above remarks it will be evident that modern electric practice has advanced to such an extent that it has become possible to design and construct electric motors to conform with the most unusual working conditions.

A METHOD FOR PRODUCING FEEBLY DAMPED HIGH-FREQUENCY ELECTRICAL OSCILLATIONS FOR LABORATORY MEASUREMENTS.*

BY L. W. AUSTIN.

The general scheme of the apparatus is shown in the accompanying diagram. Here B is a circuit interrupter, I a reactance coil, C a paper condenser of from 0·1 to 1 microfarad, T a single turn of wire placed around a large inductance L (0·3 to 1 millihenry), VC a variable air condenser, and K a coupling coil for connecting this oscillating circuit with the circuit on which the measurements are to be made. The action is as follows: When the direct circuit is broken at B, the self induction current charges the paper condenser to a sudden high potential. This gives rise to a strongly damped pulse through the single turn of wire T, which starts the second circuit L VC to oscillating in its own period, producing waves which are very feebly damped on account of its large inductance and negligible resistance.†

If very great constancy in the intensity of the oscillations is not desired, the reactance and interrupter may be in the form of the ordinary buzzer. With this carefully adjusted, the variations in the oscillations may be kept as low as 3 to 6 per cent. For stronger oscillations a mercury turbine interrupter with a separate reactance coil may be used. For the greatest constancy of working I have obtained the best results with the vibrating wire mercury interrupter. This is troublesome when used with any but very small currents on account of its tendency to throw out the mercury from the cup. This can be minimised by using a liquid amalgam made by dissolving bits of solder in the mercury, and also by using a cover provided with an opening for the platinum contact. The energy imparted to the oscillating circuit by this type of exciter can amount to at most a few milliwatts.



For telephonic reception any of the receivers ordinarily used in commercial wireless telegraphy are suitable. For damping experiments, or any experiments in which deflection measurements are necessary, I have found the most constant and satisfactory results with the silicon rectifier.

If it is possible to insert an inductance in addition to the coupling inductance in the antenna, the single turn of the exciter circuit may be placed about this, thus exciting waves of the natural antenna frequency. This gives a convenient means of bringing the antenna circuit and the closed circuit to the same tune and of testing the receiver for the actual wave lengths which are to be used.

* Abstract from the "Bulletin of the Bureau of Standards."

† A somewhat similar arrangement of interrupter and reactance coil is used by the Telefunken Company, and also by the Amalgamated Radio Telegraphic Co. in their wave meter sets, except that there the tuned circuit is connected directly to the interrupter and not excited inductively.

THE ELECTRICAL INDUSTRIAL ASSOCIATION.

Progress is being made with the formation of this Association, and we give below the first list of members of the provisional committee, which will meet Sir William Preece to invite him to accept the presidency of the Association.

Addenbrooke, G. L., M.I.E.E.
Baylor, A. K., M.I.E.E.
Beddoes, Lieut.-Col. H. R. (chairman, Morris Hawkins, Ltd.)
Bergtheil, E., M.I.E.E.
Bull, J. C., A.I.E.E. (City of London Electric Lighting Co.)
Connett, A. N., M.I.C.E., M.I.E.E.
Dickinson, A., M.I.C.E.
Drake, Bernard M., M.I.E.E.
Eck, H. Justus, M.A., M.I.E.E.
Esson, W. B., M.I.C.E., M.I.E.E.
Freeman, E. H., A.I.E.E. (Tyler & Freeman).
Garcke, Emile, M.I.E.E.
Gray, James, A.I.E.E. (Electric Construction Co.)
Gripper, F. E., M.I.E.E.
Hirst, Hugo, M.I.M.E. [C.P.A.
Lawson, J. G., M.I.E.E., M.I.M.E.
Lycett, J. A., J.P. (Birmingham & Midland Tramways Joint Committee).
Gibson, G. Marsden, A.M.I.C.E.
Mountain, M. B., M.I.E.E.
Murphy, W. M., J.P. (Dublin United Tramways Co.)
Renwick, H. B., A.I.E.E. (County of London Electric Supply Co.)
Robinson, Mark, M.I.C.E., M.I.M.E., M.I.E.E.
Sayers, Henry M., M.I.E.E.
Shubb, Lt. H. A. B. (Bournemouth).
Sutton, Geo., M.I.E.E.
Swinton, A. A. Campbell, M.I.C.E., M.I.E.E.
Wood, A. P., M.I.E.E. (Lancashire Dynamo & Motor Co.)

PARLIAMENTARY INTELLIGENCE.

WATFORD URBAN DISTRICT COUNCIL BILL.

This bill came before a Select Committee of the House of Lords last week. It was announced that an agreement had been arrived at with Watford Gas Co., which opposed the electrical clauses. The bill conferred powers to extend the limits of the electric supply area so as to take in Cassiobury Park, and to supply electricity outside the area in the event of consumers desiring a supply. The Board of Trade had reported upon the latter section and referred to the provisions of the Electric Lighting Acts (Amendment) Bill, now before Parliament, in which it was provided that authorities desiring to give a supply outside their own district must obtain an order so to do from the Board of Trade, in which would be laid down the conditions regulating the supply, and would impose obligations to supply anyone in the district who might desire it. The Gas Co. desired the Council to take that clause from the Board of Trade's bill and insert it in their bill in place of the clause in dispute, adding the limit of 500 yds., which, in the case of Watford, was limited to the area around the town in which the Council desired power to supply. The promoters agreed to do so, and the preamble of the bill was ultimately found proved.

SCOTTISH PROVISIONAL ORDERS.

Parliamentary Commissioners (Sir John Dewar, M.P., chairman, Lord Belhaven and Stenton, Lord Dunmore and Sir John Jardine, M.P.) are holding an inquiry into a number of Scottish provisional orders.

On Tuesday the order of the Colinton Tramway Co. was considered. This order authorises the laying down of an electric tramway from Edinburgh to Colinton.

Mr. JOHN WILSON, K.C. (for the promoters) said they contemplated forming a tramway which would continue the existing tramway from Edinburgh to Craiglockhart and carry it on past the site of the new cavalry barracks at Redford. The length was over 2 miles. The opposition had largely disappeared. Clauses had been arranged with the North British and Caledonian Railway Cos. The War Office, in exchange for facilities offered by the promoters, had agreed to pay a sum equal to one-third of the total cost of constructing the track of the tramways to the Union Canal and Slateford station. The War Office were to pay £485 per annum for the use of the track for three years, and if the use was continued for a longer period an arrangement had been made.

On Wednesday the promoters' case was concluded, and evidence was given in support of the opposition by the County Council and the Edinburgh Town Council. A compromise was arranged with the Town Council, and the Commissioners found the preamble proved.

Glasgow Corporation Bill.—This bill came before the Examiner of bills, Mr. Jeune, in the House of Commons on Monday. The Caledonian, North British and Glasgow & South-Western Railway Co.s had lodged memorials, alleging that no notice had been given of certain clauses when the bill was lodged. Clause 20 states that "the tramway undertaking of the Corporation shall be, and shall be deemed to have always been, part of the common good of the city," and clause 30 that "the revenue from the tramway undertaking shall be applied annually in maintaining the tramways, in paying all working and other expenses properly chargeable to revenue, in providing the interest on any moneys raised or borrowed by the Corporation for tramway purposes, &c., in providing the sum necessary to meet depreciation and in contributing to the common good, other than the branch thereof consisting of the tramway undertaking, any sum not exceeding £50,000 to be applied at the discretion of the Corporation in extinction of debt or reduction of rates, or for any other purpose to which the common good may competently be applied, and that the surplus, after providing such payments, may be applied for the benefit of the tramway undertaking."

After hearing arguments, Mr. Jeune held that clause 20 was not, but clause 30 was, covered by the notice. In giving his decision he said he was asked to hold that clause 20 was merely a declaration of the law. That was a legal question he could not answer. If it was necessary to put that clause in the bill, it seemed to him it was of sufficient importance to require notice, so that everyone affected might have an opportunity of disputing the position. Clause 30 contained the ordinary provisions for the proper maintenance of the tramway, and was incidental to the objects of the bill. Its powers only enabled the Corporation to do what they had already been doing.

Gateshead and District Tramways Bill.—On Monday this bill came before the Committee on Unopposed Bills in the House of Commons. The clause which would empower the running of trackless trolley cars with overhead electric equipment was deleted, and with this alteration the bill was allowed to proceed.

West Kent Electric Power Bill.—The preamble of this bill, by which the West Kent Electric Power Co. (Ltd.) acquire the rights granted to the Kent Electric Power Co. for the supply of electricity within the West Kent area of supply, has been passed by the Unopposed Bills Committee of the House of Commons.

Oldham Corporation Bill.—Last week a Select Committee of the House of Lords considered this Bill, which (inter alia) enables the Corporation to supply electricity to certain outlying districts, including Chadderton, Royton, Crompton, Lees and Limehurst. A clause in the bill stated that when these districts were unable to get a supply upon reasonable terms from any company authorised to supply in the district they should be empowered, by the consent of the Board of

Trade and the local authority of the district, to get a supply from Oldham Corporation upon such terms as might be agreed upon.

The select Committee found the preamble of the bill proved, subject to the electrical clauses not being acted upon without the consent of the Lancashire Power Co., such consent not to be unreasonably withheld, and the question whether it was unreasonably withheld to be decided by the Board of Trade.

LEGAL INTELLIGENCE.

Consolidated Nickel, &c., Mines (Ltd.) v. Crompton & Co.

On Wednesday Mr. ABEL THOMAS, K.C. (on behalf of defendants) applied to a Divisional Court (the Lord Chief Justice and Justices Darling and A. T. Lawrence) for a stay of execution in this case (reported in THE ELECTRICIAN for July 23). The case lasted a long time and there were at least five different questions of law upon which defendants wished to appeal. He was prepared to bring the money into Court at once. That was a case where a stay should be granted, especially when they remembered that plaintiffs had no money in bank as far as defendants knew, and no property that they could see, while their registered offices were in Guernsey.

The Court granted the stay, and ordered that notice of appeal should be given this week and the money paid into Court.

Trade Discount.

In the City of London Court last week, before Mr. Registrar Wild, a question of trade discount was raised in the case "General Electric Co. *v.* Bridges," in which plaintiffs sought to recover £1. 8s. 2d. from defendant.

Plaintiffs' solicitor said defendant was a draper and had bought Osram lamps from plaintiffs and claimed to be entitled to a trade discount: but defendant (not being an electrician) was not entitled to discount. It appeared that on previous transactions the discount had been allowed to defendant in error. On the occasions when discount had been allowed plaintiffs were under the impression that defendant was an electrician. Defendant had deducted 33⅓ per cent. but plaintiffs could only allow 20 per cent. discount upon Osram lamps.

Defendant said he was perfectly willing to alter the rate of discount which he claimed to be entitled to. For several years he had been trading with plaintiffs; he had been supplying electrical goods in fairly large quantities to theatres and private consumers. He had had correspondence with the late manager of plaintiffs' lamp department, and it was distinctly understood he had been acting with plaintiffs' late manager as agent for plaintiffs.

Eventually judgment was entered for plaintiffs for 11s. 2d.

"Z" Electric Lamp Mfg. Co. (Ltd.) v. Marples, Leach & Co. (Ltd.)

On Friday, Mr. Justice Warrington had before him a summons in this action.

Mr. COLEFAX, for plaintiffs, asked that defendants should be ordered to give further and better particulars of the objection that had been delivered by them to the action (which was a patent action). There was an allegation that the specification of plaintiffs' invention was misleading and another that the directions were insufficient. Defendants said that the invention was not proper subject matter for letters patent, and he wished to know against which of the claims of plaintiffs was that objection urged.

Mr. T. TERRELL, K.C., for defendants, said that there were three claims and they were all exactly in the same position. There was no invention, and how could he give particulars of nothing?

The summons was dismissed with costs, but leave to appeal was granted.

Re Mountain & Gibson (Ltd.)—In the Chancery of Lancashire on Monday Vice-Chancellor Leigh-Clare made a supervision order in this matter, and ordered that Mr. A. Whittaker, C.A., be appointed to act as joint liquidator, with Mr. Bowden, with a committee of inspection, in accordance with the resolution passed at a statutory meeting of creditors last week. The committee of inspection is as follows:—T. D. Nichol (Cammell, Laird & Co., Sheffield), T. F. W. Dixon (W. Shaw & Co. Middlesbrough), Samuel Roberts (W. Roberts & Son, Bury), H. E. Churchman (solicitor, 2, Norfolk-street, Strand, London), C. H. W. Lemon, (Hurstleigh, Alderley Edge).

London Electrobus Co. (Ltd.)—Mr. Justice Neville had before him on Tuesday last a petition by Messrs. Pritchetts & Gold for the compulsory winding-up of this company, but on the application of Mr. Manning (for the company) his Lordship directed the petition to stand over until next sittings.

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer. We would add that the portrait is mounted so as to be conformable as to size with "The Electrician" series of steel plate portraits, and is well suited for framing with the series.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant is wanted for the meter department of Stepney (London) electricity works. Applicants must have thorough knowledge of the maximum demand system and be able to advise consumers on power and lighting matters. Applications to the Engineer and Manager, Electricity Works, 27, Osborn-street, E., by Aug. 7. See also an advertisement.

Applications are invited for the position of head of the electrical engineering department at the Technical College, Sunderland. Salary £250, rising to £300 per annum by two equal annual increments. Applications to the secretary, Mr. T. W. Bryers, Education Offices, 15, John-street, Sunderland, by Aug. 23. See also an advertisement.

The Council of the University of Birmingham invite applications for the position of assistant lecturer and demonstrator in electrical engineering. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by noon Aug. 14. See also an advertisement.

Applications are invited for the Professorship of Physics in the Royal College of Science, Dublin. Applications by Aug. 16 to the Secretary, Department of Agriculture and Technical Instruction for Ireland, Upper Merrion-street, Dublin.

The lectureship in electrical engineering at University College, Galway, is vacant. Salary £120. Applications must be sent to the Secretary, Mr. Robt. Donovan, Royal University-buildings, Dublin, by Aug. 31.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

Woolwich Council have appointed Messrs. G. Bartholomew and C. P. H. Bowmaker engineers-in-charge at £90, rising by annual increments of £10 to £140 per annum.

EDUCATIONAL NOTICES.

University of Manchester.—A prospectus giving particulars of the lecture and laboratory courses in physics, preparing for both the ordinary and honorary degrees of this university, will be forwarded on application to the Registrar. Prof. Rutherford will meet intending students on Oct. 5.

University of Birmingham.—The full course in engineering extends over four years and students who enter after matriculation, and who pass the examinations at the end of each year, will be entitled to the degree of B.Sc. in the branch of engineering to which they devote themselves. Some particulars of the instruction given in the technical engineering classes, engineering laboratory, &c., are given in an advertisement. The session, 1909-1910, commences on Oct. 4, and detailed syllabus with full particulars of University Regulations, lecture and laboratory courses, fees, &c., may be obtained from the Secretary.

King's College (University of London).—Two exhibitions of £25 each are offered for competition in the faculty of engineering in September. Applications to the Secretary, King's College, Strand, W.C.

University College, Nottingham.—The instruction in the engineering department of this college includes courses in mechanical and electrical engineering for the B.Sc. degree and mining diploma, and ordinary courses. The session begins Oct. 4. Prospectuses may be obtained from the Registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

Austria Hungary.—It is stated that a syndicate has been formed for the construction of an electric railway from Lienz to Winklern, at an estimated cost of 2,500,000 kronen (about £104,000).

Battersea (London).—Alterations are to be made to the switchboard at the generating station at a cost of £120, and £60 is to be spent in complying with the Home Office Regulations.

Brighton.—The question of the charge to be made for electric current by the electricity department to the tramways came before the Council yesterday.

The engineer and manager of the electricity works (Mr. John Christie), reporting on the matter, states that the present rate (1·5d. per unit) only yields the barest margin of profit. By reducing that charge to 1·4d. per unit that profit was being sacrificed, and to give a 10 per cent. reduction (reducing the cost to 1·35d. per unit) would undoubtedly result in their supplying energy at less than cost price. The suggested charge of 1·4d. per unit was the lowest price which they could afford to grant.

The Lighting committee has therefore decided to make no further reduction, but the Tramways committee claim that the price should be reduced to 1·35d. per unit.

Burslem.—The technical school at the Wedgwood Institute is to be wired.

Carlisle.—An inquiry was held on Tuesday into the application of the Corporation for permission to borrow £5,750 for extensions of the electricity undertaking.

Castleford.—The Wakefield & District Light Railway Co. have been asked by the Council to submit a scheme for the supply of electricity in this district.

Cuba.—The Brussels "Bulletin Commercial" states that concessions have been granted for establishing electricity works at Colon and Cienfuegos, "although the sanction of the municipalities has not been obtained."

Customs Duties.—It has recently been decided that electric batteries for use with surgical instruments are subject, under the New Zealand tariff, to import duty of 30 per cent. ad val. (British goods 20 per cent.).

The Italian Ministry of Finance has decided that mercury vapour electric lamps shall be assimilated, for Customs purposes, to arc lamps, dutiable at the rate of 60 lire per 100 kilogs (£1. 4s. per cwt.).

Edinburgh.—At the meeting of the Corporation on Tuesday it was reported that the Electric Light committee recommended (by 7 votes to 6) that the surplus on the electricity undertaking for the past year (£2,072) be applied in relief of rates.

Mr. Rawson moved the adoption of the report.

Mr. Arbuthnot Murray (Convener of the committee) moved disapproval of the report. Under the Act one of the purposes to which a surplus on the electric lighting accounts might be applied was relief of the rates, but at the present time there was no justification for such a course. The undertaking required working capital, and if that money were taken away they would have to borrow. Besides, the surplus was not an actual cash in hand surplus, it was only assumed; and another reason was that the Corporation itself had a surplus on its accounts, and did not need to take that £2,000.

Bailie Carmichael pointed out that the town had got out of the electric light undertaking up to the present time £41,000 in relief of rates. The committee needed the money to open shops, as the Gas commission had done, to popularise the use of the electric light among the ratepayers, &c.

It was agreed that consideration of the question should be delayed until November.

Fulham (London).—The Electricity committee report that the experiment in the Fulham Palace-road of substituting for arc lamps metallic filament lamps attached to the tramway poles is successful. 144 tramway poles are to be fitted, and 48 arc posts are to be dispensed with at a cost of £507. 5s., but the annual saving will be £259. 913 metallic filament lamps are to be put in the Town Hall at a cost of £208.

Holland.—H.M. Vice-Consul de Bryne states that the number of "caps for incandescent electric lighting" exported from Flushing to the United Kingdom in 1908 was 8,000,000, compared with 5,000,000 in 1907 and 6,000,000 in 1905.

Three steamers, each 2,700 tons, 22,000 H.P. and 22½ knots, are being built in a Glasgow yard for the Flushing-Queenboro' night mail service. These vessels will be fitted with wireless telegraph and submarine signalling apparatus, and for electric lighting, &c., three dynamos, each supplying a current of 750 amperes at 225 volts will be installed in each of the steamers.

The Austrian Consul at Amsterdam states that there are good openings for small electric motors, "as motors manufactured in Holland are not considered to be of very efficient workmanship."

Inquest.—At Manchester on Monday an inquest was held on a man named Davies, who was killed at the Stuart-street generating station on Thursday last.

It was stated that Davies and a man named Wall were moving two transformers from one end of the high-tension department to the other. Davies used a plank, and for some reason or other got inside the guard rail near the electrical apparatus. Suddenly there was a flash, and Wall saw his companion fall to the ground. Artificial respiration was tried, but without avail.

Wall told the coroner that Davies got inside the guard rail to remove each transformer.

The Coroner: Why did he do so when he knew it was dangerous? I can only suggest he did so because he thought it would be the easiest way to get his plank underneath the transformer for the purpose of prising it. It was possible for him to prise the other end of the transformer. Davies was a practical man, and it was left to him.

Mr. H. C. Lamb, acting resident engineer, said there was a protecting rail, and the men knew it was dangerous to get underneath it. No one was supposed to go inside that rail at any time.

The chief electrical engineer (Mr. S. L. Pearce) said there was no more modern system of electrical equipment or protection than that in Manchester.

Mr. Brocklehurst (for the Corporation): It has been suggested there might be a glass screen or perforated screen put in front of the spark gaps. What do you think of that?

Mr. Pearce said a flash would blow a glass screen. By putting a rail 3 ft. or 4 ft. away they had put reasonable and ample protection. The workmen did not pass to and from the high-tension department. It was in a special area set apart, in the words of the Home Office, for the location of high-tension apparatus. They had an instance some time ago of a porcelain guard being blown the whole length of the engine room. If there was to be any protection it should be mechanical.

The Coroner said Davies had neglected the instructions given and was carrying out his work in a dangerous manner.

A verdict of accidental death was returned.

Japan.—H.M. Vice-Consul Firth at Osaka reports that there has been active competition between British, American and German manufacturers in the supply of electrical machinery and apparatus in the Osaka district during 1908. Until recently an American firm had a practical monopoly, but latterly British and German firms have secured contracts. It is probable that large quantities of electrical machinery, &c., will be required during the next few years, but (Mr. Firth says) it is impossible for British manufacturers to secure contracts unless they have an experienced representative on the spot.

The streets of Osaka are very narrow, but great improvements are being effected by the widening necessitated by the construction of electric tramways. The second section of the municipal electric railways has been opened, making 9 miles in all, and work is being commenced on the third section (32 miles). Electric railway communication between Osaka and Kobe and Hawadera (a seaside resort 15 miles distant on the Nankai railway) has already been established, and it is now proposed to electrify the remainder of the Nankai railway to Wakayama, 40 miles from Osaka. Electric railways to Kyoto and Arima are under construction.

Of the 6,673 factories, mills and works of Osaka, 2,696 employ mechanical power, 472 being driven by electricity, 826 by steam, 345 by gas, 575 by oil and 478 by water turbines.

Land Transport Exhibit at Brussels.—There are good prospects of an effective display being made at the Brussels Exhibition of British exhibits connected with land transport.

Models at least will be shown by all the great railway companies, both of engines and of signalling apparatus, foreign lines having something still to learn from British railway engineers. There will also be a strong and, it is hoped, a comprehensive display of British-made motor cars. It is worth remembering that the industrial conditions of Belgium are in many ways so similar to our own that there is a good market for motor wagons and other heavy vehicles.

Leeds.—At the meeting of the Corporation on Wednesday Mr. R. A. Smithson stated, in reply to a question, that there were doubts as to whether it would be necessary to obtain further powers before commencing work on the projected trackless trolley route.

If the vehicles were considered as motor 'buses, only the licence of the local authority was needed. If, by reason of the overhead wires, they were considered tramways, the question arose whether the powers already possessed by the Corporation would be sufficient. The Town Clerk had come to the conclusion that the powers of tramway construction which the Corporation now possessed could not be made to apply to that particular route. The Board of Trade was to be consulted on the matter.

SPECIAL NOTICE.

NOW READY.—Vol. LXII. of "The Electrician" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "The Electrician" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

London County Council.—On Tuesday it was agreed to lend £3,169 to Woolwich for electric lighting.

Tramways. Re-construction.—The adjourned recommendations of the Highways committee to expend £18,920 on the reconstruction of the Highgate Hill cable tramways and £5,350 on the reconstruction of tramways in Woolwich were agreed to.

New Tramways. The adjourned report of the Highways committee was submitted recommending that legislative sanction be sought for the construction of 11 additional lengths of tramway.

Mr. Shirley Benn, chairman of the committee, said that the proposals were rather above the average. He believed the Council were anxious to perfect the system as soon as possible, as they realised that they were necessary and likely to be remunerative. The result of the working showed a small profit of 0·109d. per car-mile. The committee had provided in their estimates for workmen's cars, which, although a source of considerable expenditure to the Council, were a necessity. It cost the Council when they laid a double track paved with wood £7,000 per mile, and about 10 per cent. of that amount for depreciation and upkeep each year.

All the recommendations were carried.

Cables and Feeder Pillars.—On the recommendation of the same committee estimates of £43,000 and £1,530 were allowed for the purchase of cables and feeder pillars.

Choke Coils.—It was reported that in connection with the operation of motor generators in the tramway substations experiments had been made as regarded a number of generators during the last few months with the use of choke coils when the machines commence running, with the result that they have been found to be very beneficial in preventing breakdowns at the moment of switching on machines. It was agreed to fix choke coils on 25 additional generators at an estimated cost of £1,500.

Conduit Clearing Apparatus.—Experiments have recently been carried out with a view to facilitating the clearing of the conduits on the tramways, with the result that the Highways committee were advised that a considerable saving amounting to over £2,000 a year would be effected by the use of specially-constructed conduit clearing machines. An estimate for £300 for providing six of these machines was agreed to.

Harrow-road Tramways.—The Highways committee recommended that capital estimates of £54,750 and £2,800 be authorised for the construction and purchase of the authorised extension to Edgeware-road.—*Carried.*

London County Council Tramways.—The electric tramway from King's Cross to Park-street, Camden Town, was opened for traffic on Thursday last. The continuation of this line to Hampstead is being converted to electric traction.

The Aldgate-Bow tramway, which has been altered by Messrs. Dick, Kerr & Co. from the "G.B." surface contact to the conduit system, will be opened in a day or two.

The widening of Blackfriars bridge and the laying of the rails and conduit for the Council's tramways thereon are now rapidly approaching completion, and it is expected that the work will be finished and the cars running in September.

London Hippodrome.—This well-known house of entertainment has recently undergone extensive alterations. The arena has now been fitted with seats, but these latter are removable, when necessary, for the production of the typical spectacles associated with the Hippodrome, and the arena with its iron grille can then be used in conjunction with the new telescopic stage. One-point control (from the prompt corner of the stage) seems to have been made the feature, under the new regime, of the whole of the electric and hydraulic machinery in connection with the stage and grille, and also of the lighting of the house. This latter, together with the ventilation, has now been brought up to date, and metal filament lamps, usually with frosted tips, are everywhere employed, so that, with the white, cream and gold decorations and the delicate green upholstery, there is a general air of brightness, associated with artistic colour contrasts.

As mentioned above, the lighting is controlled from one corner of the stage, from which point also radiate electric signal and telephone wires and speaking tubes to all parts of the house, whilst the maximum security against failure of the electric supply is provided as usual, by two distinct electrical services. The ventilation is on the Plenum system, and for this purpose a 12 ft. by 6 ft. fan draws air into the building through an electrically-driven revolving screen. In fact, nothing seems to have been omitted which could in any way add to the comfort and pleasure of the audience, and there is little doubt that the re-opening of the Hippodrome on Monday next, Aug. 2, will be followed by a very successful season.

Obituary.—The death is announced of Ald. Geo. Ellis, J.P., of Southsea. Deceased has been associated with electricity supply for many years, and until recently was a director of the South London Electric Supply Corp.

P.O. Telegraphs and Telephones.—At the opening of the Hull post office on 22nd inst. the Postmaster General said, in regard to the request for a reduction in telephone rates to some of the Continental countries:

As soon as the new Channel cables had been laid they would be able to give substantial reductions in telephone rates to France and Belgium. He hoped they had observed the exchange for trunk work that had been erected in the new building at a cost of £7,000. That would materially help to improve the trunk connection with Hull, and would greatly improve their position. As for the reduction made in trunk calls, they would be glad to know that the step had been fully justified, as since the charges had been reduced at night for trunk telephone calls they had increased by fully 16 per cent. The demand for direct telephone communication between Hull and Belgium and Holland had been very carefully gone into; but the amount of traffic at present from Hull was not sufficient to justify the cost of the wire. As for underground wires, he wished to say that they were carried out as a capital expenditure. They had only each year a limited amount placed at their disposal for that particular purpose. At present they adopted the rule of taking the underground cables to places where the various submarine stations touched this country, because it was advisable and to the advantage of great commercial centres that those connections with the submarine telegraphs should be fully and properly protected.

Presentation.—On Monday last Mr. A. L. Weekes, general manager of the British Electric Calibrated Fuse Co., was presented with a pedestal writing desk by the staff and employés of the company on the occasion of his marriage to Miss Alys Linnell, of Rugby.

Preston.—The Council have decided not to entertain the proposal to purchase the undertaking of the National Electric Supply Co.

Railway Electrification.—At the meeting of the East London Railway Co., on Tuesday, Lord Claud Hamilton said that since 1903 their annual receipts had steadily decreased, and in comparing 1903 and 1908 the decrease was £14,480, partly owing to competition of tramways, omnibus and other traffic of that nature, but mainly due to the discontinuance of the through service over the Metropolitan and Metropolitan District Railways. He had on several occasions dealt with that subject, but until the opening of the South London section of the London, Brighton & South Coast Railway it was impossible for them to form any accurate opinion as to the comparative cost of the installation and working of the overhead and the third-rail systems. Until then, he was afraid, they could not move in the direction of electrification.

Salvador (Central America).—The municipality of San Miguel have authorised the supply of electricity by contractors.

Servia.—In an article in the Brussels "Bulletin Commercial" it is stated that there are good openings in Servia for electrical apparatus and material, and the establishment of a depot where such goods can be seen is recommended.

Smallthorne.—The Urban Council have asked Hanley and Burslem Corporation to submit terms for the supply of electricity in this district.

South Africa.—In a table of prices of necessaries at Lourenço Marques, in the report of H.M. Consul Maugham for 1908, electric light is included at 2s. 4d. per unit.

The British Vice-Consul at Beira (Mr. Keyser) says an installation of electric lighting plant has been undertaken by an Italian and a Frenchman in partnership, the plant and material having been purchased from Italy.

Acting Consular Agent R. Willeumier, at Quilimane, says the opening of the Eastern & South African Telegraph Co.'s cable station at Quilimane has greatly benefited commerce during 1908. Telegrams now reach their destination (continues the report), which was not always the case previously.

South African Power Schemes.—The Select committee appointed by the Transvaal Legislature to consider the Transvaal Electrical Energy Bill, promoted by the Victoria Falls & Transvaal Power Co., have made a report to the Legislature.

The committee state that they are of opinion that it is inexpedient that the bill be further proceeded with during the present session, and that they have, therefore, taken no evidence; but it is recommended that proceedings upon the bill be suspended until next year, in view of the fact that the Power Companies Commission recently appointed to consider certain questions affecting schemes such as that provided for in the bill have not yet issued their report.

Steam Tram Exit.—To Bacup (Lancs.) belonged until the other day the honour of possessing the last of the steam tramways in operation. This relic of bygone errors has now been abolished, and the electrification of the tramways at Bacup is completed.

Walthamstow.—The electrical engineer (Mr. G. R. Spurr) estimates the cost of the proposed extension of mains to Highams Park at £6,828. The Electricity committee has adjourned consideration of

this matter for two months, and have also adjourned consideration of the conversion of the whole of the street gas lamps to electric light. Mr. Spurr is to submit a detailed report on the latter question.

Westminster. The St. James's & Pall Mall Electric Light Co. propose to renew 18 lamps in Regent-street (between Oxford circus and the Quadrant) with duplex Excello flame arc lamps, fitted with dioptric inner globes, at a cost of £292. 10s.

The new lamps will consume 460 watts and give a mean hemispherical candle-power of about 1,600, with a maximum of about 2,400, and, subject to the company guaranteeing a minimum candle-power of 1,400, the Council will pay half the cost, provided the company's contract for public lighting, which expires on Nov. 10, 1910, is adhered to in all other respects.

Wireless Telegraphy. The report of the directors of the Great Eastern Railway Co. for the half-year ended June 30th states that all their passenger boats on the Hook of Holland and Antwerp services have now been equipped with wireless telegraphy and submarine signalling apparatus.

Workhouse Lighting.—At their last meeting Uxbridge Guardians considered communications from their medical officer, the Uxbridge & District Electric Supply Co. and the local gas company in regard to the lighting of the workhouse.

The medical officer recommended the adoption of electric lighting, and Mr. De Salis said there was no question that the electric lighting, if they generated their own current, would be cheaper than gas lighting, and he moved that steps be taken to provide an electric lighting installation. This was rejected by 7 votes to 4, but a committee was appointed to go into the whole question.

Annual Holidays.—The Lancashire Dynamo & Motor Co., Trafford Park, Manchester, notify that their works and offices will be closed from August 16 to 21 inclusive, for the annual holiday; a small staff will be in attendance to deal with urgent matters.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Carlisle.—The accounts of the electricity department for the year ended March show capital expenditure £64,196 (increase £917).

Revenue was £13,618, working and general expenses £6,767. After payment of income-tax and capital charges, the net profit was £2,222, of which £1,000 is being placed to reserve. 1,387,253 units were generated, 75,721 supplied to public lamps (compared with 80,046 in previous year), 446,452 (438,142) to private consumers for lighting and 243,918 (98,582) for power and 377,030 (400,317) for traction. Works costs were 0·70d. (against 1·09d.) and total costs 1·04d. (1·50d.) per unit sold.

The report of the city electrical engineer (Mr. S. T. Allen) states that 59 new consumers have been connected to the mains, with the equivalent of 8,177 8 c.p. lamps, 93 per cent. of this increase being for power. Motors with the aggregate of 238 H.P. have been connected during the year, the two-rate tariff, under which a supply can be taken for power in the daytime at 1d. per unit, being largely responsible for the increase. The supply for the tramways decreased by 23,317 units and the public lighting supply by 4,325 units. The maximum demand for light and power was 563 kw. and for traction 250 kw. A 300 kw. mixed pressure d.-c. turbo-generator with surface condensing plant and water treating plant, and a complete set of auto-stokers and superheaters are about to be put in at the station.

The report and accounts were adopted by the Council at their last meeting

Darwen.—The tramway accounts for the year ended March show capital expenditure £85,565.

Revenue was £13,549, working expenses £8,875, interest, sinking fund instalment and principal repaid off loan required £1,363 and depreciation £1,050, and, therefore, there was a deficiency of £936 on the year's working. 2,549,586 passengers were carried, 244,410 car-miles run and 412,806 units used—1·68 per car-mile. Total revenue was 13·3d. per car-mile, and working expenses (including power cost and depreciation) 9·74d. The depreciation funds amount to £3,250.

Dundee.—The accounts of the electricity department for the year ended April 30 show total capital expenditure £242,552.

Revenue was £36,975 (compared with £34,073 in previous year), total costs £24,928 (£25,232), gross profit £12,047 (£9,741); interest, expenses of loans and contribution to sinking fund amounted to £11,868 (£9,578), and the surplus (carried forward) £1,256 (£1,078). 5,988,161 units were generated, and 5,173,036 sold. The total maximum supply demand was 3,104 kw.

Exeter.—The total revenue of the electricity undertaking for the year ended March 31 was £18,486. 15s. 4d., including £10,270.13s.8d. net from the sale of current by meter, £2,485. 17s. 5d. from public lighting, £4,213. 9s. 4d. from traction, the balance being from meter rental, sale of lamps, &c.

The total expenses were £9,081. 1s. 9d., leaving a gross profit of £9,405. 13s. 9d. to meet interest (£3,048. 10s. 3d.), sinking fund charges (£4,035. 11s. 8d.) and income-tax (£251. 4s. 5d.), leaving a net profit of £2,070. 7s. 5d. The total capital expenditure is £107,208. 1s. 4d., an increase of £2,976. 1s. 11d. The units sold for private lighting were 508,725, public lighting 198,208, power 88,191, and tramways 575,104, a total of 1,370,228. The charges were 4½d. per unit for lighting, 2½d. to 1¾d. for power, and 1¾d. for traction. The maximum load on the station was 1,140 kw.

The total receipts of the tramways department were £15,873. 0s. 2d. and the expenses £10,913. 15s. 2d., leaving £5,042. 13s. 9d gross profit. Interest absorbed £2,576 6s. 8d., and, after paying income-tax, &c., the balance (£2,393. 10s. 1d.) was carried to appropriation account. The contribution to sinking fund was £1,586. 7s. 6d., and the net result was a deficit of £131. 7s. 10d., against £132. 5s. 5d. in 1908. 3,891,156 passengers were carried and 418,798 car-miles run.

Hammersmith (London).—For the year ended March 31 the gross profit on the electricity undertaking was £44,474, and after providing for interest, sinking fund, &c., the net profit was £4,904.

Kirkcaldy.—The accounts of the electricity department for the year ended May 15 show capital expenditure £65,639 (increase £391).

Revenue was £10,495 (against £10,118 in previous year), capital charges £3,359 (£3,653), surplus for the year £240 (£137). Coal cost ·467d. (·536d.) per unit sold, generating costs ·812d. (·847d.), works costs (including distribution) ·867d. (·888d.), total costs (exclusive of capital charges) 1·051d. (1·099d.). 1,572,856 (1,381,106) units were sold, the tramway taking 634,386 (679,069), public lighting 101,660 (100,378), private lighting 197,886 (206,314) and motive power 638,924 (395,345), the average price obtained being 1·595d. (1·752d.). There are 471 (422) consumers and the motors connected are 882 H.P. (786). The average price received for private lighting 4·163d. (against 3·943d.), the increased price per unit being due to the use of metallic filament lamps, and also to bad trade, both causes of reduced consumption, which resulted in the consumers not obtaining such large rebates. Sale of current for power purposes has increased by 61·6 per cent., and the B.H.P. of motors connected by 12·2 per cent. Load factor was 23·5 (19·5) and the maximum load 765 kw. (811 kw.).

The capital expenditure on the tramways department is £89,447. Revenue was £14,166 (against £14,994), working expenses £9,449 (£10,070), gross profit £4,717 (£4,924), capital charges £4,517 (£5,124), depreciation £409 (as in previous year), net deficit £210 (against net profit £23). In the year ended May, 1908, however, the amount provided for redemption of debt included £633 from rates, no amount being taken from rates for that purpose in the year ended May last. 431,892 (459,065) car-miles were run and 4,666,329 (4,874,199) passengers carried and 634,386 (679,069) units used. The average fare per passenger was 0·712d. (0·711d.). Revenue per car-mile was 7·871d. (7·838d.), and working expenses (including power cost) were 5·25d. (5·26d).

Maidstone.—The accounts of the electricity supply and tramway undertakings for the year ended March 31 were approved by the Council last week.

The accounts of the electric lighting undertaking showed an income of £13,307. 13s. 2d. and an expenditure of £7,363. 11s. 11d. After paying interest, income-tax and instalment in repayment of loans the net profit was £1,072. 18s. 3d. The total capital expenditure is £78,779. 6s. 10d., compared with £71,112. 0s. 11d. in 1908. The L.G. Board recently refused to sanction loans for certain items and these have been written off as against the profits, so that now the net surplus is £2,217. 8s. 5d

The revenue of the tramways department was £9,631. 11s. 7d. After paying expenses the gross profit was £1,792. 17s. 4d. Interest, sinking fund, &c., brought the net deficit to £2,454. 14s. 10d. Capital expenditure is £81,707. 11s. 4d., against £53,210. 1s. 1d. in 1908.

Salford.—The annual report of the general manager of the Corporation tramways (Mr. G. W. Holford) and the statement of accounts for the year ended March 31 have been issued.

The traffic receipts were £237,903. 5s. 10d. (9·869d. per car-mile) and the working expenses £154,966. 15s. 4d. (6·428d. per car-mile), and the gross profit was £83,011. 10s. 6d. Interest and redemption of loans absorbed £43,524. 19s., rent of lines £26,666. 7s. 8d., depreciation and renewals fund £263. 17s. 10d., and the net profit (£17,000) has been transferred to the borough fund.

Mr. Holford states in his report that the total length of tramways (75 miles) remains the same as in 1908, but only 36¾ miles are owned by the Corporation, the remainder being worked on lease or by arrangement with other local authorities. The car-mileage run was 5,716,897, and the average consumption of electrical energy was 1·62 units per car-mile. 24 additional double-deck covered cars were added to the stock during the year.

Southport.—The accounts of the electricity department for the year ended March shows capital expenditure of £3,777 during the year.

Revenue was £25,350, expenditure £10,296, gross profit £15,054, interest and sinking fund instalment £12,048. Of the surplus, £300 has been appropriated for arc lamp renewals, £100 to motor waggon account, £2,750 contributed in aid of rates and £42 carried forward. 1,403,181 units were sold to private consumers (compared with 1,317,181 in previous year). There are 131,667 (123,200) (equivalent) 8 c.p. lamps connected. 196 arc lamps for out-side shop lighting have

been hired out and 20 motors have been connected, making a total of 90 motors. Coal cost 0·04d. per unit more, and total costs were 0·02d. more than in the previous year. The load factor was 15·74 against 14·36.

Southwark (London).—The Borough Council's electricity department spent £2,725 on capital account during the past year, making a total of £94,027.

Revenue was £16,838 (compared with £14,929 in previous year), gross profit £5,940 (£5,254) and net profit £849 (£181). 1,703,703 (1,539,800) units were generated, and there were supplied to public lamps 298,£68 (350,960) and to private consumers 1,169,100 (1,050,885). The maximum supply demanded was 900 kw. (820 kw.).

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Committee of Management of the ENNISCORTHY district asylum invite tenders for lighting Kilcarberry House from existing plant, according to specification, which can be obtained from the Clerk, District Asylum, Enniscorthy, co. Wexford. Tenders must be lodged at the Asylum Office by 10 a.m. Wednesday, August 18. See also an advertisement.

Tenders are invited for supply of ten 100-number switchboards to the Postmaster General's Department, NEW SOUTH WALES. Tender forms, &c., at the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

Tenders are invited for the supply of telephone material to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

SHEFFIELD Education committee want tenders by Aug. 10 for heating and electric lighting of the Training College Hall of Residence for Men. Specifications, &c., from Messrs. Gibbs & Flockton, 15, St. James-row, Sheffield.

The Deputy Postmaster-General, SYDNEY, N.S.W., wants tenders by 2.30 p.m., Nov. 10, for supply and erection of a branching metallic multiple magneto switchboard at the Petersham telephone exchange. Specifications, &c., at 72, Victoria-street, London, S.W.

TENDERS RECEIVED AND ACCEPTED.

The following tenders were received by Stepney (London) Council for the supply of 300 yds. 1·0 sq. in. rubber covered and fire proof cable :—

Baxter & Gaunter (*accepted*), £270, W. Geipel & Co. £315, British Insulated & Helsby Cables £397. 1s., W. T. Henley's Telegraph Works Co. £402. 3s. 9d., W. T. Glover & Co. £414. 2s. 10d., Indiarubber, Gutta-percha & Telegraph Works Co. £419. 1s. 3d.

The tenders of W. Geipel & Co. at £30 5s 7d for 30 yards of 0·3 sq in. paper-insulated cable and at £20. 6s for 110 yds 0·05 sq. in. rubber-covered and fire-proof cable have also been accepted.

Middlesex County Council received the following tenders for the completion of the Harrow-road tramway :—

Wimpey & Co. (*accepted*) **£27,132**, Thomas Adams £28,397. 12s. 4d., Clift Ford £28,611. 6s. 1d., Herbert Holloway £27,439. 9s. 5d., Dick, Kerr & Co. £28,611. 6s. 1d., Geo. Law £28,860, J. Mowlem & Co. £29,852, Wm. Manders £33,104. 19s. 11d., Underwood Bros. £27,761. 5s. 5d., Charles Wall £27,280.

Bedford electricity department have placed an order with Ed. Bennis & Co. for a pair of "Bennis" 1909 model high duty smokeless and gritless coking stokers and self-cleaning compressed air furnaces for an 8 ft. Lancs. boiler.

London County Council are recommended to enter into contracts with W. T. Henley's Telegraph Works Co. and Reid Bros. for supply of cables and for laying cable ducts for the electrification of the Highgate Hill tramways, subject to a reduction of 1½ per cent. being allowed by the former company on the cable rates included in their existing contract.

Birmingham, Tame and Rea District Drainage Board have accepted the tender of Crompton & Co. for a motor and pump at the Saltley pumping station at £877, and that of the General Electric Co. for motors and pumps at the Minworth station at £423. 10s.

Greenock Corporation has placed the following contract: One 1,000 kw. turbo-alternator, one 700 kw. alternator, high-tension switchboard and two 450 kw. rotary convertors and sub-station switchboard with the British Westinghouse Co.

Hurst, Nelson & Co.'s tender has been accepted by London County Council for supply of a truck, steel underframe, &c., for a special car to be used on steep gradients at £247, and the same firm is to supply destination indicator boxes for tramcars at £799. 10s.

For Springsmire electricity works, Dudley, an order has been placed with Ed. Bennis & Co. for a pair of "Bennis" stokers and compressed air furnaces for a Babcock boiler.

Through Mountain & Gibson (Ltd.), Elton Fold Works, Bury, Lancs., the Llandudno & District Electric Tramway Co. have placed an order for seven Warner trucks.

Fulham (London) Council have placed an order with Higgins & Griffiths for special electric light fittings for the new central library at £57. 10s.

London County Council have accepted the tender of W. T. Henley's Telegraph Works Co. for supply of cables for Southwark-street tramways at £780.

Maidstone Corporation have accepted the tender of the Western Electric Co. for supply of feeder cable at £397. The Council have also placed an order for 200 Osram lamps at 2s. 10½d. each.

Rugby Urban Council have placed an order (through Tinkers, Ltd.) with Ed. Bennis & Co. for a "Bennis" coking stoker for a Cornish boiler.

Messrs. Cammell, Laird & Co. have secured a contract from London County Council for steel tyres for tramcar wheels at £2,473. 15s.

Ilford Education committee have accepted the tender of Edgar Porter for wiring the new Goodmayes schools at £333. 8s.

Rotherham Council have accepted the tender of Halley's Engineering Co. for a motor tower wagon at £685.

Southport Education committee have accepted the tender of R. A. Ault & Sons for electric bell fitting at the schools at £35.

Greenwich Guardians have accepted the tender of Medways Safety Lift & Elevator Co. for electric lifts for the infirmary at £425.

Northampton Council have placed an order with the Premier Accumulator Co. for repairs to the traction battery at £407.

BUSINESS NOTICES.

Mr. Jens Orten-Böving, hydraulic engineer, notifies that he has taken into partnership Mr. Douglas Spencer, who has been for some years his secretary and general business manager, and Mr. P. R. Cobb, who has recently joined him. The style of the firm will henceforth be Jens Orten-Böving & Co., and the address 9½, Union-court, Old Broad-street, London, E.C. Telegraphic address remains "Jenorten London," but the telephone number will be London Wall 6480.

Arthur C. Whitney and John H. Sutherland, electrical engineers, &c., 34, Slater-street, Liverpool, have dissolved partnership. Debts by Mr. Sutherland, who continues as the Seymour Motor Co.

Jas. S. Enright and Fredk. Thompson (trading as Enright & Thompson), engineers and commission agents, 68 and 68A, Lincoln's Inn

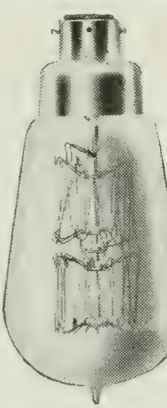
Fields, London, W.C., have dissolved partnership. Debts by Mr. Thompson, who continues.

Sale by Tender.—Messrs. Fuller, Horsey, Sons & Cassell have been instructed to offer for sale by tender in lots, the modern electric power plant at the works of the late Morris Aiming Tube and Ammunition Co. (Ltd.), Dagenham, Essex. Some particulars are given in an advertisement, and further information, with forms of tender, may be obtained from Messrs. Fuller, Horsey, Sons & Cassell, 11, Billiter-square, London, E.C., and tenders must be delivered at their offices by noon of Friday, Aug. 6.

Patent Development.—The owners of patent No. 23,501/1899, relating to "Improvements in vacuum tube lighting," and No. 12,582/1902, relating to "An improved system of electric lighting," wish to negotiate for the granting of licences. Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's-inn-fields, London, W.C.

The proprietor of patent No. 23,878/1900, for "Improvements in process of and mechanism for separation of conductors from non-conductors," is also desirous of entering into arrangements, by way of licence and otherwise, for exploiting same. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

New Type of "Tantalum" Lamp.—Messrs. Siemens Bros., Tyssen-street, Dalston, N.E., are placing on the market a new and exceptionally interesting high-voltage "tantalum" lamp for d.-c. which will give 25 c.p. at an efficiency of 1·7 watts for all voltages between 200 and 240. The general appearance is, as will be seen from the illustration, similar to that of the 32 c.p. high-voltage "tantalum" lamp, which is too well known to need comment. The new lamp, which is strong and durable, will be a great boon to contractors who have hitherto been faced with the problem of supplying private consumers with a comparatively low candle-power lamp which would burn direct on high-voltage supply. The demand for these lamps will be heavy. Messrs. Siemens Bros. are issuing a new leaflet (14B) dealing exclusively with this lamp, and will be pleased to overprint a supply for electrical contractors or ironmongers on receipt of trade card.



South Lancashire Tramways.—We have received a 36 page pamphlet containing an illustrated description, and a guide to places of interest on the various routes, of the extensive system of tramways controlled by the Lancashire United Tramways, Ltd. (which extends well over 30 miles, from Liverpool on the west to the Manchester, Salford and Bury Corporations' tramways on the east). The booklet, which is well got up, contains particulars of fares, times occupied en route, a sketch map of the lines and other useful information.

CATALOGUES, &c.

EDISWAN FITTINGS. The increasing use of electricity in collieries, mills and factories, as well as on board ship, has given rise to many varying types of fittings specially designed for use in such places. The range covered by this class of work is well illustrated in a leaflet just issued by the Edison & Swan Co. These fittings are well up to the high standard set by this firm and are eminently suitable for the work they have to do.

CASTINGS FOR ELECTRICAL WORK. In a catalogue issued by Mr. R. Clarke, 39, Featherstone-street, London, E.C., full details are given of the various castings which find an application in electrical work. These include manhole covers for sub-stations and roadway work which are airtight and watertight, but are also sufficiently ventilated, arc lamp-posts of various types and cast-iron pits for underground sub-stations. Sewer castings, manholes and other fittings in connection with draining tramways are also illustrated in this catalogue.

"STREET LIGHTING BY ELECTRICITY."—This is the title of a booklet issued by Mr. Haydn Harrison with the object of calling attention to the current types of street lighting fittings which he has been manufacturing during the last 12 months. The booklet opens with a number of illustrations showing these fittings in actual working order, while the remainder is devoted to prices and mechanical details of the various fittings, together with descriptions of Harrison's patent D.P. switch fuse, anti-vibration holders for metallic filament lamps and street photometer for testing work.

PHŒNIX BULLETIN. The Phœnix Dynamo Mfg. Co. have issued a "Phœnix Bulletin," illustrating the different types of machines made by them. These include continuous-current and three-phase generators, motors and motor-generators, while space is given to the application of Phœnix motors to driving industrial machinery.

ELECTROMAGNETIC SORTING MACHINERY. Messrs. Cookson & Co., 59-61, New Oxford-street, W.C., have supplied us with some particulars of their patent electromagnetic sorting machines for extracting and separating magnetic from non-magnetic materials. These machines are, we are informed, being used for this purpose in many engineering works, foundries, shipyards and mines. The standard size machine requires a pressure of 100 volts and takes about 4 amperes, thus costing only 4d. for a nine-hour day with energy for power at 1d. per unit.

FLEXIBLE STEEL-ARMOURED CONDUITS AND CABLES. The British Electrical & Mfg. Co. have issued two leaflets dealing with this subject. The cable illustrated and described, besides being specially suitable for use in fireproof buildings, has also been specially designed and constructed to withstand the severe conditions met with in such places as collieries, shipyards and engineering shops, as well as on the quay side and on ships.

MEASURING INSTRUMENTS.—Continuous-current measuring instruments of moving-coil type is the subject of a catalogue issued by Messrs. E. F. Moy.

MINIATURE POSTERS.—Owing to the exceptionally large demand for Messrs. Siemens Bros.' "Satisfied Consumer" adhesive labels, a fresh supply has been obtained. These labels, which are becoming known to the trade as "Stickybacks," are supplied free of charge to electrical contractors, and are suitable for attaching to correspondence, packages, &c.

CALCULATORS.—The Key Engineering Co. send a handy calculator by means of which the return on extra capital outlay may be readily determined when the introduction of gas-driven plant is under consideration. Full instructions are given with this calculator, and it should prove very useful to those interested in these matters.

BANKRUPTCIES, LIQUIDATIONS, &c.

Mr. E. W. C. Whittaker, 3, Portland-street, Southampton, has been appointed trustee in the bankruptcy of W. T. Harris (trading as W. T. Harris & Sons), electrical engineers, 460-464, Commercial-street, Portsmouth.

Claims against the Santoni Arc Lamp & Eng. Co. (Ltd.) (in vol. liq.) by Aug. 20 to Mr. W. Macl. Whyte, 11, Queen Victoria-street, London, E.C., or to Mr. G. E. Corfield, Balfour House, London, E.C.

A first and final dividend of 3s. 1d. is payable at 144, Commercial-street, Newport, Mon., to the creditors of Geo. Sutcliffe, electrical engineer, 22, Church-street, Abertillery.

A first dividend of 2s. is payable on July 31 at Mr. J. H. Haley's, 29, Tyrrel-street, Bradford, to the creditors of Arnold Roberts (trading as Roberts Bros.), electrical engineer, 21, North-parade, Bradford, and Woodlands Cottage, Rawdon.

A meeting will be held at Messrs. Dickinson, Miller & Turnbull's, 46, Grainger-street West, Newcastle-on-Tyne, on Aug. 5 to receive an account of the winding up of the Eldon Electric Co. (Ltd.) (in vol. liq.)

BOOKS RECEIVED.

Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Through the Sun in an Airship." By John Mastin. (London: Charles Griffin & Co.) 6s.

"Electricity for Everybody." By R. Borlase Matthews. (London: The Electrical Press.) 5s. net.

"Metric Tables." By Sir Guilford L. Molesworth. 4th Edition. (London: E. & F. N. Spon.) 2s. net.

"Making Wireless Outfits." By Newton Harrison. 1st Edition (London: E. & F. N. Spon.) 1s. 6d. net.

"Circuits and Diagrams." By Norman H. Schneider. Part II. 1st Edition. (London: E. & F. N. Spon.) 1s. 6d. net.

"Arbeiten aus dem Elektrotechnischen Institut der Grossherzoglichen Technischen Hochschule Fridericiana zu Karlsruhe 1908-1909." Edited by Dr.-Ing. E. Arnold. (Berlin: Julius Springer.) M.10.

"Leçons D'Electrotechnique Générale." By P. Janet. 3rd Edition. Vol. I. "Généralités.—Courants Continus." (Paris: Gauthier-Villars.) Fr.13.

"La Théorie des Courants Alternatifs." By Alexandre Russell. Translated from the English by G. Séligmann-Lui. Vol. I. (Paris: Gauthier-Villars.) Fr.15.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.

June 12, 1909.

13,827 Bastian. Transformation of electrical energy into heat energy.
13,831 Abraham & British Pneumatic Railway Signal Co. Electric relays for railway signalling and other apparatus.
13,834 Tubbs. Magazine arc lamps.
13,842 Ridings. Arc lamps.

June 14, 1909.

13,887 Williams. Enumeration of telephone calls.
13,8[illegible] D[illegible]ey. (Société L'Oleo, France.) Sparking plugs for internal-combustion engines.*
13,897 Abraham & British Pneumatic Railway Signal Co. Electrical relays.
13,919 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*
13,922 Steinacker & P[illegible]. Microphones for currents of high intensity. (Date applied for, 16/1/09.)*†
13,961 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.
13,962 B.T.-H. Co. & Gray. Electric meters. (Date applied for, 29/5/09. Comprised in application No. 12,689/09.)

June 15, 1909.

13,989 Milch. Manufacture of electric incandescent lamps.
14,019 Pinkus. Electrical motors and the like.
14,022 Parsons & Wood. Vapour lamps.
14,052 Mehne. Electric time switches.*
14,062 Backman. Metal boxes for switches and wall plugs.*

June 16, 1909.

14,097 Zealander & Conway. Electrical switches.
14,117 Grant. Electric contact breakers.
14,126 Lake. (Fabrik Elektrischer Zünder G.m.b.H., Germany.) Magneto-electric apparatus for firing electric igniters.*
14,128 Boult. (Voigt & Haeffner Akt.-Ges., Germany.) Arc lamps.*
14,153 Troike. Magneto-electric machines.*
14,165 Millauro. Arc lamps.*

June 17, 1909.

14,209 Pickford. Telephonic transmitters and the like.
14,212 Taylor. Charging and discharging secondary batteries or electric accumulators on three-wire systems.
14,230 de la Rue. Secondary batteries.
14,239 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*
14,240 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Signalling apparatus operated from a distance.*
14,244 May. Telephone system.*

June 18, 1909.

14,288 Schott & Stiftung. Electrolytic apparatus having a liquid anode. (Date applied for, 26/6/08.)*†
14,352 Georgi & Reyrolle & Co. Fault protection of cables in electrical current distribution system.

June 19, 1909.

14,363 Davis. Direct-working telephones for intercommunication purposes.
14,391 Garty. Dynamos or electrical motors.*
14,398 Berry & Markham. Electric switches and switch-fuses.
14,431 Schulze. Preventing the pulsation of electric currents generated by small dynamos and rotary converters.*

June 21, 1909.

14,450 Taylor. Balancing three-wire systems.
14,456 Taylor. Auto-transformers for use on alternating-current circuits.
14,457 Kingsbury. (Western Electric Co., U.S.) Telephone exchange electric selecting systems. (Date applied for, 15/8/08. Comprised in No. 17,209, dated 15/8/08.)
14,505 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke G.m.b.H., Germany.) Arc lamps.*
14,548 Childs & Hill. Electric ovens.

June 22, 1909.

14,579 Lamme. Controllers for polyphase alternating-current induction motors. (Date applied for, 6/7/08.)*†
14,582 Clarkson. Bonding and electrical continuity device.
14,622 Siemens-Schuckertwerke G.m.b.H. Non-interchangeable safety fuses for electrical circuits. (Date applied for, 23/6/08.)*†
14,623 Stockall. Controlling a plurality of independent electric circuits.
14,655 Wolfram Lampen Akt.-Ges. & Goll. Carbonising metallic glow-lamp filaments manufactured with organic binding agents. (Date applied for, 15/2/09.)*†
14,660 Thum. Electrolytic apparatus.*

June 23, 1909.

14,674 Weaver. Controlling electric arc lamp carbons.
14,675 Lear. Suspending or supporting of electric incandescent lamps and raising and lowering same.
14,685 Vickery. Electromechanical apparatus for the transmission, reception and indication of preconcerted signals.
14,731 Stewart & Foss. Speed control and braking apparatus for electrically-propelled vehicles.
14,732 Stewart & Foss. Mounting or supporting of electric motors on electrically propelled vehicles.
14,762 Farjas. Radio-active products possessing permanent activity. (Date applied for, 14/4/09.)*†
14,763 Lamkin & Nunwick. Electric filament lamps and the like.
14,483 Marietti. [illegible] (Date applied for, 8/7/07.)
14,513 T[illegible] & V[illegible] [illegible]
14,700 B.T.-H. Co. & Garton. Regulation of electric motors.
14,773 [illegible]
15,341 Graham. Electric insulator.
15,385 Van Ra[illegible] & C[illegible] & M[illegible] [illegible]
15,522 Taylor. Transformation of electric currents.
15,792 B.T.-H. Co. (G.E. Co., U.S.) Electrolytes for electrolytic cells.
15,936 Davy. Electric switches.
16,126 Garside. Starting switches for electric motors.
16,298 B.T.-H. Co. (G.E. Co., U.S.) Electromagnetically operated switches.
16,299 B.T.-H. Co. (G.E. Co., U.S.) Electric voltage regulators.
16,529 Bimeler. Storage batteries.
17,112 Munro & Rogers. Controlling the movements of points or switches on tramways or railways.
17,143 Tyer & D[illegible]. E[illegible]
17,161 Ashin[illegible] C[illegible] & M[illegible] [illegible] electric circuits or motors.
17,912 Payne. Sparking plugs for internal-combustion engines.
18,628 Low. Electric ignition appliances.
18,925 Cox. Adjusting electrical resistances.
19,992 Akt.-Ges. Brown, Boveri & Cie. Regulating direct-current and alternating-current machines. (Date applied for, 24/8/08.)
20,633 Bevis & Penicud. Electrical recording instruments. (Post dated, 12/2/09.)
20,708 Koe. Electric switches.
21,585 Lux. Measuring instruments for alternating currents. (Rights under sec. 91, Patents, &c., Act, 1907, not granted.)
21,936 and 21,938 Midgley & Vandervell. Direct-current dynamo-electric machinery.
23,070 B.T.-H. Co. & Pollock. Supply and regulation of electric energy employed in operation of arc lamps used in searchlights and like apparatus. (Addition to No. 4,379/05.)
23,489 Snook. High potential rectifying switch. (Date applied for, 20/7/07. Originally included in No. 13,854/08.)
23,626 Denny & Irving. Combined reciprocating turbine engine installations.
23,726 B.T.-H. Co. & Needham. Filaments for incandescent electric lamps.
24,211 Soc. Francaise d'Incandescence par le Gaz (Systeme Auer.) Incandescent electric lamps (Date applied for, 12/11/07. Addition to No. 12,720/08.)
25,537 Allmanna Svenska Elektriska Aktiebolaget. Starting and regulating compensated electric repulsion motors. (Date applied for, 27/11/07.)
26,796 Stratton & Claremont. Mechanical connectors for electric cables.
27,343 Siemens-Schuckertwerke Ges. Alternating-current meters. (Date applied for, 17/12/07.)
27,436 Blackall & Ja[illegible] [illegible]
27,470 Smith & Granville. Inductance coils for telephone cables and the like. (Cognate application, 4,376/09.)
28,189 Alexanderson. Single-phase alternating-current electric motors of the commutator type. (Date applied for, 26/12/07.)
28,271 H. Aron Elektricitats Zahlerfabrik Ges. Single-phase alternating-current meters. (Date applied for, 9/10/08.)
28,378 Eisenstein. Wireless telegraphy.
28,438 Johannet. Transmitting power at a reduced and variable speed by means of dynamo-electric generators and motors. (Date applied for, 3/2/08.)

SPECIFICATIONS PUBLISHED.

1908 Specifications.

4,666 Winn. Electric meters. (Post-dated, 2/9/08.)
9,900 Richmond. Electric batteries. (Post-dated, 9/11/08.)
10,611 Fynn. Alternate-current motors.
12,736 Heldbek. Suspending electric incandescent lamps.
12,738 Midgley & Vandervell. Electromagnetic power velocity ratio devices.
13,048 Newbould. Cut-out device for electrical conductors.
13,092 Akt.-Ges. Brown, Boveri & Cie. Transformers. (Date applied for, 28/6/07.)
13,185 Sunderland & Pillinger. Switches applicable for use with electric transformers.
13,327 Venner, Griesbach & Morris. Electromagnetic switch.
13,504 Lancashire Dynamo & Motor Co. & McLeod. Rotors of dynamo-electric machines.
13,520 Hartenheim. Control of electric motors.
13,734 Cornaro. Electrodes and resistances for electric furnaces, radiators, lamps and the like. (Date applied for, 27/6/07.)
13,781 Baldwin. Magnetic brakes for railway and tramway vehicles.
13,788 B.T.-H. Co. & Martin. Electric meters.
13,957 Ritchie. Regulating device for electric circuits.
14,192 Bousfield. (Holmes.) Rotary motors.

1909 Specifications.

78 Dey. Controlling electric motors.
319 Rogers & Brecknell, Munro & Rogers. Electric signals for tramways, railways and the like.
335 Rapid Magnetting Machine Co., Thompson & Davies. Magnetic separating machines. (Date applied for, 14/7/08.)
580 Siemens-Schuckertwerke Ges. Electrical resistance coils of covered wire. (Date applied for, 9/1/08.)
590 Marchal. Continuous-current dynamo-electric machines. (Date applied for under Rule 13, 14/8/08.)
1,345 B.T.-H. Co. (G.E. Co., U.S.) Aluminium electrolytic cells. (Date applied for, 4/9/08.)
1,679 Siemens Bros. Dynamo Works & K[illegible]. Cooling [illegible] machines.
3,028 Cutler & Barnett. Electric liquid heater.
3,599 Grunwald. Electrical induction furnaces. (Date applied for, 7/5/08.)
3,759 Bosch. Lubricating the interrupter cams of magneto-ignition apparatus. (Date applied for, 31/10/08.)
3,831 Storer. Armature windings for dynamo-electric machines. (Date applied for, 2/3/08.)
3,849 Craig & Acer. Dynamometer. (Addition to No. 24,790/07.)
3,951 B.T.-H. Co. (G.E. Co., U.S.) Incandescent electric lamp filaments and apparatus.
4,026 and 4,027 Schiessler. Wireless telephony. (Date applied for, 30/3/08.)
4,028 Schiessler. Electric condensers. (Date applied for, 30/3/08.)

COMPANIES' MEETINGS AND REPORTS.

Direct United States Cable Co. (Ltd.)

The sixty-fourth ordinary general meeting was held on Tuesday, Mr. E. M. Underdown, K.C., presiding.

The GENERAL MANAGER AND SECRETARY (Mr. T. Finnis) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: The revenue for the six months to June 30, after deducting out payments, amounted in round figures to £56,445, the working and other expenses, including income tax, but exclusive of cost of maintenance of cables, absorbed £25,036, leaving a balance of £31,409 as net profit, making with £4,506 brought forward from the previous half year, a total of £35,915. This has been appropriated as follows: An interim dividend of 4s. per share to March 31 required £12,142, a proposed final dividend of 4s. per share and a bonus of 1s. per share to June 30 requires £15,177. We transfer to reserve fund £5,000 and carry forward the balance of £3,596, which, together make up the before mentioned total of £35,915. A considerable period of trade depression has, we hope, now passed over, and the cable business shows signs of revival, with the result that our revenue exhibits an improvement of £5,077 during the past half-year as compared with the corresponding half of 1908. The working expenses in London and at the stations show but slight variation as compared with those of the corresponding period of 1908. The remaining expenses and other payments which appear on the revenue account show a decrease of £68. The reserve fund has been credited with £9,733 from interest on the investments, £1,501 from profit on the

sale of securities and with £5,000 transferred from revenue, and having on the other hand been debited with £13,857, for cost of maintenance of the cables, the balance of the account now amounts to £510,267. The investments stand in the balance-sheet at £493,004, after allowing for the provision of £40,000 made two years ago on account of market depreciation. It is satisfactory to note that their present market value is between £9,000 and £10,000 in excess of the reduced figure at which they stand in the accounts. There is improvement in the reserve fund to that extent. With regard to the reserve fund, I have often called your attention to the advantage of the form that we have adopted in meeting repairs and maintenance out of the interest on the reserve fund. Although on this occasion we had some heavy repairs the reserve fund, with the operations that we suggest, remains fully adequate to meet our requirements, and, in fact, the situation is improved. So much for the reserve fund. I will now give you a summary of the results of working during the whole financial year. The receipts of revenue have been £112,780, less expenditure £50,393, leaving a balance of £62,387. We have paid in dividends £51,603, and placed £10,000 to reserve, making £61,603. Adding the increased balance in hand as compared with June, 1908, amounting to £784, the total is as above £62,387. The reserve account has been increased on balance during the year by £5,071. There was transferred from revenue £10,000, interest on investments £18,882, and profit on sale of securities, £1,595. That makes £30,477. We deduct the cost of maintenance of the cables £24,901, and the installation of gas at Ballinskelligs, our station on the coast of Ireland, £505. Making the deduction of £25,406 from £30,477, we have an increased balance of £5,071. I have mentioned the reserve fund, and you have probably heard criticism upon the cost of messages to the public. It is just as well to remember that the rate per word is now according to the net results of the Atlantic cable companies—so extensive is the use of codes by means of which one word is made to express many words and sentences—is such that the actual cost to the public is even below the word rate suggested by those who have no practical knowledge of distant telegraphy. To return to cost of maintenance, an expert who was good enough to express his approval of the state of our cable, which, I may say, in passing, is now in good working condition, said that the different renewals that we have made arising out of the repairs being required to the cable have resulted in our placing a very considerable length of new cable at the bottom of the sea, and thereby increasing the general value of the cable and its strength. So, we are not simply maintaining but we are actually improving our cable which has already been in existence, as you know, for so long a time. Our relations with the allied companies are excellent. The Government has, I think, met us in several points with regard to our continuance of our business and our licences. Altogether, I think I may congratulate the shareholders upon the position of the undertaking. Before I conclude I should like to speak of our staff. For instance, there is our staff in our stations on the other side of the Atlantic, the staff on the West of Ireland, and the staff in our various stations in this country. Our staff have discharged their duty in a way that deserves the commendation of the proprietors as it has obtained that of the Board. I now move the adoption of the report and accounts.

Sir JAMES PENDER seconded the resolution, which was carried unanimously.

Sir James Pender, Bart., and Mr. C. E. Gunther, the retiring directors, and the retiring auditors were then re-elected, and a cordial vote of thanks to the chairman, directors and staff terminated the proceedings.

Telegraph Construction & Maintenance Co. (Ltd.)

The half-yearly general meeting was held on Tuesday, Sir JAMES PENDER, Bart., presiding.

The SECRETARY (Mr. C. W. Clarke) read the notice convening the meeting.

The CHAIRMAN then said: Since our meeting in March last we have received with sincere regret the resignation of our chairman, Mr. William Shuter, whose continued ill-health and advanced age compel us to accept this resignation, and so terminate his long and valued service to the company, which I am sure will be equally felt by the shareholders. (Hear, hear.) Mr. Willoughby Smith, who has been for some years known to you as manager of our gutta percha works, has been elected to a seat on the board, and will act as joint managing director with Mr. F. R. Lucas in place of Mr. Shuter. The question of chairmanship is still under the consideration of the board. Our works continue to be actively employed, and our ships are at sea. The "Colonia" is laying a new cable and picking up an old one, and the "Cambria" is away repairing a broken cable, both ships being on the other side of the Atlantic. We have fitted them this last six months with Marconi wireless apparatus, because, although when laying a cable our ships are in communication with the shore, there are times when repairs are being made that we should be glad to speak to the shore, and the installation we have made will enable us to do so. Our new ship, the "Telconia," of which an account appears in THE ELECTRICIAN for July 16, has been visited by a number of men experienced in the work which it is designed to do, and the completeness of her arrangements has been generally appreciated. This year we have made and laid a heavier type of cable than we have ever had to deal with before. This cable weighs 62½ tons to the mile, and is designed to resist the crushing strain of icebergs grounding on the coast of Newfoundland. At this meeting we present no report and accounts, but we meet to give the shareholders an opportunity of asking any questions they may think desirable.

Mr. H. H. CROFT: I am sure the shareholders, both present and absent, will have heard with regret the announcement of the retirement of Mr. William Shuter. I do not think there is anything the shareholders can do to give expression to their feelings except by a unanimous vote of regret at Mr. Shuter's retirement. I feel certain we all concur in that expression of opinion. (Hear, hear.) The appointment of Mr. Willoughby Smith to be a director of the company is very satisfactory. That gentleman has been associated for a great number of years with the company. Speaking for myself, I should very much like to see a prominent officer of the Navy again associated with the Telegraph Construction & Maintenance Co.

The chairman invited Mr. F. R. Lucas to reply.

Mr. LUCAS said: I am sure we all concur in the expressions which Mr. Croft has used in reference to the retirement of Mr. Shuter. With regard to the appointment of a naval officer as a director of the company, the board appreciate with Mr. Croft the importance of this question. The point, however, is not before us to-day. With regard to the contract for the new deep sea cable which has been mentioned, we usually refrain from giving details of these contracts. These matters are not always our secret to make public, and those for whom we do the work would probably resent our making public such particulars.

There being no further business, Mr. CROFT proposed a hearty vote of thanks to the chairman, directors and staff of the company, which was seconded by Mr. G. J. ROW, and carried unanimously.

The CHAIRMAN having briefly replied, the proceedings terminated.

City & South London Railway Co. (Ltd.)

The fiftieth ordinary general meeting was held on Tuesday. The Right Hon. C. B. STUART-WORTLEY, K.C., M.P., presided.

The SECRETARY (Mr. W. F. Knight) read the notice convening the meeting.

The CHAIRMAN said: We are glad to meet you in more encouraging circumstances, and to be able to claim that we were right when six months ago we said that the comparatively unfavourable results of the half-year then ended were due to temporary and abnormal causes. We have a net increase of £1,062 in gross receipts, and a net decrease of £989 in expenses; an increase of £2,051, and on adjustments an increase in the balance available for dividend of £1,662. We have £269 more to pay now than we had last year in dividends on preference stocks; so that there is a final resulting improvement of £1,393 in the sum available for the ordinary shareholders. By carrying forward only £457 less than we did this time last year, we are able to find the £1,850 necessary to provide the extra ¼ per cent. which the ordinary shareholder so well deserves, and which we recommend that he should receive. This result, though not brilliant, is at least satisfactory. The half-year shows larger gross receipts and a larger number of passengers carried than any previous half-year in our history, and the percentage of working expenses shows a gratifying decrease (as between the June half-years of 1908 and 1909) from 46·28 per cent. to 44·63 per cent. We have kept our service going with 92,673 trains, against 94,636. The number of passengers carried per train has been 121·15 against 115·09, the receipts per train have been 18s. 3·64d. against 17s. 9·04d., and per train-mile 2s. 5·93d., against 2s. 5·03d. The only receipt which shows a decrease is per passenger, which have gone down from 1·75d. to 1·72d. This shows that the average distance travelled has been shorter. On the other hand all the expense ratios show decreases: 1s. 2·11d. total expenses per train-mile, against 1s. 2·16d.; loco expenses per train-mile 4·52d., against 4·68d., and traffic charges 6·13d. per train-mile, against 6·27d. The accounts show an increased amount paid during the half-year in local rates, and the general manager is endeavouring to get valuations reconsidered in our favour. Competition with London County Council tramways and the motor omnibuses continues to be so severe that the question has arisen whether there should not be some revision, in favour of our passengers, of certain fares and season ticket rates. This is under consideration. We have specially to note the decrease of receipts on Sunday. The competition of the London County Council tramways and the diminished receipts on Sundays are perhaps more closely connected than might be supposed, and we cannot with justice to our shareholders, continue to allow those who, on other days are our own passengers and patrons, to be taught and encouraged to use other systems than our own. We propose, therefore, to defend ourselves against this particular competition by modifications of our Sunday time-table, which we hope will shorten the actual hours of Sunday duty worked by individual members of our staff, yet will preserve to the great majority of them the alternate Sunday off which they now enjoy. The report speaks of the projected high-level subway to connect our station at the Bank with the stations of the Central London and Waterloo & City lines. I enlarged fully on this matter six months ago. I am glad to say Parliamentary sanction to this scheme may be regarded as practically assured. I now move the adoption of the report and accounts.

Mr. C. SEYMOUR GRENFELL seconded.

Mr. EMANUEL LEVY approved the proposed Sunday alterations, and suggested a profit-sharing scheme, so as to give all the employés of the company, including the secretary and manager, a share in the profits. He proposed that 5 per cent. should be deducted from the ordinary shareholder's dividend each half-year and divided among all employés who have been over six months in the company's employ—such dividend to be divided among them in the proportion of the salaries or wages they receive.

Mr. J. WHITE referred to the heavy additional expense of the proposed high-level subway at the Bank.

Mr. PORTER mentioned the continual decrease in season ticket traffic, and suggested the issue, in conjunction with the other tube railways, season tickets to commercial travellers solely who travel chiefly in the middle of the day. He thought they were not quite fairly treated by some of the allied lines. If a passenger asked for a ticket from Finsbury Park to Euston they were given one that, instead of your changing at King's Cross, sent you round Russell square, Holborn, Covent Garden Leicester-square, Tottenham Court road, Warren-street and Euston. That ought to be stopped in the interests of all the lines. In every case it should be the shortest route ticket issued.

The CHAIRMAN, in reply, said: In regard to profit-sharing, there is no scheme which has been oftener proposed for all railway companies and not to this one alone. The principal difficulty is that the amount to be distributed would be so extremely minute. I think everyone would be in favour of a profit-sharing scheme, but in the case of railways no one has ever succeeded yet in framing a practical scheme. I am sorry Mr. White disapproves of our new subway because, practically six months ago, the proprietors agreed to it. Mr. Porter recommends through season tickets for commercial travellers. The difficulty is that the other tube railways do not issue season tickets at all at present. The difficulty of getting all passengers sent by the shortest route is one which the Directors are constantly keeping in mind. The resolution was then carried with one dissentient.

A resolution approving the dividends was then carried, and a vote of thanks to the Chairman, the general manager, the secretary, officers and staff, brought the proceedings to a close.

AFRICAN TRANSCONTINENTAL TELEGRAPH CO. (LTD.)—At the meeting on Monday Mr. R. Maguire said that the line was being maintained in good working order. During the past six years the deficit on working had been each year lessened, due to saving in expenses and not to an increase of revenue. The whole position of the company was engaging the attention of the board, as the circumstances of cable companies had entirely altered since Mr. Rhodes initiated the Cape to Cairo telegraph 17 years ago. With a view to lessening the deficit on working, the board had increased by 50 per cent. the charge for code and cypher messages, but the rate for plain language messages had not been altered. It was hoped that an appreciable increase of revenue would take place from the higher charge, but the difficulties of a cable company in a country with a comparatively small population were very great.

The directors' report for the year ended March 31 stated that the northern terminus of the line was still at Udjidji, on the east coast of Lake Tanganyika, no arrangements having yet been found possible for the provision of funds for its further construction northwards. The whole position was engaging the serious attention of the board. The gaps in the British East Africa Administration's telegraph had been further reduced within the year, and the distance to be covered before Cape Town and Cairo were joined by an unbroken line of telegraph had now been reduced to about 520 miles. The annual working expenditure of the line wss not yet balanced by the revenue, and the deficiency continued to be advanced by the British South Africa Co. The deficit on the working of the line for the past year showed a considerable decrease compared with that of the previous year, and there would be a further decrease in 1908-9. It has been decided to raise the tariff rates for code and cypher messages by 50 per cent.—from 3d. a word to 4½d. a word. That had been rendered necessary by the general adoption of the five letter combination codes.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The total receipts from Jan. 1 to June 30 last, including £1,565. 9s. 1d. brought forward, amounted to £211,759. 15s. 4d. Traffic receipts show an increase of £14,503 compared with the corresponding half-year of 1908. Working expenses amounted to £72,345. 9s. 3d., a decrease of £950. 8s. 10d. The directors have, before declaring the net profits, set apart £10,000 to the renewal fund, leaving £129,414. 6s. 1d. Quarterly interim dividends of 15s. per cent. on the ordinary stock and £1. 10s. per cent. on the preferred stock were paid on May 1 (absorbing £52,500), and second quarterly interim dividends of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred stock (amounting to £52,500) will be paid on July 31. The balance of £24,414. 6s. 1d. is carried forward.

BRITISH EMPIRE TRUST CO. (LTD.).—The chairman (Mr. R. M. Horne-Payne) stated at the meeting of the company on Tuesday that the companies with which they were connected were all prospering exceedingly. The British Columbia Electric Railway pursued its wonderful course of progress, and every indication went to show that the progress of the next ten years would be even greater than that of the past decade. He could apply the same words to the Shawinigan Water and Power, to the Toronto and to the Winnipeg, and to the Sao Paulo Electric Railway Companies. The Monterrey Railway, Light and Power Co. was a new undertaking, which they were confident would repeat the history of the other similar undertakings with which they were associated.

BULUWAYO WATERWORKS CO. (LTD).—At the meeting last week the chairman (Col. the Right Hon. A. R. M. Lockwood, M.P.) stated that the improvement in the years accounts was partly due to decreased working costs, resulting from the installation of new machinery and other economies, and partly from an increase in the number of consumers for both water and electric light. During the year £4,588 was spent on capital account, principally in connection with the erection of a new engine and dynamo, which were working very satisfactorily and showed a considerable reduction of working costs compared with the old plant. The number of consumers had been steadily increasing, but it was probable that, owing to the growing use of metallic filament lamps, the electric light revenue might temporaily show some reduction. Since the last meeting they had had to submit to arbitration the question of the instalment of osram lamps for street lighting and they had lately received information that at the beginning of next year they would be compelled to instal osram lamps.

CENTRAL LONDON RAILWAY CO.—During the half-year ended June 30 the capital expended was £4,571. 18s. 4d. Compared with the corresponding period in 1908, there has been a decrease of £19,646. [illegible] in revenue receipts and of £258. 14s. 5d. in working expenses. The balance carried to net revenue is £64,139. 10s. 1d. After providing for debenture interest and other payments, the balance is £84,093. 6s. 2d. The directors recommend a dividend on the undivided ordinary stock at the rate of 3 per cent. per annum and on the preferred ordinary stock at the rate of 4 per cent. per annum for the half-year. Dividend on the deferred ordinary stock not being payable until the result of the working of the whole year is ascertained, the balance (£44,750. 14s. 2d.) is carried forward. The number of passengers carried during the half-year was 18,989,109, against 19,901,750 in the corresponding half of 1908 and 21,996,623 in the December half-year, 1908. The experience of the increased fares has been too brief to permit of the expression of a decided opinion on the experiment. Passengers exchanged with other Companies' lines increased by 1,067,706, indicating the value of the through booking arrangements.

CROMPTON & CO. (LTD.)—At the meeting, on Monday, the chairman (Mr. John Trotter), said that there could be no doubt that the result of the past year's working would be regarded as disappointing, but the shareholders would have probably anticipated that result as inevitable, in view of the trade depression. He felt that the depression of trade was caused by over expenditure, much of it of an unproductive kind on the part of individuals, municipalities and even the Government itself. There was further slackness of trade owing to recent legislation, or attempted legislation. He deplored the fact that the electrical plant required for the Victoria Falls Power Co.—a concern operating in a British colony—had been obtained, not from home manufacturers, but from Germany. The profit made by the company in the past year was 3 per cent. less on the turnover than in 1907. There seemed no immediate prospect of a rise in profits. They had turned out non-electrical apparatus, in addition to the usual electrical plant, and they had obtained a patent for a new auto-converter invented at their works, and which had recently been fully described in the technical press. A fair share of Government orders was still being received by them, but he regretted that foreign competition was still very keen, and customers, instead of giving orders as formerly, invited tenders from a number of firms. The net result of the year's trading was that they were able to pay their way, but they could not declare a dividend.

DUBLIN UNITED TRAMWAYS CO. (1896) (LTD.)—At the meeting on Tuesday, the directors reported that for the half-year ended June 30 the amount available for division was £42,526. 10s. 9d., out of which it was recommended that dividends be paid for the half-year at the rate of 6 per cent. per annum on the preference and at the rate of 6 per cent. per annum (tax free) on the ordinary shares. The dividends recommended will absorb £35,025, leaving £7,501. 10s. 9d. to be carried forward.

The chairman (Mr. W. M. Murphy), in moving the adoption of the report, said that the receipts from passenger traffic were £132,754, or £344 less than for the corresponding half-year of 1908. The service of express cars on the Dalkey line was much appreciated, and they hoped to make further developments in the same direction. In order to do that with success they would have to get power from the Board of Trade to run at a somewhat higher speed than at present, and they contemplated making application to the Board for that purpose. In "other receipts" there was an increase of £750, including an addition of £630 to parcel traffic, of which £189 was due to an increase in the number of parcels despatched in the usual way, and £441 to sums collected from passengers carrying parcels along with them. In working and general expenses there was a saving of £3,420, compared with 1908. In the cost of generating and distributing electric current there was a saving of £573, and under the head of maintenance there was a decrease of £1,206, of which nearly £800 was for maintaining car trucks. Now that nearly all the trucks were running on steel wheels, they found a sensible diminution in the cost of maintaining them, as they wore very much longer than chilled iron wheels and they required to be renewed much less frequently. Rates and taxes showed an increase of £478, and there were also some special charges amounting to £958. The ferro-concrete lining of one of the chimneys which was completed had proved quite satisfactory, and it was intended to have the second chimney treated with the same material in the present half-year.

DUBLIN & LUCAN ELECTRIC RAILWAY CO.—After providing for debenture interest, the available balance for the half year ended June 30, is £1,153 10s. 9d., out of which the directors recommend payment of the half-yearly preference dividend. £250 is allocated to Messrs. Dick, Kerr & Co. further on account of the sum still due to them on account of electrical equiqment (reducing that debt to £350), and the balance of £428 10s. 9d. is carried forward.

LONDON, BRIGHTON & SOUTH COAST RAILWAY CO.—The directors' report for the half-year ended June 30 states that the enlargement and improvement of the locomotive shops at Brighton, the construction of carriage and wagon shops at Lancing and the completion of the electrical equipment of the South London Railway formed the main items of expenditure. A public service of electrically-worked trains will be running on the South London Railway between Victoria and Peckham Rye in a few days. The satisfactory result of the trials

which had been proceeding for some months past led the board to hope that its working would be successful.

It is announced that October 1 has been fixed as the date for inaugurating the full service, but an experimental service on a smaller scale will be started in a day or two. The time taken by steam trains from Victoria to London Bridge is 36 min.; electric traction will reduce this to 25 min., and it is intended to run a ten minutes' service.

METROPOLITAN RAILWAY CO.—At the meeting on Wednesday, Sir Chas. McLaren, Bart., said that there had been increases during the half-year from the traffic on practically all sections of the line, and there could be no doubt that the public were beginning to realise in a way they had not done before the advantages of electric underground train service generally. Including season ticket holders, they had carried during the half-year 49,647,199 passengers, against 48,243,951, and the receipt per passenger was 1·48d., against 1·46d. Parcels traffic showed a satisfactory increase of about £1,990.

RIO DE JANEIRO TRAMWAY, LIGHT & POWER CO.—The directors' report states that during 1908 the work of construction have been actively continued and much of the work has been completed. As regards electric light and power distribution, the duct system, which was nearly completed in 1907, has been extended by 50,810 ft., making a total of 1,373,049 lineal ft. of duct now in place. The underground cables have been greatly extended, there being now in use 10 high-tension feeders and a large amount of secondary cable, aggregating 1,031,602 ft. in length. 24·8 miles of tramway track were completed before the end of the year. Considerable progress has been made in the development of the telephone system, a total of 45,280 ft. of cable having been installed in the overhead and underground zones. Owing to trade depression, the disturbance to the service of the tramways due to the reconstruction and electrification of its lines, &c., the gross income shows very little increase over 1907, but the ratio of net to gross income of the tramways has increased from 38·61 per cent. in 1907 to 42·19 per cent. in 1908. Close attention has been paid to the development of the power demand, and the first large mill (a cotton factory) was put into operation with an installation of 800 H.P. Other important contracts for the supply of electric energy were closed, the largest of which was that with the Rio de Janeiro Flour Mills & Granaries, Ltd. (an English corporation), for 1,800 H.P. Contracts were also closed for 1,700 H.P. with the Bangu Cotton Mills, located 17 miles from the city at the town of Bangu, and 990 H.P. with the Fabrica Alianca, another large cotton mill in the city. The telephone subscribers have increased from 2,680 to 3,520. The gross revenue for the year was $175,000, increase $58,800, or 50 per cent. over 1907, and the net revenue increased from $47,700 to $104,700, or 119 per cent.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

CHIPPENHAM ELECTRIC SUPPLY CO. (LTD.) (104,107.)—Reg. July 19, capital £5,000 in £1 shares, to adopt an agreement with Chippenham Corporation and to carry on in Chippenham and elsewhere in Wiltshire the business of suppliers of electric light, electricians, engineers, &c. Private company. First directors, J. H. Edwards and E. Neal (both permanent).

ESPLEN, SWAINSTON & WILSON (LTD.) (104,204)—Reg. July 23, capital £500 in £1 shares, to carry on in the United Kingdom, the River Plate district of South America and/or elsewhere the business of consulting, refrigerating, electrical and superintending engineers, naval architects, &c. Private company. First directors, W. Esplen, J. Esplen, W. H. Swainston and J. J. Esplen. Reg. office, Billiter-buildings, 22, Billiter-street, London, E.C.

FILAMENTS, LIMITED. (104,108.)—Reg. July 19, capital £500 in £1 shares, to adopt an agreement with J. W. H. Reynolds for a secret process for the manufacture of metal filaments for electric lamps, and to carry on the business of manufacturers of and dealers in metal filaments for electric lamps and apparatus used in connection therewith, &c. Private company. First directors, J. W. H. Reynolds and W. G. Bate. Reg. office, 6, Newcastle-street, London, E.C.

LIGHTING (LTD.) (104,154.)—Reg. July 21, capital £1,000 in £1 shares, to carry on the business of manufacturers of and dealers in lamps, burners, parts and apparatus for lighting and other purposes, electricians, engineers, &c. Private company. Reg. office, 25, King-street West, Manchester.

SYLVERLYTE (1909) (LTD.) (104,237.)—Reg. July 24, capital £200,000 in £1 shares, to acquire any inventions relating to electric and other lamps, or any lenses, reflectors or other component parts or accessories for use in connection therewith, in particular to acquire British patents No. 5,191 of 1904 and No. 10,696 of 1908, to acquire the business and assets (except cash in hand) of the Sylverlyte Electric Lamp Co. (Ltd.), and to carry on the business of manufacturers of and dealers in lamps, reflectors, lenses and other articles, electricians, glass blowers, engineers, meters, instruments, motors, batteries, wires, switches, &c. First directors, A. E. Berthoud, J. S. Burns, T. E. Dickinson, H. Harker and S. F. Rumball. Reg. office, 13, Sise-lane, London, E.C.

MORTGAGES AND CHARGES.

LANCASHIRE DYNAMO & MOTOR CO. (LTD.) (61,447.)—Issue on July 12 of £100 debentures, part of a series of which particulars have already been filed.

NEW IGNITION SYND. (LTD.)—Issue on July 12 of £500 debentures, part of series created Nov. 12, 1908, to secure £5,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £4,000.

RECEIVERSHIP.

BIRMINGHAM ELECTRICAL CASE CO. (LTD.)—P. T. Thompson, 21, Salisbury-road, Handsworth, Birmingham, ceased to act as receiver or manager on June 28.

CITY NOTES.

MEMORANDA (July 29).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{1}{8}$d. per oz. Consols $83\frac{7}{8}$—$83\frac{5}{8}$ for money and for account. Consols Pay Day, Aug. 5; Stock and Shares Continuation Day, Aug. 10; Ticket Day, Aug. 11; Pay Day, Aug. 12; Mining Shares Carry Over Days, Aug. 9 and 23.

PRICES OF METALS (London).—*Copper*, cash, 58[illegible]; three months $59\frac{1}{16}$. *Lead*, English, $12\frac{3}{4}$—$13\frac{1}{8}$; foreign, cash, $12\frac{1}{2}$; three months, $12\frac{13}{16}$. *Spelter*, cash, $21\frac{7}{8}$—22. *Tin*, English, 131—133; foreign, cash, 133; three months, $133\frac{1}{2}$—$134\frac{3}{8}$. *Iron*, Cleveland, cash, 48/10, and three months, 49/7. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)—The directors have authorised payment of the interim preference dividends (less tax) for the half-year ended June 30, and have declared an interim dividend on the ordinary shares at the rate of 5 per cent. per annum (less tax) for the same period.

BRISTOL TRAMWAYS & CARRIAGE CO. (LTD.)—An interim dividend has been declared at the rate of 6 per cent. for the half-year ended June 30.

BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend for the half-year to June 30 on the ordinary shares at the rate of 9 per cent.

CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)—The directors have declared a dividend of 1s. 3d. per share for the quarter ended June 30.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend on the preference shares at the rate of 6 per cent. per annum (less tax) for the half-year ended June 30, and an interim dividend on the ordinary shares for the same period at the rate of 4 per cent. per annum (less tax), both payable August 8. The transfer books and register of members will be closed from 27th inst. to Aug. 7, inclusive.

HADFIELD'S STEEL FOUNDRY CO. (LTD.)—The directors have declared an interim dividend of 1s. per share on the ordinary shares.

IMPERIAL TRAMWAYS CO.—The directors announce that no interim dividend will be paid on either class of shares.

KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares for the half-year ended June 30 at the rate of 8 per cent., payable to Aug. 12.

LIVERPOOL DISTRICT LIGHTING CO. (LTD.)—Subject to final audit an interim dividend at the rate of 4 per cent. (less tax) for the half-year ended June 30 has been declared. Mr. Edward Lawrence has been appointed a director of the company.

LIVERPOOL OVERHEAD RAILWAY CO.—The accounts for the past half-year show an available balance of £7,696. 4s. 8d., and the directors have resolved to recommend a dividend at the rate of 5 per cent. per annum on the (1892) preference shares, leaving £4,696. 4s. 8d. to be carried forward.

METROPOLITAN ELECTRIC SUPPLY CO.—The directors have declared an interim dividend at the rate of 5 per cent per annum for the half-year ended June.

METROPOLITAN DISTRICT RAILWAY CO.—The directors recommend a dividend for the past half-year at the rate of 3 per cent. per annum on the 4 per cent. guaranteed stock, £10,000 being placed to reserve for renewals. A year ago the dividend on the guaranteed stock was at the rate of $1\frac{1}{4}$ per cent. per annum.

OXFORD ELECTRIC CO. (LTD.)—The directors have declared a dividend on the ordinary shares at the rate of 5 per cent. per annum.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed July 30 a special settling day in, and have granted quotations to, scrip, fully and partly paid, for £150,000 5 per cent. second mortgage debentures of the *Bombay Electric Supply & Tramways Co. (Ltd.)*, and scrip, fully paid, for £100,000 5 per cent. first mortgage debentures of the *Southern Electric Tramways Co. of Buenos Ayres (Cie. de Tranvias Electricos del Sud)*. The committee have been asked to appoint a special settling day in, and grant a quotation to, £80,000 $4\frac{1}{2}$ per cent. first mortgage debenture stock of the *Chiswick Electricity Supply Corpn. (Ltd.)*, and also to appoint a special settling day in 77,039 preferred ordinary shares of £1 each (12s. 6d. paid) of the *National Telephone Co. (Ltd.)*.

VICKERS, SONS & MAXIM (LTD.)—The directors have elected Mr. Frank Barker a director of the company.

WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)—The directors have declared an interim dividend for the half-year ended June at the rate of 10 per cent. per annum, less tax.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 21	1,894	− 96	7	11,010	− 20[illegible]
Airdrie	„ 16	234	− 18	28	6,036	− 144
Anglo-Argentine	„ 22	38,297	+ 4,240	29	1,132,806	+ 65,520
Ayr Corporation	„ 21	875	− 15	10	3,805	− 170
Baker St. & Waterloo Ry.	„ 24	3,035	+ 195	3	9,535	+ 425
Barnsley	„ 16	162	− 8	28	1,640	− 204
Barrow	„ 16	259	− 25	28	6,159	− 481
Bath Electric Trams, Ltd.	„ 21	1,031	+ 248	29	21,274	+ 898
Birmingham Corporation	„ 24	6,255	+ 47	17	110,182	+ 3,228
Birmingham & Mid.	„ 9	1,113	+ 255	27	22,416	+ 277
Blackburn Corporation	„ 21	1,149	− 130	17	19,357	− 628
Blackpool and Fleetwood	„ 24	1,063	− 155	3	3,125	+ 48
Bolton Corporation	...	...	...	...	...	...
Bombay	June 24	R36,230	− R1,870	24	R953,192	+ R55,810
Bournemouth Corporation	July 21	1,681	− 42	16	26,559	− 23
Bradford Corporation	„ 24	5,024	+ 101	16	81,736	+ 1,472
Brighton Corporation	„ 25	1,028	− 37	17	15,910	+ 768
Bristol Trams & Carriage	„ 23	5,973	+ 500	9	52,380	+ 223
Burnley Corporation	„ 24	1,185	− 85	17	21,712	− 60
Burton Corporation	„ 25	278	− 2	17	4,461	− 134
Bury Corporation	„ 25	1,116	− 69	†17	19,980	− 590
Calcutta Tramways Co.	„ 24	R49,140	+ R3,170	3	R154,202	+ R18,124
Camborne-Redruth	„ 24	122	− 9	30	3,645	− 91
Cardiff Corporation	„ 17	2,257	− 61	16	33,903	− 1,003
Cavehill	„ 16	216	+ 84	28	2,311	− 174
Central London Railway	„ 24	5,427	− 2,593	3	16,329	− 6,174
Charing C., Euston & H'stead	„ 24	3,930	+ 745	3	11,820	+ 2,0[illegible]
Chatham & Dist. Lt. Rys.	„ 22	1,013	+ 196	29	22,614	+ 1,347
City & South London Rly.	„ 25	2,986	+ 252	3	9,259	+ 637
City of Birmingham	„ 16	3,021	+ 213	28	78,147	+ 695
Colchester Corporation	„ 21	216	+ 4	3	6[illegible]5	− 57
Cork Electric Trams Co.	„ 22	551	+ 67	29	12,245	− 861
Croydon Corporation	„ 23	1,569	+ 11	[illegible]6	24,682	+ 79
Devonport & Dist. Trams	„ 16	372	− 66	28	10,189	− 2,304
Dover Corporation	„ 24	233	− 54	17	3,40[illegible]	− 400
Dublin & Lucan Railway	„ 23	159	− 3	[illegible]	506	+ [illegible]
Dublin United	„ 23	5,933	+ 4	3	18,910	− 101
Dudley-Stourbridge	„ 16	930	+ 26	28	21,863	− 606
Dundee Corporation	„ 24	1,239	− 65	†10	11,413	− 458
East Ham Council	„ 24	1,163	+ 301	§16	16,984	+ 2,[illegible]
Exeter Corporation	„ 23	350	− 21	17	5,871	+ 544
Gateshead & Dist. Trams	„ 16	1,0[illegible]8	+ 5	28	27,674	− 317
Glasgow Corporation	„ 24	13,032	− 1,077	‡18	130,673	− 4,425
Glossop Trams	„ 17	129	− 2	29	3,457	− 123
Gravesend—Northfleet	„ 16	231	...	28	5,521	− 215
Great Northern & City Rly.	„ 24	1,278	+ 14	3	3,969	− 24
Gt. Northern, Piccadilly, &c	„ 24	5,3[illegible]0	+ 230	3	16,435	+ 510
Greenock & Port Glasgow	„ 16	549	+ 63	28	14,563	+ 192
Hartlepool Tramways	„ 16	280	− 11	28	6,201	− 100
Hastings Elec. Trams Co.	„ 22	1,134	− 95	3	3,[illegible]	− 5
Hong Kong	„ 24	$5,052	+ $1,96[illegible]	3	$[illegible]	+ $[illegible]
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation	„ 21	2,5[illegible]6	+ 74	16	40,998	+ 403
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	„ 21	141	− 5	16	2,149	− 173
Ipswich Corporation	„ 24	486	+ 15	17	6,636	+ 15
Isle of Thanet Co.	„ 24	1,222	− 73	§31	17,803	+ 13[illegible]
Jarrow	„ 16	131	+ 21	28	3,187	+ 275
Keighley Corporation	„ 22	1[illegible]9	+ 2	16	2,803	+ 67
Kidderminster & District	„ 16	112	− 5	23	2,752	− 102
Kilmarnock Corporation	„ 24	165	− 3	10	1,512	− 79
Lanarkshire Trams Co.	„ 22	1,693	+ 3	29	36,203	− 1,696
Lancashire United	„ 21	1,341	− 1[illegible]0	29	37,982	+ 1[illegible]0
Leamington	„ 16	157	− 7	23	4,581	+ 16[illegible]
Leeds Corporation	„ 24	6,982	+ 75	17	113,700	+ 427
Leicester Corporation	„ 24	2,311	− 139	3	6,717	− 321
Leith Corporation	„ 17	6[illegible]8	+ 87	9	5,606	− 505
Lincoln Corporation	„ 21	133	+ 7	17	2,116	+ 9
Liverpool Corporation	„ 17	10,993	− 49	‡28	300,205	− 2,017
Liverpool Overhead Rly.	„ 25	1,410	− 77	‡14	5,8[illegible]6	− 43
Llandudno & Colwyn Bay Ry	„ 23	562	+ 18	34	7,010	+ 1,636
*London County Council	„ 10	36,843	+ 2	§11	5[illegible]2,776	+ 15,307
London United	„ 24	7,424	− 675	‡32	1[illegible]2,148	− 16,2[illegible]9
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	...	...	...	...	...	...
Manchester Corporation	...	...	...	...	...	...
Mersey Railway	„ 24	1,873	+ 92	3	5,7[illegible]6	+ 235
Merthyr	„ 16	233	+ 17	28	5,905	+ 55
Metropolitan Dist. Railway	„ 24	10,845	+ 1,753	3	31,3[illegible]0	+ 3,245
Metropolitan Elec. Trams	„ 16	6,438	+ 487	28	167,0[illegible]0	+ 13,444
Middleton	„ 16	355	− 15	28	9,253	− 709
Nelson Corporation	„ 21	133	− 24	§15	2,314	− 103
Newcastle-on-Tyne Corp.	„ 24	3,805	− 36	15	65,371	− 1,425
Newport (Mon.) ‡	„ 24	6[illegible]9	− 43	17	11,202	− 311
Northampton Corporation	„ 23	514	+ 31	§17	8,001	+ 147
Oldham, Ashton & Hyde	„ 16	508	− 12	28	15,498	− 1,028
Oldham Corporation	„ 25	1,834	− 263	17	33,259	− 2,220
Perth (N.B.) Corporation	„ 21	15[illegible]	− 5	[illegible]	1,521	− 47
Perth (W.A.) Elec. Trams	„ 23	1,2[illegible]2	− 52	29	41,376	− 55
Peterborough	„ 16	119	− 1[illegible]	24	3,161	− 2[illegible]0
Portsmouth Corporation	...	...	...	...	...	...
Potteries	„ 16	1,713	− 115	28	49,146	− 1,246
Preston Corporation	...	...	...	...	...	...
Rotherham Corporation	„ 22	5[illegible]7	− 55	16	9,[illegible]22	− 324
Rothesay	„ 16	3[illegible]7	+ 26	24	1,113	− 70
Salford Corporation	„ 23	1,390	3[illegible]1	‡17	78,063	− 2,589
Sheerness	„ 16	57	− 5	24	1,317	− 203
Sheffield Corporation	„ 25	5,565	− 181	§17	98,346	− 1,296
Singapore Trams	„ 21	$1,0[illegible]4	+ $84	3	$2[illegible],012	+ $1,333
South Metropolitan	„ 15	836	+ 31	28	21,345	− 373
South Staffs	„ 16	843	− 22	28	23,137	− 1,289
Southend Corporation	„ 21	935	+ 138	15	8,291	+ 1,183
Southport Tramways	„ 15	326	− 8	28	7,620	− 218
Stalyb'dge, Hyde, &c., Jt. Bd.	„ 24	821	− 111	§15	12,923	− 551
Sunderland Corporation	„ 25	1,256	− 118	17	19,329	− 847
Sunderland District	„ 21	5[illegible]5	− 48	33	17,011	− 710
Swansea Trams	„ 16	1,0[illegible]6	+ 10	28	25,872	+ 488
Swindon Corporation	...	...	...	...	...	...
Taunton	„ 16	45	...	28	1,032	− 76
Tynemouth and District	„ 16	3[illegible]8	+ 60	28	5,61[illegible]	+ 16
Tyneside Trams Co.	„ 21	514	+ 10	3	1,420	+ 151
Wallasey District Council	„ 24	9[illegible]3	− 3[illegible]	§16	15,726	+ 474
Walsall Corpn.	„ 24	519	− 30	29	14,663	− 1,137
Warrington Corpn.	„ 24	378	− 10	16	6,234	+ 17
West Ham Corporation	„ 15	2,355	+ 206	15	36,151	+ 2,161
Weston-super-Mare	„ 16	283	+ 36	28	2,792	+ 165
Wolverhampton Co.	„ 16	493	+ 66	28	11,523	− 1,171
Wolverhampton Corpn.	„ 21	867	...	3	2,533	...
Worcester	„ 16	201	− 7	28	7,381	− 128
Wrexham	„ 16	37	− 7	28	2,663	− 123
Yorkshire W.R. Trams	„ 25	1,095	− 92	30	34,670	...
Yorkshire Woollen District	„ 16	901	+ 18	28	21,724	− 505

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed. July 28	Rate % Yielded (£ s d.)	Dividend Due.	Business Week to July 2[illegible] Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7 0	Bournemouth & Poole Elec. Sup. Ord.	9½ −10½	[illegible] 1 9	Mar, Sep	[illegible]	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾ −10¼	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼ −10¾	5 11 6	Feb, Aug	10	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	[illegible] −103	4 7 6	Jan, July	..	..
5	3 6	Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 9	May, Nov	..	..
5	5 6	Brompton & Kensington Elec. Sup. Ord.	8 −8	5 17 [illegible]	March ...	[illegible]	—
5	3 6	Do. 7 per Cent. Pref.	8 −8½	4 2 6	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97 −100	4 0 6	June, Dec	..	—
5	2 6	Charing Cross (W. End & City) El. Sup. Co.	4 −4	5 1[illegible] [illegible]	Feb, Aug	..	—
5	2 3	Do. 4½ per Cent. Pref.	4½ −5	4 10 0	Feb, Aug	[illegible]	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 −99	4 1 9	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99 −101	4 9 9	..	100½	99½
5	2 3	Do. City Undertaking 4½% Cm. Pref.	3½ −4	5 2 6	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3½ −4	4 [illegible] 3	March ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 −103	4 7 [illegible]	June, Dec	..	..
10	7 0	City of London Electric Lighting Ord.	16½ −1[illegible]	[illegible]	Feb, Aug	1[illegible]	..
10	6/0	Do. 6 per Cent. Cum. Pref.	12 −13	4 1[illegible] [illegible]	Jan, July	12	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4 0 [illegible]	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 −102	4 [illegible]	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1¾ −2	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3¼ −3½	3 17 8	April, Oct	..	..
10	6 0	County of London Elec. Supply Ord.	8 −8½	5 17 [illegible]	Feb, Aug	[illegible]	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10½ −11	5 6 0	Mar, Sept	11	[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	103 −106	4 5 0	Jan, July	1[illegible]	
St.	4½%	Do. Second Deb. Stock	100 −103	4 7 6	May, Nov	..	..
5	3 6	Folkestone Electricity Supply Co. Ord.	4⅝ −5¼	5 9 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 −5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 −102	4 [illegible] 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7¼ −7⅝	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord.	6¾ −7⅜	5 2 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝ −6⅞	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 −100	4 0 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	..
St.	4½%	†Kent Elec. Power Co.	83 −87	5 3 6	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 6 8	Mar, Sept	..	..
5	3 0	Do. 6 per Cent. Pref.	5⅛ −5½	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 −97	4 2 0	Jan, July	..	—
5	3 0	Metropolitan Electric Sup. Ord.	4½ −4¾	5 16 0	April, Oct	[illegible]	4[illegible]
5	2 3	Do. 4½ per Cent. Cum. Pref.	4¾ −5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ −86½	4 1 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	94 −97	4 12 6	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4¾ −5	4 2 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	81 −85	5 5 11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4⅞ −5	2 10 0	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅝ −5	5 1 3	Feb, Aug	..	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 −99	4 1 8	Jan, July	—	.
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 19 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 −91	5 0 0	Jan, July	..	..
10	6 0	†Notting Hill Electric Ord.	11¼ −12¼	5 14 6	March ..	—	..
5	4 6	Oxford Electric Ord.	6 6½	6 8 0	March ..	—	—
St.	4%	†Do. 4 per Cent. Deb. Stock	95 −98	4 2 0	Jan, July	..	.
5	5 0	St. James' & Pall Mall Elec. Ord.	8¾ −9¼	5 8 0	Feb, Aug	9	..
5	3 6	Do. 7 per Cent. Pref.	7⅜ −7⅞	4 11 3	Feb, Aug	—	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	81 −85	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord.	[illegible]	..	Feb	..	..
5	4 0	South London Electric Supply Ord.	2¼ 3⅛	6 8 0	April ...		..
St.	5	Do. 5% 1st Mort. Stk. Red.	101 −103	4 17 0	—	103	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	—
1	0 8⅔	Do. 7 per Cent. Cum. Pref.	1⅛ −1⅜	5 7 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −104	4 6 9	April, Oct	—	—
5	2 6	Urban Electric Supply Ord.	½ −1	—	April, Oct		..
5	2 6	Do. 5 per Cent. Cum. Pref.	1¼ −1½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	78 −80	5 12 0	April, Oct	..	—
5	5 0	Westminster Elec. Sup. Ord.	8¾ −9⅛	5 11 0	Mar, Sept	9	—
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4¾ −5¼	4 8 0	Jan, July	5	—
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	†Baker St. & Waterloo 4% Perp. Db. St	97 −99	4 1 0	Jan, July	98	..
1	..	Bath Elec. Trams Pref. Ord.	¼ −⅜	..	April	..	.
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 −91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88 −91	4 19 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	7¾ −8¼	7 1 0	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	7½ −[illegible]	4 11 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	99½ 100½	3 19 7	Feb, Aug	..	—
10	..	British Electric Traction Ord.	⅝ −⅞	..	June, Dec	..	..
10	3/0	Do. 6 per Cent. Cum. Pref.	2½ −2¾	10 18 0	Feb, Aug	4[illegible]	4⅝
St.	5%	Do. 5 per Cent. Perpetual Debs.	86 −90	5 11 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	65 −70	6 8 [illegible]	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	61 −63	5 11 0	Feb, Aug	6[illegible]	62
St.	4%	Do. 4 per Cent. Pref. Stock	83 −85	4 14 0	Feb, Aug	.	..
St.	2½%	Do. Deferred Stock	43 −45	[illegible] 11 0	Feb	..	..
100	4%	‡Do. 4 per Cent. Debs.	100 −102	4 18 0	Jan, July	[illegible]	101½
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	91 −93	4 [illegible] 0	Jan, July	[illegible]	[illegible]
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ −5¼	4 1[illegible] [illegible]	April, Oct	..	.
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	.	..
St.	1½%	City & South London Rly. Con. Ord.	31½ −32½	4 13 0	Feb, Aug	..	.
St	5%	Do. 5 per Cent. Perp. Pref. (1891)	110 −112	4 9 0	Feb, Aug	.	..
St.	5%	Do. (1893)	105 −109	4 11 [illegible]	Feb, Aug		..
St.	5%	Do. (1901)	103 −105	4 15 0	Feb, Aug	.	—
St.	5%	Do. (1903)	91 −97	5 3 0	Feb, Aug		—
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 −101	3 19 0	May, Nov	10[illegible]	100
10	6/0	Dublin United Trams. 6 per Cent. Pref.	13 −14	4 5 9	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ −1	..	Feb, Aug	—	..
10	..	G. Northern, Picc. & Brompton 4% G.Pf	8 −9	..	Feb, Aug	.	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 −95	4 1 0	Jan, July	94½	94¼
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1 −1¼	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	75 −80	5 12 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 −4½	13 0 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 −6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	83 −84	5 7 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅜ −1⅜	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58 −60	6 7 0	Jan, July	.	—
10	6/0	Lanarkshire Tramways	9⅞ −10	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ −90½	5 10 6	Jan, July	..	.
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	[illegible]	5 [illegible] 8	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	[illegible]	..	Jan, July	[illegible]	
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68 −71	5 12 6	Jan, July	6[illegible]	6[illegible]
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug	—	..
1	10[illegible]	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 −97	4 12 9	Jan, July	..	—
St.	½%	Metropolitan Railway Consolidated	40¼ −41	1 4 3	Feb, Aug	41½	40¾
St.	3%	Do. Surplus Lands Stocks	67 −69	4 7 0	Feb, Aug	68½	67½
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3 17 0	Feb, Aug	..	..
St	3½%	Do. 3½ per Cent. "A" Preference	84 −85	4 1 6	Feb, Aug	84	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	83 −85	4 2 6	Feb, Aug	.	84
St.	3½%	†Do. 3½ per Cent. Debenture Stock	92 −94	3 11 6	Jan, July	[illegible]	[illegible]

In calculating the yield allowance has been made for accrued interest but *not* for redemption
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—Continued.

Share	Last Dividend	Name	Price Wed., July 28.	Rate % Yielded £ s. d.	Dividend Due	Business Week to July 28 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—Continued.					
St.	3½%	†Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	92¼	92
St	..	Metropolitan District Railway Ord.	17¼—17½	—	Feb, Aug	17⅞	17⅛
St	..	Do. Extension Pref. (5 per Cent.)	45 —47	..	Feb, Aug	46¾	45½
St	3½%	Do. Asserted Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	65 —67	5 4 0	Feb, Aug	66¼	66½
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	76½	76½
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	1¾%	Do. Guar. Stock 4 per Cent.	93 —96	4 3 6	Mar, Sept	95½	94
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	139 —141	4 5 0	Jan, July	140½	139½
St.	4%	Do. 4 per Cent. Ditto	93 —95	4 4 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	82 —86	5 16 0	Jan, July	—	..
..	...	Undergd. E. Rys. Lon. 6% In. bds. with coup. 3	36 —38	..	June, Dec	..	..
..	5	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	102½
..	4½	Do. 4½% Bonds with coup. 3	87 —89	5 1 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—2¼	—	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	82 —86	5 4 9	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅜—½	..	..	—	..
1	1/4½	Do. 6% Cum. Pf.	¾—⅞	6 17 0	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.	4¼—4⅜	4 15 9	April, Oct	4⅜	4¼
1	0/7½	Do. Pref.	1⅜—1½	4 0 0	..	..	—
5	6/0	British Insulated & Helsby Cables Ord.	7⅜—7⅞	6 9 0	July, Feb	7⅝	..
5	3/0	Do. 6 per Cent. Pref.	6¼—6⅝	4 10 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	3/16—5/16	..	Feb, Aug	..	—
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	98½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	..	..
St.	4½%	Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	10 —10¾	6 19 6	Jan, July	10⅝	10 11/32
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	Jan, July	5½	5½
St.	4½%	Do. 4½ per Cent. 1st Mort. Debs. (red.)	104½—106½	4 5 6	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	1⅛—2	6 6 0	May, Nov	1 15/16	1 29/32
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 6	Feb, Aug	..	..
	1/0	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	6 11 9	March ..	..	..
	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1 1/16	5 14 0	April, Oct	..	..
1	0/8½	Consolidated Electrical Co.	⅜—½	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1⅛—1¼	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	½—1	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	90 —93	5 7 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1¼	8 0 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 3/32—1 7/32	4 16 9	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 —102	4 8 0	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	—
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	†Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 5 0	Jan, July	19½	5⅛
2	..	Electric Construction Co.	7/16—11/16	..	Jan, July	..	—
2	2/9¾	Do. 7 per Cent. Cum. Pref.	1 7/16—1 11/16	8 0 0	July	..	..
St.	4%	†Do. 4 per Cent. Perp. 1st Mort. Debs.	63—67	5 19 0	Jan, July	..	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71 —77	6 10 0	...	..	...
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	7⅞	7 11/16
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	12 —12¾	6 0 6	Feb, Aug	12½	12
5	2/3	Do. 4½ per Cent. Pref.	4⅞—5½	4 2 0	Feb, Aug	5	—
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14½—15¼	6 10 0	Feb, Aug	15⅛	14⅞
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—11¼	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	—	—
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	1/16—¼	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	81 —84	5 7 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1½	—	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	..	—
12	24/0	Telegraph Construction & Maintenance	34½—36	5 2 0	Mar, July	35	34
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99½—101½	3 18 6	Jan, July	—	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 5/16—2 7/16	4 11 6	—	2 3/16	2⅜
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1¼	3 12 9	—	1	1
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	101½—103½	3 17 6	June, Dec	103½	102
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 6 0	June, Dec	105¼	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	106	105½
10	8	†J. G. White & Co. 6% Cm. Pref.	9 —10	8 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅝—3⅛	9 12 0	Apr, Oct	—	—
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	..	—
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3¼	—	June, Dec	3	2⅞
100	5%	Do. 5 per Cent. Debs. (red.)	92 —95	5 5 6	June, Dec	..	..
St.	15/0	Anglo-American	58½—60½	5 7 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	102½—103½	5 16 6	F,My,Ag,N	103	102
St.	3/0	Do. Deferred	17¼—17½	5 7 0	F,My,Ag,N	17¼	17¼
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	89 —91	4 8 0	Jn,Ap,Jy,O	90	..
10	6/0	Cuba Submarine Ord.	8¼—8¾	6 15 0	Feb, Aug	..	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	2⅞—3⅜	5 13 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅜—8⅞	5 12 9	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99% 101%	4 9 0	Jan, July	..	.
20	4/0	Direct United States Cable	12⅞—13⅜	6 5 6	Ja,Ap,Jy,O	13⅛	13
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 —101	4 9 0	June, Dec	..	..
St.	25/0	†Eastern Ordinary	125 —128	5 9 6	Ja,My,JyO	126½	126¼
St.	17/6	†Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,JyO	85	85½
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	106	..
St.	2/6	†Eastern Extension	11¾—12	6 0 0	Ja,Ap,Jy,O	11⅞	11¾
100	4%	Do. 4 per Cent. Deb. Stock	104 —106	3 16 3	Feb, Aug	104¾	104¼
25	4%	Eastern & S.Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	.	..
1	1/0	G.N. of Copenhagen, with Coupon 76	26 —27	6 2 0	Jan, July	26¼	—
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 —101	4 9 0	June, Dec	..	..
25	52/6	Indo-European [illegible] all	61½—62½	5 16 9	May, Nov	62	..
100	$1	Mackay Companies Common	80 —84	4 16 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April	..	..
1	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99 —101	3 19 0	June, Dec	—	—
2½	1/3	West Coast of America	1⅛—1⅜	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	..	West India & Panama	½—⅝	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref	8 —8½	7 1 0	May, Nov	8¼	8⅛
10	12/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	—	—
100	5%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	101	..
10	3/0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	13⅞	13½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102½—104½	3 18 6	June, Dec	102¼	102
	4%	Western Union Telegh. $1,000 4% Bonds	90 —92	4 7 0	[illegible]	..	..

Share	Last Dividend	Name	Price Wed., July 28.	Rate % Yielded £ s. d.	Dividend Due	Business Week to July 28 Highest	Lowest
		TELEPHONES.					
100	$8	Amer. Telephn. & Telegh. Cap. St.	143½—144½	6 13 9	..	143⅝	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	97½	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103 —105	4 15 0	Mar, Sept	..	—
5	3/0	Chili Telephone	8¼—8½	4 14 0	August ..	8⅜	8¼
1	0/7½	Monte Video Telephone Ord.	13/16—15/16	6 8 0	Nov	..	—
1	0/6	Do. 5 per Cent. Pref.	¾—⅞	5 14 3	May, Nov	..	..
St.	6%	National Co. Pref. Stock	109 —110½	4 16 6	Feb, Aug	109½	108
St.	6%	Do. Def. Stock	125½—127½	4 14 0	Feb, Aug	126¾	12..
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10¼—11	5 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10¼—11	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5⅞	4 5 0	Feb, Aug	6½	5..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97½—99½	3 10 6	June, Dec	97½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	Jan, July	100½	..
1	1/0	Oriental	1 5/16—1 7/16	5 7 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 3/16—1 5/16	5 4 0	April, Oct	1⅛	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85½—87½	4 11 6	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 —101	4 9 0	Jan, July	..	..
5	8/0	United River Plate	7⅛—7⅜	5 8 0	July	7¼	7..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	5 10 6	June, Dec	5¼	..
St.	4½%	Do. 4½ Deb. St. Red.	102 —104½	4 6 3	Jan, July	—	..
		FINANCIAL INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	3¼	..
10	5/6	Globe Telegraph & Trust	10¼—10¾	6 7 0	SpDcMrJu	10 3/16	10..
10	3/0	Do. 6 per Cent. Pref.	13¼—13¾	4 7 0	SpDcMrJu	13⅜	1..
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	130½	.
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	5/0	Anglo-Argentine 10% Cum. 2nd Pref.	9 5/16—9 11/16	5 3 6	April, Oct	9..	
5	1/2 7/11	Do. 5% Non-cum. 3rd Pref.	4 5/16—4 9/16	5 10 3	Jan, July	4½	
St	4%	Do. 4% Deb. Stock	90¼—91¼	4 7 0	June, Dec	91½	9..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	101 —103	4 17 6	Jan, July	—	.
1	3/6	Brisbane Electric Trams. Invest. Ord.	6½—6¾	4 9 0	May	6 11/16	.
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	..	
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100½—104½	4 4 0	Jan, July	102	
St.	8%	British Columbia El. Ry. Df. Ord.	143 —147	5 9 0	Mar, Sept	147	14..
St.	6%	Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	..	.
St.	5%	†Do. 5% Cum. Perp. Pref. Stock	107 —110	4 11 0	Jan, July	108½	1..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	
100	4½%	†Do. Vancouver Power Debs.	101 —104	4 7 0	Jan, July	103	
St.	4½%	Do. 4½% Perp. Con. Deb. St.	101½—103½	4 7 0	—	103	
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99½—101½	4 18 6	Mar, Sept	101½	
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	95 —99	6 0 1	Feb, Aug	..	
5	2/0	Calcutta Tramways (1 to 137,610)	4½—4⅞	4 2 0	Mar, Sept	4 11/16	
10	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	4⅞	
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	—	
St.	..	Cape Electric Tram Shares	⅛—⅜	..	..	..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 11/16—5 15/16	4 4 0	F,My,A,N	5⅞	
St.	4%	Do. 4 per Cent. Deb. Stock	99 —101	3 19 0	June, Dec	..	
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	..	
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..	
100	5%	Do. 5 per Cent. "A" Deb. Stock	90 —93	5 7 6	Jan, July	91½	
5	6%	Do. 6 per Cent. "B" Ditto	64 68	8 13 0	Jan, July	..	
5	1/0	Lisbon Elec. Trams. Ord.	1 5/16—1 7/16	4 14 0	July	..	
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 3/16—1 5/16	5 1 0	Jan, July	—	
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	97 —101	5 1 0	Jan, July	..	
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 95	5 2 0	Jan, July	..	
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 2 6	Feb, Aug	—	
100	$1½	Mexico Trams Co. Com. St.	124½—127½	3 18 3	..	130	
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	93 —95	5 10 6	..	94	
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	103½	
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	103¾	
1	0/6	Perth Elec. Trams Ord.	⅛—⅜	8 0 0	May	..	
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—	
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅞	5 4 8	..	5½	
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..	
100	..	Rio Janeiro Tram, Lt. & P. Co.	85½—87½	..	..	..	
..	5%	Do. 30 yr. Gold Bnds.	85½—87½	5 14 0	..	93	
100	5%	Do. 50 yr. Mt. Bnds	84 —86	5 17 0	..	85	
—	$1½	Sao Paulo Tramway, Light & Power Co. $100 Stock	148 —151	6 12 6	..	150½	
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	97 —99	5 1 0	June, Dec	98½	
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 12 0	Feb, Aug	..	
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅝	5 11 0	Mar, Sept	..	
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	—	
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93½—95½	4 13 6	Jan, July	95	
5	4/9	Calcutta Elec. Supply Ord.	5¾—6¼	6 8 0	April, Oct	6⅛	
100	$1½	Canadian Gen. Elec. Co. Com. St.	122 —126	5 14 0	..	126½	
100	$3½	Do. 7% Cm. Pf. Stock	116 —118	6 3 6	..	115½	
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	81½ - 83½	5 16 0	..	83½	
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	..	..	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Deb Stock	...	5 8 0	Jan, July	—	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	81½ 83½	5 16 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	..
10s	4%	Kalgoorlie Elec. Power & Ltg. Ord.	¼—⅜	..	..	½	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	¾—⅞	6 18 3	April, Oct		—
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	76 —80	6 5 0	April, Oct	77	.
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	82 —84	5 10 0	..	84½	8..
St.	$1	†Mexican Lt. & Power Co. Com. St.	65 —70	6 9 6	—	71	
500	5%	Do. 5% 1st Mort. Gold Bnds.	85 —90	5 11 0	..	89	
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	131 —135	4 15 0	F,My,A,N	132¼	
1	1/7½	River Plate Electricity Co. Ord.	[illegible]	5 11 0	April		
1	1/2⅝	Do. 6 per Cent. non-Cum. Pref	[illegible]	5 1 6	May	..	
St.	5%	Do. 5 per Cent. Deb. Stock	102 —105	4 15 0	Jan, July	..	
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	[illegible]	5 7 6	April, Oct	5½	
5	3/0	Do. 2nd Pref.	5⅜—6	5 0 0	—		
100	$1	†Shawinigan Water & Power Co. Ca	92 —94	4 7 3	—		
..	5%	Do. 5 per Cent. Bds.	101 —106	4 14 3	Jan, July		
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	96½—97½	4 12 6	—	99	
St.	4½	Toronto Power Co. 4½% Db. St.	97½—99½	4 10 6	..	99	
..	[illegible]	Victoria Falls Power Co. Pref.	[illegible]	5 14 0	Jan, July	—	

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NOTES.

Current for Tramways.

As to what constitutes a fair price for electrical energy supplied to electric tramways is always a fruitful topic of discussion between experts, on account of the difficulty of accurately apportioning the various running or fixed costs of an electric supply station to any particular units generated. The question is also frequently debated—more or less non-technically—by municipal committees and councils, since where both the electric tramways and electric supply undertaking are controlled by a municipality, the more successful of the two undertakings is often regarded as making a profit at the expense of the other. On the other hand, it must be admitted that in a number of cases the charge for energy supplied for electric traction seems to compare unfavourably with that made to private power consumers, particularly where the tramways are operated by a company. This subject has been much to the fore of late, and in our present issue it is referred to in connection with the electricity undertakings at Aberdeen, Brighton and Peterborough. In the first and last mentioned cases the question at issue was between the municipal electricity supply undertaking and a tramway company, and we notice that at Aberdeen Mr. W. H. PATCHELL, who was called in as arbitrator, has decided in favour of a fixed charge of £4. 10s. per kilowatt plus ½d. per unit, whilst at Peterborough Sir ALEXANDER KENNEDY has given his award in favour of 2d. per unit for the first 120,000 units per annum and 1¼d. per unit for any energy in excess of that amount. It is stated that in both cases the companies have obtained some advantage from the arbitrations.

AT Brighton the recommendation of the Electric Lighting Committee that energy should be supplied to the Tramway Committee at 1·4d. per unit was amended by the substitution of the figure "1·3d." for "1·4d.," the lower figure being arrived at as a compromise between the recommendations of the two committees. The Electric Lighting Committee, while not admitting that they could produce current at this figure, offered that price to the Tramways Committee, since it was not considered practicable to decide in the Council the actual cost of the supply. It is worth noting, moreover, that the town clerk thought it would be accepted as a general principle that the supply should be as nearly as possible at cost price, the electricity department including a charge, if so desirous, to provide a contribution to the reserve fund. It is, however, by no means certain that all engineers will agree with the opinion expressed by the town clerk, since it is probable that the ordinary electricity consumers would be unfairly treated if the electric tramway supply, which is often a very large proportion of the total output of electricity, were given at the *estimated* cost price, a provision for reserve fund being optional on the part of the Electricity Committee. The question is certainly one on which the opinion of the electrical engineer to the Corporation should be treated with the greatest consideration. It is noticeable that Mr. J. CHRISTIE in his report stated that the present rate of 1·5d. per unit only yields the barest margin of profit, any reduction below 1·4d. per unit certainly resulting in a supply at less than cost price.

The Rating of Turbo-generators.

A FEATURE of steam turbines to which we have frequently drawn attention is the difficulty of assigning a value to

their full-load capacity, due, of course, to their ability to take very large overloads. Thus, a so-called 9,000 kw. Curtis turbine delivered to the electricity supply undertaking at Chicago showed on test, of which the particulars were given in our issue of July 2nd, a steam consumption of 12·9 lb. per kilowatt-hour at a load of 10,156 kw., 13·05 lb. at 12,108 kw. and 13·6 lb. at 13,900 kw., the steam being superheated in each case to the extent of 140°F. or thereabouts. Difficulty may therefore arise in making comparisons between the results with various machines. In this connection we may draw attention to the turbo-generators supplied to the Commonwealth Edison Company, of Chicago, a description of whose supply system has been appearing in our columns during the last few weeks, concluding in the present issue. The plant installed in the Fisk-street station at Chicago has always been referred to as consisting of 8,000 kw. units, whereas the turbo-generators in the new Quarry-street station, which has only recently been equipped, are stated to be of 14,000 kw. capacity. The difference in the output of the two sizes of units is not, however, so great as is indicated by these figures, since the capacity of the later machines is stated to be their guaranteed output for continuous operation, whilst in the case of the 8,000 kw. units the rating was merely nominal, and on the new rating they should be considered as being more nearly 12,000 kw. units. This point is of interest, since we notice that several units of from 8,000 kw. to 14,000 kw. capacity have been reported within the last year as being installed in various American electrical undertakings, and difficulty may be experienced in making comparisons between these installations if the basis on which the rating of the different plants is determined is not always stated, or if any return is made to the now defunct N.H.P.

The Large Gas Engine.

THE advance of the large gas engine in this country has been slow compared with that on the Continent, and opinions as to its future have been diverse. Some engineers have been sceptical, others enthusiastic. But whatever the frame of mind, the progress of this rival of the steam engine has been watched with keen interest. This week we are able to announce a further step forward, in that the well-known firm of Galloways Limited have found the outlook sufficiently promising to undertake the manufacture of the gas engine of EHRHARDT and SEHMER. Thus the Key Engineering Co., who have shown much persistence in their crusade, will in future be able to represent English as well as German interests. We understand that those responsible for Messrs. Galloways' policy were very well satisfied with their preliminary investigations on the Continent, and are confident in the future of the large gas engine in general, and of the Ehrhardt and Sehmer engine in particular. We may therefore expect further developments, which may have a not unimportant bearing upon electricity supply in due course. Meanwhile, it is interesting to note that a 1,200 H.P. Ehrhardt and Sehmer engine has been running satisfactorily on producer gas for the past two years at the works of an English chemical company.

Synchronisation of Public Clocks.—"The Times" states that a letter has been addressed by the British Science Guild to London local authorities urging the necessity of the synchronisation of all clocks exposed to public view, and alleging the insufficiency of the powers given to Metropolitan borough councils. The guild suggest that further action be taken with a view to remedying the present state of affairs.

Electrical Engineers in South Africa.—The "Engineer" states that, as the result of several representative meetings, it was recently decided to form a South African Institute of Electrical Engineers, and at a largely attended meeting, held on July 12th, at the Grand National Hotel, Johannesburg, the Institute was duly founded and draft rules approved. A provisional committee was elected to act as the council until the first general meeting of members, when the officers and council will be elected.

London, Brighton & South Coast Railway Electrification.—At the meeting of the company on Wednesday last the chairman, Lord Bessborough, announced that the work of electrically equipping the South London line was nearly completed. It is proposed to commence the full service between Victoria and London Bridge on October 1st, but a section of the route—viz., between Victoria and Peckham Rye—will be opened for public service at the end of the present month. The chairman also announced that the receipts during the past half-year seemed to show that the worst of the tram and motor omnibus competition had now been experienced.

The Crystal Palace School of Engineering.—Several departments of this school were open for inspection last week, the occasion being the presentation of certificates at the close of the second term of the thirty-seventh year of its existence. The chair was taken at the assembly in the lecture theatre by Col. Sir Edward Raban, K.C.B., R.E., Director of Works to the Admiralty, and in addressing the students he congratulated them on the excellent reports made by the examiners on their work. The fact that a very high average of marks had been obtained by the majority of the students and not, as was sometimes the case, by the good work of a few, was, he thought, specially satisfactory, showing the keenness of the students as a whole.

Electricity in Gas Works.—Mr. C. D. Haskins in a recent address, reported in the "Electrical World," illustrated the widespread uses of electricity, and remarked that any authority on gas would, if he were questioned very closely, admit that no modern gas works should be without its electric service. The most modern gas plants, built, say, in the last two or three years, consumed an average of about 1 kw.-hour for every 1,000 ft. of gas produced. The tar pumps, the water pumps, and the coal conveyors, the blowers, were all heretofore extravagantly operated by wasteful steam lines; the more wasteful engines had disappeared, and as one gas man said recently, "Of course we don't advertise it, but electricity is really the only safe thing to light a gas works with."

Electricity Supply in Vienna.—According to "L'Electricien," the generating stations which are at present supplying Vienna have now reached their maximum output, and a scheme is being proposed for establishing in the valley of the Nees a large hydro-electric station, which will generate and transmit to Vienna the whole of the electrical energy necessary for supplying the requirements of the town. The broad outlines of the scheme have only up to the present been considered, and there are many points of detail yet to be worked out. It is thought that it will be possible to utilise the hydraulic energy of the Nees between Admont and Weissenbach-Saint-Gallen by constructing suitable barrages. The first cost of the scheme is estimated at £2,000,000, and, if the project is realised, opportunity will be taken to introduce electric traction on the suburban railways in the neighbourhood of Vienna.

Cable Interruptions.	Date of Interruption.
Tangier—Cadiz	May 19, 1909
Tourane—Amoy	June 17, 1909
Assab—Perim	July 8, 1909

Institutions of Engineers and Shipbuilders.—A joint summer meeting of the Institution of Engineers and Shipbuilders in Scotland and of the North-East Coast Institution of Engineers and Shipbuilders is being held this week at Glasgow. On Wednesday and Thursday mornings the programme consisted of the reading and discussion of Papers, the afternoons being devoted to visits to works, &c., in the neighbourhood, whilst to-day (Friday) an excursion takes place on the Firth of Clyde. The proceedings are to conclude to-night with an "At home," the president of the Scotch Institution, Mr. J. Ward, and Mrs. Ward receiving the members of the Congress and their friends. Among the works visited yesterday were those of Messrs. Mavor & Coulson, an interesting display of electrical machinery being there shown. This included a three-speed 5 H.P. spinner motor in operation, a proposed method of speed control for electric ship propulsion being demonstrated. An alternating-current motor wound with four and six poles for use with two separate generators of different frequency also provided an alternative method of ship propulsion. A 10 H.P. single-speed spinner motor illustrated the use of alternating-current motors for starting up against load without the use of resistances or electric control, whilst a "Pick-quick" coal-cutter and an entirely enclosed dust and explosion-proof motor, cooled by air acting through radiators, showed the possibilities of electrical applications underground.

Electrically Driven Colliery Pumps.—A recent number of "Engineering" gives the following details of some electrically-driven pumps of the Zeche Concordia, near Oberhausen, which show an unusually high mechanical efficiency. The plant was installed underground, at a depth of about 1,350 ft., by the Isselburger Hütte A.G., and the results of the tests conducted by the Steam Boiler Supervision Association, of Essen, are published in the "Zeitschrift des Vereines Deutscher Ingenieure" of May 8. The pump is a twin differential plunger pump; the plunger diameter is 205 mm. (8 in.), the stroke 600 mm. (24in.), and the motor, which is fixed directly on the crank-shaft, makes 92 revs. per min. It will be seen from the subjoined table that the efficiency of the electric motor was not high, only 87·35 per cent., allowing for all losses. The mechanical efficiency of the pump probably reaches the practical limit, and is in striking contrast to the results obtained with a centrifugal pump installed in the same colliery. The high efficiency of the pump shows that the Fernis valves, which are ring valves provided with cup leathers, must perform their functions admirably. The following results were obtained:—

	Plunger Pump.	Centrifugal Pump.
Water raised ....m³/min.	3·63	3·7
Height ....m.	414·43	414·43
Density of water	1·016	1·016
Manometric head of water..........m.	429·8	430·0
Revs. per min.	91·6	1,482
Efficiency of motor	87·35	94·1
Volumetric efficiency of pump p.c.	99·5	—
Mechanical efficiency of pump p.c.	96·5	68·6

Another very large underground mine pumping plant has been installed by the same Isselburger Hütte, in the Holland Colliery, near Gelsenkirchen. The plunger in this case has a diameter of 8½ in., and a stroke of 32 in. The pump works at 53 revs. per min., raising 8 cubic metres per minute of water (density 1·005) to a height of 1,980 ft. The three-phase motor can yield 1,300 H.P., but is not fully utilised. The poor efficiency of the electric motor in the first-mentioned case may be due to overheating. The pump is supposed to be more economical than two of half the power, but exact tests have not yet been made.

A New Method of Transmitting Messages by means of Small Electrical Oscillations through the same Circuit.—About a year ago M. E. Mercadier described in the "Comptes Rendus" a method by which he was able to send several telegrams between Paris and Marseilles along a two-wire circuit, not connected to earth, by alternating-current signals of different frequencies, apparatus of the Hughes type being employed. It was also found that these signals could at the same time be imposed on other signals produced by continuous current, provided that with the Hughes apparatus the former lasted about $\frac{1}{25}$th of a second, or, when the Baudot apparatus was used, that the discharges did not exceed $\frac{1}{70}$th of a second. It was of interest from the scientific point of view and very important from the practical point of view to discover whether the same results could be obtained on a single telegraphic conductor connected to earth at its two ends, as is usually the case, or whether these phenomena were adversely affected by the natural earth currents and induced currents due to power transmission in the neighbourhood of the ends of the wire. Experiments have, therefore, been made on a wire between the telegraph central stations in Paris and Lyons, using three Hughes alternating-current instruments, and also a Hughes apparatus and a four-key Baudot apparatus working with continuous-current. M. Magunna succeeded in overcoming the effects of the earth currents at Lyons, where they are particularly strong, with the result that experiments turned out well, as they did in the case where two wires were employed.

Institution of Electrical Engineers.—On Thursday of last week a special general meeting was held to consider two resolutions in regard to the Institution's new home, the proceedings being opened by the president, Mr. W. M. Mordey, with the following remarks:—

We have now reached a very important stage in connection with our new building on the Victoria Embankment.

On June 30th last year, at a special general meeting, authority was given for the purchase of the property for a sum of £50,000. This purchase was duly completed on June 1st this year, the purchase money being provided as follows:—

From the accumulated funds of the Institution ...	£24,000
From a mortgage on the building	26,000
	£50,000

Ever since the meeting of June 30th last year, the Council have been engaged on the consideration of various schemes for adapting the building to the purposes of the Institution, and they have finally decided that it will be in the best interests of the Institution to enlarge and improve the entrance hall and to rebuild the theatre completely. Plans prepared by our architect, Mr. Percy Adams, have been considered, and finally specifications have been issued and tenders obtained for the work. The result is that an expenditure estimated at £18,000 is necessary to cover these alterations in the building and the equipment and furnishing of the large library on the first floor, and of the parts of the building to be occupied by the Institution, including also the cost of a lift and various other matters necessary to adapt the whole of the other parts of the building to the requirements of our tenants, the Colleges of Physicians and Surgeons.

The new theatre will be a very handsome one, appreciably larger than that of the Institution of Civil Engineers, in which we have for so long had the great privilege of holding our meetings. The modified entrance hall will provide a very attractive and convenient means of access to the theatre, library, offices and public rooms.

The funds of the Institution would be sufficient for the purpose of the required expenditure if we sold the Tothill-street site at the price we gave for it—viz., £17,500—a price which we are advised is a low one. It is believed that when the time is more favourable we shall be able to dispose of the site at a profit.

Meantime we have arranged for

A mortgage on the Tothill-street property, of	£11,500
And have securities available amounting to	4,000
A total of	£15,500
As already explained	
The estimated expenditure is about	£18,000
And adding for contingencies and margin	2,000
We require a total of	£20,000
We are therefore short to the extent of about............	£4,500

The sale of Tothill-street at cost price would, after paying the mortgage off, yield £6,000. To meet this expenditure of £4,500, and to justify the Council in putting before the members a recommendation to proceed with the proposed alterations, the past and present members of the Council have guaranteed the difference between the assets and the requirements, on the understanding that if they are called upon to make any payments under this guarantee, they are to be repaid out of the funds of the Institution when available, either as a result of the sale of the Tothill-street property, or from contributions to the building fund, or otherwise.

Two resolutions are before you: the first is necessary to meet the wishes of the Economic Life Assurance Society from whom we have borrowed a sum of £26,000 on the security of the new building; the second is a resolution approving the proposed expenditure.

The resolutions (confirming the arrangement with the Economic Life Assurance Society and authorising an expenditure not exceeding £20,000 respectively) were supported by Mr. R. Kaye Gray and Mr. Robert Hammond, and were carried unanimously.

WEST HAM ELECTRICITY SUPPLY ACCOUNTS.

These accounts, for the year ended March 31st last, which we briefly summarised in a recent issue, have been looked forward to with much interest by electrical engineers in view of the progressive policy adopted at West Ham as regards power supply. Briefly we may say that a surplus of £3,854 is shown in the accounts, compared with a deficit of £4,670 in the previous year, so that considerable financial progress is evident.

Mr. A. H. Seabrook, who has recently taken up his new appointment with the Marylebone undertaking, is still connected with the West Ham undertaking as their consulting engineer. His report on the present accounts is of particular interest. He mentions that the improved financial result, equivalent to £8,523, is mainly due to the increased power demand, which has grown from 4,000,000 to over 8,000,000 units during the past year; but the improvement is also partly due to the fact that the Sales Department has had a complete year under proper organisation, whilst the reorganisation of the generating station has been completed to such good effect that $5\frac{1}{2}$ million units more than in the year 1907-8 have been generated at an additional cost of only £700. Another important factor in the difference between the results of the last two years has been that of capital charges; for some time past heavy capital expenditure has been incurred in laying the foundation of a big power business, and such outlay is only now beginning to be remunerative.

It will be seen from the analysis of the expenditure given below, that the total cost per unit, excluding capital charges, is now only 0·60d., compared with 0·83d. a year ago, showing therefore a reduction of nearly 30 per cent., and we understand that although this figure is one of the lowest ever recorded in this country it is likely to be considerably improved in the next year or two. Mr. Seabrook points out in his report that although the electricity department has been much criticised on account of the sum appearing under the heading of rates the Corporation of West Ham has nothing whatever to do with rating or assessments, these being fixed by an independent and unsympathetic body, the Assessment committee of the West Ham Guardians.

In connection with the revenue it is worth noting that the amount received for private lighting shows a decrease, compared with that in the previous year, the figures being £22,784 and £23,996 respectively, so that the value of the power load is thereby emphasised, and Mr. Seabrook rightly draws attention to the fact that although the sales of high-priced lighting units have decreased, and those of the low-priced power units (which are said by many people to be unremunerative) enormously increased, a greatly improved financial result has been obtained. He also mentions that all the large power users are now customers of the electricity department and appreciate the fact that the Corporation can not only give them a supply of electricity, but are prepared to, and do, supply them with the whole of the accessories in the form of wiring, equipments, motors, lamps, &c., for the use of electricity. The whole arrangement may therefore be considered as self-contained. The department takes the whole responsibility and carries out the complete equipment and supply. In spite of the most powerful opposition this policy is growing, says Mr. Seabrook, and there are obvious signs that it is going to become as general in the electric supply industry as it has become in the gas supply business. Reference is also made in the Report to the sales department, which has made a profit of £500, after being charged with the whole of its own materials and labour, management, printing, &c., and 4 per cent. on all work carried out to cover general establishment charges, &c. Mr. Seabrook does not associate himself with the theory that a sales department need not be self-supporting because it increases the business of the main undertaking. He considers it should stand on its own bottom as a separate organisation. Neither, as a supply manager, does he recognise the theory that a municipal corporation, having electric supply powers, might, for the sake of increasing the business and employment of the borough, supply electricity for industrial purposes below cost price. This, he says, has not been the practice at West Ham, but it is a course of action that he believes the West Ham Council would be perfectly justified in taking if they considered it to be to the interests of the borough generally. He considers that all the departments of a municipality are run for the benefit of the borough at large, and not for each department in particular, and as the very existence of West Ham depends upon its manufactures, the Council would be justified in fostering those manufactures and industries to the best of its ability.

Turning now to the statistics of the year's working, the total number of units sold was 15,522,065; of these 1,928,528 were for private lighting, 735,157 for public lighting, 8,190,453 for power and heat and 4,617,927 for traction. The sales for private lighting show a decrease of almost 200,000 units, whilst the average price received for these units increased from 2·58d. to 2·72d. The average price received for power fell, however, from 0·695d. to 0·591d. per unit, and the average of all supplies from 1·22d. to 1·02d., traction remaining constant at about 0·99d. It is satisfactory to record that the load factor increased from 23·5 per cent. to 29·1 per cent., and that 267 new consumers were connected, the total number of consumers at March 31 amounting to 2,245; 388 new motors were also added during the 12 months, representing 2,459 H.P. and bringing the total horse-power to 8,683. It is interesting to notice that the maximum load recorded only increased from 5,500 kw. in 1907-8 to 6,100 kw. in 1908-9, whilst the plant capacity was increased during the year from 8,400 kw. to 11,400 kw.

We give below an analysis of the expenditure during the last financial year, together with the cost of working per unit sold, the latter figures for the previous year being given for the sake of comparison :—

		Cost per unit sold. 1908-9.	1907-8.
Generating Costs.			
Coal, &c.	£16,104	0·25d.	0·32d.
Oil, waste, water, &c.	675	0·01d.	0·02d.
Salaries and wages at station	4,118	0·06d.	0·07d.
Repairs and maintenance	2,765	0·04d.	0·08d.
Miscellaneous (testing, &c.)	496	0·01d.	0·01d.
Total Generating Costs	£24,158	0·37d.	0·50d.
Distribution Costs.			
Wages	—	0·00d.	0·00d.
Repairs and maintenance of mains, fuses, &c	£3,546	0·05d.	0·07d.
Do. of motors (including depreciation)	1,509	0·02d.	0·04d.
Use of tramway feeders	50	0·00d.	0·00d.
Attending public lamps	1,654	0·02d.	0·04d.
Total Distribution Costs	£6,759	0·09d.	0·15d.
Management Costs, &c.			
Salaries	£2,434	0·04d.	0·05d.
Printing, stationery, &c.	408	0·01d.	0·02d.
General establishment charges	1,345	0·02d.	0·04d.
Special charges	3,018	0·05d.	0·05d.
	£7,205	0·12d.	0·16d.
Rents, rates and taxes	£1,001	0·02d.	0·02d.
TOTAL COSTS (*ex* Capital Charges)	**£39,123**	**0·60d.**	**0·83d.**
Capital Charges.			
Interest	£14,155	0·22d.	0·32d.
Sinking fund	12,477	0·19d.	0·22d.
Contribution to capital account pending borrowing	2,130	0·03d.	0·06d.
Special charges	750	0·01d.	0·01d.
Total Capital Charges	£29,512	0·45d.	0·61d.
TOTAL COSTS (including Capital Charges)	**£68,635**	**1·05d.**	**1·44d.**
TOTAL RECEIPTS (from all sources)	**£72,489**	**1·12d.**	**1·34d.**
BALANCE	**£3,854**	**0·07d.** (surplus)	**0·10d.** (deficit)

The balance of £3,854 was placed to the reserve fund, whic only amounts to £5,886, but Mr. Seabrook points out that n less than £93,000, or over 21 per cent., of the total capit expenditure of £438,558 has been repaid or is provided for the sinking fund, so that as the undertaking is only 10 yea old, a substantial reserve fund is unnecessary. The iten

which make up the above capital expenditure are as follows, together with the cost per kilowatt installed :—

		Per kw. installed.
Land	£119	£0·01
Buildings	78,266	6·87
Machinery and plant	185,251	16·25
Tools	407	0·03
Mains and service	117,680	10·27
Transformers, &c.	34,288	3·01
Meters, &c.	13,366	1·17
Electrical instruments	1,224	0·11
Lamps, columns and fittings	7,355	0·64
Furniture	602	0·05
	£438,558	£38·41

Mr. Seabrook points out that the total capital expended per kilowatt of plant installed is the lowest in the country, and in marked contrast with the statements in regard to over-capitalisation of the undertaking. The capital expended per million units sold is also said to be the lowest in the country.

RECENT DEVELOPMENTS IN TRANSFORMING APPARATUS.*

BY H. W. TOBEY.

Summary.—In this Paper the author describes some recent developments which have taken place in oil transformers, series transformers and small lighting transformers, and in the electric annealing and tempering furnace. Particulars are also given of a modern testing equipment.

Forced Oil Transformers.—As the size of transforming apparatus increased it became necessary to provide additional tank surface in the shape of corrugations or veins in order, not only to radiate the increased amount of heat, but also to maintain a difference in temperature between the upper and lower portions of the oil, so as to cause its more rapid circulation. Even this arrangement, however, proved inadequate, and an internal water-cooling coil was introduced. But the size of units continuing to increase, the amount of heat to be dissipated became still greater, and the seat of its generation more and more remote from the cooling surfaces, so that the forced-oil type of transformer has had to be introduced. Several advantages resulted. With the increased circulation all parts of the coils and core were maintained at a more uniform temperature. This also made it possible to transfer a greater quantity of heat to the oil, and, further, heat pockets were eliminated. Thus it has been possible with this type of construction to reduce considerably the cost of the transformer, but, on the other hand, additional auxiliary apparatus is required in the way of pumps, coolers, &c., which tend somewhat to offset this saving ; in fact, it does offset it where the combined capacity of the individual units is much less than 5,000 kw.

The size of the unit and the voltage affect the adoption of forced-oil circulation for the following reasons : For transformers of comparatively small capacities and high voltages the size of the conductor and dimensions of the coils must be such as to give the required mechanical safety and rigidity. In other words, the conductor and coils are made as small as safety will allow. It is manifest, then, that nothing would be accomplished by resorting to forced circulation. With these considerations in mind, it is usually found inadvisable to make this type in sizes of less than 1,200 kw. to 1,500 kw.

In equipments already designed and built the practice has been to employ two complete sets of cooling and circulating apparatus, one to be used as a spare unit in case of failure of the other. Each consists of a pump for circulating the oil, a surface condenser or cooler, and a pump for circulating the water, all of these being suitably connected to the transformer by means of delivery and return pipes.

This type of transformer is similar to the standard water-cooled type without the cooling coil. Provision is made, however, for the uniform distribution of incoming oil by enclosing the lower part of the coils with a metal box fitted with baffle plates. Oil is led into this chamber by means of a vertical pipe passing down through the cover. The outlet is placed somewhat above the tops of the coils and considerably below the surface of the oil, so that there will be no danger of uncovering the former and so that no air will be drawn into the system. For large plants this arrangement of a cooling system common to a number of transformers is working admirably. There are now installed and in successful operation in various parts of the United States more than 102,000 kw. of 60 cycle 60,000 volt forced-oil transformers.

In some plants where the conditions are suitable, it has been thought advisable to adopt individual coolers and separate oil-circulating pumps and motors. In one installation, consisting of six 5,000 kw. units, the waters in the tail race pass in close proximity to the transformers. This feature was taken advantage of by specifying individual coolers to be placed in the tail race, where the circulating oil can be efficiently cooled without resorting to any auxiliary water-circulating devices. Each unit will also be provided with its own oil pump and motor, making it entirely separate from the others.

There are some plants, however, where conditions preclude the use of individual condensers or coolers ; certain steam-power plants, for example, or water-power plants where the tail race is remote from the transformer house. To provide for such conditions a new type of forced-oil apparatus has been developed which is entirely self-contained. Even the external cooler is done away with, so that the equipment is still more flexible than the one in the installation referred to above. In this apparatus the cooling coil is placed inside the tank, as in the water-cooled type, except that its convolutions extend nearly to the bottom. A cylindrical or elliptical metal casing, depending upon the contour of the tank, separates this coil from the main oil chamber, with the exception of one or more openings at the bottom. By means of an individual motor and circulating pump mounted on the cover or in close proximity to the transformer, the oil is pumped out at the top of the central chamber and into the space enclosing the cooling coil. The head caused by the resulting difference in level thus greatly increases the natural oil circulation through the coils and core. The result is an outfit of extremely simple design, which, on account of its self-contained features, is as flexible as one of the ordinary water-cooled type. It embodies the same features as the forced-oil equipments already built, and at the same time prevents troubles in one unit from spreading to the others. An equipment consisting of two 3,000 kw. transformers of this description is soon to be put in service.

It is customary in forced-oil apparatus to circulate sufficient water to carry away the heat with a rise in temperature of the water of approximately 10 deg. This usually requires about one-third of a gallon per minute per kilowatt loss in the transformer. Approximately the same temperature rise is allowed in the oil, so that the greatest difference in oil temperature between the bottom and top of the tank is not far from 10 deg. The specific heat of oil is a little less than one-half that of water, therefore its theoretical rate of flow would be approximately double. Practice bears this out, except that in some cases it is found advisable to increase the flow of oil to three or 3½ times that of the water. In any case, however, the flow of water and oil should be so adjusted as to avoid chilling the oil and retarding its circulation.

From the foregoing it is evident that, as the size of transformers increases, the tendency is to provide means of increasing the rate of flow of the cooling oil. If we assume this rate equivalent to unity in the self-cooled type, it will be between two and three times this in the ordinary water-cooled design. With the forced-oil type of transformer the rate of circulation by artificial means will be increased from three to four times that of the self-cooled type.

The rate at which oil circulates in the various types of transformers is usually thought to be extremely sluggish. It might be of interest, therefore, to cite a concrete example. For instance, in the 7,500 kw. transformers recently installed, the oil circulates at the rate of 100 gallons per minute, while the calculated rate of flow through the various coils and core channels is something like 30 ft. per minute. Based on these figures, which were obtained from actual measurements, together with results obtained from water-cooled transformers designed for a similar temperature rise, the rate of oil flow is probably not far from 50 gallons per minute for a 7,500 kw. unit, while the oil must pass through the various ducts at the rate of 15 ft. per minute. Even the natural circulation, then, due to the difference in temperature alone, is not so slow as is sometimes imagined.

Future developments are difficult to foretell ; refrigeration has been suggested, and, as this presents several advantages over the methods already in use, it may, perhaps, be considered for certain special designs.

Oil-filled Leads.—Modern power developments have made it necessary to design and build transformers for voltages of 100,000 and above. While the design of the internal parts to meet these requirements was difficult enough, the problem of bringing out the high-tension leads was one which required perhaps fully as much consideration. It has been customary with apparatus of moderate voltage to rely on leads insulated with wrappings of tape, with the additional protection afforded by porcelain bushings. To prevent surface leakage from the end of the terminals to the case, the lead was either made very long or provided with a number of circular barriers or discs. It became extremely difficult and expensive, however, to use this design for apparatus of 70,000 or 80,000 volts, so that the idea occurred to utilise oil. The first oil-filled lead put into service was made up of a series of resin-filled circular wooden sections mounted one on top of the next with pressboard collars between.

* Abstract of a Paper read before the Schenectady section of the American Institute of Electrical Engineers.

In later patterns moulded compound was substituted for the wood, and the oil space inside was broken up into several sections by pressboard tubes extending the entire length of the lead. Openings at top and bottom of these tubes allowed for ready filling with oil and for circulation. With this design, the distance from the end terminal to the body of the lead next to the case is usually about 50 per cent. greater than the natural voltage jumping distance for which the lead is designed, while the length of the creepage path is made about three times this amount by the presence of the pressboard discs. What the final limit of this type of lead will be is not yet known. It has already been used successfully on commercial apparatus requiring tests of somewhat more than 300,000 volts.

One of the desirable features of this type is the ability to distribute the electrostatic strain. Moreover, the oil in the various internal tubes is free to circulate, and thus prevent local heating. Not only has the lead been used to good advantage in high-voltage power transformers, but also in the construction of certain types of series transformers.

Series Transformer.—Previously to about three years ago it was considered sufficient to insulate the series transformer with the same margin of safety as that allowed in potential transformers—that is, double the line voltage. Owing to several reasons, however, it was deemed advisable to require an insulation test of three times that of the operating circuit. In the first place, the secondary of a series transformer is usually earthed; being the first apparatus in the path of a lightning discharge, it often receives the entire blow, and acts in the capacity of a lightning arrester. Moreover, it furnishes current not only to the measuring instruments, but also for the various limiting and protecting devices, and the safety of the attendants depends on its insulation. With increase of pressures former designs became unwieldy and expensive, and in getting out a new type it was evident that the methods used for the insulation of a transformer built on a core without magnetic joints were the only ones that appeared at all practicable. In consequence, it became necessary to investigate the use of a core having one or more joints, it having been previously thought that those of the jointless type were cheaper to build. Contrary to belief, however, it was found that a design could be developed by using a core having joints which not only would be cheaper but at the same time more accurate than those previously constructed. When these points were proved it was natural to utilise the U-shaped punchings which had been so long in successful use in the construction of the core-type transformer. This, then, resulted in the adoption of form-wound coils, the secondary and primary being wound separately and receiving enough varnish tapings to stand the required test voltage. The coils were then assembled on one leg of the core, with the secondary next to the iron and the primary slipped over it, the core being suitably clamped to the frame, which furnished support for the secondary terminals and feet for the mounting of the device as a whole. The resulting transformer had many advantages over the older type, but still left things to be desired, the most prominent of which was shortening of the time required to produce it.

About this time there were great strides in the use of moulded insulation, and the idea occurred to utilise such material in connection with high-voltage series transformers by moulding it completely round the primary coils. This was accomplished only after many trials, for it should be remembered that not only must the compound be a good insulator electrically, but also a good heat conductor; it must be mechanically strong, and designed to withstand repeated expansion and contraction; and it must be capable of being formed round the coil at not too high a temperature, otherwise the cotton covering of the conductor would be ruined. In addition to these requirements, the preparation must not soften at operating temperatures, and must not be too expensive. In spite of these numerous conditions, a compound meeting them all was developed. During the first attempt to use this compound the enclosing casing was moulded in halves, these being placed round the coil and sealed together. During test, however, weakness developed at the joints, and this form was abandoned. The arrangement finally adopted, the one now successfully used, consists of a complete compound ring, the sides of which are open at the top. The primary coil is placed in this ring and the open sides are folded over and forced together under a pressure in excess of 2 tons per square inch, at a temperature of about 200°C. The result is a coil with suitable leading-out terminals enclosed in an insulating casing without a single joint or seam. It readily withstands a test of 50,000 volts. In fact, it will not break down at much less than 80,000 volts. This, then, results in a series transformer that is absolutely safe for operation on 15,000 volt circuits, is neat in appearance, is less expensive to build and can be made in a much shorter time.

It is interesting to note that the length of time consumed in insulating coils with tape, using the original method, was more than 20 days; the new method requires 30 minutes.

We have been considering the use of dry types only, requiring tests as high as 50,000 volts. On general principles, however, it would be preferable to resort to oil much below this point. But this has not been considered advisable, owing to the strong preference to avoid its use in switchboard construction. Oil is used, however, for all transformers requiring a pressure test of more than 50,000 volts. The arrangement of coils and core in this type of transformer is somewhat similar to that for the lower voltage dry transformer using ring punchings. The usual practice is to wind the secondary directly on the core, and to provide a number of tabular barriers, nested one within the other with oil spaces between for insulation, the primary being threaded through as already mentioned. This construction, combined with the oil-filled lead previously described, has been used successfully for apparatus requiring tests as high as 300,000 volts.

Lighting Transformers.—A great deal of attention has been given to this type in the way of reducing losses, improving the operation and lowering the cost without affecting durability and safety. Considering one particular size, the 5 kw. size for example, it was usual 10 years ago to find the core losses approximating 90 watts or more. Improvements in material and design brought this core loss down to 80 watts, and still later to 70 watts when silicon iron was introduced. Then an entirely new form was designed and the core losses were again reduced 10 or 12 per cent., bringing them to slightly more than 60 watts. During the last year still another improvement has been made in transformer iron; by taking advantage of this improvement and again modifying the design, the core loss on the 5 kw. size was reduced to 45 watts. Thus, in 10 years' time, by steady improvement in design and by using the best material, the core loss has been reduced to half its original amount. During the same time the quality of the apparatus has steadily improved and the cost of manufacture has been lessened.

Among the features of interest in the latest design, perhaps the most noticeable are the symmetrical arrangement of the coils and core, and the ingenious interlocking of the latter in the central leg. These features, together with a correct proportioning of parts, have resulted in a relatively short mean length of iron and copper circuits. Another important feature of this design is the restricted area in the central core. This results in, first, the shortening of the mean length of turn in the copper circuits; secondly, an increase in flux-density in the central leg of the magnetic circuit. Such an increase in density results in higher losses in this part of the core, but they are more than offset by low losses in the four external magnetic circuits, where the area of cross-section can be made large without in any way interfering with the space occupied by the winding.

Tungsten Lamp Compensator.—This device was developed to accommodate low-voltage tungsten lamps to standard circuits, usually reducing the latter voltage in the ratio of about 4 to 1. It is so arranged that it can be inserted in an ordinary lamp socket. Although the capacity is small (25 watts), it has been possible by careful design and correct proportioning of material to obtain an efficiency of over 85 per cent., and this efficiency is maintained for voltages ranging from 110 to 130 and for loads ranging from full to less than half.

The electric hardening and annealing furnace, which has been developed during the past few months, has many valuable features. Its bath is composed either of pure barium chloride, of a mixture of the chlorides of barium and potassium, or, in some cases, of a mixture of potassium chloride and sodium nitrate, depending on the temperature at which it is desired to operate. By selecting the proper mixture and adjusting the current which flows directly through the bath, any temperature from 200°C. to more than 1,300°C. can be obtained and held at a perfectly uniform value.

Transformer Testing Equipment.—The equipment as now installed is entirely non-combustible—the floors are of concrete, the framework of piping and angle iron, and the switchboard of slate and marble. All voltages above 500 are considered dangerous and are treated accordingly, by protecting them and keeping them out of reach. To reduce the fire risk, and at the same time to facilitate the making of connections, &c., a pit 7 ft. deep, from 14 ft. to 20 ft. wide, and over 130 ft. long has been installed, in which are placed all oil-filled transformers while on test. This pit is provided at one end with a 30 in. drain pipe leading to the river, so that in case of fire the oil can be readily removed. As a still further safeguard, a 2 in. pipe connected with the live-steam supply has been arranged for. This will make it possible to smother a fire by steam, should oil at the bottom of the pit become ignited. All oil for testing is stored under ground and entirely away from the main building. When it is considered that the testing equipment is located in the midst of a floor area of more than 9 acres, 60 per cent. of which is covered by one roof, the importance of these precautions cannot be overestimated.

The majority of the generators and the testing transformers have their windings arranged in eight sections, so that they may be grouped

all in series, all in parallel, or in series parallel. This construction, together with the regulating winding and field control, makes it possible to obtain any desired voltage at a moment's notice. The eight-section arrangement is carried out also in the three-phase apparatus as well as in the single phase. The ammeters for these machines, instead of being inserted in the outside circuit, as is customary, are connected into one winding only, so that, regardless of the arrangement of connections, the instrument indicates at all times the proportionate load being carried. This largely eliminates danger of overloading due to the numerous forms of connections which are possible. The fields of all generators and motors in the test, both alternating current and direct current, are designed for excitation at 125 volts. Each direct-current generator is provided, not only with an ordinary circuit-breaker and no-voltage release, but also with a speed-limiting device which automatically cuts the machine out if the speed exceeds a certain predetermined value. The ratio-transformers are all made for 25 cycles, and cannot be burned out at low frequencies, an accident which has occurred more than once when those of 60 cycle design were available.

One operation during the testing of transformers, particularly when they are of large size, and one which has always required a large amount of time and expense, is the heat run. Even when this is hastened by an overload, as has usually been customary, a number of hours elapse before the cold oil is brought up even to normal operating temperature, and, moreover, all heat must be supplied electrically. These two drawbacks have been overcome in the new equipment by heating the oil by steam before it is forced into the transformers. The oil as it comes from the heater is stored in a large tank, where it can be drawn off as required, and on the completion of the heat run the oil from the various pieces of apparatus is again pumped back into this tank, so that its temperature can be maintained at a comparatively small cost.

Another saving has been introduced in connection with the use of water for cooling water-cooled transformers. One of the conditions of test is that this incoming water shall be maintained at a uniform temperature of 15°C., which means that during winter weather every gallon used must be raised at least 10 deg. This has ordinarily been accomplished by passing it through some type of heater, allowing it to escape into a drain after accomplishing its purpose. In the new equipment, the water discharged from each transformer is led back to the receiving tank and mixed with the cold incoming water in such proportions as to maintain a temperature of 15 deg., thus saving the expense just mentioned. Thermostats and controlling devices automatically maintain this uniform temperature.

To eliminate the effect of low power-factors on the main generating plant, and to add to the flexibility of the testing equipment, the two-phase 60 cycle power, as originally generated, is not taken from the incoming lines until it has passed through motor-generator sets, these sets being installed on the floor of the testing room. By suitable excitation, then, the power factor of the generating station is maintained at a remarkably high value, usually about 97 per cent., while the power factor of the testing load varies between 10 to 40 per cent., averaging not over 25 per cent.

The various individual testing boards are provided with similar sets of current and potential transformers, voltmeters, ammeters and wattmeters, all of which are connected to special switches by permanent wiring. These arrangements are so complete that the man in charge of a test, by merely operating certain switches, can measure any loss or load from 37 volts to 15,000 and from 0·5 to 500 amperes, at power factors ranging from 10 to 100 per cent., while frequencies of 25, 30, 40, 50, 60 or 80 can be obtained at a moment's notice. All things considered, the equipment in point of safety to life, efficiency of operation and general arrangement is, so far as I know, the most complete of its kind.

A LAST WORD ON THE NEW "TELEFUNKEN" SYSTEM.

BY GRAF ARCO.

When THE ELECTRICIAN of June 18th last appeared with the article of Herr von Lepel on p. 374, I was away and could not, therefore, reply. The editor of THE ELECTRICIAN was informed of this by a telegram from the Telefunken Company.

I should like to recur to this and answer Herr von Lepel's following three statements. According to Herr von Lepel :—

1. At the beginning of 1907, he, Herr von Lepel, showed Herr Rendahl and me his transmitter arrangement, and requested our secrecy. A year later, under the name of "singing sparks," the Telefunken Company made public a method taken from Herr von Lepel's.

2. The similarity between the "singing sparks" and von Lepel's arrangement was so great that even the Telefunken engineers in their laboratory called the new Telefunken arrangements the "Lepelei."

3. In my publications I had knowingly told an untruth in not only ignoring von Lepel's patents, but even stating I had no knowledge of his apparatus.

With regard to No. 1: What did Herr von Lepel, at the beginning of 1907, really show Herr Rendahl and me? Herr von Lepel came to the Telefunken Company to offer us his new generator for, as he alleged, undamped oscillations, and soon after showed it us in our laboratory. The generator consisted of two massive iron cylinders of about 2·5 cm. in diameter and 5 cm. in length, the front surfaces of which were ground flat. He fed it by a continuous current at 220 volts, inserting in series with the generator an incandescent lamp, the two iron cylinders being connected at the same time with an oscillatory circuit consisting of a capacity and self-induction. To set this arrangement in action the front surfaces were smeared with a liquid (partly a special oil, partly a solution in spirit) and then put very close to one another. (I estimate the distance at considerably less than 0·1 mm.) After troublesome experiments and regulation we succeeded in producing oscillations for some minutes. These were recognised by the flash of a small incandescent lamp of about 10 to 20 watts, which under the most favourable circumstances burnt for a few minutes with a flickering irregular light. (I should here like to remark beforehand that also the improved generator shown us two or three months later by Herr von Lepel in his house, like the first, showed the same incompleteness, both with regard to difficulty in the regulation and irregularity of working.) Herr von Lepel then maintained that the electric oscillations were undamped. We took a wavemeter, explained to Herr von Lepel its principle and use in taking resonance curves according to Bjerknes, and in this way ascertained that the oscillations produced were not only not undamped, but even more strongly damped than those of normal spark-exciters. We were, therefore, obliged to decide that the arrangement was unsuitable for telegraphy, on the one hand on account of the irregularity of working, and, on the other, on account of the damping of the oscillations. We expressed, however, the opinion that the great damping would perhaps be admissible for telephony, and that the arrangement, therefore, might be worth consideration for this purpose.

With respect to the possibility of getting the arrangement patented, I remarked on the following points to Herr von Lepel: In my opinion it would be very difficult to get effective patent protection for the arrangement shown us. At the most, only the special liquids with which he smeared the electrodes, would come under consideration. I further remarked to Herr von Lepel that, in spite of the failures so far, the Telefunken Company was interested in the matter to a certain extent, because the employment of a continuous low-tension current for feeding would have been serviceable, and the improving of the arrangement was not quite out of the question. The Telefunken Company, therefore, made an agreement with Herr von Lepel to the following effect :—

For a few hundred marks Herr von Lepel bound himself to place the arrangement at the disposal of the Telefunken Company for several weeks, and to do his best in the mean time to improve the arrangement.

Within this time of option Herr Rendahl and I, on a fresh invitation from Herr von Lepel, went to see him in his own house, because, as he alleged, the arrangement there worked much better. We found, however, the same state of things as above mentioned, with the only exception of a screw attached to the generator for its better regulation, but which proved to be of no use whatever.

These are all the technical arrangements and experiments the Telefunken Company was ever shown by Herr von Lepel. I should like to state most emphatically that on no occasion were we shown such a generator circuit, as Herr von Lepel avers, coupled with a secondary circuit, not to speak of any

"stosserregung" produced by it. Never was a secondary circuit associated with a generator circuit, and Wien's method, forming, as is well known, the principle of the "singing sparks," was never tried.

With regard to No. 2. Do the Telefunken Company's engineers really call the arrangements for producing "singing sparks" the "Lepelei"?

I have expounded under No. 1 what Herr von Lepel showed us, and in my lecture at Cologne I described the apparatus with which the Telefunken Company is working at present. From this description every expert will understand the difference in the technical means, and will never believe that the Telefunken Company's engineers called the "singing sparks" the "Lepelei." But as Herr von Lepel, at the end of his article, plays this argument as his trump card, I will, unnecessary as it appears, add a few words.

I feel perfectly convinced that Herr von Lepel himself does not believe the expression "Lepelei" was or is used seriously for our present system. I can assure Herr von Lepel the assertion has caused the greatest amusement among our engineers, and although, as I find is true, the expression was used, and rightly, it was a nick-name of a decidedly "uncomplimentary" nature, temporarily employed by some disdainful engineers at the time when, in the laboratory, at my instigation, a generator was used for experimental purposes such as Herr von Lepel had shown us, with massive iron electrodes fed by a continuous low-tension current, the electrodes smeared with liquid. It is perhaps not uninteresting to state that the results at that time agreed with those of Herr von Lepel. We succeeded in producing oscillations with a continuous current at 440 volts and an electrode distance of about 0·05 mm., when the electrodes had been smeared with oil or spirit. The working of the generator was very uncertain and irregular, and under the most favourable circumstances stopped at the moment when the liquid covering the electrodes was exhausted. Though the oscillations showed a very considerable damping, arc-like, but not spark-like, discharges could be noticed when a proof-spark gap was fed by the excitation circuit. With this arrangement, which has justly been called the "Lepelei," the discharges of the condenser take place at a very high rate, perhaps some 10,000 per second, and occasionally even at a higher rate. In connection with this, one might, perhaps, try to give a definition of arc and spark-excitation serviceable for certain purposes. By arc-excitation one might understand that method of producing oscillations by which the rate of condenser discharges is equal to or about the frequency of the oscillations; by spark-excitation, that method by which this rate is considerably less. The expression "Lepelei" did not last any longer than this short experimental stage. We then reverted to the pure "Wien" method, using an alternating high-tension current with only 1,000 condenser discharges at an oscillation frequency of more than 100,000—*i.e.*, we returned to a pure spark method with considerable intervals between the trains of oscillations; we constructed spark-gaps of particularly suitable material and of a new special form, and finally transformed all the apparatus. In short, thus arose the new Telefunken system, at which a considerable number of very able, indeed eminent, engineers had been working indefatigably for almost a year, a system which is described in numerous German patent applications, certain of which are lying open now at the patent office. Has Herr von Lepel really the courage to claim as "Lepelei" the contents of all, or at least part, of these applications?

With regard to No. 3: Have I, in my publications, knowingly ignored the patents granted to Herr von Lopel in the different countries?

First of all, I mentioned the French patent in THE ELECTRICIAN of March 21, p. 229, and expounded the reasons why I was obliged to suppose Herr von Lepel now no longer used this apparatus. This patent was mentioned and commented upon also in my lecture at Cologne. It is true that I did not mention Herr von Lepel's German application lying open at the Patent Office. The latter, moreover, is taken entirely from the French patent, so that any special mention of it was unnecessary, even superfluous. Nevertheless I had referred to it in my notes. But the footnote mentioning Lepel's German application had been struck out by the patent office of the Telefunken Company because the criticism of a German application, which is lying open at the Patent Office, is not permitted by law, vide Seligsohn: "Patentgesetz p. 297, and Damme: "Das deutsche," Patentrecht," p. 103.

In his article in THE ELECTRICIAN Herr von Lepel having mentioned, regardless of the Act of Parliament, the Telefunken Company's German patent applications lying open at the Patent Office, and translated the text arbitrarily into English, has thus encroached on the rights of the Telefunken Company, and laid himself open to legal proceedings.

The final settlement of the dispute over priority, in the legal and patent question, will slowly and in due course be made by the German Patent Office, or perhaps in a court of law. The examination of the witnesses for the gentlemen concerned will probably be necessary, but the result will be conclusive. Herr von Lepel has raised an objection to a great number of the German Telefunken applications, maintaining they have been unlawfully derived. He will have to give reasons for this assertion. With these remarks I myself irrevocably decline any further discussion on the subject in the technical press, even if he should think of reproaching me with having stolen the Bank of England! I, however, bind myself in THE ELECTRICIAN to make public the final judgments of the German Patent Office, and eventually of the German Courts of law as soon as they are given.

After thus describing, on the one hand, the arrangement of Herr von Lepel that we tested at his renewed request, and, on the other, in my lecture at Cologne, those arrangements the Telefunken Company is using, the expert unprejudiced reader will be able to judge even now whether Von Lepel's imputations are just in accusing Herr Rendahl and me of unlawfully appropriating his system, and in accusing me of having in my publications knowingly ignored the truth.

It is a well-known custom of Englishmen, in all debates, never to allow the matter to become personal. Also Herr von Lepel in his article says that he has aimed at this, but whether with success is an open question. In any case I believe I am entitled to suppose he will approach this ideal much nearer when he has gone through a 10 years' hard and exceptional experience as an engineer as I have myself.

THE ELECTRIC POWER SUPPLY OF CHICAGO.

(*Concluded from page 626.*)

QUARRY-STREET STATION.

The general lay-out of the Quarry-street station differs somewhat from that of the Fisk-street station just described. Owing to the narrower site the boilers are in two parallel rows instead of the equipment for each unit extending at right angles to the turbine room as at Fisk-street. For the same reason the switch house is included in the station building instead of being a separate structure as at the older station. Although the Fisk-street station now has a record of steam consumption of 12·94 lb. per kilowatt-hour, nevertheless it is expected that the efficiency of the new station as a whole will be better than that of its more imposing neighbour.

A general idea of the arrangement of the plant can be obtained from Figs. 17 and 18. Completed as planned, the building will be 463 ft. long and 208 ft. wide, and will contain six 14.000 kw. units. The portion now built is a little over half of this, or about 270 ft. long and of the width mentioned, and three 14,000 kw. turbo-alternators have been installed. The station comprises four sections, separated by fire walls, and extending longitudinally the whole length of the building. These are the train shed, on the north side, where the coal cars are received, next the boiler room, then the turbine room, while the switch house forms the southern section. In the south-west corner is the Quarry-street substation, while various offices, lavatories, test rooms and the like are provided. Elaborate provisions for the welfare of the men are not needed, owing to the proximity of the Fisk-street station. The turbine room in particular, over 60 ft. high, impresses one by its size; it contains the largest prime movers in the world in point of rating, but they do not look large in it.

The operating room or gallery is in the switch house, but extends through into the turbine room with a curved glass front. It will be in the centre of the southern wall of the turbine room when completed and about 35 ft. above the floor. From this point the

operator can survey not only the generating units, but also the accessories, such as boiler-feed pumps, oil pumps, oil filters, &c., which are not placed in a dark corner of the boiler room, as is sometimes the case. The turbine room is finished in white enamelled brick. There is a visitors' gallery running along the north wall, and another interesting feature is a permanent railroad track extending for the whole length of the building between the row of turbines in the centre and the south wall of the room.

The Quarry-street station may be said to embody the very latest advances in electric power-house design. These are:—(1) The size of the units, said to be the largest prime movers in use in the world. (2) The ventilation of these units is entirely new. (3) The degree of vacuum obtainable in winter is actually 98 per cent. of the absolute zero of pressure. (4) By a boiler setting new to central station power-house design practically smokeless combustion is secured. (5) The plant will require a minimum of labour. (6) A split-pole rotary converter is installed (said to be the first machine of its type). (7) Electrical connections in the switch house are compact and comparatively simple, with several new features, including specially designed disconnector switches at the base of the oil switches which add much to the safety of operation.

Arranged in two rows parallel to the turbine room are eight watertube Babcock & Wilcox boilers for each turbine unit. Each boiler has 5,000 sq. ft. of heating surface, exclusive of the superheating surface. The boilers are designed for 225 lb. gauge pressure and for a maximum steaming capacity of 35,000 lb. per hour. The superheater is designed to give from 150°F. to 175°F. of superheat when the boiler is operated at 30,000 lb. of steam per hour.

As mentioned above, the boiler setting, it is stated, represents a new departure in power-house design adapted from recent marine practice. The furnace is placed under what is ordinarily the rear header of the boiler. This arrangement makes a somewhat higher setting than usual, but it enables considerable improvement to be made in boiler efficiency. It embodies the idea of a long flame chamber expanding in volume to aid combustion, as opposed to the old practice of a short flame chamber and contraction in volume, which prevented complete combustion. Owing to the greatly increased size of the combustion chamber, complete combustion is obtained before the hot gases come in contact with the heating surfaces of the boiler. Thus, the operation of the plant is practically smokeless, while the efficiency of the boiler is increased and there is a distinct advance in economical working.

The turbo-alternators now in use consist of five-stage Curtis steam turbines direct coupled by means of a vertical shaft to General Electric 9,000-volt, three-phase, 25-cycle, four-pole, revolving-field generators. The speed of operation is 750 revs. per min., and the units are rated at 14,000 kw. on the new maximum continuous rating; that is, for 24-hour service. The machines stand about 27 ft. above the floor. Including the condensers in the basement, the entire height of each unit is 33 ft. 4 in., while the diameter is 14 ft. 8 in. The turbines are arranged in right and left order, and between them are placed the auxiliaries.

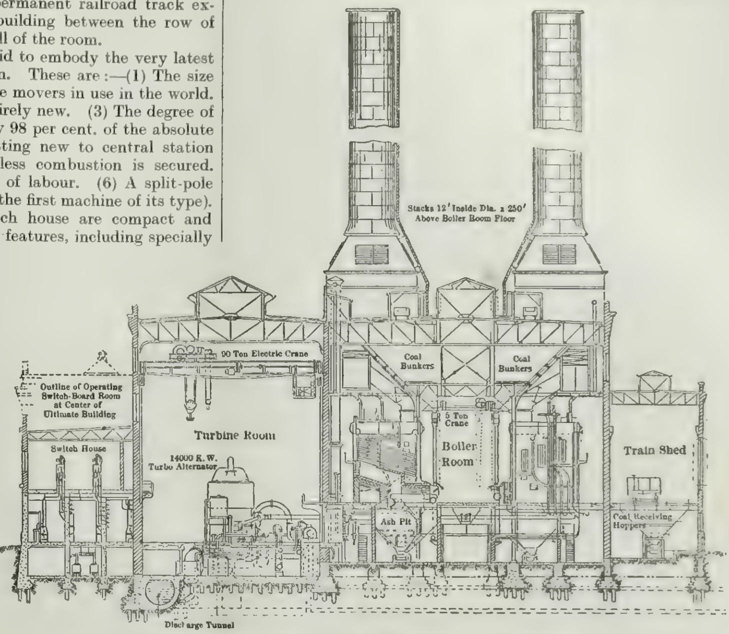

FIG. 17.—CROSS-SECTIONAL VIEW OF QUARRY-STREET STATION.

The condensers are arranged horizontally in the basement and are situate two-thirds under their respective turbines and one-third to the right or left under the space used on the floor above for auxiliaries. This is a new and important development, for it contributes greatly to the absolute steadiness of running which is so greatly desired. Each condenser has 25,000 sq. ft. of surface.

FIG. 18.—ELEVATION OF TURBINE ROOM, QUARRY-STREET STATION.

As to the means adopted to secure ventilation of the generators; in the basement is a specially constructed air chamber connected with the outside air. A great elliptical air duct equal in area to a

circle of more than 6 ft. in diameter, which leads from this chamber to the top of the turbo-generator, is a very conspicuous feature of the machine. Vanes are placed on the encased revolving field core, which thus acts as a gigantic fan and draws air through the duct, thoroughly ventilating all parts of the machine. The heated air is blown out through the laminations of the stationary armature and rises to the top of the turbine room, where there are numerous window openings. This arrangement necessarily takes up a good deal of space, but it is simple, automatic and very effective.

In the main shaft, between the turbine and the generator, is inserted a flexible friction coupling which in the case of a short-circuit or the machine getting out of phase yields to the stress, thereby protecting the unit from serious injury. This is another new feature, tried for the first time in the Quarry-street station.

Excitation of the main generators has been most carefully provided. For the six ultimate units five 150 kw. exciters will be installed, three driven by horizontal Curtis steam turbines and two by 25-cycle, 220-volt induction motors. In addition there is an excitation storage battery of 70 cells in the basement, whilst in an emergency the split-pole rotary converter of the substation could also be used for excitation.

Two switchboards are placed on the turbine-room floor. One is for the exciters and the storage battery, a feature being that all the motor-operated rheostats are placed on top of the board in plain view. The other board is for the distribution of energy for the local 115-230-volt, three-wire, direct-current service. The six leads from each of the generators are in tile ducts cemented in. They follow the under side of the air duct down to the basement and continue to the switch house adjoining.

The switch house has two storeys and basement, with the addition of a third storey in the longitudinal centre of the ultimate building

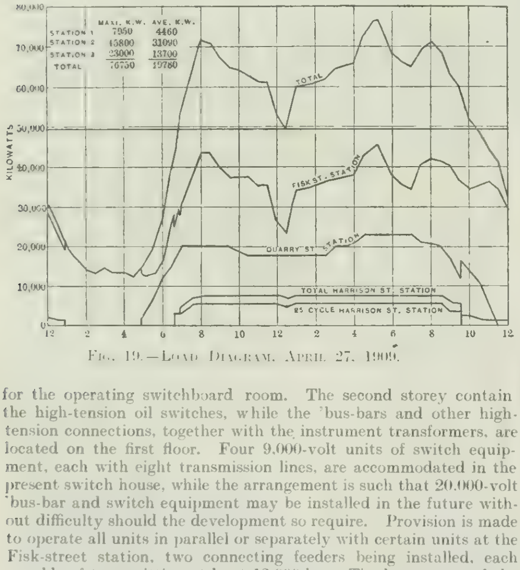

Fig. 19.—Load Diagram, April 27, 1909.

for the operating switchboard room. The second storey contain the high-tension oil switches, while the 'bus-bars and other high-tension connections, together with the instrument transformers, are located on the first floor. Four 9,000-volt units of switch equipment, each with eight transmission lines, are accommodated in the present switch house, while the arrangement is such that 20,000-volt 'bus-bar and switch equipment may be installed in the future without difficulty should the development so require. Provision is made to operate all units in parallel or separately with certain units at the Fisk-street station, two connecting feeders being installed, each capable of transmitting at least 12,000 kw. The basement and the first floor are divided for their entire length into three chambers, but the second floor contains all the oil switches for four switch units in one room. The oil switches are arranged in two rows, one for group or tie switches between the generator, transfer and line 'bus-bars, and the other for the outgoing high-tension transmission lines. Eight switches are built together in each row to insure stability and economise space.

Simplicity in design characterises the high-tension 'bus-bars and their connections and compartments. All 'bus-bars are arranged in vertical position, each conductor being confined to a special fire-proof compartment and supported on porcelain insulators. All 'bus-bar barriers and shelving are made of "Elecrete," a new form of concrete designed for electrical use. All copper bars and rods, properly insulated, are separated by barriers, and the instrument transformers are likewise contained in "Elecrete" compartments with special chambers for fuses within easy reach.

The generator leads for each phase, consisting of 1,000,000 circ. mil lead-covered cables, after leaving the series transformers, are taken to the generator and transfer 'bus-bar oil switches, enabling energy to be furnished to the feeders of any switching unit. The transfer 'bus-bar is located above the generator 'bus-bar on the same wall and runs throughout all switching units, sectionalised at certain points by means of oil switches, while the generator 'bus-bar is individual for each unit. The line 'bus-bars are two in number for each switching unit, with four transmission lines connected to each bar.

The operating room, on the third floor of the switch house, but also opening into the turbine room, contains all switchboards for the operation of generators and lines. Machine control and line control are effected on two distinct boards arranged in curved form and nearly opposite each other. This gives the switchboard attendant an unobstructed view of all meters and controlling instruments. He is also in position to take a general survey of the whole turbine room. All oil switches, generator field switches and field rheostats are remote-controlled by means of an auxiliary low-tension system operating at 115 volts.

A local substation with the usual arrangement of transformer, rotary converter and switchboard is placed on the first floor at the west end of the switch house. It is of unusual interest because it contains, in commercial service, what is said to be the first experimental split-pole rotary converter ever built. This type of machine does away with the potential regulator, and was described in a Paper by Mr. C. W. Stone in The Electrician, April 24, 1908, p. 57. In any synchronous converter the direct-current voltage has a definite ratio with respect to the alternating-current voltage impressed upon the collector rings and this can be varied within certain limits by changing the width of the pole arc. The function of the regulating pole is to vary the width of this arc and hence the ratio of alternating to direct-current E.M.F. by assisting or opposing the flux in the main pole. The machine is of 500 kw. rating. The output is used at present for supplying energy to lamps and motors in the station. Energy is used also for charging the battery.

Unusually complete fire protection is afforded at the Quarry-street station. A 1,000 gallon, 125 lb. centrifugal motor-driven fire pump delivers water to a permanent piping system, with hydrants placed at convenient points about the building and property. The piping system has a further connection to the river, by which a fire boat could force water through it. In addition, there is a similar connection on the street, to which fire engines could be attached. Moreover, the building is as nearly fireproof in construction as human ingenuity can make it.

In conclusion, we may refer to Fig. 19, which shows the total load on the system for April 27th last. It will be seen that between 7 a.m. and 10:30 p.m. the load never fell below 50,000 kw., whilst reaching a maximum of only 76,700 kw., conditions which must be considered almost unique in electricity supply. It is also of interest to compare this diagram with Fig. 1, which shows the load for a day in December last, and an estimate can then be made of the lighting "peak."

The description of the Chicago electric power supply given above is taken from articles which have appeared in the "Electrical World," whilst some of the illustrations are from Mr. Philip Dawson's forthcoming book on "Electric Traction on Railways."

Electric Pumping for Irrigation.—According to the "Electrical World" the water for the canal and ditches forming the irrigation system round Mercedes, Texas, is pumped from the Rio Grande by means of electrical energy which is supplied from a central power plant situated in the town of Mercedes, 7 miles from the pumping station. The Mercedes plant will be one of the largest electrical pumping irrigation systems in the world when the plans are fully carried out. Water will be supplied for more than 200,000 acres of land, situated in the valley of the lower Rio Grande. The central power plant at present generates at 6,600 volts, the three-phase currents being transmitted to the pumping station situated upon the bank of the river, 7 miles distant, where they operate an induction motor driven pump, which has a capacity of 60,000 gallons per minute. The equipment of the central power plant consists of two generators of 300 kw. each and a 15 kw. lighting set for supplying the town of Mercedes, when the main sets are shut down. The main canal of this system is already completed for many miles across the valley land, and carries a stream of water 145 ft. wide and 10 ft. deep. The canal is capable of being navigated by barges and boats. There are a number of other small electric pumping plants along the upper course of the Rio Grande river, particularly in the vicinity of Laredo, where a number of farmers receive electrical energy for operating their respective pumping stations from the electric power plant in the town.

THE MERCHANT VENTURERS' TECHNICAL COLLEGE, BRISTOL.

ELECTRICAL EQUIPMENT OF THE NEW BUILDING.

(*Concluded from page 630.*)

ELECTRICAL ENGINEERING LABORATORY.

The new electrical engineering laboratory (Fig. 13) has not been inaptly termed the focus of all the electrical systems in the building. It is a wide airy room measuring 76 ft. by 22 ft., in which, as mentioned above, are placed the main switches and meters controlling the supply of alternating and direct current from the city mains for both lighting and power, as well as distributing switches and the starting gear for the main ventilating fans, while the main lighting switchboard is just outside this laboratory. The controlling pendulum for the electrically worked clocks and the machine which controls the ringing of the college bell (already described) are also placed here, and are directly under the control of the professor of electrical engineering. Most of the electrical experimental plant of the college is installed in this laboratory, but a large amount of machinery which is in daily use throughout the building for various purposes is also available for the students to work on. Such apparatus includes two 25 kw. dynamos in the engine room, a 15 H.P. motor with an automatic starter in the engineering workshop, ventilating fans, and the lift and various other motors.

The main part of the equipment for demonstrating the characteristics of the chief types of machines, and their behaviour when running, consists of seven machines set with their shafts in line, and arranged so that any two or more adjacent ones may be coupled together mechanically. An arrangement of terminals (Fig. 15) similar to that described below for the battery system is also available in this laboratory, banks of these terminals being placed opposite each machine on the wall, so that any desired electrical connections can easily be made. Easy control is, therefore, obtained while an almost total absence of loose wire is another much-to-be-desired result. Several extra attachments on the machines, including a special brake, provide an exceptionally good opportunity for studying thoroughly and measuring accurately the various properties of electrical machinery. In this connection we may draw attention to a very complete system of hand-rails which is provided to prevent accidental contact between students and machinery. These hand rails are so arranged that they can be withdrawn when a close inspection of the machinery is necessary, but when it is running they are fixed in place and prevent any accidents. Owing to the arrangement of the terminals mentioned above, all measuring instruments and controlling apparatus are placed at some distance from the machine, so that the experiments can be carried out with a maximum of ease and a minimum of danger.

The experimental machines erected in this laboratory include a four-pole open-type dynamo, by Mavor & Coulson, with shunt-wound fields. Its rated output as a motor is 5 H.P. at 500 volts, or $2\frac{1}{2}$ H.P. at 250 volts, the speed being 1,200 and 600 revs. per min. This machine was specially built for use in the college. Its armature is provided with six slip-rings, so that one, two, three or four-phase currents may be obtained, or it may be driven as an alternating-current motor, and thus used as a rotary converter. It is fitted with two exploring coils for use with the oscillograph. One of these shows the distribution of the flux, and how the armature reaction changes this with the load. The other is a new type of indicating coil, by means of which the changes of the current in an armature coil, while it is short-circuited by the brushes, can be studied without sensibly affecting the normal conditions of the armature circuits. A pair of exploring brushes can be moved round the commutator by means of a separate rocker, and are used to demonstrate the effect of armature reaction in modifying the distribution of voltage from segment to segment. An instantaneous contact device is attached to the shaft for finding wave forms by the point-by-point method. This method is used as a check on that of the oscillograph, but has not been otherwise much used since the latter was introduced.

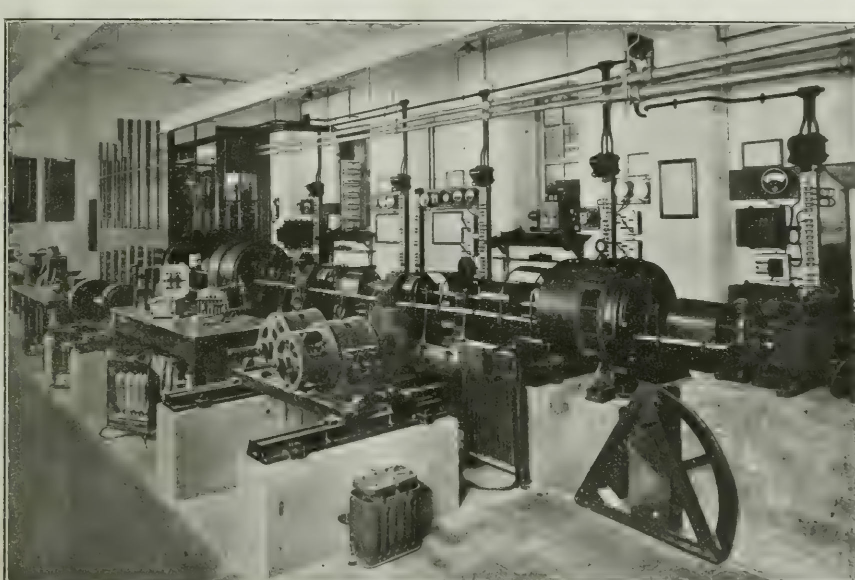

FIG. 13.—PART OF THE ELECTRICAL ENGINEERING LABORATORY.

The brake mentioned above for use with these machines

is of the Thomson pulley type, though greatly improved as regards ease of adjustment and accuracy of measurement. By its means it is said that the mechanical output can be measured with at least as great an accuracy as the electrical input.

The next machines in this laboratory are two eight-pole six-phase alternators fixed on one bedplate, and made by the Electric Construction Co. These each give an output of 3 kw. at 50 volts per phase and a frequency of 93 per second. The stator of one of them is mounted on ball bearings, and is provided with a lever for measuring the torque. The two may be coupled together and run as generators driven by either of the adjacent machines, or one may act as generator and the other as motor for a Hopkinson test, or one may be synchronised with the city mains and run as a motor therefrom. There are two over-type machines with shunt-wound fields and a rated output of 40 amperes at 105 volts, made by the Newton Electrical Works, as well as a four-pole variable speed ventilated motor by Messrs. Mavor & Coulson, and a Manchester-type dynamo by Messrs. Mather & Platt, which can be experimented upon by the students and their various properties put on record.

without undue mutual interference. There can be no manner of doubt that it is perfectly adequate to take its place as part of the Faculty of Engineering in the new Bristol University.

The battery house which adjoins the electrical engineering laboratory contains the three batteries mentioned below, and which have been supplied by the Electrical Power Storage Co. The positive battery contains 10 E.P.S. DH 11 cells, having a normal discharge current of 60 amperes for seven hours, or 175 amperes for one hour. The normal and maximum charging currents are 60 and 90 amperes respectively. The middle battery has 15 and the negative one 35 E.P.S. SH 7 cells, the normal and maximum discharge for these being 25 amperes for seven hours or 78 amperes for one hour, while the normal and maximum charging currents are 27 and 40 amperes respectively.

Engine and Testing Room.

There is a certain amount of interesting plant, from the electrical point of view, in the engine and testing room (Fig. 14). A reciprocating steam engine and a De Laval steam turbine

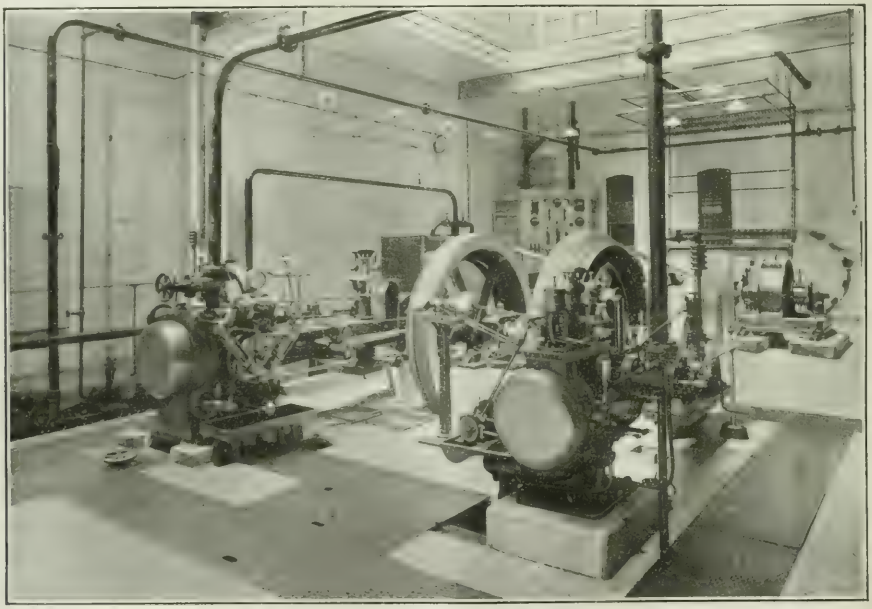

Fig. 14.—Part of the Engine and Testing Room.

There are also a number of small machines in the laboratory, including 3 H.P. and ½ H.P. Siemens motors, and two three-phase induction Brush motors. A transformer by Messrs. Crompton & Co. is also erected, and steps up the voltage from 105 to 1,500 volts. The laboratory is also well provided with oscillograph, meters and galvanometers and other measuring instruments. The galvanometers are arranged on special pillars to avoid vibration, and are erected in pairs, the beams crossing each other and impinging on scales placed opposite them on a triangular-shaped bench. Adjoining the laboratory is the photometer room, in which electric lamps can be tested. It is furnished with standard lamps, a Wright steel-tube photometer bench and photometers of various types. The potentiometers for measuring the current and voltage are placed in the main laboratory, and the students working them can be communicated with through windows.

This electrical laboratory, a general view of which is given in Fig. 13, is, as will be seen, well equipped, and is so arranged that a large number of students can work in comfort and

are installed at one end, with their auxiliary pumps and necessary testing appliances. The other end is occupied by machinery which is used for testing materials.

The experimental engine is of the horizontal compound condensing type, and is built in such a way that a number of experimental determinations can be carried out on it by students under working conditions; its capacity is 60 H.P. when running at 140 revs. per min. The high-pressure cylinder is fitted with patent drop-valve gear, and the low-pressure cylinder with gear of the well-known Corliss type. The De Laval steam turbine is of 10 H.P. capacity and runs at 20,000 revs. per min. It is fitted with a reducing gear and a friction brake, and is arranged to exhaust either into the atmosphere or to the surface condenser. The steam for this engine is supplied by a Babcock & Wilcox water-tube boiler, and whence it is passed either directly to the engine or through a superheater. Arrangements have been made for testing the composition of the flue gases, while the flue temperatures are indicated by an electrical pyrometer.

The electrical plant in the engine room forms an experimental lighting and power station, where senior students may become familiar with the running of the plant under actual working conditions. Two four-pole dynamos, built by Mavor & Coulson, have been erected, and these supply 120 amperes at 210 volts when running at 900 revs. per min. The switchgear for controlling these is fitted on a special switchboard, and consists of the usual circuit-breakers, fuses, shunt regulators and measuring instruments. This switchboard contains apparatus so that each machine can work on its own load separately, or be connected in parallel or in series as required. In this way power at 500 volts can be supplied to the electrical engineering laboratory, or the voltage can be adjusted to any other value which may be required for experimental purposes.

CURRENT FOR EXPERIMENTAL PURPOSES.

Special circuits for the supply of alternating current for experimental purposes to the various lecture rooms have been provided. At each feeding point a three-pole switch is fitted which controls the current to three special terminals, from which alternating current at a voltage of 210 or 105 volts can be supplied as desired. These circuits are quite independent of the main lighting and power supply in the building, and therefore any interference or irregularity in the latter through experimental work being suddenly thrown on or taken off is avoided. In addition, six terminals are connected to the batteries mentioned below.

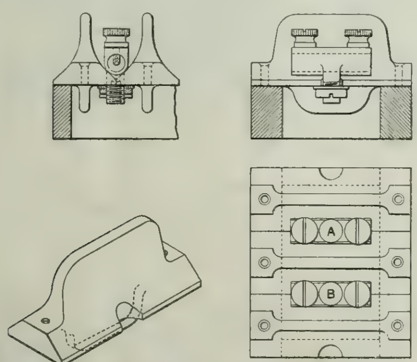

FIG. 15.—TERMINAL BLOCK.

Three batteries are also provided for use on experimental work. One of these has a maximum discharge rate of 175 amperes, and consists of 10 cells with two intermediate tappings. The other two batteries consist of 15 and 35 cells respectively, and have a maximum discharge rate of 78 amperes. These three batteries are usually connected in series, thus giving a total E.M.F. of 120 volts, and from them a six-wire system is taken to the electrical, engineering, mechanical and physical laboratories, as well as to the lesser hall and science lecture theatres and the advanced chemical laboratory and lecture theatre. The great hall is also supplied with current from this battery. All these circuits may be disconnected from the battery and connected to any of the machines in the electrical engineering laboratory or engine room, when any special requirement, such as polyphase current, is desired in any of the above mentioned rooms. The six terminals connected to the battery at each point are marked with their normal potential to earth—viz., 0, 4, 10, 20, 50 and 120 volts respectively. The P.D. between any pair is obtained by taking the difference between the numbers marked on them, so that 14 voltages, varying between 4 and 120 volts, are obtainable, and the most suitable E.M.F. for any experiment can be chosen. The terminals used for this purpose are of special design, and are due to Prof. D. Robertson, professor of electrical engineering in the college. What may be called the "permanent connections" are made to the backs of the terminal blocks, which fit loosely into special porcelain troughs, so that each terminal is adequately separated from the next one to it, but is easily withdrawn when the wires are disconnected. The terminal proper consists of a block of metal, which is drilled and fitted with two terminal screws. Into the channel thus provided the experimental wires can be inserted and screwed up, and current thus taken off to any desired point. This terminal plug has been the result of a good deal of experience, and fulfils in the best way possible the many requirements of laboratory work, where many temporary connections have perforce to be made.

The arrangement of the six wires mentioned above is different in the various places. In the electrical engineering laboratory all six wires are taken to every point, in the advanced chemical laboratory the first four only are taken to the benches, while in the physical laboratory pairs of terminals are fixed to the benches and are connected to a terminal board, where all six wires are available and where they may be connected to any pair. The four wires in the combustion compartment of the chemical laboratory can be connected in parallel when extra large currents are required for use with an electric furnace. It will, therefore, be seen that it is practically possible to obtain at a large number of points through the building electric currents at very widely varying voltages, and even of different kinds, while at the same time the ordinary circuits for lighting and power are left undisturbed. This marks a very distinct step forward, and makes the electrical installation at the Merchant Venturers' Technical College of very great interest, and a distinct landmark in the equipment of technical institutions.

The wiring work and general installation in connection with the electrical equipment of the college has been carried out by Messrs. Reynolds & Bradwell, of Birmingham, to the designs of Prof. Robertson.

CONCLUSION.

It will be seen, therefore, that not only has great care been taken to provide up-to-date lighting and power installations for the general work of the College, which can, if necessary, be tested by the students without trouble, but, as regards the electrical part of the work, endeavours have been made so to equip a series of experimental circuits that work requiring widely varying currents and voltages can be carried on simultaneously if need be without interfering with the "permanent" wiring of the building. The whole of the electrical work has been carried out to the designs and under the personal supervision of Prof. D. Robertson, professor of electrical engineering in the Merchant Venturers' College; and to him, and to the contractors whose names are mentioned in the body of this article, we must express our thanks for the information we have been able to place before our readers concerning a very creditable piece of electrical engineering work.

WETTERHORN ELECTRICALLY-OPERATED CABLEWAY.

BY LOUIS DUBOIS.

There has been lately installed on the slope of the Wetterhorn, Switzerland, an electrically-operated aerial cableway which presents some interesting features. The present cableway was designed for the use of tourists, and its object is to lessen the time as well as the fatigue in climbing this high mountain. This appears to be the first time that such an aerial ropeway, with long spans, has been used for a passenger service. Many instances are to be found where the ropeway is very successfully applied for transporting material, and in Argentina and other places there are installations of this kind in which the span is as long as 1,500 ft. to 2,500 ft. The present aerial cable plant for passenger use is due to M. Feldmann, a prominent Continental engineer, who was lately concerned in drawing up the plans for the Elberfeld-Barmen suspended railway, this latter being now in operation in Germany. No trouble was found in adapting the cable system for passenger use, and the Wetterhorn ropeway was opened for traffic on July 27th last year. Since that time it has worked very

satisfactorily, and is much patronised by tourists, seeing that it lies in the neighbourhood of Grindelwald, the well-known excursion centre in the Jungfrau region, this point being easily reached by rail from Interlaken. Apart from the Jungfrau, the Wetterhorn is much visited, but heretofore the climb was a difficult one, hence the idea of installing the present cableway upon the slope of the mountain. It starts from the lower cable station (altitude 1,253 metres) and reaches the upper station of Enge, which lies at an altitude of 1,678 metres. The highest point of the Wetterhorn lies at an altitude of 3,703 metres.

As was to be expected from a first attempt of this kind, great care was taken to include every possible means of safety in operating the system, and this is especially true as regards the braking devices, of which there are a number, some of which are operated electrically. The construction of the cableway was carried out by the L. von Roll Iron Works of Berne (Giesserei Berne), to whom the writer is indebted for the present information and views of the plant. The electrical outfit was installed by Messrs. Brown, Boveri.

Fig. 1.—View of Car in Transit.

The cableway (Fig. 1) is built in duplicate, one ropeway being used for the ascending and one for the descending car, the two being stretched parallel and at the proper distance apart. For each cableway there are two steel cables placed one above the other, so as to carry between them a small rolling carriage, from which the passenger car is suspended. The carriage (Fig. 2) runs upon two rollers at the top and two at the bottom, each pair of rollers bearing upon one of the cables. From a pivot at the middle of the carriage the cabin is hung by means of an iron strap, as will be seen from the illustrations. To the front end of the carriage is attached a double cable of somewhat smaller size, which serves for the purpose of traction, this latter being of the counterbalanced type such as prevails in cable inclines —that is, the traction cable from one car is taken up to the top station, passes around the cable drums and then is connected to the second car, one car, therefore, descending while the other is ascending.

The electrical apparatus, consisting of rotary converter, storage battery, motor and controlling devices, is well planned for operating the plant under the best conditions. From an electric plant located not far from the base of the incline at Grindelwald there is delivered three-phase current at 2,400 volts by an overhead power line. In the lower station there is laid out an electric plant designed to receive this current, and in turn to supply direct current, seeing that the cable-drum motor is designed on this latter system; and this was done in preference to the use of three-phase current to allow the use of a storage battery in parallel upon the motor circuit, so that in

Fig. 2.—View of Car and Trolley.

case of a temporary failure of the power plant the cableway will not suffer thereby, but can be kept in service by the use of the storage battery. All the electrical apparatus pertaining to the current supply proper is located in the lower station. The high-voltage current is received by a rotary converter,

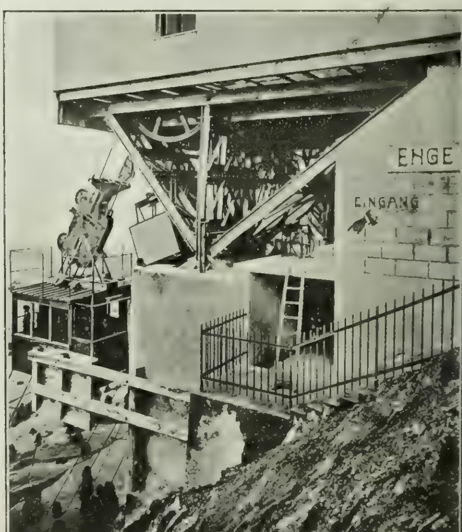

Fig. 3.—Upper Station (note cable passing through car).

which is designed to supply 800 volts direct current at the other end. From the switchboard, to which is connected the storage battery, the 800 volt current is transmitted by an overhead line to the upper station.

In Fig. 4 will be seen the essential features of the motor drive which is used for the cable drums, the view, Fig. 5, showing the general disposition of the station. The direct-current motor A carries a pinion, B, which drives the large gear C, this latter being mounted on the countershaft T, held in the bearings *nn*. On the other end of the shaft is the bevel pinion F, which drives the gear G, placed on a vertical shaft between the cable drums. These latter are seen at I, I′. On the upper end of the shaft are mounted the pinions H, H′, which engage with a large gear having about the same diameter as the cable drums. One of the large gears is mounted above the cable drum at I, while at I′ it lies beneath, so that the pinions H are placed one above the other. The double cable for the ascending and the descending cars will be seen at L, L′ at each side of the station. The present motor is rated at 50 H.P.

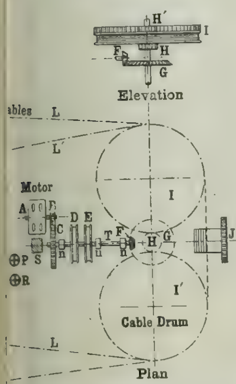

FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF MOTOR DRIVE.

To the right of the motor and in the foreground is the controller P of the motor. Mounted on the motor shaft are two brakes, D and E. The brake D is operated by hand by means of the hand wheel R, which is mounted next the controller. The second brake E is of the automatic type, such as is frequently applied to such cases, and it comes into action should the current supply fail for any reason. By this brake the drum can be stopped before the car has travelled 2 metres. At the usual speed of operating the cableway, allowing 1·20 metres per second for the car, the present motor answers all requirements, and on the tests it is found not to take more than 45 H.P. even in the most unfavourable conditions of working.

The passenger car is 3·35 metres in length and 3·20 metres wide, and is divided into two compartments by a longitudinal partition, giving a capacity of eight persons seated and eight standing. It weighs 4·4 tons when empty, and 5·8 tons when containing the full passenger load. The gradient of the cableway is 116 per cent. on the average, but in some places it exceeds this figure considerably. For this reason it is necessary to let the cables pass through the centre of the car during part of the trip. Accordingly a space of 0·5 metre is left at the central part of the car, using for this purpose a double partition between the compartments, so that the cables can be accommodated in this way (Fig. 3).

For the suspension cables there is employed a 45 mm. steel wire rope whose tensile strength is tested with a load of 150 tons, giving a good factor of safety, as the actual load used on the cable is only 14 tons as a maximum. The cable weighs 11 kg. per metre. The two traction cables are 30 mm. steel cable weighing 2·8 kg. per metre and tested at 43 tons, the required maximum load being only 2·5 tons. The two traction cables are attached to the ends of a cross-arm at the front of the car, and the cross-arm forms part of a special mechanism designed to give effective braking of the wheels of the rolling carriage in case one of the tractive cables should break. In such a case the unequal pull on the cross-arm causes a device to operate by which the carriage is blocked tightly upon the carrying cable owing to the action of a powerful spring. By means of this device the car can be stopped within a distance of 0·25 metre. It can also be operated by hand, should this be desired. This form of brake is found to be better adapted for the needs of the present system than either an air brake or an electric brake, and the shock is deadened by the elasticity of the cable.

In the upper station (Fig. 5) there is provided an electric braking method which is used in the regular service for stopping the car when it comes to the level of the upper station platform. This is effected by using an automatic switch device with a projecting lever, mounted in the path of the car at a distance of about 4 metres below the platform. When the car comes along it strikes the lever and the switch device then operates to throw off the motor from the line and short-circuit it upon a set of resistance coils, these being contained in the box S mounted beside the motor. The resistances are designed so that they cause the motor to give the usual electric braking effect and in such a way that the car is stopped just opposite the landing platform of the station. This device is entirely automatic, and it secures the accurate stopping of the car without any attention. In the station is mounted an auxiliary drum, J, next the main cable drums, so that in case of accident the cable can be worked by hand at a slow speed in order to bring the cars to the station. Should the car become stuck upon the cableway for any reason, means are provided for letting down a small rescue car upon the cableway so as to reach the main car.

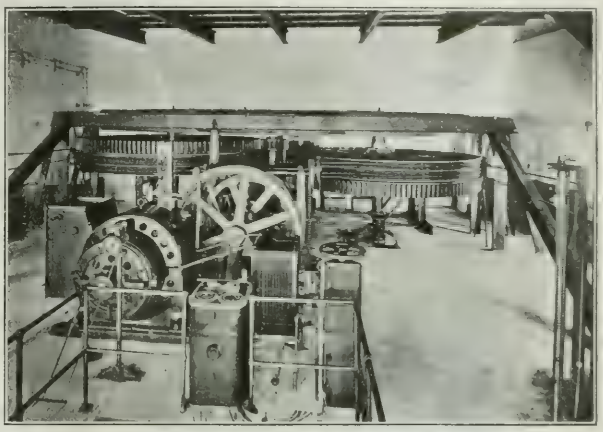

FIG. 5.—VIEW OF INTERIOR, UPPER STATION.

MODERN SUBMARINE TELEGRAPHY.*

BY S. G. BROWN.

(Concluded from page 624.)

I come now to the instruments employed to work the cables, starting with the sending end. As before pointed out, the various letters of the cable alphabet are composed of combinations of + and — electrical impulses, or of the records that these impulses produce. The letter *e* is a + impulse, *t* a — one ; *a* is composed of two impulses, a + and —, and so on for all the other letters. The operator has, therefore, first to translate the message to be sent into the cable code and then to tap on the sending key the order of the impulses that make up the code message. A sending key consists of two levers, the depression by the finger of either one or the other determines which end of the battery the + or — end is joined to the cable.

Sending messages by hand is open to two objections : One, want of speed, the other, want of accurate spacing of the letters. A good trained clerk can send at the rate of about 140 letters per minute but as most cables are capable of being worked at greater speeds automatic or machine transmission has now become universal.

An automatic transmitter is an instrument that does the work of the clerk in sending. The two levers of the hand key are now operated upon by mechanism driven by a motor through the agency of a perforated ribbon. Everyone who is acquainted with the pianola, or automatic piano player, knows that the music to be played is punched as holes in a broad paper strip : this strip is run through the machine and determines which levers are to press upon the keys of the piano. The operation of the automatic transmitter is precisely like this, only instead of the extended keyboard there are two keys, a + and —, and the paper strip is a narrow ribbon with only two rows of holes to work the levers. To send a message the clerk, first, by means of a hand perforator, punches the message as com-

* Abstract of a lecture delivered before the Royal Institution.

binations of holes in the paper ribbon : this ribbon, after being perforated, is fed through the automatic transmitter.

The automatic transmitter is a motor-driven instrument, adapted to feed the perforated ribbon over the ends of a pair of blunt needles. These needles are kept perpetually moving up against and away from the moving ribbon ; but if there is a hole in the paper that particular needle over which it is fed will find it, and the needle will move a little way through the hole. Attached to the two needles are contact levers which connect the cable with one or the other pole of the sending battery. When there are no holes in the paper ribbon the needles move up against the paper, and the further movement is arrested and the contact with the battery is not closed ; but when there is a hole in the paper, the further movement enables the contact lever to close the battery circuit and thus send the signal.

The sending levers do one or other of two things : They join the cable to earth (in other words, they short-circuit the cable end), or they disconnect the cable from earth and connect it to the battery so that the battery may send a signal. At the end of each signal the cable is automatically put to " earth." Every signalling impulse due to each hole in the paper is, therefore, divided into two parts, the battery or signalling and the earthing portion. These two portions are adjustable relatively to one another ; when the best relationship has been found it is maintained at that adjustment. The object of earthing the cable after the battery contact is to allow the cable to discharge itself and thus clear itself for the next signal.

Automatic transmitters constructed on this principle, are called " plain " automatics, and are in universal use. The " curb " was a device applied to an automatic to sharpen the signalling impulse, and thus gain greater definition and increased speed by reversing the battery at the termination of every battery period. The reverse battery voltage helped to neutralise the charge already in the cable, and thus discharge the cable in quicker time than by simply earthing the cable, as in the " plain " automatic. Unfortunately, the use of the " curb " results in a greater voltage stress on the sending end of the cable, for the reason that the reverse voltage of the " curb " is added to the voltage already in the cable ready to discharge, and the rapid reversal of current resulting upon the application of the " curb " is liable to cause " jar " disturbances on the duplex balance. For these reasons " curb " automatics are not now employed.

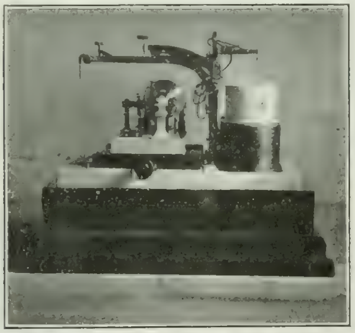

Fig. 8.—High Speed Relay (side view).

The pointer is constructed of quartz fibres kept in tension by a thin copper wire, the whole weight of the pointer being not more than one to two grains.

Instruments adapted to receive messages at the end of long submarine cables must of necessity work at the highest possible speed that the cable will allow, and are of extreme sensitiveness ; as a consequence they are of great delicacy.

There are two kinds of receivers now commonly employed—viz., the siphon recorder and the " drum " cable relay. (We show in Fig. 8 the latest form of the author's high-speed relay). The siphon recorder, invented by Lord Kelvin in 1867, is an instrument that inks the message as received on a moving band of paper. The " drum " cable relay, by means of an electric contact-making device, brings in a fresh source of energy from a local battery, so that the electric signalling impulses are multiplied many times over in power, and are thus enabled to do many useful things besides inking the message, such as working signalling keys to re-transmit the message on to another line or to guide the levers of an automatic punching machine to perforate the message. The siphon recorder requires the constant attention of a clerk, the " drum " cable relay does not.

The siphon recorder consists of a bent glass siphon tube nearly as fine as a human hair. The siphon is suspended by a fine bronze wire ; one end of the tube dips in a reservoir of blue aniline ink, the other end can move across the surface of a travelling band of paper, upon which it inks its movement. If the end of the siphon touched the paper the friction thus introduced would be fatal to the proper working of the instrument, because of the loss of sensitiveness ; it is, therefore, kept in a state of constant vibration by attaching the tube near its end by means of a silk fibre to an electromagnetic vibrator. The message is thus recorded as a close row of ink dots on the moving paper, and the glass tube is quite free to swing sideways under the action of the received signals. The siphon tube is joined by two silk fibres to a rectangular suspended coil of fine insulated copper wire, which coil hangs in a strong magnetic field. The currents from the cable flow through the wire of the suspended coil and the reaction of these currents with the magnetic field cause the coil to oscillate to one side or the other, dependent upon the direction of the current. The motion of the coil is transmitted by means of the two fibres to the siphon, and thus the signals are recorded as received.

Ever since the invention of the siphon recorder efforts have been made to turn it into a relay, but two difficulties had to be faced. The extreme feebleness of the received signalling currents was such that they were incapable of opening and closing a battery circuit so as to do useful work in that circuit. The reason for this is that a certain force is required to press the relay contacts together to complete the circuit, and a certain force to break the circuit when formed ; these forces of " make " and " break " are too great for the cable relay to supply under normal working conditions. The second difficulty was the want of definition in the signals received to operate relay. They were too ill-defined, and the zero line wandered too greatly to ensure that a relay with a fixed mechanical zero would work satisfactorily. These two difficulties were overcome by the invention of the " drum " cable relay and the magnetic shunt.

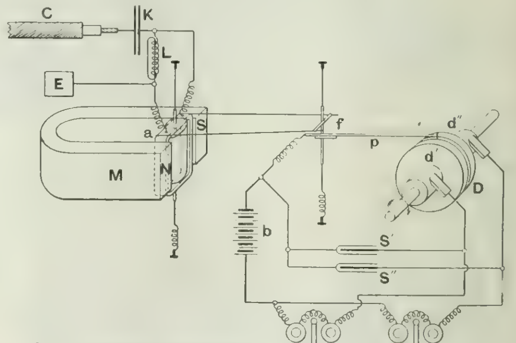

Fig. 9.—Drum Cable Relay.

The drum cable relay (Fig. 9) is similar to the siphon recorder. It is the same so far as the suspended coil and connecting fibres are concerned, but in place of the siphon tube a relay contact arm is provided. The end of this arm is arranged to press upon the surface of a revolving drum. The outer drum surface of gold or silver is divided into three parts—a central insulated portion, upon which the end of the contact arm normally rests when no signals are received, and portions one on each side of the central one ; these outer divisions are included in the circuit of a local battery, and two Post Office pattern relays. When the relay arm is deflected to one side or the other, upon the receipt of the signal it slides or skates into contact with one or other of the outer portions of the drum, and thus closes circuit of the battery through one or other of the Post Office relays. This second relay is thus operated, and in turn works a " sounder " key to re-transmit the signal into a second cable.

To reduce the electrical resistance that is found to exist in the contact between the relay pointer and the revolving drum, and to allow a large current to pass, condensers are placed across to short-circuit the contact. These short-circuiting condensers are very important to the proper working of the relay, as without their aid very little current indeed could be obtained in the local circuit to do useful work. The cable relay is a delicate instrument, and mechanical effects had to be produced by means of energy four-millionths of that required to produce 1 c.p. of an ordinary carbon lamp. The operation of the relay throughout is quite automatic and reliable, and no clerk is required to supervise.

The drum relay has two properties that peculiarly fit it for cable work :—

1. The relay contact is always made, because the contact arm never leaves the surface of the drum.

2. By the rotation of the drum the friction between the arm, to side motion, and the surface of the drum is reduced in a most wonderful way, so that the arm may be moved by the extremely feeble forces received at the end of the cable.

The relay has a fixed mechanical zero, the centre of the insulated portion, to which the end of the arm must return after every signal or group of signals, and the zero of the electrical signals has been made by electrical adjustment to coincide with the mechanical zero. If there was not this coincidence there would be mutilation of the re-transmitted signals.

The working of the relay is complicated by the requirements of the telegraph service, which demand that a condenser should be included in the suspended coil circuit. The object of this condenser is to exclude the possibility of interference from " earth " currents, which sometimes flow along the cable. The presence of this " earth " current is due to outside electrical influences, atmospheric or celestial.

Now, these " earth " currents, if allowed to flow through the suspended coil, would produce deflections that would interfere with the proper working of the relay. The magnetic shunt, which is always placed across the coil, does shunt the " earth " current to a very great extent, but does not always get rid of it, and so, to make matters sure, the " unshunted " series, or Varley condenser, is included in the system. The condenser, unfortunately, polarises or charges up under a series of signalling impulses of the same polarity or sign, and for this reason itself causes a wandering of the electrical zero of the signals ; we are, therefore, trying to stop one kind of variable zero effect by a device that produces another one of its own. The effect of the wandering zero, due to the series condenser, can be cured, because the wandering, unlike that of the " earth " currents, follows a regular law—viz., the law of the signals themselves. The relay produces the signals and combination of signals in its local circuit precisely the same as the signals or combination sent through the cable that work it, and are at the same time causing the variable zero. Current is, therefore, taken from the local circuit and passed through an electrical retarding device, which is called the " local correction circuit," consisting of a series of inductances and shunting resistances. The local circuit is so adjusted in its value that the current at the far end rises exactly as there is a drop in the received signalling current through the series condenser. The correction current is passed through a separate winding on the suspended coil of the relay, and produces an effect on the coil exactly opposite to that produced on the main winding by the variable zero itself—that is to say, two variable zeros of equal strength but of opposite directions are superimposed on the suspended coil, and thus neutralise one another ; the variable zero of the signals themselves is thus eliminated. Local correction is a very important part of the relay adjustment and cannot very well be dispensed with.

During the year 1908 the Eastern Telegraph Co. most generously lent me their lines for a trial of my " high-speed " system of working. The cable over which the tests have taken place stretches from Porthcurnow, in Cornwall, to Gibraltar, and is normally worked at 170 letters per minute each way with the siphon recorder as receiver. With the new method, using a special relay, traffic has been carried continuously duplex at 230 to 240 letters per minute. On special trial runs, not carrying traffic, and not sending into the cable at the receiving station, although on duplex conditions, a speed of 280 letters per minute has been obtained.

The principle of operation is as follows : When a submarine cable is forced much beyond its normal speed of working the quick-changing signals, such as make up the letter C, are the first to fail, or, in other words, do not arrive with sufficient strength to work the receiver. It was found on trial that, allowing more of the current from the cable to flow through the receiver—say by increasing the size of the receiving condenser—the first and last signal of a series of reversals could be obtained with sufficient strength to work the relay efficiently. The relay, once started, is arranged to bring in fresh energy from its local battery, through a special retarding circuit, to add to the strength of the quick-changing currents on its own coil, and thus the reversals are made strong enough to give a good record, which without this aid they would have been unable to do. By these means weak signals are built up at the receiving end of the cable, and the speed of working can thus be materially increased.

It is fortunate that the class of signal that has the greatest difficulty in getting through the cable is the easiest to be added to when received. The " high-speed " relay works, therefore, not from the signals received from the cable only, but also from those that it transmits through its own local circuit, the record that it makes being the combined action of the two.

For most of the calculations in this lecture I am indebted to Prof. John Perry, and this, I am sure, is a sufficient guarantee for their accuracy.

THE ELECTRIC DRIVE AND MARINE PROPULSION.

Among the Papers read last week at the Liverpool meeting of the Institution of Mechanical Engineers was one by Mr. A. J. Maginnis on " The Advance of Marine Engineering in the Early Twentieth Century." In this Paper the author reviews the rapid progress made in the adoption of the steam turbine for marine propulsion during the last few years. Although the first turbine-driven craft, the " Turbinia," appeared in 1894-6, it was not until 1900 that the first order for a real test of this form of propulsion for a commercial venture was placed. The great success of this vessel on the River Clyde led to the rapid adoption of the turbine, culminating in the ss. " Lusitania " and " Mauretania." Up to the present time, however, but little progress has been made in the adoption of turbines for slow-going merchant or other vessels, owing, no doubt, to the difficulty of applying the turbine to the single propeller, but the author considers that in no other field of operation is there such an opening for a simple form of rotary machinery. The only feature which has so far been against the use of turbines for cargo boats is the mechanical one of relative speed of turbine rotor and propeller, and it is much to be desired that a similar syndicate to that which initiated the start on the River Clyde boats be formed to make a start with a cargo boat, say, of 2,000 to 3,000 tons dead weight and 10 knots speed. It also is necessary for those now actually engaged in the manufacture of turbine machinery to give the matter the most careful investigation, for the author, speaking with considerable knowledge and experience of reciprocating or piston machinery, has no hesitation in stating that rotary machinery must eventually replace the present system. To show how rapidly turbine machinery has come to the front, it may be mentioned that in the merchant service turbine propulsion has risen from one steamer and 3,500 H.P. in 1901 to 64 steamers and 603,200 H.P. in December, 1908, and there is no doubt that the adoption will become increasingly rapid in the future, as the system spreads amongst all classes of steamers.

After referring to internal combustion engines, and also drawing attention to many features to recommend liquid fuel for marine purposes, the author discusses the electric drive as follows :—

Direct Electric Drive for Propellers.—The fact that the coming power for marine propulsion must be directly rotary coupled with the success of the steam turbine has brought forward another system, which in the author's opinion will soon be widely adopted—namely, the application of electric power direct to the propeller shafts. The advantages likely to accrue from the adoption of direct electrical shaft drive are : (1) Reversal of the propeller with full effective power is attained and readily effected. (2) The design of both the steam and electric plant can be so modified as to enable the naval architect to make better and more profitable arrangements for both passenger and cargo space. (3) The movements of the propellers can be controlled direct from the bridge. (4) Electricity, like steam, is capable of being readily applied to all the other requirements of shipboard, such as steering, windlass and winch work, with more economical distribution. It is not proposed to use electric drive on fast vessels (naval or mercantile) where the turbine has been so successful, but to apply it to the slower-going cargo tramps, as if the promises now put forward are carried out—and electricians state that they are quite within the range of present practice—it will present the most simple means of obtaining rotary motion slow enough in speed to apply to the ordinary screw propeller working at from 70 to 120 revs. per min. The proposals put forward are described in Papers brought before the Institution of Engineers and Shipbuilders in Scotland by Mr. Mavor,* and before the Institute of Marine Engineers by Mr. Durtnall.†

Should this system of main electric drive come about, it may be safely said that a new era of electric navigation is about to dawn, and one promising great results. For instance, the continued decrease in the boiler pressures as commenced with the steam-turbine machinery will, no doubt, be further continued, and even lower pressures than now exist will be made use of, which will largely decrease the weight of boiler installations and so cheapen the first cost. Through the fact of the greater portion of the machinery being electrical other than mechanical, the heavy weights of such moving parts as pistons, piston and connecting rods, valves, &c., will be done away with, and so render the outfit and overhauling of the electric boat more simple and more easily effected than on the steam-propelled craft at present in use.

* THE ELECTRICIAN, Feb. 28, 1908, p. 762.

† THE ELECTRICIAN, July 31, 1908, p. 608, and March 19, 1909, p. 887.

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POWER SUPPLY.

The check experienced by most central stations in the sale of electrical energy for lighting purposes, due chiefly but not entirely to the adoption of metal filament lamps, has emphasised the advantages of a large power load. In fact, practically the only towns where marked progress has been made in electricity supply during the past year are those in which a large motor load has been cultivated. Such a load takes some little time to obtain, and the effects now becoming apparent in towns where such a policy has been pursued, are really the results of several years' steady effort. A striking instance is provided by the West Ham undertaking, which, notwithstanding a decrease of about 10 per cent. in the number of units sold for lighting during the past year, is able to show a greatly improved financial result, on account of a large development in the power load, although the latter only brings in an average revenue of 0·59d. per unit.

It must not be forgotten that all types of electric lamps provide an extensive field for improvements, since their efficiency is only of the order of one per cent.; there is always, therefore, the possibility of a reduction in the demand for electrical energy for a given amount of light as more efficient means of transformation are discovered. There is, of course, some compensation in the fact that the advent of improved lamps is always likely to be accom-

panied by an influx of new consumers, until the time arrives when electric light will have become the customary illuminant, but this is not a topic which we need discuss at the present moment.

When, on the other hand, we consider the electric motor, its present high efficiency leaves little opportunity for improvement, so that we may assume in practically all cases that the demand for electrical energy for power purposes will increase steadily as further applications of the electric motor to industrial and domestic apparatus take place. It is evident, therefore, that whilst endeavouring to develop the lighting load, particularly as regards street lighting, which offers a very promising field for the new lamps, engineers should devote their main attention to obtaining all the power load within reach of their mains, including therein heating and cooking. If the greatest possible success is to attend this policy it is necessary that the prices offered should be attractive to power users, though, on the other hand, they must not be unremunerative to the undertaking. In this connection the names of a few towns where a progressive power policy has been pursued will at once occur to the minds of our readers. Bolton provides a good example, as we mentioned a week or two ago when analysing the last annual accounts of the electricity department. Another undertaking in which a very advanced policy has been adopted is that at West Ham, and the results there achieved are of the greatest interest, since the policy was subjected to much criticism at the recent Local Government Board inquiry, the result of which is not yet known.

Elsewhere in the present issue we analyse the accounts of the West Ham undertaking, and one of the most striking features of the results there set forth is that the average price received for power supply during the past year was only 0·59d. per unit. It may be thought that such a low price can only be offered at the expense of the lighting consumer, but this can scarcely be the case, since the average price charged for lighting was only 2·72d., with a maximum charge of 3d., which compares very favourably with that in any other town in the country. Also it should be noted that the output of units for power was more than four times that for lighting, so that if the power tariffs were unremunerative this would be readily apparent in the financial results. It would appear, therefore, that the lighting consumers are deriving considerable benefit from the low works costs rendered possible by the large power load. The prices charged for public lighting—1·53d. per unit—and for current sold for electric traction—0·99d. per unit—cannot be considered excessive.

The low prices at which electrical energy is being offered in West Ham are undoubtedly due first to the low total works costs, which, it will be noticed from our analysis of the accounts averaged only 0·60d. per unit—a figure in close agreement with that of 0·59d. per unit recorded at Bolton, where the power load again plays the predominant part in the output—and, secondly, to the low capital expenditure of £38·2 per kilowatt of plant installed, a figure claimed by Mr. A. H. Seabrook to be unequalled by any other undertaking in the country. This is a most important result, for high capital cost per kilowatt is one of the heaviest handicaps in attempting a cheap supply of electrical energy. It is, in fact, impossible to quote really low prices if this cost is high; and such loads as those due to electrochemical works are unobtainable, because the prices offered cannot be sufficiently attractive to a long-hour consumer.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electric Lamps. By Maurice Solomon. (London: A. Constable & Co.) Pp. xviii.—311. 6s. net.

The revolutionary advance which has been made during the last two years towards the production of more efficient electric lamps gives an exceptional interest to any publication on the subject at the present time, and the book before us is no exception. When improvements in electric lamps are matters of daily occurrence, any treatise on the subject has inevitably to meet the criticism that if it is not beginning to be out of date at the time of issue it cannot long be regarded as depicting the latest phase of the question. An examination of this book, however, will show the most casual observer that it contains original data and much information, both practical and theoretical, which will make it valuable both as a book of reference for the student and a practical handbook for engineers who desire to make intelligent use of the improvements which have lately taken place in nearly all forms of electric lamps. We are glad to see that Mr. Solomon has not hesitated to deal in considerable detail with those portions of his subject in which he is specially expert, perhaps even to the extent of giving them undue weight compared with some other sections of the book which have, relatively, a greater importance. The detail, for instance, with which the condition of stability for the burning of the Nernst glower is described and the useful chapter on the testing of arc lamp carbons will give value to the book, when it can no longer be regarded as altogether up to date from the point of view of the most recent improvements.

The first third of the book deals with the general principles of radiation, photometry and methods of testing. In his remarks on the accuracy obtainable in photometric measurements (p. 36) the author does not appear to appreciate the possibilities of the "double comparison" method for eliminating the personal error and simplifying many of the difficulties and complications of commercial and standard photometry. We cannot help regarding the chapter on photometry as the weakest in the book, and we look in vain through the description of various photometer heads, &c., for an explanation of the best methods and apparatus for use in connection with the photometric measurements discussed in subsequent chapters. It is just to a work of this nature that we should have turned for practical advice as well as information on the subject of this much maligned branch of measurement.

In the interesting chapters on the carbon lamp the Engineering Standards Committee's specification for tests on these lamps is somewhat adversely criticised. As, for instance, on pp. 93 and 94, in which it is submitted that the life test starting at definite watts per candle does not give practical results as compared with the life test starting at definite voltage. The reasoning, however, is not very convincing, since it appears that the E.S.C. specification arranges in the first place that all lamps in a consignment shall fall, as regards their rating, about a definite value of candle-power and watts: and then ensures in effect that only the lamps which have that definite value shall be tested for life. Thus, those lamps are excluded which are on the boundary and which, if tested at rated voltage, would give a value for the life which would not represent the mean of the consignment.

The chapter on metallic filament lamps contains, in outline, descriptions of the various methods used in the manufacture of osmium, tantalum, and tungsten lamps, and classifies their properties in a manner which enables them to be easily compared.

The three chapters devoted to arcs and arc lamps contain much practical information. In this as in other chapters Mr. Solomon has wisely refrained from burdening the reader with details of the different commercial lamp mechanisms, and has dealt almost entirely with the arc lamp under the headings of "open," "enclosed," "alternating current," "flame," &c., giving the peculiarities of each and the duty to be expected from the various types. Throughout the whole book tables are given, comparing the cost and the various systems of lighting, based for the most part on very reliable data and forming therefore a fund of information, which is, we think, unequalled in any existing publication. In the last chapter a comprehensive comparison is made between the various forms of electric lamps.

Modern Power Gas Producer, Practice and Application. By Horace Allen. (London: The Technical Publishing Co.) Pp. vii. 323. 6s. net.

The author of this book states in his preface that his aim has been to define the ruling principles of the gasification of fuel and to describe the developed practical commercial types of producers. The book contains 22 chapters and an appendix. The first chapter deals with the question of natural gas in England, which is hardly germane to the subject, followed by four chapters on manufactured gas (blast furnace, coke oven, town gas and producer gas) with tables and particulars relating to the chemistry of gas production generally, and two chapters on coal and the gasification of fuel.

The following two chapters are devoted to pressure gas producers of the various standard types, with reference also to special types designed for bituminous coals and other fuels, in which the claims of the various inventors, such as appear in their descriptive pamphlets, are set forth. The Loomis Pettibon plant, designed for a wide range of fuels, including wood, is described, and some particulars of a test are given, but the author has omitted all reference to the Riché plant, which is perhaps the best known and most successful of this type.

Suction gas plant is dealt with in the following three chapters, and some reference is made to the Derby trials of the R.A.S.E. One footnote respecting these trials erroneously suggests that a gas engine of the vertical type does not work on the Otto cycle. Several plants which do not seem to have emerged from the experimental stage are here noticed. The next chapter deals with the various points to be considered in successful suction producer practice, and in this readers are left, perhaps wisely, to draw their own conclusions, as plants differing very widely in details are all in satisfactory operation. Another chapter refers in a somewhat perfunctory way to the application of the producer to marine work. Blast furnace and coke oven gas are then considered with particulars of washing and purifying apparatus.

The use of gas in the engine is then considered, and the remainder of the book is occupied with details of gas analysis, and the testing of gases and other fuels, followed by a list of some recent patents and an appendix describing one or two more gas plants. A notice of one small vertical gas engine appears to have strayed into the book with its indicator diagram, and not being illustrative of any point in particular does not seem to be at all at home amongst the other notes, of which this volume is a miscellaneous collection.

It is a sound rule for books of this class that the reference letters in the text shall appear in the illustration of the particular apparatus described, and vice versa. This rule is not always followed, the effect being somewhat annoying to the studious reader.

The author in his preface acknowledges his indebtedness to the authors of numerous works consulted, and this forms the keynote of his book, which is a *réchauffé* of articles and Papers contributed by many authors, including himself, to the various technical publications and societies. We cannot, however, congratulate him on having served it up in the most digestible manner, the arrangement of the matter under the various heads of his subject being very confusing. In one place he brings his subject up to date (unintentionally, we hope) by altering the date of an extensive test on a gas plant from 1895 to 1905, the same tables and the report quoted appearing in the 1895 edition of the book from which they are taken. The mass of detailed information in the book requires very considerable re-arrangement before the volume can be ranked with some others on the same subject which we have received, and the index is totally inadequate. This is possibly an advantage, as it has been carelessly drawn up, and its lack of completeness therefore makes it somewhat easier to sort out the references which are given. As a book of the scissors and paste type the volume has its merits, and, with the blemishes referred to above removed, may be useful to the student in this branch of engineering. W. Marsden.

TRIPLE-FREQUENCY CURRENTS IN NEUTRALS OF THREE-PHASE STAR CONNECTED ALTERNATORS.

By E. W. Marchant, D.Sc., and J. K. Catterson-Smith.

Summary.—The authors show how triple-frequency currents arise in the neutrals of three-phase star connected alternators. The effects produced by such currents are considered, and finally means are indicated for rendering these effects negligible.

The recent discussion on the triple-frequency currents, which have been found to flow between three-phase star connected alternators when their neutral points are interconnected,

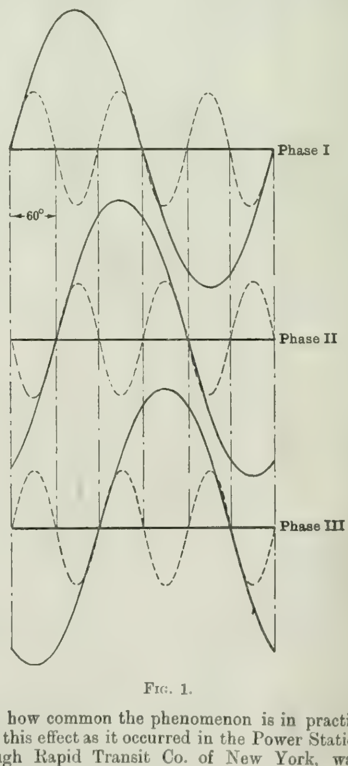

Fig. 1.

has shown how common the phenomenon is in practice. An account of this effect as it occurred in the Power Station of the Interborough Rapid Transit Co. of New York, was given about two years ago.* Although the origin of these neutral currents of triple or higher frequency is well known to be due to difference of E.M.F. wave form of alternators working in parallel, it may be well to consider briefly the conditions underlying the phenomenon. The windings of a three-phase machine are separated by 60 electrical space degrees and the passage of the flux generates an E.M.F. in the bars in each slot of identical wave form, but with the crests separated by 60 electrical time degrees, as shown in Fig. 1, phases I., II. and III.

* "Electric Journal," Vol. III., September, 1906, and Vol. IV., December, 1907.

The windings are indicated in Fig. 2, with one end of each phase made common for the ordinary star arrangement. The line or terminal voltage is the resultant of the voltages in two phases, and on referring again to Fig. 2 it will be seen that

V_a=sum of E.M.F.s in I. and II., at 60 deg.
V_b=sum of E.M.F.s in I. and III. at 60 deg.
V_c=difference of E.M.F.s in II. and III., at 120 deg., *i.e.*, sum at 60 deg.

Hence the line voltage cannot contain ripples of triple frequency or its multiple, for, as will be seen from Fig. 2, the addition of these waves at 60 deg. cancels all the harmonics which have a frequency which is a multiple of three.

It is thus clear that unless the neutral point is earthed there can be no triple-frequency currents; if, however, a neutral connection is provided, as shown in Fig. 3, and the phase

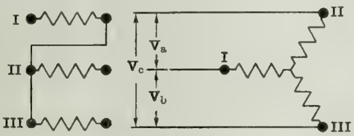

FIG. 2.

E.M.F. wave-form of the two machines differs, then the local circuits will carry currents due to the resultant of the E.M.F.s of higher frequency. The triple-frequency currents flowing in each of the three-phase generators are shown in Fig. 3, and it is seen that the triple-frequency currents in the three circuits are in phase with each other, provided the windings are symmetrical; hence the current in the neutral will be three times as large as the current flowing in each winding. In the first place it should be noticed that these currents are much larger than would have been expected at first sight from any difference in wave-form of the two generators, that is, the triple-frequency current is much larger than the current which would flow were the difference in wave-form of the two machines in parallel of the same magnitude, but of five or seven times the main frequency.

If we consider a three-phase winding such as is shown diagrammatically in Fig. 4, it is clear that if each phase carries

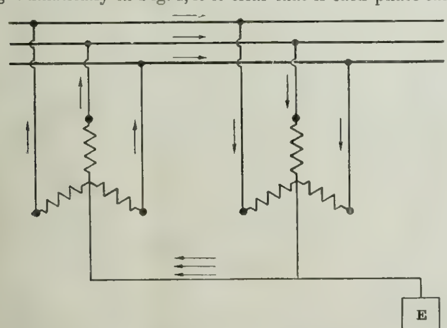

FIG. 3.—PATH OF TRIPLE-FREQUENCY CURRENT BETWEEN TWO STAR-CONNECTED THREE-PHASE MACHINES.

a triple-frequency current of equal magnitude the winding is as a whole non-inductive unless there is an appreciable amount of slot-leakage flux. The directions of the triple-frequency currents are indicated in the figure at the instant of maximum values, and it will be seen that adjacent coils neutralise each other as far as any magnetomotive force acting on the main magnetic circuit due to triple-frequency current is concerned. This fact, that the stator windings are practically non-inductive to triple frequencies, is the reason for the large currents observed even when the wave-forms of the phase E.M.F.s of the machines contain relatively small triple frequency components.

The amount of the slot leakage flux depends upon the shape of the slots, the length of the air-gap, the distribution of the winding (being greatest for concentrated windings in narrow slots) and the total number of conductors. In the case of a turbo-alternator generating a given E.M.F. at a given frequency, the number of stator conductors is less than in the case of the corresponding slow-speed alternator, and this is probably the reason why the triple frequency phenomenon has not been so noticeable in slow speed sets as it has become in turbo-alternators, where the impedance of the local circuits is small owing to the wide slots, long air-gaps and small number of bars. It is, of course, possible that a current of any frequency, which is a multiple of three times the main frequency should flow round the local circuit, but it is always

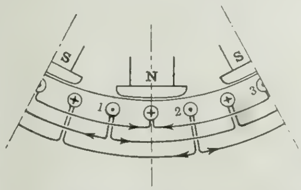

FIG. 4.—SHOWING DIRECTIONS OF TRIPLE-FREQUENCY CURRENTS.

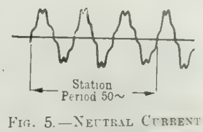

FIG. 5.—NEUTRAL CURRENT OF 150~ AND 1,050~.

likely that the main component will be of triple frequency, since the reactance due to slot leakage will be proportional to the frequency, and will therefore increase with the frequency of the circulating currents.

In one case which is given below, Fig. 5, it will be noticed that there is a component of this circulating current of a frequency 21 times the main frequency.

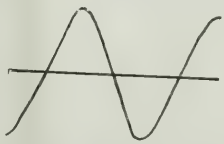

FIG. 6A.—OPEN CIRCUIT PHASE P.D., MACHINE A.

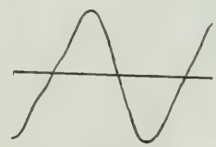

FIG. 6B.—OPEN CIRCUIT PHASE P.D., MACHINE B.

The experiments described below were made on a number of 2,000 kw. turbo-alternators of two different types. One set (A) having 4 poles with 8 slots per pole per phase and running at 1,500 revs. per min., of which the open circuit wave-form of E.M.F. is shown in Fig. 6A, and the other set (B) having 6 poles with 4 slots per pole per phase and running at 1,000 revs. per min., of which the open circuit wave-form of E.M.F. is shown in Fig. 6B. It was found that when two machines of the same type were in parallel, the circulating current was very small, from 5 to 6 amperes in the neutral, in

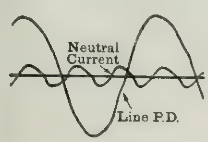

FIG. 7A.—TRIPLE FREQUENCY NEUTRAL CURRENT BETWEEN TWO SIMILAR A MACHINES.

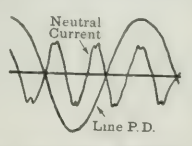

FIG. 7B.—TRIPLE FREQUENCY NEUTRAL CURRENT BETWEEN TWO SIMILAR B MACHINES.

a machine giving 200 amperes per phase, *see* Figs. 7A and 7B. Both of these wave-forms are very nearly sinusoidal, an analysis giving

$$e_a = 100 \sin pt - 7 \sin 3pt - 9 \sin 5pt \quad . \quad \text{(Mc. A.)}$$
$$e_b = 100 \sin pt - 3 \sin 3pt + 4 \sin 5pt \quad . \quad \text{(Mc. B.)}$$

And it is interesting to note that although the quintuple frequency component is approximately as big as that of the triple frequency, there is no quintuple frequency component of neutral line current because of the greater impedance of the stator windings to quintuple frequency circuits.

When a machine of type A was run in parallel with a machine of type B, the triple-frequency component of E.M.F. was sufficient to give a current of 60 amperes through the neutral wire; see Fig. 8.

Using these figures to estimate the approximate inductance of the circuit due to slot leakage, the results obtained are :—

Reactance per phase	3·5 ohms.
Self-induction per phase	0·0037 henry.
Turns per phase	16 four-turn coils.
Axial length of stator laminations	91 cms.
Flux per centimetre of imbedded conductor per ampere	7·6 C.G.S. lines.

which figure is well in agreement with other determinations.* The form of the slot is shown in Fig. 9.

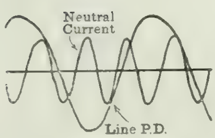

Fig. 8.—Triple Frequency Neutral Current between Machines A and B.

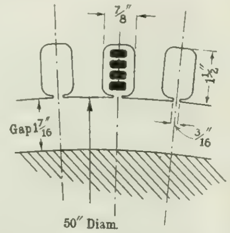

Fig. 9.—Stator Slots in Turbo-Alternators. Type A.

In some cases the value of the neutral line current increased to 120 amperes, this happened when the excitation of the two machines was such as to make their loads of different power factors, and is shown in Fig. 10. It will be seen that the waveform is slightly different from that shown in Fig. 8. The triple-frequency current in the local circuit is shown in Fig. 11, superposed on the normal line current from machine A when it is running in parallel with B.

Effects Produced by Triple-frequency Currents.—These currents may cause additional heating in the armatures of two machines coupled in parallel. The additional heat produced is,

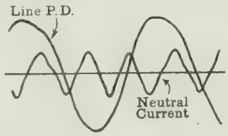

Fig. 10.—Machine A. 185 amperes, cosϕ 0·85.
Machine B. 180 amperes, cosϕ 0·60.

however, comparatively small, even when the neutral line currents are of very large dimensions. If a current is represented analytically by an equation of the form

$$i = I_1 \sin pt + I_3 \sin 3pt - \theta_3 + I_5 \sin 5pt - \theta_5 \ldots\ldots$$

It is well known that the heating effect, produced when this current flows through a resistance R

$$= \frac{R}{2}(I_1^2 + I_3^2 + I_5^2 \ldots\ldots).$$

If, for example, I_3 is 20 per cent. of the fundamental I_1, the heat produced when this current flows through a circuit of resistance R

$$\text{watts} = \frac{R}{2} I_1^2 (1{\cdot}04),$$

i.e., is only 4 per cent. greater than when this triple-frequency current is not present. Another effect of these currents is that they reduce the power factor of a machine which is carrying them, for the currents only produce heat in the resistances of the machines and of the paralleling cables, and their power factor is therefore very small. When a power factor meter is connected to a machine carrying these currents, its reading may be considerably lower than that corresponding to the real angle of lag between the fundamental wave of P.D. and the fundamental wave of current, as, for example, is found in the case of circuits supplying alternate-current arcs. This may cause difficulty in parallel working as alternators in parallel usually have their excitations adjusted so as to give the same reading on a power factor meter, and this adjustment may not correspond with minimum cross current. The method of determining the best power factor for any individual machine coupled to the 'bus bars would be to find the excitation for which the current flowing to it through the neutral wire is a minimum.

It should be noticed that the magnitude of the current flowing round the local circuit of star-connected generators, coupled in parallel is normally not so large as the local current flowing in a mesh-connected generator with the same irregularity in its open circuit wave form. In the mesh-connected machine the three triple-frequency components of E.M.F. in the three circuits will be in phase with each other, if the machine is symmetrical, whereas with two slightly dissimilar machines star connected and coupled in parallel, the worst possible case is that in which the triple-frequency E.M.F.s are in phase; and sometimes they may oppose each other and produce no resultant. The impedance of the path for the triple-frequency currents in mesh generators is due only to slot-leakage-reactance, and resistance, just as in the star-connected generators. It follows then that the mesh-connected generator is equivalent to the worst possible case of two star-connected generators coupled in parallel, all the machines being supposed to have a given magnitude of triple-frequency E.M.F. in their wave form.

Method of Avoiding Triple-frequency Current.—The recent discussion on triple-frequency currents has led to a number of suggestions as to the methods which may be adopted for getting rid of them.

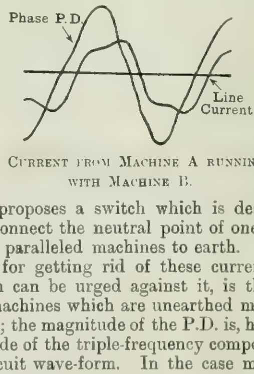

Fig. 11.—Line Current from Machine A running in parallel with Machine B.

Mr. Rider* proposes a switch which is designed so as to automatically connect the neutral point of one, and only one, of a number of paralleled machines to earth. This method is quite effective for getting rid of these currents. The only objection which can be urged against it, is that the neutral points of the machines which are unearthed may rise to quite high potentials; the magnitude of the P.D. is, however, limited by the magnitude of the triple-frequency component of E.M.F. in the open circuit wave-form. In the case mentioned above the value of this component was about 240 volts, and this potential is not a dangerous one, although it would obviously be necessary to take greater precautions than are usual in insulating and protecting the neutral point, when this arrangement is used.

Other suggestions have been to insert resistances or choking coils between the neutral points of each machine and earth.

Mr. Brazil† has pointed out that the best form of resistance to use is one which becomes less as the current through it increases, and he proposes carbon powder resistances; the limit to be placed on this resistance depends on the circuit-breakers in the machine circuit. There appears to be little doubt that alternators running in parallel should have their neutrals earthed and that choking coils are the best means of preventing triple-frequency currents.

The impedance of a choking coil to the triple-frequency current is three times what it would be for normal frequency currents, and it is, therefore, equivalent to a resistance which falls to one-third of its previous value, whenever it has to carry an out-of-balance current due to a fault, and so will not interfere with the proper operation of the circuit-breakers. It is possible to use quite a small reactance in the choker, and yet to cut down the triple-frequency current to negligible dimensions.

* Parshall and Hobart, "Electric Machine Design," p. 496, 22·5 lines per ampere per inch.

* Proc. Inst. of Elec. Eng., March, 1909.
† "The Electrician," May, 1909, p. 140

CORRESPONDENCE.

CHARGES FOR ELECTRICAL ENERGY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been very much interested in the discussion at the meeting of the Municipal Electrical Association and in your editorial regarding the publication of preferential terms granted to large users of electricity by municipal trading concerns.

Some years ago in Boston we felt that it was not necessary to have secret agreements, and that when any preferential terms were granted to one user, they should be granted to other users under the same circumstances. We have been acting on this principle for the last five years.

I enclose copy of our rates, and may say that no contracts are made, or supply furnished, except at these rates, with the exception of a few old contracts antedating the establishment of standard published rates. On these schedules we supply very large customers paying us up to £10,000 and £20,000 a year.

In individual cases we realise that it might be easier to get business if we could make special rates, but, on the whole, we feel that we stand much better by being able to say to every prospective customer that he can have the same price as any existing customer under the same circumstances. As soon as the customers as a whole find that they cannot get preferential terms, other than as their conditions warrant, they cease to ask for them.—I am, &c., R. S. HALE,

Boston, July 19. Supt. Sales Department,

Edison Electric Illuminating Co. of Boston.

[Mr. R. S. Hale encloses with his letter the schedule of rates, dated March 1, 1909, of the Edison Electric Illuminating Co. of Boston, and we observe that the schedule is divided into: (*a*) Lighting rates, (*b*) power rates—with a sub-heading elevator rates, (*c*) yearly lighting rates (for lighting consumers making yearly agreements), and (*d*) permanent electric rates (for consumers who make long term agreements). As these rates are of interest we summarise them below:—

(*a*) *Lighting Rates.*—The price charged for electrical energy is 6d. per unit, with a minimum charge of 4s. per month per meter.

(*b*) *Power Rates.*—The same price and the same minimum charge as for lighting up to a consumption equivalent to 23 hours' use per month of the consumer's maximum demand; for additional energy up to the equivalent of 103 hours' use of the maximum demand 4½d. per unit; and 3d. per unit for all energy in excess of this amount. In addition, whenever that portion of a consumer's bill which is calculated at the 4½d. and 3d. rate, or both, exceeds £2 per month, a discount of 70 per cent. is allowed on such excess amount over £2. Also, whenever a consumer's bill, after the foregoing deductions have been made, exceeds £20 per month, a discount of 30 per cent. will be allowed on any amount in excess of £20.

(*b*1) *Elevator Rates.*—Consumers using electrically driven elevators can be charged at the power rates, or, if they prefer, on the following sliding scale: 6d. per unit (with the usual minimum charge of 4s. per month per meter) up to 300 units per month; 2½d. per unit for energy between 300 and 600 units per month; 1½d. per unit for energy between 600 and 4,000 units per month, and 1¼d. per unit for all energy used in excess of 4,000 units per month.

(*c*) *Yearly Lighting Rates.*—A fixed charge of £12 per year, payable in equal monthly instalments, is made per kilowatt of maximum demand up to and including 15 kw., of £7·2 per kilowatt between 15 kw. and 55 kw., and of £6 per kilowatt for any demand over 55 kw. In addition, there is a charge for all energy consumed of 2½d. per unit up to 1,500 units per month, of 1½d. per unit for energy exceeding 1,500 units per month and not exceeding 5,500 units per month, whilst 1¼d. per unit is charged for all energy in excess of 5,500 units per month.

(*d*) *Permanent Electric Rates.*—These apply to consumers who sign agreements for at least 50 kw. of permanent electric service. The charge is divided into fixed costs, running costs and excess costs. The fixed cost is the same as that given above for yearly lighting rates. The running cost is 2½d. per unit up to 1,500 units per month; 1½d. per unit between 1,500 and 5,500 units per month; ¾d. per unit between 5,500 units and 105,500 units per month; ⅝d. per unit for energy in excess of this amount. If the company are not required to supply lamps and attend to the installation, a deduction of ¼d. per unit is made from the net amount of the bill. For intermittent loads up to 40 per cent. in excess of the kilowatts applied for by the consumer, an excess price of 10d. per unit will be charged for all electricity furnished at any time in excess of the kilowatts applied for.

In case of power the maximum demand is taken as the average of the regular monthly readings of the indicator between October 1st and the following February 1st in each year. Also, the demand in no case shall be less than one-third of the highest reading during the previous 12 months, or less than 1 kw. (10 kw. in the case of an elevator used on the power rates). Consumers can have their maximum demand indicators cut out one night in each month, provided a 48 hour written notice is given to the company.

In the case of lighting, the demand indicators are read between November 1st and the following February 1st, whilst 0·2 kw. is regarded as the minimum demand.—ED. *E.*]

THE PHOTOMETRY OF DIFFERENTLY COLOURED LIGHTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I would thank Mr. Lauriol for his interesting communication in your last issue confirming my article on this subject at least qualitatively. From what Mr. Lauriol says in his letter, and after somewhat hurriedly reading through his communication (in French) in the "Bulletin" of the Société Internationale des Electriciens, I understand that he compared a carbon lamp with a Nernst lamp, employing a Simmance Abady flicker head, tests being made with the disc moving and also at rest, and that a difference in the reading of no less than 20 per cent. was found. This goes much further than the difference I found with carbon and tungsten lamps and is indeed startling.

Mr. Abady will have his little joke. Of course he knows that I would never give preference to any particular type of photometer just because it favoured one type of lamp. The reason for preferring to go by the results of a Bunsen or Lummer is obvious enough. The conditions are nearer to those of practical illumination.

As no one has offered an explanation why a flicker photometer gives incorrect results, I will venture an explanation as a guess. In the eye we have the rods and the cones. The rods are supposed to be affected only by intensity, the cones also have the property of distinguishing colours. When a flicker head is run up to speed so that the colour sensation disappears, it may be that the cones are simply unable to follow the quick changes fast enough, and we have rod vision only, like we have at night when any one can notice that all objects not artificially lighted lose their colour. If the cone and rods are unequally sensitive to different parts of the spectrum, it follows that rod vision would give different photometric results to rod plus cone vision.

I have it on the authority of Messrs. Simmance and Abady that some colour-blind people obtain normal results with a flicker head. I have it on the authority of others of equal standing that some colour-blind people do not get normal results with a flicker. The explanation is that there is more than one sort of colour blindness. If the cones only are affected it would explain this difference and rather confirms my suggestion that the rods and cones are not necessarily equally affected by different parts of the spectrum.

As a confirmation of my tests I would like to mention that I have recently sent up to the National Physical Laboratory a couple of tungsten lamps for comparison. I tested these lamps each against a different carbon standard, using the Bunsen disc. Mr. Paterson tested them for me against his tungsten standards, which have been set up from carbon standards using the Lummer head throughout. Mr. Paterson's figures are 0·6 per cent. and 0·9 per cent. greater than mine. I also tested these lamps on a flicker and obtained about 5 per cent. less.—I am, &c., LANCELOT W. WILD.

Westminster Electrical Testing Laboratory, July 30.

RESEARCHES IN RADIO-TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you have the kindness to publish the following observations on the letter of Mr. E. Bellini published in your issue of July 23rd.

Mr. Bellini says that priority of the triangular aerial for circularly or elliptically polarised electromagnetic waves is certainly due to me. I may say, further, that I have used this form of aerial with good results, not only with elliptically polarised waves but also with plane polarised waves. These results are stated in official documents of the Royal Italian Navy, which fortunately are at my disposal. I further hold

several documents signed by Mr. Bellini attesting these good results.

Further, I declare that, in contradiction to Mr. Bellini's statement, Mr. S. G. Brown has never patented the triangular aerial, the aerial of X form, or that of V form, or my numerous other forms of aerial conductors.

In the British patent S. G. Brown, No. 14,449 (1899), Mr. Brown says: "This placing the wires half a wave-length apart causes the system to send its waves, or receive them, from mainly one direction, which direction would seem to be that of the plane of the wires.

"If the vertical wires were not so carefully adjusted to the wave-length they would transmit or receive the Hertzian waves from any direction."

My aerial conductors are not vertical, they are of V, of X, or of triangular form, or they are situated in a way that the plane of one of the inclined conductors makes a given angle with the plane of the other conductor. Mr. S. G. Brown, in describing his system, has implicitly excluded the particular forms of my aerial conductors, and it would be simply an absurdity to give to his words such an interpretation that would destroy the essential characteristic of the Brown method.

Mr. Blondel, in his Belgium patent (June 16, 1902), describes a radiator system of two or more parallel antennæ, whose distances and phases are fixed according to the length of the waves, &c.

My antennæ of V, of X or of triangular type form an angle between themselves; consequently they cannot be parallel.

I further declare that in several of my patents my aerials are equally for use with the elliptically polarised waves as for the plane electromagnetic waves.

Thanking you in anticipation for your kindness.—I am, &c.,

Turin, July 26. ALESSANDRO ARTOM.

ELECTRICITY TARIFF IN ST. MARYLEBONE.

At their meeting last week the St. Marylebone Council approved a report by Mr. A. H. Seabrook, the new manager of the electricity undertaking, on simplifying the existing systems of charging for electrical energy. The first part of the report contains an explanation of the terms employed; Mr. Seabrook then puts forward a complete scheme of optional tariffs suitable for all consumers; "large consumers" being classed as those requiring powers of 50 kw. and upwards; "medium-size consumers" being those requiring from 20 kw. to 50 kw., and "small consumers" those requiring power of an amount less than 20 kw. The tariffs proposed are given in the following extracts from the report. The term "power required" is used instead of consumer's maximum demand.

Large Consumers.

Power required.	Min. fixed Annual Charge.			
200 kw.	£900	0	0	
175 kw.	853	2	6	Additional kws. pro rata per kw., or part thereof per annum; and 1d. per unit for all units consumed.
150 kw.	787	10	0	
125 kw.	703	2	6	
100 kw.	600	0	0	
75 kw.	487	10	0	
50 kw.	350	0	0	

Terms.—Ten years' contract and exclusive use of electricity for lighting and power (motors). The "kw. charge" payable annually in advance.

Medium-size Consumers.

Power required.	Min. fixed Annual Charge.			
45 kw.	£337	10	0	
40 kw.	300	0	0	Additional kws. pro rata per kw., or part thereof per annum; and 1d. per unit for all units consumed.
35 kw.	266	17	6	
30 kw.	240	0	0	
25 kw.	209	7	6	
20 kw.	180	0	0	

Terms.—Five years' contract and exclusive use of electricity for lighting and power (motors). The "kw. charge" payable annually in advance.

General (Large and Medium Consumers).—The above are minimum terms under these conditions, and are not inflexible, and if it is inconvenient for a consumer to pay annually in advance, or to enter into a long period contract, the "kw. charge" will be accordingly increased, taking into consideration the directions in which the consumer cannot meet the conditions. The Council also may at their discretion (per their general manager), ignore the "annual or kw. charges" for uses of electricity other than lighting and motors, provided the premises are lighted exclusively by the Council.

Small Consumers.

Lighting only:—Telephone system of charge.

Power required.	Min. fixed Annual Charge.			
18 kw.	£166	10	0	Additional kws. pro rata per kw. or part thereof per annum; and 1d. per unit for all units used.
15 kw.	150	0	0	
12 kw.	126	0	0	
10 kw.	110	0	0	
8 kw.	92	8	0	
7 kw.	82	5	0	Additional ½ kws., pro rata per kw. per annum; and 1d. per unit for all units consumed.
6 kw.	72	0	0	
5 kw.	62	10	0	
4 kw.	51	0	0	
3½ kw.	44	2	0	Additional 1/10th kws., pro rata per kw. per annum; and 1d. per unit for all units consumed.
3 kw.	39	0	0	
2½ kw.	33	16	3	
2 kw.	26	10	0	
1¾ kw.	24	10	0	Additional 1/20th kws., pro rata per kw. per annum; and 1d. per unit for all units consumed.
1 kw.	14	0	0	
¾ kw.	10	10	0	
½ kw.	7	[illegible]0	0	
¼ kw.	3	10	0	
1/10th kw.	1	8	0	

The charges for all units consumed to be paid weekly, monthly or quarterly as required. I expect that a large proportion of the present and future consumers will be 1 kw. and under. I propose that this tariff be known as the "Telephone System of Charging," which is self-explanatory, as most of the consumers are telephone users and understand the fixed payment annually in advance, and 1d. per call. No contract for a number of years is proposed with these small consumers, unless any consumer particularly desires it. The annual charge is to be paid annually in advance and based on the consumer's "power required" for the previous year. In the case of new consumers, whose "power required" is not ascertained, the "annual charge" for the first year is to be assessed by the general manager, and after the first year the same procedure as with old consumers.

Flats.—The practice of farming out current to flat-holders by flat-owners will have to be carefully looked into, because it is to flatholders I am looking for extensive use of heating and cooking apparatus.

Small consumers: Heating, cooking and other uses of electricity, excluding lighting and motors.—I do not suggest any alternative to the 2d. and 1d. maximum demand system for consumers using motors, *i.e.*, factories, &c., at present. I recommend the following scale of charges for heating, cooking and other uses:—

Power required.	Fixed annual charge.			
¼ kw.	£0	5	0	And 1d. for all units consumed payable weekly, monthly or quarterly, as the Council may require.
½ kw.	0	10	0	
¾ kw.	0	15	0	
1 kw.	1	[illegible]0	0	
2 kw.	1	10	0	
3 kw.	1	15	0	
4 kw.	2	0	0	
5 kw. and upwards	2	2	0	

The "kw. charge" is payable annually in advance. The scale for heating and other uses of electricity only applies where the lighting of the premises is exclusively electricity from the Council's mains. These terms again are minimum terms; any consumer who wishes to pay quarterly instead of annually will be charged a correspondingly higher rental. For uses of electricity under this tariff we can generally assess the apparatus itself, *i.e.*, a 4-lamp radiator would be £1 per annum, and five radiators (or their equivalent) would be £2. 2s., and so on.

General Remarks: All sizes of consumers.—I am satisfied that we shall do better with our existing consumers with a simplified tariff; that it will be easier to get additional lighting business; and that with the proposed rate for heating and cooking, &c., we can compete with gas. Under this tariff the consumer must give all facilities for inspection of installations and apparatus by duly authorised officers of the Council, periodically. One advantage of this "annual charge" plus 1d. per unit tariff is that one meter only is required, the "power required" or "maximum demand" indicator remaining on all premises as at present, as the whole tariff depends upon the "power required" or "maximum demand."

I am of opinion that flat rates as a rule are incorrect methods of charge, and I would not recommend an extension of such rates for this district. The only fair method of charging on the flat-rate system is to group various classes of supply and give each class of supply a different flat-rate according to load factor, which would result in no end of dissatisfaction amongst consumers. The "maximum demand" or "power required" system of charging is the correct one, the difficulty having been to get it simple and understandable by consumers. This proposed tariff, I think, meets this difficulty. The variation in "annual charge" as between large and small consumers differentiates between wholesale and retail supplies. The annual payment in advance for large and medium consumers lessens the risk of bad debts to the Council, and further, in the case of small consumers, renders deposits unnecessary.

A most important point to the consumer is that one set of wiring only is necessary in all premises, even where lighting, heating, and cooking are mixed up. As to what may be termed "lighting," "power," "heating," "cooking" and other uses of electricity, the general manager's decision must be final.

In the case of large and medium consumers the tariff is to take effect at once; but in the case of small consumers, from December 31st next.

ON THE MAGNETIC PROPERTIES OF CERTAIN COPPER ALLOYS.*

BY A. D. ROSS, M.A., B.SC., AND R. C. GRAY.

Summary.—Manganese-aluminium bronzes exhibit less hysteresis, but are also less magnetic, after quenching. If rich in copper, they are more magnetic at $-190°$C. than at 15 C. Continued baking reduces the susceptibility and increases the hysteresis towards definite limits. In Heusler alloys containing 76, 62 and 55 per cent. copper respectively, and the remainder manganese and aluminium in atomic proportions, the critical temperatures are 280 C., 500 C. and 345 C. The quenching and liquid air effects in the Heusler alloys are very similar to those in Cu_3Al.‡

In May, 1907 a Paper was read before this society by one of us on the magnetic properties of the Heusler alloy.† After that date the investigation was extended to two other copper-manganese-aluminium alloys, and latterly the scope of the research has been further extended by a series of tests carried out by the present authors on simple aluminium and manganese bronzes, and on the constituent metallic elements in the pure form, while additional tests have been made on the manganese-aluminium bronze.

The specimens referred to in this Paper had the following compositions :—(1) Casting B.—62 per cent. copper, 25 per cent. manganese, 12·5 per cent. aluminium, and a trace of lead. (2) Casting D.—76 per cent. copper, 16 per cent. manganese, and 8 per cent. aluminium. (3) Casting E.—55 per cent. copper, 30 per cent. manganese, and 15 per cent. aluminium. (4) 5 per cent. aluminium-bronze (that is, 5 per cent. aluminium, 95 per cent. copper). (5) 10 per cent. aluminium-bronze. (6) 60 per cent. aluminium-bronze.

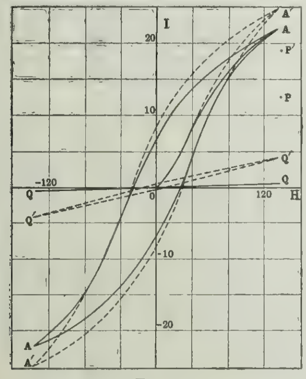

FIG. 1.

(7) 70 per cent. aluminium-bronze. (8) 30 per cent. manganese-bronze. (9) Pure aluminium. (10) Pure manganese. B is the ordinary Heusler alloy. The specimens from castings B, D and E were cylinders of length 20 cm. and diameter about 1 cm. They were tested in the condition as cast, except that the ends were cut off square. The other materials in the above list were too feebly magnetic to lend themselves to testing in the usual magnetometric method. The specimens were accordingly cast in the form of small cylinders 8 cm. in length and 6 mm. in diameter, and were magnetised by means of a powerful electromagnet.

For testing the castings B, D and E the Gray-Ross magnetometer‡ was used. The magnetisation of the other specimens was carried out with the large electromagnet belonging to the Physical Laboratory of Glasgow University. A field of 4,400 C.G.S. units was obtained, and the permanent magnetism so induced in the specimens was measured by a delicate magnetometer.

In the previous Paper an account has been given of the effects of liquid air on alloy B both in the cast and in the quenched condition. Similar tests were now made with alloy D. The quenching was carried out at 450°C. Fig. 1 exhibits the results obtained. In calculating H, the strength of the magnetising field, allowance has been made for the end effect of the magnetising solenoid, and Du Bois's factors are employed in deriving the true field from that due to the current in the helix. The values of I, the intensity of magnetisation, are obtained on the assumption that the polar distance of the cylindrical specimens is ⅚ their total length—an assumption which has been justified by comparison of such specimens with others turned down into ellipsoids of revolution. The curve AA shows the magnetic condition of the alloy in its original state. On re-testing with the specimen at the temperature of -190 C. the dotted line curve A'A' was obtained. After being quenched at 450 C. the specimen was almost non-magnetic, as indicated by QQ. On cooling, however, to $-190°$C. there was a marked increase in permeability and hysteresis, as shown by the curve Q'Q'. Another specimen which had been very rapidly cooled in the process of casting gave P and P' respectively for the highest points on the 15°C. and the $-190°$C. magnetisation cycles. It exhibits a large liquid air effect, and therein resembles the quenched material.

Similar tests on alloy E—an alloy much poorer in copper—are given in the Paper. The hysteresis is almost inappreciable, and the liquid air effect is reversed in direction.

Effect of Baking the Alloys.—Various temperatures up to 500 C. were employed. The result of this thermal treatment has therefore been (i.) to lower the saturation intensity continuously towards a limiting value, (ii.) to cause at first a slight increase in the susceptibility for low fields, (iii.) to reduce the susceptibility for all fields towards a definite limiting value, (iv.) to reverse the liquid air effect in specimens baked for more than 8 hours. The hysteresis was also found to increase with time towards a maximum value. The effect of baking alloy B has also been investigated by the authors. It has been found that the best magnetic condition of the alloy is obtained by exposing the material for a period of 6 to 8 hours at a temperature of 170°C. This results in an increase of over 10 per cent. in the saturation value of I,* while the short duration of the baking process does not produce any marked increase in the hysteresis loss in taking the material through a magnetic cycle. Prolonged heating at the same temperature slightly reduces the susceptibility, and greatly augments the coercive force and the hysteresis loss.

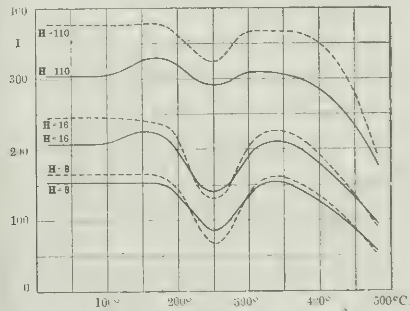

FIG. 2.

Fig. 2 shows the results of exposing the alloy B to steadily increasing temperatures. In each case the alloy was placed in a furnace at the required temperature, kept there for three hours, and then the furnace was shut off and the alloy allowed to cool in position and tested cold. The tests were made for a series of temperatures from 50 C. to 480 C. The dotted lines give the results of similar tests made with the baked alloy cooled to $-190°$C. The curves show the improvement of the material for high fields with baking at temperatures in the neighbourhood of 170°C. They also exhibit a marked deterioration in the magnetic quality after baking of the specimen about 250°C., and a subsequent recovery prior to a rapid deterioration after 330 C. This dip in the curves is very remarkable, and points to some extensive change in constitution of the material. It is noteworthy, too, that the growth of hysteresis is specially rapid in the case of specimens exposed to temperatures between 200°C. and 250°C., and the maximum limit attained is greater than in specimens which have been subjected to prolonged heating at about 320°C. The variation in the liquid air effect shown in Fig. 2 is also interesting. With the material in the condition as cast, cooling to -190 C. improves the quality for all fields. In the case of specimens which have been baked at temperatures in the neighbourhood of 250 C. the effect is reversed in sign for fields below 30 C.G.S. units, and it is much reduced in magnitude for high fields. The quality of specimens baked at 330°C. is much the same as in the unbaked condition, both as regards tests at room temperature and at that of liquid air. In specimens exposed to still higher temperatures the susceptibility once more falls off, and this is again accompanied by a lessening and final reversal of the liquid air effect.

* Abstract of a Paper read before the Royal Society of Edinburgh.
† THE ELECTRICIAN, December 27th, 1907.
‡ J. G. Gray and A. D. Ross, "On an Improved Form of Magnetometer, &c.," "Proc. Roy. Soc. Edin.," 1908-9.

* Baking, however, always reduces the values of I corresponding to small fields.

Brief reference is next made in the Paper to critical temperatures.

Simple Bronzes, Manganese and Aluminium.—These materials were magnetised with a field of 4,400 C.G.S. units, and their permanent magnetism was subsequently measured. Some of the results given show that the intensity of magnetisation for the cast materials magnetised at 15°C. and −190°C., and when quenched at 500°C.-600°C., and tested at the above temperatures was for No. (4) 0·010, 0·091, 0·029 and 0·110 respectively, No. (5) 0·184, 0·228, 0·145 and 0·175, for No. (8) 0·057, 0·072, 0·096 and 0·118, and for No. (10) 4·76, 4·68, 3·74 and 3·70. The two aluminium alloys which show a specially marked improvement in magnetic quality when cooled to liquid air temperature are the two bronzes which contain free copper. The same two (viz., the 5 per cent. and 70 per cent. bronzes) also show an increased retentivity in the quenched state. This again agrees with the results obtained for metallic copper. The 10 per cent. aluminium-bronze does not contain free copper, and does not improve on quenching. It shows, however, an increased retentivity at liquid air temperature. Accordingly, one or both of the compounds Cu_4Al and Cu_3Al is magnetic. The 60 per cent. aluminium-bronze, which consists of $CuAl_2$ and eutectic, is practically non-magnetic. The 30 per cent. manganese-bronze contains free copper and exhibits the same peculiar properties as the two aluminium-bronzes which had free copper, in so far as its retentivity is greater at liquid air temperature than at 15°C., and is greater in the quenched than in the cast condition. The manganese which is a constituent of this bronze is, comparatively speaking, strongly magnetic, but the effects of liquid air and quenching are the reverse of those found in the manganese-bronze. In a Paper to be laid before this society by Mr. J. G. Gray and one of us it will be shown that manganese-steel does not give an increased residual magnetism after quenching, as does manganese-bronze, and further that when in the normal condition its quality degenerates slightly when the material is cooled to −190°C. Manganese-steel is therefore somewhat similar to pure manganese in its magnetic properties, and gives effects altogether unlike those found in the purest copper. Accordingly, as manganese-bronze resembles copper in its magnetic properties and is essentially different from manganese and manganese-steel, it seems natural that its magnetism may be due in great measure to the free copper contained, and not to a manganese-copper constituent. Also, the tests indicate that pure aluminium (such as had been used in making the aluminium-bronzes and the Heusler alloys) is not susceptible of retaining any measurable trace of permanent magnetism. The result of the tests on the materials (4)-(10) is therefore to show that specimens containing free copper undergo a marked improvement in magnetic quality on cooling from 15°C. to −190°C., and that quenching is likewise accompanied by an increase of residual magnetism—except, of course, in so far as these effects may be masked to a greater or less extent by those due to the presence of other magnetic materials.

The Magnetism of the Heusler Alloy.—These results have an important bearing on the magnetism of the Heusler alloy. A characteristic feature of these bronzes is that their retentivity at the temperature of liquid air is greater than at room temperature. Such an effect is of the same kind as that given by free copper. It is also similar to that found in the 10 per cent. aluminium-bronze, but its great magnitude in such cases as the quenched castings D is more suggestive of the free copper than of the copper-aluminium compounds. Hitherto the magnetism of the Heusler alloy has been often ascribed to the manganese alone, whose transformation temperature, it has been conjectured, is lowered by its solution in the other constituents. The authors do not claim that the investigations afford an explanation of the magnetic phenomena of the Heusler alloy, but they consider that the magnetic properties of the alloy show a suggestive similarity to those of Cu_3Al, and that the presence of free copper in the alloy may at least play a not unimportant part in determining the magnetic behaviour of the bronze. That manganese is also an important factor is unquestionable, as its omission destroys the remarkable properties of the bronze just as the exclusion of the copper would do. It should be noticed, in support of the view here adduced, that the liquid air effect in the Heusler alloy increases in magnitude with increasing copper content, and hence probably with increasing amount of free copper.

Tramway Transfer.—Ince-in-Makerfield District Council give notice of intention to lease to Wigan Corporation (for 21 years from July 1,1909)the tramway extending from Wigan to Hindley boundary of the Council's district at a yearly rent of £25, plus interest and sinking fund on £5,000 expended by the Council on and about the purchase of the tramway, and 8 per cent. on the cost of any additional works which the Corporation may require to be constructed by the Council under the lease.

SOME APPLICATIONS OF ELECTRICITY IN MEDICAL AND SURGICAL RESEARCH.

[COMMUNICATED.]

Newcastle-upon-Tyne has long been famous for its physicians and surgeons, the University of Durham College of Medicine having turned out many distinguished men in the course of its existence. Dr. George Yeoman Heath was president of the college from 1874 to 1892. At his death on March 4, 1892, he left £6,000 which was applied to the erection and equipment of laboratories of physiology and comparative pathology, together with club rooms and a gymnasium for the students.

The "Heath Wing" of the college has now been erected for some considerable time, and the applications of electricity therein contained cannot be regarded as in the experimental stage. It is, therefore, interesting to note the way in which electricity enters into its equipment. The building is three storeys high, the ground floor containing an entrance hall, a cloak room, restaurant, smoking room and reading room for students, and a gymnasium, all of which present a very handsome appearance. Lighting is carried out throughout the building by Nernst or carbon filament lamps suspended from the ceiling, except in the case of the bacteriology class room, to be mentioned later. The first floor has upon it the rooms devoted to chemical physiology, consisting of a general laboratory, a preparation room and an experimental physiology laboratory and private room of the professor. The second floor deals in a similar way with bacteriology, there being a lecture theatre, a bacteriology class room, a research room, the professors' private room and a sterilising room. There are, in addition, numerous store rooms, dark rooms, &c. One interesting feature of the laboratories, and one on which their cleanliness largely depends, is that all the walls are painted with enamel, and that there is not a single sharp corner in the rooms, every corner being finished in cement and rounded off. This gives greater facility for cleaning.

In the physiological section the work of examining the functions of the muscles is, among other things, carried out, and the experimental physiology laboratory, which is intended to accommodate 40 students at a time, contains a considerable amount of apparatus in which electricity takes a part. There is, for example, a series of instruments for recording the effect of electric shocks on the muscles. Around a vertical brass drum, uniformly rotated by means of a rope gearing and countershaft, driven by an electric motor, is placed a sheet of blackened paper. A light style, in the shape of a crank lever, is pivoted to a stand on the upper surface of which is a slab of cork. To this slab is fixed, by means of pins, the muscle upon which it is desired to experiment, and one end of which is attached to the short arm of the lever. Two electrodes leading from the terminals of a small battery-operated induction coil are placed on the muscle or its nerve, and the application of the current produces a spasmodic contraction of the muscle, the horizontal pull of which produces a vertical movement of the style on the drum. A curve is, therefore, marked on the blackened surface, the height of which bears a ratio to the amount of contraction of the muscle equal to the ratio of the two arms of the lever, and the time taken to produce the movement is measured by the vibrations of a tuning fork. The current in the induction coil can be varied by means of a rheostat, and the muscular contraction is, therefore, studied under all conditions of stimulation.

A somewhat similar apparatus is used for the study of the effect of various drugs on the action of the heart, and the whole of the drums are driven by a ½ H.P. motor operating the shafting over the benches by means of a rope drive over a jockey pulley. Another interesting electrical appliance in this department is an instrument for accurate time tracing, to be applied to the drums before described, and made by the Cambridge Scientific Instrument Co. It consists of a horizontal tuning fork, which, under the influence of an electric current, vibrates at a frequency of 100 per second. A small electromagnet placed at the face of the top limb of the tuning fork, through which current is interrupted by the movement of the vibrating arm, attracts a light armature carrying a small style. This instrument is placed adjacent to a revolving drum bearing blackened paper, on which a curve can be described, as shown above, and the vibration of the armature makes the style imprint on the paper a series of curves, the space between the apex of each curve on the paper corresponding to a time interval of $\frac{1}{100}$ second. In this way very accurate measurements of the motion of muscles and similar experiments can be taken. For larger gradations of time a somewhat similar apparatus, made by Messrs. C. F. Palmer & Co., of London, S.W., and consisting of a style which marks at intervals of one second is used. This instrument consists of an electromagnet which receives periodic impulses through an electric current controlled by a pendulum which closes the circuit at the end of each swing, these swings being accurately adjusted to one per second.

In the research drum is a similar recording drum to those above described, but on a much larger scale, the drum being 10 in. long by 9 in. diameter. It is operated, in addition to other apparatus in this section, by a ½ H.P. motor, and a one-second timing apparatus, similar to the one just described, is attached. A somewhat interesting piece of apparatus using the motive power is a respiratory pump for the purpose of artificial respiration. For the purpose of separating the corpuscles in samples of blood an electrically-driven centrifuge, revolving at 1,500 revs. per min., is installed, in which the flasks containing the samples are placed radially, their necks being pointed to the centre of the centrifuge. The relatively heavy corpuscles of the blood pass outwards to the base of the flask, thus rendering division between the corpuscles and fluid portions of the blood possible.

It should be mentioned that in the roof of the building is installed an electrically driven fan running at the rate of 250 revs. per min., and drawing 15,000 cubic ft. per minute. By this means a draught is maintained in the draught cupboards of the chemical physiology laboratory on the first floor, and ventilation of the whole building is provided for. On the second floor the use of electricity is not so extensive, being practically limited to lighting. An interesting feature of the bacteriology class room is that all the benches are equipped with shaded lamps, so arranged that a strong light is thrown upon the objects under observation while being shaded from the student's eyes. A similar centrifuge to the one above described is used in the examination of water and milk, and for other purposes. The lecture theatre is equipped with an optical lantern operated by means of a 10 ampere scissors-type arc, while a table lantern with a Nernst projector lamp is also in use. The whole of the building is fitted with telephones, both on the National service and a private intercommunication system. The lighting and power service, which is derived from the mains of the Newcastle-upon-Tyne Electric Supply Co., is brought in at the basement, and is a three-wire continuous-current system with 480 volts between the outers. The electric lighting equipment consists of 34 ½ ampere Nernst lamps, 11 ¼ ampere Nernst lamps, and 122 incandescent lamps in groups and singles, and six motors. In the basement is an interesting research apparatus, consisting of a Bruce-Peebles 240 volt 4 H.P. motor driving a two-cylinder air compressor, capable of giving air pressure up to 200 lb. per square inch. This is conducted to a strong steel cylinder some 2 ft. in diameter capable of being hermetically sealed.

The whole equipment demonstrates that in modern medical and surgical research electricity is used in a manner which, though unfamiliar to the engineer engaged in the ordinary sphere of heavy electrical applications, nevertheless has a direct and very important bearing on the welfare of the human race. We are indebted to the Council of the University of Durham College of Medicine for their permission to make this brief and, we fear, somewhat cursory summary of the electrical appliances in this latest department of the college.

LEGAL INTELLIGENCE.

R. W. Blackwell & Co. v. Derby Corporation.

In the Court of Appeal on Thursday last week (before Lords Justices Moulton and Buckley) plaintiffs appealed from an order of Mr. Justice Bucknill in Chambers staying this action under sec. 4 of the Arbitration Act.

Mr. ATKIN, K.C., said the question was whether the judge in his discretion was right in staying the action on the ground that the contract between the parties contained an arbitration clause under which disputes arising under the contract were to be referred to the arbitration of the borough engineer of the Corporation. The contract was for the construction of electric tramways in Derby. The borough engineer had certified for certain penalties in respect of alleged delay in completing the contract, and plaintiffs' case was that the delay arose from the arbitrary conduct of the borough engineer himself, in, as alleged, directing the work to be done in a certain manner and with materials to be obtained from specific firms, and in refusing to permit plaintiffs to store material required for the work in certain places. The action was brought to recover the balance alleged to be due under the contract. Counsel submitted that the judge was wrong in staying the action, inasmuch as the dispute was not one which ought fairly to be referred to the arbitration of the borough engineer, who, in order to arrive at a conclusion, would have to sit in judgment upon himself.

Mr. DANCKWERTS, K.C. (for defendants), submitted that the dispute was such as must have been in the contemplation of the parties when it was agreed that the borough engineer should act as sole arbitrator. The authorities showed that an arbitrator appointed under a contract was only displaced, and the jurisdiction of the courts called in aid, when it was shown that the arbitrator was likely to be biased, or that he had been guilty of misconduct, such, for instance, as receiving bribes. In the present case the bona fides of the borough engineer could not be attacked, the only suggestion being that, as he had certified for penalties, as he was entitled to do under the contract, he was not a fit person to arbitrate on the dispute. Courts ought to act on fixed principles, and, having laid down certain principles, they ought to be true to them, and people in entering into such a bargain did so with knowledge of those principles, and in the belief that they would be supported by the courts.

Lord Justice MOULTON, in giving judgment, said that there was no doubt with regard to the law to be applied. Each case had to be dealt with on its own facts. In his opinion, where the nature of the dispute arising from facts which were subsequent to the contract was such that the court thought that the arbitrator was not likely to be able to deal impartially with the dispute, it was open to the court, and it was their duty, to refuse to enforce the arbitration clause. It was suggested that that ruling would make arbitration clauses useless, but courts were quite able to judge of what was the subject of the dispute, and they would not be misled by unfounded allegations. In the present case he was satisfied that the dispute was substantially whether the borough engineer from the first acted unreasonably towards the contractors from the point of view of the contract. Corporations were, in his opinion, too fond of putting officers of their own in the position of engineers under a contract, and they forgot that, as the officer had to perform other duties for the Corporation, there might arise conflicting interests between those duties and his duties under the contract which might give rise to unfair treatment of the contractor by reason of the zeal with which the officer performed those other duties. In the present case he was of opinion that the court would not be acting in the spirit of the law if they were to shut the doors of the courts to the action, and force it to be referred to arbitration. He was satisfied that there was a substantial dispute arising out of events which occurred subsequent to the making of the contract, and he did not think they ought to force it to be tried by the engineer, whose conduct was practically the sole point in dispute.

Lord Justice BUCKLEY concurred, and said he did not in any way reflect upon the borough engineer, but in the circumstances he did not think he was the proper person to determine the dispute.

The appeal was allowed, with costs, and the order staying the action set aside.

Clarke v. West Ham Corporation.

On Friday the Court of Appeal (the Master of the Rolls and Lords Justices Farwell and Kennedy) delivered a considered judgment in this appeal of defendants from a judgment of Mr. Justice Coleridge. (The facts were reported in THE ELECTRICIAN for March 5.)

In delivering judgment, the MASTER OF THE ROLLS said the appeal raised an important question—whether West Ham Corporation could by notice limit their liability to pay damages for an accident due to their negligence. Defendants claimed, as statutory assignees of the undertaking of the North Metropolitan Tramways Co. and by the Act of 1869, which incorporated that company, power was given to the company to make and maintain certain street tramways. By sec. 67 the company were authorised to demand tolls from every passenger travelling of not exceeding 1d. per mile, and by sec. 68 every passenger travelling upon the tramways might take his personal luggage, not exceeding a certain weight, free of charge. By sec. 70 the company were not to be bound to carry, unless they should think fit, any articles other than such passengers' luggage, a section which seemed to imply an obligation to carry passengers and passengers' luggage. By sec. 71 a list of all authorised tolls which should be exacted by the company had to be exhibited on the inside of every carriage. That section seemed plainly to indicate that they could not exact the maximum authorised toll if they put up inside their carriages only a smaller toll. By the North Metropolitan Tramway Act, 1870 (sec. 34), the company were required at all times, after the opening of the tramways for traffic, to run certain workmen's trams at cheaper fares to be fixed by the Board of Trade. That section seemed to him to imply an obligation to carry passengers, with a superadded obligation, if the Board of Trade so directed, to carry workmen at special rates at special hours. By the North Metropolitan Tramways Act, 1884, the company were authorised to make and maintain certain further tramways (including the Barking-road line), and by sec. 48 the sections of the Acts of 1869 and 1870, to which he had referred, were incorporated. The accident to plaintiff took place on the Barking line. It seemed to him that the provisions of that statute plainly indicate that the tramways were not for the mere private benefit of the undertakers, but were for the public benefit. By the West Ham Corporation Act, 1898, the Corporation were authorised to purchase the tramways of the North Metropolitan Tramways Co. within the borough, and to exercise all powers possessed by that company, and (in addition) they were authorised to use electric power. The Corporation had acquired the line on which the accident occurred. The charges made by defendants for a portion of the Barking line were less than the maximum. The only charge printed on the inside of the car for the distance travelled by plaintiff was ½d., but they inserted inside their carriages a special notice as follows: "Passengers are being carried at less than maximum authorised charges, and every passenger is notified that, in consideration thereof, a passenger is only carried on the terms that the maximum amount recoverable from the Corporation on account of any injury or damage suffered by a passenger, and for which the Corporation is legally liable, is £25. Except as above, every passenger travels at his own risk. Passengers can only travel subject to being bound to observe the by-laws for the time being." It was admitted that plaintiff was aware of that notice. Plaintiff was seriously injured by an electric shock due to the negligence of defendants. The jury awarded £500 damages, and judgment was entered for that sum, the learned judge declining to give effect

to the contention of defendants that the £25 paid into court by them was all that plaintiff could claim.

The first and main point to be considered was whether there was an obligation upon defendants, so long as the tramways were being worked, to carry a member of the public, not being an objectionable person within the meaning of by-law 4, who desired to enter a car in which there was a vacant place, or were defendants under no such obligation, but at liberty to refuse to take anyone except upon such conditions as de endants thought fit to impose? In his opinion there was such an obligation upon defendants, or, in other words, plaintiff had a right on paying, or offering to pay, his fare to travel in the tramcar. It was quite true that that obligation was not imposed in clear and express terms, but he could not think that the sections to which he had referred admitted of any other conclusion. Parliament had allowed the levying of tolls, which, again, seemed to him to negative the idea that defendants could pick and choose their passengers. Moreover, the by-laws, which had statutory effect, strongly supported that view. If he was correct in that view, it followed that the right conferred upon plaintiff was a right to be carried on payment of the published fare namely, 1d. and that there was no justification for qualifying plaintiff's right by the addition of a term limiting liability for negligence to £25. It might be, though he hesitated without further argument to so hold, that if defendants had chosen to publish two lists of fares in their carriages, one of which contained their maximum rates and the other contained reduced rates, and an option were given to a passenger to pay either the full rate without any limitation of liability, or the reduced rate with a limitation of liability, a passenger electing to pay the smaller fare would be bound by the terms on which, and on which alone, the reduced rate was accepted. In that case there might be consideration for the limitation of liability, but in the present case it seemed to him that no option was given. The plaintiff had paid the only fare which defendants could demand, and defendants were no more entitled to limit their liability to £25 than they would be to negative all liability for negligence. In his opinion it was not useful to refer to provisions contained in the Railway Acts or to cases decided under those acts. He based his judgment on the simple proposition that plaintiff, who had a right to be conveyed in a tramcar on payment of the published fare, enjoyed that right with everything incidental to it, including a right to such damages as a jury might assess by reason of defendants' negligence. He thought that the appeal failed, and must be dismissed with costs.

The Lords Justices also delivered judgments dismissing the appeal.

A stay of execution was granted pending an appeal to the House of Lords, on the terms that plaintiff was to have his costs in the court below and in the Court of Appeal taxed and paid him in any event, and that defendants should pay him £1 a week till the hearing of the appeal.

Morrison v. British Aluminium Co. (Ltd.)—On Friday last Mr. Justice Warrington allowed this debenture holders' action for the appointment of joint receivers to stand over until the second motion day next sittings, all parties agreeing.

PARLIAMENTARY INTELLIGENCE.

Colinton Tramways Order.—As announced in our last issue, the Parliamentary Commissioners who considered this order last week found the preamble proved, subject to the adjustment of clauses. At the instance of the Edinburgh Town Council it was decided to insert a clause reserving to the Council the right to construct a small section of tramway in Slateford-road. The Chairman said the Committee did not contemplate giving the promoters any power to go into the city. The Corporation should not be inconvenienced by the construction of that tramway, and not be driven to make a tramway if they were not disposed to do it.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of head of the electrical engineering department at the Technical College, Sunderland. Salary £250, rising to £300 per annum by two equal annual increments. Applications to the secretary, Mr. T. W. Bryers, Education Offices, 15, John-street, Sunderland, by Aug. 23. See also an advertisement.

The Council of the University of Birmingham invite applications for the position of assistant lecturer and demonstrator in electrical engineering. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by noon Aug. 14. See also an advertisement.

A pupil is wanted for a low-tension, three-wire station in South London area. Opportunities given for obtaining experience in central station and mains work. See advertisement.

One or two draughtsmen, used to mechanical design and with knowledge of high-class electrical switchgear, are wanted. See an advertisement.

Applications are invited for the post of lecturer and assistant in the department of electrical engineering of the Glasgow and West of Scotland Technical College. Commencing salary £175. Applications by Aug. 17 to Prof. Magnus Maclean, D.Sc. See advertisement.

An assistant is wanted for the meter department of Stepney (London) electricity works. Applicants must have thorough knowledge of the maximum demand system and be able to advise consumers on power and lighting matters. Applications to the Engineer and Manager, Electricity Works, 27, Osborn-street, E.

Applications are invited for the Professorship of Physics in the Royal College of Science, Dublin. Applications by Aug. 16 to the Secretary, Department of Agriculture and Technical Instruction for Ireland, Upper Merrion-street, Dublin.

The lectureship in electrical engineering at University College, Galway, is vacant. Salary £120. Applications to the Secretary, Mr. Robt. Donovan, Royal University-buildings, Dublin, by Aug. 31.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

There is a vacancy for a lecturer and demonstrator of physics at the Sir John Cass Technical Institute, London. Commencing salary £150. Applications to the Principal by Aug. 28.

Owing to the resignation of Mr. Brownscombe, Dover Council have promoted Mr. Osborne to be senior shift engineer, and Mr. Greenhouse has been appointed junior shift engineer.

The Ross Goldfields Co. (N.Z.) have appointed Mr. Falkenbach as their chief electrician and Mr. Thomson (of Waipori) and Mr. Dinnie (of Otoru) as his assistants.

The Burma Government have obtained the sanction of the Secretary of State for India to the appointment on a permanent footing of Mr. B. Raikes (who was appointed in 1905 for three years) as provincial electrical inspector in Burma. The salary is to be R.600 (£40) per mensem, rising by annual increments of R.40 to R.1,000 (£66. 13s. 4d.), with an additional allowance of R.100 per mensem while employed in Burma.

EDUCATIONAL NOTICES.

University of London (University College).—The courses in mechanical, civil, municipal and electrical engineering begins on Monday Oct. 4. The College contains spacious electrical and mechanical engineering laboratories, workshops, drawing office, &c. Special and post-graduate courses on "Steam Turbines," "Recent Methods and Instruments in Surveying," and "On the Theory and Design of the Ideal Arch, Metal and Masonry" have been arranged. Further particulars may be obtained of the Secretary, Mr. Walter W. Seaton, University College, Gower-street, London, W.C.

King's College, London.—The session 1909-1910 commences on Oct. 6. Prospectuses and information relating to the courses of instruction in the Faculty of Engineering and Applied Science and Division of Architecture may be obtained from the Secretary, Kings College, Strand, W.C. Evening classes are held in electrical and mechanical engineering, drawing, mathematics, physics, &c.

University of Liverpool.—The session 1909-1910 commences on Tuesday, October 9. The courses of study in the faculty of engineering, leading to the ordinary degree of B.Eng., extend over at least three years, and are so arranged as to afford a general scientific training for those who intend to become engineers or naval architects, or to enter any allied profession. The honours course enables students to specialise in some branch of the profession, and opportunities are afforded for post-graduate work and research. Prospectuses from the registrar, Mr. P. Hebblethwaite, M.A.

University of Glasgow.—The next session commences on Oct. 11 next and ends on March 17, 1910. Students in the department of engineering and mining and naval architecture usually spend the summer months in practical work, thus receiving their training on the sandwich system. Prospectuses for the course of B.Sc. and D.Sc. in Engineering and syllabus of classes will be forwarded on application to the Assistant Clerk, Matriculation Offices, The University, Glasgow.

University of Manchester.—A prospectus giving particulars of the lecture and laboratory courses in physics, preparing for both the ordinary and honorary degrees of this university, will be forwarded on application to the Registrar. Prof. Rutherford will meet intending students on Oct. 5.

University College, Nottingham.—The instruction in the engineering department of this college includes courses in mechanical and electrical engineering for the B.Sc. degree and mining diploma, and ordinary courses. The session begins Oct. 4. Prospectuses may be obtained from the Registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

Hackney Technical Institute, London.—The next session commence on Sept. 20. There are evening lecture and laboratory courses in electrical engineering, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses may be obtained from the Principal of the Institute, Dalston-lane, London, N.E.

British School of Telegraphy.—There is a wireless telegraphy department attached to this school, at which practical and theoretical instruction is given. Particulars from 175, Clapham-road, London, S.W.

Accrington.—The Postal Authorities have agreed to pay £100 annually for five years for the conveyance of the mails, postmen, &c., on the local tramways.

Argentina.—The "Review of the River Plate" says Messrs. F. Dall & Co., have applied to the Buenos Ayres Legislature for a concession for an electric tramway between Bonaca and Chascomus.

Florencio Varela Municipality will shortly sign a contract for the erection and equipment of electricity works.

Messrs. Bancalari & Forchiere have obtained the contract for the provision of public and private electricity supply at Toay.

Santa Fe Government have contributed $40,000 (gold) towards the cost of new machinery for the electricity works of Santa Fe Municipality.

Asylum Lighting.—An adjourned inquiry was held on Friday into the application for sanction to a loan of £4,300 for completing the electric lighting of the Richmond Asylum (Dublin).

Mr. G. Horan (for the Joint Committee of Management) said that the original loan asked for was £3,800; the increase of £500 was required owing to alterations in the proposed system of supply. The present cost of lighting the asylum with gas was £1,872. 3s. 7d., and the cost (under the recent proposal of the Gas Co.) would be £1,378. 16s. 10d., but some of the buildings had at present no fittings for gas, and would require to be tubed. The estimated cost of lighting by electricity would be £1,517, including capital charges. £672 was estimated as the cost of current for the asylum buildings. The Joint committee recognised that the estimate for electric lighting was £140 in excess of the latest offer for gas, but notwithstanding they recommended the acceptance of the former, as they considered that the advantages gained by the use of electricity would compensate for the difference. They had been advised, and their experience had taught them that in such buildings as the Richmond Asylum it was essential to have the rooms and corridors well lighted and that the risk against fire should be made as small as possible.

Mr. Richard Jones (chairman of the Asylum Board) gave evidence in support of the application.

Australasia.—The "Australian Mining Standard" states that Launceston (Tasmania) Council on June 1 unanimously adopted a motion by Ald. Oldham that a poll of the citizens be taken on the question of the construction and operation of electric tramways by the municipality at a capital cost not to exceed £60,000.

The equipment of Hampden Shire Council's electricity works at Terang was completed about the beginning of June. The charge to private consumers for current is 8d. per unit. The same Council's loan of £7,000 for electric lighting at Camperdown was over-subscribed.

The Poowong and Jeetho Shire Council have accepted the offer of McLean & Co., (Melbourne), for the erection and equipment of an electricity station at Korumburra (Victoria).

Buln Buln Shire Council have accepted the offer of the Drouin Co-operative Butter Factory for the electric lighting of Drouin for seven years.

At a recent meeting of the board of the Ross Goldfields Co. (N.Z.) it was announced that the contractors (Messrs. Mabin & Welch) had practically completed the installation of electric pumping plant at the Company's mines, and (as stated in another column) resident electricians had been appointed.

Sebastopol Council have granted an extension of two years for the construction of electric tramways to the borough by the Ballarat (Victoria) Electric Tramways Co.

Awards.—The dispute between Aberdeen Electricity committee and the Aberdeen Suburban Tramways Co., as to the charge to be made for electric current supplied to the company, was referred to Mr. W. H. Patchell, and the award has now been issued.

Mr. Patchell has made the fixed charge £4. 10s. per kilowatt per annum, plus ½d. per unit used. The company is to pay the Corporation a minimum of £900 per annum. The award means a reduction of ¼d. per unit on the old rate. Mr. Patchell has fixed five years as the term of the agreement.

The question of the charge to be made for electric current supplied to the Peterborough tramways was recently referred to Sir Alex. B. W. Kennedy, who has now issued his award, and fixes the price (for five years from Sept. 1, 1907) at 2d. per unit for the first 120,000 units in each year, and 1¼d. per unit for all energy beyond that quantity. This represents a reduction of nearly £200 a year on the present consumption.

Barking.—The Council have applied for a loan of £2,500 for extensions of the electricity undertaking.

Bodmin.—The Council are negotiating with Messrs. Meagor for the erection of electricity works.

Brighton.—Last week the Council considered the reports of the Lighting and Tramways committees on the question of the charge to be made for electric current supplied to the tramways department, and, after discussion, a compromise was arrived at, the price being fixed at 1·35d. per unit for the current year.

Brussels Exhibition, 1910.—In connection with this Exhibition the National Electrical Manufacturers' Association has issued a circular to its members in which the following suggestions are made :—

(1) Joint action on the part of members who propose to exhibit, by arranging for someone to report to them regarding the positions available. (2) In the case of joint exhibits the association could arrange for members to co-operate and obtain an arrangement of space, show-cases, &c. (3) The actual cost of sending a representative to report or of a joint exhibit to be shared by the exhibitors.

Burnley.—The Electricity committee have altered their practice as to the cost of laying services, and in future the cost of laying cable in excess of the statutory 60 ft. must be paid by the consumer.

Canada.—The Canadian Bridge Co. have orders for 3,000 steel towers for the transmission line of the Ontario hydro-electric commission from Niagara Falls to Toronto and other towns. It is expected that 175 miles of line will be erected by the end of the approaching autumn.

East Ham.—Sanction has been received to a loan of £1,836 for tramway work.

The engineer and manager (Mr. W. C. Ullmann) has been instructed to make and fix 100 manganese steel plates over the tramway rail joints at a cost of 35s. for each joint.

Eccles.—The chairman and vice-chairman of the Electricity committee and the borough electrical engineer (Mr. H. W. Angus) are to visit Leeds, Wigan and London for the purpose of inspecting water softening plant.

Embezzlement.—At Glasgow Sheriff Criminal Court on Thursday last Arthur Delves, late manager of the Airdrie & Coatbridge Tramways Co. pleaded guilty to a charge of embezzlement.

Accused was charged with embezzling £204. 14s. 10d. between Jan. 4, 1908, and June 19, 1909. For several years accused had been manager of the tramways company at a salary af £250 per annum. A sentence of three months' imprisonment was passed.

Epsom.—An adjourned inquiry was held last week into the application of the Council for sanction to borrow £1,500 for extensions of the electricity undertaking. The clerk (Mr. E. G. Wilson) and the acting electrical engineer (Mr. A. C. Gilling) were present and answered a number of questions as to the financial position which were put by the inspector, Mr. H. Ross Hooper.

Exhibition.—The "Bellettino Finanze ed Ferrovie" (Rome), states that sections of the International Lighting and Optical Exhibition, which is to be held at Genoa this year, are to be devoted

to present and past methods of lighting, the application of light to medical purposes and artificial lighting in the agricultural industry.

Finchley. In reference to the recent L.G. Board inquiry into the Council's application for sanction to a loan of £2,200 for arc lighting the Board have inquired whether the Council had carefully considered the relative cost of electric and gas lighting, and have asked for copies of the reports of the Highways and Lighting committee on the subject.

In the course of a lengthy reply the clerk (Mr. E. H. Lister) stated that, as regards the question of the illuminant to be used for the streets, the Council considered they were the best judges, and did not feel that they could submit to any outside pressure to force upon them an illuminant of which they do not approve, and which they considered for the present purpose was not so satisfactory as the one they proposed. They respectfully submitted that the point which the Board was called upon to decide was whether a loan should be granted for the necessary sum to enable arc lighting to be installed, and not as to whether gas or electricity should be used.

On and after Oct. 1 the charge for arc lighting is to be at the rate of £5. 15s. 3d. for 383 hours per annum per 5 amp. circuit at 250 volts, and pro rata for a longer period or for a larger or smaller circuit. The price for power and heating is to be 2d. per unit for the first 90 hours per quarter of the maximum demand and 1d. for all other units consumed; and the charge to bona fide wiring contractors, having showrooms in the district, is to be 2d. per unit.

Application is to be made to the L.G. Board for sanction to spend up to £750 for experimental works in boring for water.

Frinton-on-Sea.—Frinton-on-Sea Electric Light & Power Co. recently put down additional plant at the electricity works, including a 150 H.P. vertical gas engine (driven by suction gas), manufactured by E. S. Hindley & Sons, of Bourton, Dorset, and London. Additional feeders and distributing cables, &c., have also been laid.

Gillingham.—The Council have replied to the recent communication of the L.G. Board refusing to sanction a loan for extensions of the electricity works, and a special report of the electrical engineer on the present position of the undertaking has been forwarded to the Board. In the meantime, consideration of the suggestion that a consulting engineer should be called in has been postponed.

Gloucester.—The Council are to apply for a provisional order for the rural area.

Halifax.—On the recommendation of the Tramways and Electricity committee the charge for electrical energy supplied to the tramways has been reduced to $1\frac{1}{8}$d. per unit, such reduction to take effect from April 1, 1908.

Hull-Hessle Tramways.—Negotiations are proceeding between Hull Corporation and Hessle Council for the extension of the Hull municipal tramways to Hessle at an estimated cost of £30,000.

India.—"Indian Engineering" for June 26, states that Mr. J. L. Meares, electrical adviser to the Government of India, has been summoned to Simla to discuss a revision of the draft bill of the new Indian Electricity Act.

Infirmary Lighting.—The South Metropolitan Electric Tramways & Lighting Co., who supply current to the Children's Infirmary at Carshalton and The Downs School at Sutton, have agreed to instal auto-transformers and metal filament lamps in those institutions, under an agreement which will extend to Dec. 31, 1918, and in which the company undertake not to raise their price of current for lighting purposes above $2\frac{1}{2}$d. per unit. Current for charging electric vehicles is to be supplied at $1\frac{1}{2}$d. per unit instead of $2\frac{1}{2}$d. The approximate cost of the change over is £660.

Infirmary Lifts.—The consulting engineer to the Islington (London) Guardians (Mr. Enright) has been asked to prepare a specification for converting one of the lifts at the Highgate Hill infirmary into an electric one.

Islington (London).—Last week the Lighting committee submitted their estimates for public lighting, which included £6,397 for supply of electricity to the public arc lamps and £1,750 for maintaining and trimming same.

Mr. Vorley moved an amendment that the first item be increased by £634, making it £7,031 instead of £6,397. He was not in favour of keeping up the price of current to the public lamps, but the reduction in price must depend upon what the undertaking could bear and what their obligations were. All the world knew that 42 years for the loans was too long, but the new calculations should be based upon the liabilities they had to repay and the money they would require for replacements.

After discussion, the amendment was rejected.

Italy.—H.M. Vice Consul A. J. Ogston states that appliances now in course of erection at the port of Spezia include two electric cranes, with grain discharging apparatus, each to handle 36 tons of grain per hour, and electric coal handling plant to unload 2,000 tons of coal or more per day (of 10 hours).

Kings Lynn.—New schools are to be erected and wired for the electric light.

Kingston-on-Thames. Electric power is to be used for pumping at the sewage works.

Leith.—The remainder of the Leith-Granton tramway extension has been opened for traffic.

Leyton.—At the last meeting of the Council it was agreed to adopt electric lighting in a number of additional thoroughfares.

Light Railway.—The Padstow, Bedruthan and Mawgan Light Railway (Extension of Time) Order has been submitted to the Board of Trade for confirmation. Objections by August 26.

London County Council Tramways.—The construction of the conduit tramway along Southwark-street was commenced on Thursday last.

On Saturday the service on the Council's overhead trolley tramway from the Streatham terminus of the conduit system to the Croydon Corporation's overhead system at Norbury was opened for traffic. Through bookings on the L.C.C. and the Croydon Corporation lines have been arranged.

The electric tramway from Hackney Station to Cambridge Heath Station was opened on Saturday. The portion of the system in Clapton is being converted, and electric cars will soon be running to Stoke Newington and Stamford Hill.

Other lines opened on Saturday were Essex-road, Islington, and the conduit line from Aldgate to Bow Bridge recently laid down in place of the "G.B." surface contact system.

Amongst the projected tramway works are the extension of the Tooley-street to Deptford line, in one direction to London Bridge and in the other to Greenwich, and extensions of the lines at Tooting and Chelsea, while parliamentary powers are to be sought for lines from the Marble Arch to Cricklewood, Chalk Farm to Child's Hill and Putney Bridge to Wandsworth.

Longton.—Extensions of mains, estimated to cost £1,550, have been authorised by the Council, who have applied for sanction to a further loan of £1,250.

Middlesbrough.—Sanction has been received to a loan of £18,922 for extensions of mains, house services, public lighting, &c.

Mine Explosion Inquiry.—At Hamilton (N.B.) Sheriff Court on Thursday last a public inquiry was conducted, before Sheriff Thomson and a jury, into the circumstances of the explosion which occurred at Ferniegair Colliery on June 27, when one man was killed and two others subsequently succumbed to their injuries.

It was stated that at the time of the explosion the deceased workmen were getting ready for the week's work an electrically-driven coal-cutting machine. The evidence of various officials went to show that after the explosion the lamps of the deceased workmen had been found locked and bearing no signs of having been tampered with, while there was no evidence of matches or pipes having been used. Their explanation of the explosion was that it had been caused by a "feeder" or "pocket" of gas suddenly bursting out into the workings. They could not state how the gas had become ignited, but admitted the fury of the explosion would be accentuated by the presence of coal dust at the face.

Mr. R. Nelson, H.M. Inspector of Mines, said he visited the colliery on July 1. He had previously learned that one of the deceased had been engaged lengthening the electric cable, and what he found in the pit on the occasion of his visit bore out that idea. The workman had apparently disconnected a single length, and was in the act of inserting the two ends together when the explosion occurred. A spark would undoubtedly be caused at such a moment. For a pit in which safety lamps were used the design of the gate-end box was very bad. No precaution was taken to have it totally enclosed and made gas-tight. The plug connection was also not suitable, and in his opinion the conditions at the colliery on the day of the explosion invited an explosion immediately gas made its appearance.

The jury returned a verdict that a spark from the electric cable ignited the gas and caused the explosion. They were also of opinion that, whether or not the workmen were to blame for manipulating a "live" cable in the presence of gas, the employers were in fault in respect (1) that the examination by the acting fireman on the morning of the explosion had been perfunctory and insufficient to discover gas; (2) that the electric plant was not suitable for a fiery mine; and (3) that there was an absence of due inspection from time to time of the electric apparatus installed in the pit.

Netherlands. It is stated that a project is on foot for the construction of electricity works for supplying current in the eastern district of North Brabant, as far as Bois le Duc and the centre of Limbourg, including Luremonde, Venloo and Wurt.

Personal.—Mr. Gerald Hooghwinkel, M.I.E.E., M.I.M.E., will shortly leave England for Mexico on professional business, and intends to study the openings for British enterprise with reference to contracts for public works in that country. He is willing to take charge of any special interests which may be entrusted to him.

Mr. Albert Gay, borough electrical engineer of Islington has been appointed President of the Associated Municipal Electrical Engineers (Greater London) for 1909-10.

Presentation. Mr. Chas. Cuthbertson, A.M.I.E.E., the electrical engineer of the electricity supply department of the Longton gas and electricity works, was recently presented by the employes with a marble clock, on the occasion of his marriage.

Provisional Order Revocation.—The Board of Trade have revoked as from July 28 the Walton-le-Dale Electric Lighting Order, 1904.

Russia.—H.M. Vice-Consul W. S. Walton states that the bulk of the electrical machinery imported into the Marinpol district in 1908 was of Belgian, German and French manufacture.

St. Mellons.—The Rural Council have consented to mains being laid at Fields Park by Newport (Mon.) Council.

South African Power Supply.—At recent sittings of the Commission on Power Supply in the Transvaal the "Transvaal Leader" states that—

Mr. P. Whiteside, M.L.A., gave evidence on behalf of the South African Engine Drivers and Firemen's Association. The adoption of electric power would, he said, mean a most serious displacement of white drivers in the country. From the Government mining engineers' report it would be seen that 261 men were the average firemen employed, and the whole of these would be displaced, besides a large proportion of the fitters, mechanics, turners and boilersmiths, through the elimination of steam engines and boilers. He referred to the fact that Germans were supplying and erecting the plant, and would, doubtless, operate it. The State must have full control of all concerns threatening the rights and liberties of citizens, and if the Government could not adopt that view it must see that legislation should be postponed so that exhaustive inquiries could be made as to the effects of similar legislation elsewhere. The association had no objection to, say, the Randfontein group selling the overflow of their power to their neighbours, but they did object to one company having the monopoly of supply. He agreed with the principle that anything tending to cheapen power was calculated to increase the development of the colony. The question of a site for a power station should be decided by the people concerned, and he placed in the forefront the principle of cheapening production; it was only a question of safeguarding the people of the State. He would extend the policy of nationalisation to the erection and maintenance of stations and lines and the generation and supply of power. If rights were given to private corporations they should include an expropriation clause. His association favoured a State monopoly, failing which State control.

Mr. Sidney Bilborough said cheap power was of the first importance to the Transvaal, and as a result of its adoption he would expect that the coal consumption would not be diminished. It would place the inland colonies in an advantageous position compared with the coast colonies, and that would, he thought, conduce to the good of South Africa as a whole. He referred to the report of a Canadian Commission, and said that the electric smelting of ores was possible where power was produced at 0·3d. per kilowatt-hour. That figure was about one-twentieth of the lowest cost of production in South Africa. Better results from Transvaal coal could be obtained by washing. If special facilities were given to one power company there should be some method of control to secure purchasing in the open market. He did not agree that the cost of power produced from coal could be brought down as low as ¼d. per unit. To do so plant would have to be cheaper and the station have to be at the pit's mouth, which, in turn, would mean a long transmission line.

Southampton.—At the last meeting of the Council the borough electrical engineer (Mr. H. F. Street) presented an interesting report in regard to free wiring.

Mr. Street considered it most lamentable that the electricity department should be prohibited from carrying out free wiring when the same privilege was enjoyed by so many other undertakings in the country. All undertakings owned by companies took the fullest advantage of those powers, and benefited enormously thereby; gas companies also did fitting work, and therein lay the whole secret of their success. The Southern Free Wiring Co., which had carried on work in the town, had for reasons that had nothing to do with the Corporation, practically given up canvassing for new work, although of course the Corporation was still collecting the money due to them on account of existing contracts from sundry consumers. The method adopted was to charge 1d. per unit extra on all of the company's consumers, which money was paid over to them. He wished it to be clearly understood that it was not his desire for the department to undertake the wiring work themselves; that came entirely within the province of the wiring contractors of the town. The whole of the necessary expenditure could be defrayed out of revenue or the reserve fund. Assuming they invested £2,000 of their fund in free wiring they ould instal about 2,600 lamps at a cost of 15s. per lamp, which was above the average of the cost of installation in Southampton. The revenue on that from sales of electricity at ordinary rates would be £600, to which ould be added the extra cost for free wiring, which, at, say, 1d. per unit would amount to not less than £200. With assisted wiring the revenue would be greater. They had the support of all the principal wiring contractors of the town, who saw in the proposal a considerable increase of business coming to them.

The Electricity committee recommended the Council to obtain parliamentary powers for the purpose suggested by Mr. Street, but an amendment referring the matter to the Parliamentary committee was carried.

Sunderland.—The Corporation are recommended by the Electricity committee to reduce the charge for electric current to the tramways department from 1⅛d. to 1½d. per unit.

Sweden.—Arrangements are being made for the erection of three electric furnaces for the production of pig iron, in connection with the Tröllhattan water power electricity works. Each furnace is to be capable of producing 7,500 tons of pig-iron per annum, and the cost per ton is estimated at 51 kronor (£2. 16s. 8d.).

Tunbridge Wells.—The Lighting committee report that during the 14 years' existence of the electricity undertaking a gross profit of £59,327 has been earned on a capital outlay of £80,519. 4s. 10d. There are 960 consumers (representing the equivalent of 64.126 8 c.p. lamps) connected, or about one-sixth of the total number of ratepayers.

Wireless Telegraph Notes.—It is announced that the wireless telegraph operators who are working on board the ocean liners between New York and other countries are being organised into a trade union, and that the first list of members will number about 700.

A conference of underwriters will meet at Baden-Baden on Sept. 12 when the question of reducing the premiums on vessels equipped with wireless telegraph installations is to come forward for discussion.

Workhouse Lighting.—Belfast Guardians have appointed a special committee, consisting of the chairmen of the different committees, to consider and report upon the question of lighting the workhouse electrically.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Birkenhead.—The accounts of the tramways department for the year ended March were presented to the Council on Wednesday, and showed total receipts of £56,111. 19s. 10d., including £55,097. 12s. 10d. from passenger fares.

The total working expenses were £35,431. 10s. 8d. (6·651d. per car-mile), and the gross profit was £20,638. 9s. 3d. After paying interest and sinking fund charges there was a net deficit of £905. 10s. 10d. The total capital expended is £363,428. 6s. 1d.

The total income of the electricity department was £19,724. 18s. 10d., including £18,838. 12s. from the sale of current by meter, and motor and meter rental, &c., made up the balance. The total expenses were £8,610. 10s. 11d., and the gross profit was £11,114. 7s. 11d. Interest absorbed £4,725. 14s. 7d., amounts appropriated to sinking and stock redemption funds ceme to £3,437. 10s., and after deducting income tax and contributing £629. 0s. 7d. to capital account and £1,249. 3s. to renewals fund, £1,000 was applied to relief of rates. The capital expended is £150,689. 12s. 10d., an increase of £13,240. 1s. 4d.

Hammersmith (London).—The accounts of the electric lighting department for the year ended March 31 show a total income of £55,981. 2s. 4d., including £46,135. 13s. 5d. for the supply of current for private lighting, £4,955. 1s. 5d. for public lighting.

The expenses were £31,506. 4s. 7d. and the gross profit was £24,474. 17s. 9d., against £18,531. 11s. 9d. for 1907-8, and after paying interest, redemption of loan charges, &c., the net profit was £4,904. 5s. 11d. against £13. 16s. 10d. The capital expended to date is £311,479. 10s. 8d., an increase of £21,258. 11s. Owing to the enormous fluctuations in the lamps connected at the Franco-British Exhibition and Olympia, no figures are given for the lamp connections and the revenue per lamp. The average price obtained was 1·57d. per unit for public and 1·78d. for private lighting. There are 339 motors (2,665 H.P.) connected, and the total number of consumers is 2,336. The units generated amounted to 7,639,395, and 747,250 units were purchased; 6,198,339 units were supplied to private consumers and 564,522 to the public lamps (204 arcs, 63 small arcs and 204 incandescents). The maximum supply demanded was 4,400 kw.

In the report of the borough electrical engineer (Mr. G. G. Bell) it is stated that the revenue from the Franco-British Exhibition proved disappointing as, owing to the incomplete state of the grounds during the early months, it was impossible to take full advantage of the satisfactory contracts concluded.

Hull.—The profits on the municipal electric tramways for the past year was £24,318. 14s. 4d., of which £18,000 has been applied to relief of rates. The profit is £5,576. 10s. 7d. below the figures for 1908. The traffic revenue was £128,647. 8s. 7d., the number of passengers carried being 32,958,883, compared with 30,964,254.

The profit on the electricity department was £1,165. 8s. 5d., compared with £2,398. 11s. 9d. in 1908.

On the telephone account the net surplus was £1,040. 9s. 5d., a decrease of £14. 11s. 7d.

Kilmarnock.—The accounts of the electricity supply undertaking for the past year shows income £6,051, compared with £5,513 in the previous year.

The gross profit was £3,087 (£2,463), capital charges required £2,940 (£2,821), and the net profit was £147, compared with a loss of £358). 738,013 (679,233) units were sold, including 333,419 (225,824) for private lighting and power, 344,145 (362,545) for traction, and 59,715 (89,575) for public lighting. There are 272 (229) private consumers with 21,724 (equivalent) 8 c.p. lamps connected. Works costs were 0·604d. (0·682d.)

and total costs (exclusive of capital charges and cost of maintenance of arc lamps) 0·900d. (1·025d.)

The report of Mr. Burbidge, burgh electrical engineer and tramways manager, states that cost of coal per unit sold is the lowest in Great Britain (0·197d. per unit, against 0·343d. in 1908), and for an output of under 750,000 units the total costs are only higher than one undertaking (the latter paying less than £50 a year for rates and taxes, compared with £382 at Kilmarnock). As in other towns, the use of metallic filament lamps has affected the output.

The tramway traffic receipts were £7,790 (£8,007), working expenses £6,306 (£6,456), net deficit £2,009 (£1,852).

Receipts per car-mile were 6d. (6·33d.), working expenses 4·86d. (practically the lowest in Great Britain). 311,499 (306,170) car-miles were run and 2,181,167 (2,296,261) passengers carried. Average fare per passenger was 0·86d. (0·84d.).

Marylebone (London).—The accounts of the electricity supply department for the year ended March 31 were presented to the Council last week, and showed total revenue £156,032. 17s. 9d., including £146,359. 1s. from the sale of current by meter, £1,841. 3s. 9d. from public lighting and £5,505. 12s. 7d. from meter rental.

The total expenses were £47,452. 0s. 7d. and the gross profit was £108,580. 17s. 2d. Interest absorbed £76,913. 10s. 9d. and repayment of loans £34,193. 10s. 6d., and after making provision for Parliamentary expenses, &c., there was a deficit of £3,930. 9s. 3d. The total capital expended is £2,024,401. 19s. 2d., an increase of £16,293. 4s. 7d. during the year. 11,862,300 units were generated; 8,843,089 units were supplied to private consumers and 157,772 to the public lamps. The total maximum supply demanded was 7,077 kw.

The Electric Supply committee, in their report, expressed pleasure that the result of the year's working had exceeded their expectations, and that in place of the deficiency, shown by their estimates, of £6,967, the debit balance was only £3,930. 9s. 3d., notwithstanding the heavy expenses of opposing schemes before Parliament (£1,163), which could not have been anticipated. The costs per unit sold were 1·19d., against 1·39d. in 1907-8.

An interesting report by the general manager (Mr. A. Hugh Seabrook) on the method of charging for current is abstracted on page 678 of this issue.

St. Pancras.—The accounts of the electricity department for the year ended March 31 were presented to the Council last week.

The Electricity committee recommended that, out of the profit of £7,126. 17s. 2d., £4,000 be voted to relief of lighting rate, £3,126. 17s. 2d. being carried to reserve. The Finance committee thought no sum should be allocated for relief of the lighting rate, and recommended that the matter be held over until the Council's requirements for the ensuing half-year are known. The total expenditure of the undertaking was £542,469. 11s. The gross income for the year was £75,358. 14s. 9d., a decrease of £2,243. 12s. 11d. compared with the previous year, and an increase of £1,187. 4s. 9d. compared with 1906-7. After meeting all working expenses and repayment of loans and extension of the net profit was £6,925. 18s. 10d. (compared with £9,454. 7s. 3d.), making, with £200. 18s. 4d., the difference in the provision made for outstanding charges £7,126. 17s. 2d.

Councillor Ingram said the drop in revenue was caused by the loss of several large customers and by the general adoption of metal filament lamps. Generally speaking consumers were increasing their lighting accounts. They had effected a number of economies during the year. Coal now cost 0·52d. per unit, against 0·55d. last year; oil and waste cost 0·04d. per unit, against 0·05d. The average price to private consumers had been 2·65d., against 2·68d. The gross profit for the year was £32,000, which on the net capital was 7 per cent. and on the gross capital 6 per cent.

The recommendation as to the £4,000 for the lighting rate was withdrawn and the accounts referred to the Finance committee for report.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

London County Council invite tenders for the manufacture, delivery and laying of about 6½ miles of 0·075 sq. in. three core lead-covered h.t. cables, &c., and about 46 miles of single core lead-covered l.t. cables, telephone cables, &c.; manufacture (but not erection) of 50 tramway feeder pillars; laying about 16 miles of stoneware cable ducts, including necessary manholes, repaving, &c., and manufacture and delivery of 140,000 ducts of glazed stoneware for electric cables. Drawings may be inspected and specifications, &c., obtained at the County Hall, Spring Gardens, S.W. Tenders addressed to the Clerk of the London County Council, Spring Gardens, must be in by 11 a.m., of Tuesday, Sept. 14. Further particulars are given in an advertisement.

Edinburgh Corporation invite tenders for the supply at the McDonald-road electricity supply station of a motor-alternator. Specification, form of tender, &c., can be obtained at the engineer's office, Dewar-place. Specification, general conditions and drawings can be seen at (but not obtained from) the office of the consulting engineer, Sir A. B. W. Kennedy, 17, Victoria-street, London, S.W.

Tenders to the Town Clerk, City-chambers, Edinburgh, by Sept. 4. See also an advertisement.

Edinburgh Corporation also want tenders by Sept. 4 for the electric lighting installation at the new slaughter houses. Specification from the Engineer, Dewar-place, Edinburgh.

Tenders are invited for supply of ten 100-number switchboards to the Postmaster General's Department, New South Wales. Tender forms, &c., at the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

Tenders are invited for the supply of telephone material to the Postmaster-General's Department in New South Wales. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

The Committee of Management of the Enniscorthy district asylum invite tenders for lighting Kilcarberry House from existing plant, according to specification, which can be obtained from the Clerk, District Asylum, Enniscorthy, co. Wexford. Tenders to the Asylum Office by 10 a.m., Aug. 18.

Sheffield Education committee want tenders by Aug. 10 for heating and electric lighting of the Training College Hall of Residence for Men. Specifications, &c., from Messrs. Gibbs & Flockton, 15, St. James-row, Sheffield.

Tenders are required by Sept. 10 for supply and erection of overhead cables in connection with the electric lighting of Ballinasloe District Lunatic Asylum. Specifications from Mr. G. B. Meenan, 5, Charleville-road, Rathmines, Dublin.

York Corporation want tenders by 9 a.m. Aug. 27 for supply of 18 double-deck tramcars and one watering car. Specification from the City Electrical Engineer.

The Deputy Postmaster-General, Sydney, N.S.W., wants tenders by 2:30 p.m., Nov. 10, for supply and erection of a branching metallic multiple magneto switchboard at the Petersham telephone exchange. Specifications, &c., at 72, Victoria-street, London, S.W.

The "Zentral Auzeiger" (Vienna) for July 25, states that the Turkish Ministry of Marine, Constantinople, invite tenders for the supply of electrical apparatus for the Imperial Fleet. Particulars from the Conseil de la Marine, Constantinople.

Tenders are wanted for the erection of electricity works and the supply of electric light to the towns of Carmelo and Villa del Rosario, Department of Colonia, Uruguay. Conditions at the Intendencia Municipal, Colonia, where tenders are to be delivered by 2 p.m., August 30.

TENDERS RECEIVED AND ACCEPTED.

West Ham Corporation received 12 tenders for supply of six tram-cars, and accepted that of the United Electric Car Co., for car bodies, at £1,952, and that of the Brush Co., for electrical equipment, at £1,161.

An order has been placed by West Ham Corporation with E. Peckham and the Anti-Magnolia Co., at £150, for the purchase of two trucks for the tramway undertaking, and the purchase of the material for five others, these to be constructed at the car sheds on payment of a royalty of £10 per truck to Mr. Peckham. The estimated cost of the seven trucks is £550.

Leyton Council have received the following tenders for the electric lighting of the Sybourn-street schools :—

Johnson & Phillips (*acptd.*)...	**£172**	Fryer & Co., W. J.	£250
E. E. Beaven	369	Lund Bros. & Co.	249
Vaughan Eng. Co.	340	Hodgson & Co.	247
M. Parker	312	Ryan & Son	245
Alliance Elec. Co.	295	Pinching & Walton	242
C. Larkins & Co.	279	Russell, Bridger & Co.	238
Jackson Bros.	271	Tilley Bros.	232
W. Simmons	271	Ewart & Son	232
Elec. & Motor Co.	264	Foote & Milne	228
Halsey, J. T.	259	Rowland & Hulton	222
Headland & Headland	256	H. J. Whitehead	215
R. H. & J. Pearson	254	Whitehead Bros.	211
D. J. Macdonald	251		

St. Pancras (London) Council received the following tenders for annual supply of arc lamp carbons :

Sloan Electrical Co. (*accepted*), £382. 1s. 8d. ; W. Geipel & Co., £362. 3s. 4d. ; H. G. Mayer & Co., £420 ; Crompton & Co., £424. 8s. 4d. ; G. Braulik, £452. 5s. ; Andrew & Suter, £467 ; General Electric Co., £498 ; Siriuswerke (M. Seeck), £513. 6s. 8d. ; Ship Carbons (Ltd.), £516. 5s. ; Siemens Bros. Dynamo Works, £672. 5s. ; Piggott Electrical Co. (Smith Bros.), £758.

Gravesend Electricity committee have received the following tenders for supply and erection of an automatic stoker :—

Erith's Eng. Co.	£280	Jas. Hodgkinson (Ltd.)	£163
W. R. Mills	215	Meldrum Bros. ....130 &	155
Underfeed Stoker Co.	200	Crosthwaite Fire Bar Synd..	150
Babcock & Willcox	190	Jas. Proctor (Ltd.)	125

G. Weymouth Proprietary (Ltd.) are supplying six electric goods lifts for the new offices of the Victorian Railway Department, Melbourne. Edmiston & O'Neill are also supplying one electric lift at £475.

Pontypridd Council received 15 tenders for the supply and erection of a 500 kw. combined steam dynamo, and 14 tenders for the supply and erection of condensing plant. The consideration of the tenders has been adjourned until after the holidays.

Staffordshire County Educational committee have accepted the offer of Hanley Council for power during daylight for the pottery school and electric ovens at a fixed charge of £1 per quarter and a flat rate of 1d. per unit.

The Metropolitan Asylums Board have accepted the tender of W. J. Fryer & Co. for carrying out alterations to electric lighting installations in some of the Board's institutions.

Barnstaple Guardians have accepted the tender of Jas. Malone for wiring the workhouse at £122. 10s. There were seven tenders, ranging from £120. 1s. 10d. to £191. 10s.

Hanley Council have accepted the tender of the Chloride Electrical Storage Co. for maintaining the storage battery for ten years, at £5 per annum.

Hull Electric Lighting committee have accepted the tender of Siemens Bros. & Co. for the supply and laying of electric mains, &c. (until March, 1910) at schedule rates.

Marylebone Electric Supply committee have accepted the tender of the London Electric Firm for arc lamp lowering gear at £250.

Luton Council have accepted the tender of W. H. Allen, Son & Co., for a 500 kw. steam dynamo, at £2,370.

Eastbourne Council have accepted the tender of Lassen & Hjort for condensing plant at £155.

Grimsby Council have accepted the tender of J. Wilson & Co. for additional pipework for the superheaters.

Salford Council have accepted the tender of G. Harland Bowden & Co. for re-wiring the Royal Technical Institute at £765.

Eccles Council have accepted the tender of Waring & Gillow for wiring the Corporation-road houses at £48. 15s.

Longton Council have accepted the tender of the Electric Construction Co. for a 300 kw. dynamo, coupled to a Belliss engine.

The South Australian Cabinet recently approved the acceptance by Adelaide Tramways Trust of the tender of Noyes Bros. for 50 car bodies (made by the Brill Co., Philadelphia) at £36,673. The highest tender (from an Adelaide firm) was £45,361. Later information is that instead of Brill bodies Messrs. Noyes Bros. have arranged for the manufacture of the bodies at Pengelley's Coach Factory, Edward's Town (S. Australia).

The Postmaster-General's Department, Hobart, have accepted the tender of the Western Electric Co. for a switchboard, with power plant, &c. (£3,019), 600 wall telephones (£1,237), 100 table telephones (£188), 750 protectors (£94), 50 wall telephones for party lines (£144) and 20 table telephones for party lines (£46), and that of British Insulated & Helsby Cables for 100 extension switch and bell sets (£165), 15 switchboards for four lines (£66) and 8 for six lines (£51).

Sydney N.S.W. Council recently called for tenders for a two years' supply of motors—schedules, A and B for d.c., and schedules C and D for a.c. motors.

The tenders received were examined by Mr. Forbes Mackay (city electrical engineer), who advised the acceptance of the tender of Noyes Bros. under schedules A, B and C, and that of Staerker & Fischer (representing the A.E.G.) under schedule D. The Electric Lighting committee adopted this recommendation, but the Council gave the entire contract to Noyes Bros., whose tender was lower under A, B and C, while that of Staerker & Fischer was lower under D. The reason given for the action of the Council was that Noyes Bros.' tender was the lowest average.

BUSINESS NOTICES.

Increase of Cable Prices.—W. T. Henley's Telegraph Works Co. announce that, owing to the continued high price of Para rubber, they are compelled to raise their prices for Association grade cables, and therefore, until further notice the prices for the cables given in their lists dated March, 1907, Sept., 1908, and April, 1909, will be subject to trade discounts of 15 per cent., and 10 per cent. The prices of Non-Association cables are also increased.

We are informed that the whole of the members of the Cable Makers' Association have decided to increase their prices to the extent set out above.

Messrs. Davidson & Blackadder, 50, Wellington-street, Glasgow, have been appointed agents for the St. Helens Cable & Rubber Co. for the whole of Scotland. Mr. J. W. Logan will continue to represent the company in the Scottish district as a member of Messrs. Davidson & Blackadder's staff

The Electro-Mechanical Brake Co. inform us that in order to thoroughly re-organise and develop their business they have secured the services of Mr. E. J. Chambers, J.P., M.I.Mech.E., as chairman and managing director. Mr. Chambers is a director of Messrs. Bullers (Ltd.), of Tipton, Hanley and London, and also chairman of Messrs. H. & T. Danks (Netherton) (Ltd.).

The British Prometheus Co. have appointed Simplex Conduits (Ltd.) their sole selling agents in London, the South and West of England and S. Wales. The management of the department will be in charge of Mr. Beves, who have been associated with the Prometheus Co. since its inception. He will be assisted by Mr. Bennett.

Patents Development.—The owners of patent No. 23,501/1899, relating to "Improvements in vacuum tube lighting," and No. 12,582/1902, relating to "An improved system of electric lighting," wish to negotiate for the granting of licences. Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's-inn-fields, London, W.C.

The proprietors of patents No. 23,878/1900, for "Improvements in process of and mechanism for separation of conductors from non-conductors," and No. 16,435/1905, for "Improvements relating to transmission systems for wireless telegraphy and telephony" are also desirous of entering into arrangements, by way of licence and otherwise, for exploiting same. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

Plant Wanted.—An advertiser requires a 50 H.P. d.c. totally-enclosed motor for 500 volts.

Chartered Institute of Patent Agents.—The qualifying examination of persons desirous of being registered as patent agents will be held in November next. Particulars can be obtained from the Secretary, Chartered Institute of Patent Agents, Staple Inn-buildings, London, W.C.

New Motor Starting Switch for Printing Machines.—Particulars of a new type of motor starting switch for use with printing machines have been sent us by the Adams Mfg. Co.

The starting of printing presses is very hard on the switchgear on account of the constant "inching," which causes most injurious arcing of the contacts of the starting switch, with the result that ordinary starting switches are soon destroyed, and even though renewable contacts may be used, the renewals are so frequently required as to become a nuisance as well as a serious expense. To prevent this injurious arcing all sorts of devices have been employed. For small flat bed machines, however, the initial cost of self-acting motor starters is often considered prohibitive. With the object of rendering ordinary hand-operated starters suitable, carbon auxiliary contacts, magnetic blowouts, interlocked solenoid switches, &c., have been employed. These have failed because they have protected only the first step, whereas the minder, whose eyes must be on the machine and not on the starter, pulls the handle, when inching, over to the third or fourth contact, or perhaps further, and in moving it back a destructive arc across the starter steps results. The new "Igranic" switch employs an interlocked magnetic circuit-maker and breaker, and no matter how far the operator pulls the handle over in a forward direction, the slightest backward movement instantly opens the circuit-breaker and no arcing can occur on the starter

SPECIAL NOTICE.

NOW READY.——Vol. LXII. of "THE ELECTRICIAN" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

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steps because they are "dead." The circuit-breaker has carbon contacts and magnetic blowout and will open-circuit an infinite number of times without receiving injury. In addition, the interlocking of the circuit breaker with the starter makes it impossible to close the motor circuit except with all the starting resistance in circuit, so that the motor receives proper protection and the starting switch may be said to be practically fool-proof.

CATALOGUES, &c.

WIRELESS CLUSTER FITTINGS.—We have received from the fittings department of Messrs. Siemens Brothers Dynamo Works a copy of their latest "Tantalum" arc list (29-B), illustrating numerous new designs of the patent wireless cluster fittings supplied by the firm. These will be of particular interest to shopkeepers, and contractors who have shop fitting work on hand are advised to at once obtain a copy, which we understand, will be supplied free of charge, or in quantities, printed with the contractor's name and address, on application to the Fittings Department, Tyssen-street, Dalston, London, N.E.

PETROL ELECTRIC VEHICLES.—Messrs. W. A. Stevens (Ltd.), Victoria Works, Maidstone, have issued a new catalogue dealing with the Hallford-Stevens petrol-electric omnibuses and commercial vehicles. Full specifications of these vehicles are shown, with illustrations of several types that have already been supplied. The same firm send a pamphlet dealing with their system of battery charging, by means of which, it is claimed, the batteries for electric omnibuses can be charged from the electric supply mains with an extremely small loss of efficiency.

CARBON FILAMENT LAMP PRICES.—Messrs. Siemens Brothers Dynamo Works, Tyssen-street, Dalston, N., have their latest catalogue of carbon filament lamps now ready. This list, which is very complete and illustrates many types of lamps as stocked, will interest every electrical man, as prices have been reduced throughout. The reductions in prices of radiator lamps, lamp lacquers and obscuring varnishes are particularly notable. Quantities of this list, printed with the name and address of the electrical contractor, will be supplied free on application.

STARTING GEAR.—We have received from Mr. Geo. Ellison, Victoria Works, Birmingham, a pamphlet of various types of starters manufactured by him. Special gas-tight and dust-tight panels are illustrated, and the various protective devices used are described. An artistic calendar card for the month of August is also to hand.

ELECTRIC TYRE PUMP.—The Eclipse Electric Co., Bootle, send us a circular dealing with their "Whipall" electric tyre pump. It is claimed that the maintenance cost of this pump is extremly small, while at the same time it can be easily attached to any electric light fitting. The same firm also send a pamphlet on the "Little Giant" dust extractor, which is apparently a hand-operated system of suction cleaning.

"TANTALUM" LAMPS IN RUSSIA.—Messrs. Siemens Brothers, of Dalston, London, have prepared an effective showcard which we illustrate. As will be seen, the design is similar to that of the well-known "Satisfied Consumer," and has been adapted to meet the Russian idea of what such a consumer should be. This serves to show that the fame of the "Tantalum" lamp is wide spread. We also learn that the "Satisfied Consumer" has shown his face in Spain and Portugal.

STEPS AND LADDERS.—Messrs. J. H. Heathman & Co., Parsons Green, S.W., send their latest list of various types of ladders and steps, fire-extinguishing apparatus and pumps.

IRONCLAD DISTRIBUTION BOXES.—The Sun Electrical Co., Charing Cross-road, London, W.C., have ready an instructive circular dealing with some of their ironclad distribution switch and fuse gear. The prices of these items compare favourably with anything at present on the market, and by the illustrations and descriptions given the boxes appear to be of a very serviceable type.

"ECLIPSE" METALLIC LAMPS.—We have received from Mr. Geo. Braulik, 8, Lambeth-hill, E.C., a new pamphlet giving full particulars, prices, &c., of his "Eclipse" metallic filament lamps.

REFLECTORS.—The Silver Lined Shade & Reflector Co., 4, Milk-street, E.C., send us a pamphlet on their silver-lined shade reflectors. They are claimed to be unbreakable and untarnishable.

WATER-TIGHT FITTINGS.—Messrs. Haslam & Schontheil, Cardiff, are issuing a new price list on cast-iron and watertight electric fittings. The list deals very fully with the various types of watertight fittings made by this firm, and the illustrations give an excellent idea of their leading features.

BANKRUPTCIES, LIQUIDATIONS, &c.

Meeting of creditors and contributories in the liquidation of the Uxbridge & District Supply Co. (Ltd.) were held on Friday

The statement of affairs disclosed, as regarded creditors, loans on debenture bonds £52,579, unsecured creditors £6,622. 4s. 5d., against assets £74,949; and as regarded contributories a deficiency of £10,526. 16s. 9d. The assistant official receiver (Mr. H. E. Burgess) stated that the company was promoted in 1900, a certain amount of capital being offered to the public for subscription. The capital of the promoting syndicate was £1,000, the intention being to get the provisional order into working and then to make over the concern to another company. That was found impracticable. Ordinary shares representing £26,275 had been allotted, chiefly for cash, and the rest of the company's capital had been raised by debentures. The General Electric Co. undertook to finance the concern on certain conditions, and had financed it to a considerable extent, but later on it had been considered desirable to transfer the debentures held by the General Electric Co. to the Metropolitan Electric Supply Co., and at the present time there is some £43,000 due to the latter company. The transfer was effected by agreement. Under that agreement the Metropolitan Co., in consideration of the Uxbridge Co. withdrawing its opposition to a bill then being promoted by the Metropolitan Co., undertook to acquire the interest of the General Electric Co. and of Callender's Cable & Construction Co., who also held debentures. After deducting working expenses, the profit was £2,903, which went in payment of interest on the debentures. The failure of the company was attributed to want of working capital to enable it to carry out the extensions necessary to make it a paying concern. The assets had already been subject to some considerable reduction for depreciation, and the figures given in the statement of affairs were thought to be substantially correct. Mr. J. Conacher is acting as special manager of the company, and it was stated that schemes for the future carrying on of the business were under consideration.

Both meetings passed resolutions in support of the official receiver as liquidator of the company, and nominated a committee of inspection.

A meeting will be held on Sept. 14 at the office of Mr. W. H. Stentiford, 1, Broad-street-place, London, E.C., to receive an account of the winding up of the Eastern Electrical Synd., Ltd. (in liquidation).

COMPANIES' MEETINGS AND REPORTS.

Anglo-American Telegraph Co. (Ltd.)

The half-yearly general meeting was held on Friday last. Mr. FRANCIS A. BEVAN presided.

Mr. T. H. WELLS (the secretary) read the notice calling the meeting and the report of the auditors.

The CHAIRMAN said: I congratulate the stockholders upon the increase in our receipts during the past half-year. The increase over the corresponding half-year is £14,500, and the receipts from the "Minia" also show an increase of £3,000, making £17,500. The expenses have decreased by £950, but as we have brought forward a less balance of about the same amount the result is that the net increase in the amount available for distribution is £17,451. 12s. 8d., and in addition we have just made up during the past year what we had lost during the previous year. The increase is due to general business and especially to Receipts from the "Stock" business, which is an invention of our manager, Mr. Carson, and it has proved a very fruitful source of income to this company. I am glad to say there seems to be, generally, an improved condition of things in trade between this country and the United States, and, therefore, we may hope that we shall continue to have good receipts during the next half-year at least. The renewal fund has also increased (I am now speaking of the year, not of the half-year) from June 30 to the present date by £21,380, although we have had to debit the fund with £13,000 for special repairs to the "Minia," with £5,700 on cable expended on general repairs, and with £15,250 on account of repairs to the 1874 cable. You will remember that Mr. Benson referred to this matter when speaking from the chair last half-year. I regret to say that, owing to very bad weather, up to the present we have not been able to effect the repair of that 1874 cable. We believe that in a short time the repair will be made. It is a great disappointment to us not to be able to announce to you to-day that that 1874 cable is repaired. With regard to this cable and to its breaking, I must say that, so far as we can see, all the expenditure—or almost all—which we have incurred during the last three years in the renewal of our cables on the west coast of Ireland has been due mainly to the reckless conduct, if I may so call it, of the fishing vessels. At the present time we have expended some 400 miles of cable in renewing our cables on the west coast of Ireland,

and we have cut out some 30 previous repairs. That these repairs are due, as I have said, to the trawlers is proved by a letter we received a few days ago from the secretary of Lloyd's, who states that a trawler had picked up 75 fathoms of cable while fishing 35 miles off the Blaskets, and this cable has proved to be one of our old broken cables—the 1865 or the 1866. That has only come to our knowledge within the last few days. We proposed to the Committee which recently sat that trawling should be prohibited in shallow waters off the Irish coast, where cables were known to be laid. But we were unable to get the Committee to agree to this, the alternative of the Committee being the examination of the trawls on fishing vessels by a Government official. It is clear that the protection suggested by the Committee is not sufficient. We can only hope that this recent discovery may lead to some more stringent measures. This difficulty with trawlers is not confined to this side of the Atlantic. On the other side matters seem to be rather serious, as the trawlers interfere with ordinary trade as they interfere with our cables. All this shows how right the directors have been in maintaining a large renewal fund. If it had not been for this fund we should have had to go on to our general receipts to provide for these repairs. You will remember that some time ago we set aside £90,000 against depreciation of our securities. I said at the time that I did not think it likely there would be suddenly a large appreciation; the position now is that there is an appreciation of something like £13,000. Therefore it was not too much to set aside, and there it must remain for the present. There is now only one other matter I may refer to briefly—the suggestion of reducing rates. You will have seen that the Eastern Companies have agreed to reduce rates for Press messages, but so far as the Press is concerned in Atlantic rates we are not disposed to make any reduction at present—in fact, there is no room for it. As to social messages, we wish to give the public the best possible service at the lowest possible cost, but we have at the same time to consider the interests of our stockholders, and we do not see at present that there is room for much, if any, reduction. I now move the adoption of the report and accounts.

Sir GERALD FITZGERALD, K.C.M.G., seconded the resolution, which was carried unanimously, and a hearty vote of thanks to the chairman, directors and staff terminated the proceedings.

BAKER STREET & WATERLOO RAILWAY CO.—The capital expenditure during the half-year amounted to £71,880. 8s. 9d., and the gross revenue receipts were £91,510. 5s. 8d., an increase of £7,981. 10s. 6d. for the corresponding half of last year. The working expenses amounted to £42,224. 9s. 6d., a decrease of £3,228. 2s. 4d. After providing for interest, rents and preference dividend and reserving £4,000 for contingencies and renewals, there remains £18,304. 4s. 10d. available for ordinary dividend, and the directors recommend that a dividend at the rate of 1½ per cent. per annum be declared on the ordinary shares, and an additional dividend at the rate of 1½ per cent. per annum (making 3 per cent. per annum in all) on the ordinary shares other than those held by the Underground Electric Railways Co. of London (or their nominees), leaving £3,105. 12s. 10d. to be carried forward. Including workmen and season ticket holders, 14,325,065 passengers were carried (against 12,940,801 in the June half-year, 1908), the train mileage was 637,202, and the average receipt per passenger was 1·46d. The directors recommend that the Paddington extension, as authorised, should be abandoned, and all questions as to extension of the railway beyond Edgware-road left for future consideration.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—Including the amount brought forward, the balance profit for the half-year ended June 30 (after providing for debenture interest) is £4,685. 16s. 9d., and the directors recommend a dividend at the rate of 4 per cent. (£3,000), writing off £750 to depreciation and £500 to general reserve, leaving £435. 16s. 9d. to be carried forward. The number of passengers carried during the half-year was 963,460, and the receipts from all sources £11,910. 18s. 7d.

CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY CO.—The capital expenditure during the past half-year was £145,798. 14s. 3d. The gross receipts amounted to £105,182. 10s. 4d., an increase of £16,299. 10s. 2d. for the corresponding half of 1908. The working expenses were £57,795. 6s. 2d., an increase of £1,302. 12s. 6d. After providing for interest and rents, and reserving £3,000 for contingencies and renewals, the balance available for ordinary dividend was £18,813. 0s. 8d., and the directors recommend that a dividend at the rate of ¾ per cent. per annum be declared on these shares, leaving £2,590. 10s. 8d. to be carried forward. Including workmen and season ticket holders, 14,862,882 passengers were carried, the train mileage was 991,747 and the average receipt per passenger 1·63d.

CHILIAN ELECTRIC TRAMWAY & LIGHT CO. (LTD.)—The result of the company's operations for the past year (after deducting interest and redemption of debentures, London and other charges) shows a balance of £8,832. 10s. 6d.; added to £1,712. 9s. 10d. brought forward, making £10,545. 0s. 4d. £8,000 has been transferred to renewals reserve, leaving £2,545. 0s. 4d. to be carried forward. The year under review shows a further development in tramway traffic: 68,342,366 passengers were carried, earning $5,696,868.69, against 61,451,234 passengers earning $5,011,363.34 in 1907. The receipts for light and power were $3,681,118.09, against $2,658,254.51. The increased demands for power for tramway operations, as also for the extension of the public lighting, made it necessary for the company to partially limit supply to the increasing demand for private lighting and power installations. The company hope shortly to be able to meet all demands that may be made upon them for both power and lighting. The works for the installation of water power are expected to be completed and the hydro-electric power plant to be ready for operation at the close months of the year.

GREAT NORTHERN & CITY RAILWAY CO.—The total revenue receipts for the six months ended June 30 were £40,801. 16s. 3d., and cost of working was £21,040. 2s. 7d., or 51·56 per cent. Net revenue was £19,761. 13s. 8d., which is insufficient to meet the company's fixed charges for the half-year. £3,209. 6s. 3d., which has been provided from outside sources, has enabled the company to meet these charges. The number of passengers (including season ticket holders) was 6,041,755 against 6,875,602 for the corresponding period last year. The number of local season tickets issued was 3,345, against 4,004. The number of three-route season ticket holders using the line during the past half-year was 2,725 against 2,892 for the corresponding half-year. The decrease in the number of passengers carried and in the receipts earned is mainly due to the competition of electric tramcars.

At the meeting on Wednesday the Earl of Lauderdale said there had been no new form of competition, and there was a tendency to the natural growth of the traffic, owing to the increase of population and to the greater facilities of transport available in London. Tramway competition had come to stay, and if the tube railway was to overcome the difficulties of the position it could only do so by the excellence of its service and the completeness of through bookings from Moorgate-street. They were in negotiation with the Great Northern Railway Co. in regard to fares.

GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.—For the half-year ended June 30 the capital expenditure amounted to £169,488. 9s. 11d. The gross receipts were £157,993. 4s. 1d., an increase of £10,229. 11s. 2d. compared with the corresponding half of last year. The working expenses amounted to £73,404. 13s. 1d., a decrease of £1,578. 16s. 11d. After providing for interest, rents and preference dividend, and reserving £6,000 for contingencies and renewals, the balance available for ordinary dividend was £33,592. 3s. 6d., and the directors recommend that a dividend at the rate of 1 per cent. per annum be declared on these shares, leaving £8,352. 7s. 6d. to be carried forward. Including workmen and season ticket holders, 19,155,883 passengers were carried (against 17,446,477 in the June half-year, 1908), the train mileage was 1,236,320 and the average receipt per passenger 1·89d.

LANCASHIRE POWER CONSTRUCTION CO. (LTD.)—The directors' report for 1908 states that the period has been one of re-organisation, the results of which will only become apparent during the current year's work. With regard to the Parliamentary company: The plant at the generating station and the sub-stations had been maintained in good condition, and, together with the mains, was proving itself reliable in operation. Various extensions of the mains had been made in order to supply new power users, the most important being an overhead line of over three miles in length to Turton. The company had succeeded in negotiating wayleaves on reasonable terms for nearly all the important extensions which had recently been desirable, the cost of such extensions being greatly reduced thereby. As regards the prospects of the company, there was a very marked improvement. Several contracts of considerable magnitude had recently been received for the supply of electrical energy, and although the full benefit of those contracts would not be felt until 1910, they would substantially add to the current year's revenue. The returns for the first six months of the present year showed an increase in revenue of 25 per cent. and the expenses a considerable diminution compared with the corresponding period of 1908. There was good reason to anticipate a credit balance at the end of the year after meeting all working and management expenses. At the close of the period covered by the accounts, 5,960 H.P. had been connected with the company's mains out of a total capacity of approximately 12,000 H.P. Since then a considerable number of additional orders had been secured, and at June 30 approximately 6,590 H.P. was connected, besides a further 1,160 H.P. arranged for but not yet connected.

At the meeting of the Lancashire Electric Power Co. and its affiliated company (the Lancashire Power Construction Co.) on Thursday last, the chairman (Mr. H. F. PARSHALL) said the re-organisation of the company was not completed till the end of 1908. Since the re-organisation steady progress had been made, and more satisfactory contracts had been entered into since it had been realised that the company was in a strong financial position. He was pleased to say that the Board of Trade had sanctioned the transfer from local authorities to the company of a considerable number of lighting orders. Those orders were a valuable asset to the Lancashire Power Co., as the districts were along their trunk mains. One of the most satisfactory developments was in connection with the supply of electric power to collieries. It was thought that the business of the Lancashire Power Co. would be largely confined to cotton mills, but, as a matter of fact, a number of collieries were finding it to their advantage to take a supply of electricity from the company. During the last six months the output had increased something like 30 per cent., while the total costs of production were actually less, the revenue increase being £1,500. That satisfactory increase was due to the fact that the advantages of the company's supply were getting to be better understood by Lancashire manufacturers. During the year a L.G. Board inquiry was held at Radcliffe, in whose district their power station was situated, and the attitude taken up by the Board was to discourage the development of the Council's undertaking for the purposes of power generation, and a recommendation was made to the effect that the position of the company should be taken into consideration by the Council. Radcliffe was practically the only local authority with which the Power Company was not on the best of terms. Having regard to the advan-

ages of a power scheme in such a district, the position taken up by Radcliffe Council was impossible to understand. It had appeared to the directors advisable to apply to the Board of Trade for a provisional order to supply electricity in Radcliffe district, as there were most important customers in that district willing to deal with the company.

LIVERPOOL OVERHEAD RAILWAY CO.—For the half-year ended June 30 the gross revenue receipts amounted to £35,188. 1s. 7d., and the working expenses to £27,372. 13s. 8d. The number of passengers carried was 4,900,216, against 5,167,464 in the preceding half-year. The shrinkage in passenger traffic during the half-year resulted in a reduction in revenue of £2,486. 14s. 7d., which is attributable to depression in trade. By introducing a more frequent but less costly service of trains and effecting other small economies in working expenses, a saving of £3,138. 7s. was effected. After meeting working expenses, paying debenture interest, &c., and adding £4,210. 4s. 11d. brought forward, the balance is £7,698. 4s. 8d., out of which the directors recommend the declaration of a dividend at the rate of 5 per cent. per annum on the (1892) preference shares (less tax), leaving 4,696. 4s. 8d. to be carried forward.

LONDON, CHATHAM & DOVER RAILWAY CO.—Sir Wm. Hart-Dyke, Bart., referred, at the meeting on Wednesday, to the effect of tramway competition on the company's suburban traffic. It had been suggested that they should electrify their railway, but he believed they would all agree with the views of Mr. Cosmo Bonsor when he urged that if they made any endeavour to compete with that tramway traffic it must be an effort very thorough and searching in its character. It would be useless to experiment on a small portion of their system, because their competitors would throw all their energies into meeting that small effort and, therefore, it would probably meet with disaster. There would be not only an enormous outlay involved to electrify the whole of the system where the trams ran to their termini, but, he believed, it would be impossible to carry out any scheme without considerably more elbow-room than they possessed.

LONDON, BRIGHTON & SOUTH COAST RAILWAY CO.—Lord Bessborough stated at the meeting on Wednesday that, in regard to their South London electric section, a trial service of 16 trains had been running between Battersea Park and Peckham Rye for the last three months. The full service between Victoria and London Bridge would commence on Oct. 1, but they intended to open a public service between Peckham Rye and Victoria at the end of the current month, and as everything in connection with the trial service had been most satisfactory, he predicted that the service initiated at the end of the month would be thoroughly efficient and attractive. With the establishment of the full service the trains would be accelerated from 36 to 24 minutes; a much more frequent service would be run, and both ordinary and season ticket fares would be revised, so that they should regain some of the business that had been lost through the electric tram and motor 'bus competition. They had, however, seen the worst of the latter form of competition.

NATIONAL BOILER & GENERAL INSURANCE CO. (LTD.)—The directors' report for the past year states that the balance at credit of profit and loss is £22,364, and a dividend is recommended at the rate of 6s. per share, tax free, for the half-year to June 30, with a bonus of 2s. per share.

SINGAPORE ELECTRIC TRAMWAYS (LTD.)—The report for 1908 (presented at the meeting on Wednesday) stated that the excess of revenue over expenditure was £24,294, against which has been charged debenture interest, depreciation and royalty, £28,335, leaving a loss for the year of £4,040. The demand for energy for lighting and power shows a satisfactory increase, the receipts from this source being 94 per cent. higher than in 1907. The new 200 kw. steam lighting set has been erected and is now taking the lighting load. The new bridge over the Singapore river is still not completed. Some other important work is proceeding.

At the meeting on Wednesday, Mr. E. Davis (who presided) stated that the total traffic receipts amounted to £55,985. 12s. 9d. (or nearly 4 per cent. less than in 1907), the receipts per mile being 6·89d., against 7·41d. The decrease in revenue was due to the great depression in trade, and more particularly among the Chinese community. The receipts for the current year (up to July 31) showed an increase over the corresponding period of 1908 of $7,070. The system of reserving first-class accommodation had been found to be of benefit to the company. The receipts from the supply of energy for lighting and power showed a gratifying increase (being $31,126, against $15,999) over the receipts for 1907. That branch was one with great potentialities, and as further installations were brought on to the municipal mains the returns should increase largely. Up to April 30 last the revenue under that heading shows a further increase of 48 per cent. compared with the corresponding four months of 1908. All the necessary materials for the track and for the electrical equipment of section No. 6 of the tramways were on the spot. The completion of that section should result in a considerable augmentation of the passenger receipts.

SOUTH AMERICAN LIGHT & POWER CO. (LTD.)—For the year ended March 31 the net profit is £5,274. 15s. 6d., added to £147. 7s. 2d. brought forward. The directors recommend a dividend of 4 per cent. on the issued capital, absorbing £4,520, and payment of interest at the rate of 4 per cent. on the £15,961. 2s. 10d. further capital expenditure incurred during the year by the railway company, requiring £274. 11s. 9d.; the balance (£627. 10s. 11d.) being carried forward. There are 715 customers against 462 in 1908, and the connections to the mains also show a considerable increase.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ALBA LAMP SYND. (LTD.) (104,342.)—Reg. July 29, capital £3,000 in 2,925 preferred ordinary shares of £1 each and 3,000 deferred ordinary shares of 6d. each, to acquire the benefit of and develop and turn to account an invention relating to a central reflector electric lamp. Private company. First directors, S. Fawns (chairman) and A. E. McCracken. Reg. office, 149-150, Finsbury-pavement House, London, E.C.

ALFRED WISEMAN (LTD.) (104,365.)—Reg. July 30, capital £15,000 in £1 shares, to take over the business of an iron and general metal founder, engineer, electrical and other tramway equipment manufacturer, &c., carried on as "Alfred Wiseman," the "Electric Tramway Equipment Co.," "S. C. Parkes & Co." and "F. & J. Allen." Private company. First directors are A. Wiseman and J. W. Harris (both permanent).

BARBADOS ELECTRIC SUPPLY CORPN. (LTD.) (104,367.)—Reg. July 30, capital £60,000 in £1 shares, to adopt agreements with the Anglo-American Debenture Corpn. and to carry on the business of electricians, mechanical engineers, suppliers of electric and other power, manufacturers of and dealers in apparatus used in connection with the generation, supply and distribution of electricity, &c. First directors, Col. W. F. Leese and G. H. J. Hooghwinkel. Reg. office, 24, Martin's-lane, London, E.C.

CHAS. E. GOAD (LTD.) (104,276.)—Reg. July 26, capital £6,000 in £1 shares, to take over so much of the business of making surveys and preparing plans for insurance companies, survey and plan work generally and civil and electrical engineering carried on by C. E. Goad except in Canada and Newfoundland). Private company. First directors, C. Edward Goad (governing director), C. Ernest Goad, J. S. Gord and A. Walch (all permanent). Reg. office, 53, New Broad-street, London, E.C.

ELECTRICAL ENGINEER (LTD.) (104,347.)—Reg. July 29, capital £1,500 in 1,425 preferred ordinary shares of £1 each and 1,500 deferred shares of 1s. each, to acquire the rights and property in connection with the newspaper or periodical known as the "Electrical Engineer," to adopt an agreement with C. S. Sarle and to carry on the business of newspaper and magazine proprietors and general printers and publishers, advertising agents, &c. Private company. First directors are H. A. Gwyne, G. Cadogan-Rothery and C. S. Sarle.

TRACTION SUPPLIES CO. (LTD.) (104,338.)—Reg. July 28, capital £5,000 in £1 shares, to carry on the business of electricians, electrical engineers, manufacturers of and dealers in fittings and accessories used in connection with electric traction, lighting or heating, &c. Private company. First directors, W. C. Thompson, W. M. Scott and A. White. Reg. office, Gill Bridge-avenue, Sunderland.

MORTGAGES AND CHARGES.

VERITYS LIMITED.—Trust deed dated May 17, supplemental to deed of Oct. 31, 1908, and modifying same for purpose of converting £60,000 debentures thereby secured into debenture stock; charged on the company's freehold and other property, present and future, including uncalled capital. Holders: Trustees, Executors & Securities Insurance Corpn.

RECEIVERSHIP.

RENO ELECTRIC STAIRWAYS & CONVEYORS (LTD.)—A notice of the appointment of Mr. Lancaster, 1, Basinghall-street, E.C., as receiver and manager, by order of Court dated July 23, 1909, has been filed.

CITY NOTES.

MEMORANDA (Aug. 5).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{1}{2}$d. per oz. Consols $83\frac{15}{16}$—$84\frac{1}{16}$ for money, $84-84\frac{1}{8}$ for account. Consols Pay Day, Sept. 1; Stock and Shares Continuation Days, Aug. 10 and 24; Ticket Days, Aug. 11 and 25; Pay Days, Aug. 12 and 26; Mining Shares Carry Over Days, Aug. 9 and 23.

PRICES OF METALS (London).—*Copper*, cash, $58\frac{11}{16}$; three months $59\frac{5}{8}$. *Lead*, English, $12\frac{3}{4}$—$13\frac{1}{8}$; foreign, cash, $12\frac{9}{16}$; three months, $12\frac{7}{8}$. *Spelter*, cash, $21\frac{7}{8}$—22. *Tin*, English, 132—134; foreign, cash, $133\frac{3}{8}$; three months, 134—$134\frac{7}{8}$. *Iron*, Cleveland, cash, 49/7, and three months, 50/4. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the four weeks ended June 25 were 689,235, compared with 561,055 units in the corresponding four weeks of 1908.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.) The directors have declared an interim dividend at the rate of 5 per cent on the ordinary shares of the West End undertaking.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The directors have declared a dividend on account of the year 1909 on the ordinary shares of 5s. per share, less tax.

W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)—The directors have declared an interim dividend at the rate of $4\frac{1}{2}$ per cent. per annum (less tax) on the preference shares and on the ordinary shares at the rate of 10 per cent. per annum (tax free) for the half-year ended June 30, both payable Sept. 1.

SOUTH METROPOLITAN ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.) The company announces that the question of the payment of a dividend on the preference shares is deferred until the accounts for the whole year are in the directors' hands.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 23	1,529	– 583	8	12,539	– 791
Airdrie	„ 23	210	+ 2	29	6,307	– 142
Anglo-Argentine..............	„ 29	35,434	+ 177	30	1,168,210	+ 65,697
Ayr Corporation	„ 31	483	– 42	11	4,2[illegible]	– 213
Baker St. & Waterloo Ry....	„ 31	3,125	+ 405	4	12,660	+ 830
Barnsley.........................	„ 23	166	– 16	29	4,807	– 220
Barrow	„ 23	272	– 13	29	6,130	– 493
Bath Electric Trams, Ltd...	„ 28	1,001	+ 105	30	22,275	+ 1,033
Birmingham Corporation...	„ 31	6,446	+ 120	18	116,628	+ 3,349
Birmingham & Mid.	„ 16	835	+ 58	23	23,301	+ 332
Blackburn Corporation	...	...	...	...	...	...
Blackpool and Fleetwood...	„ 31	1,201	– 96	4	4,323	– 48
Bolton Corporation	Aug. 1	2,210	– 290	18	41,988	– 990
Bombay	July 1	R34,152	+ R1,804	25	R987,345	+ R57,614
Bournemouth Corporation..	„ 23	1,707	– 173	17	28,266	– 206
Bradford Corporation.........	...	...	...	...	...	...
Brighton Corporation	Aug. 1	1,218	– 68	18	17,128	+ 701
Bristol Trams & Carriage...	July 30	5,802	+ 226	10	53,191	+ 419
Burnley Corporation	„ 31	1,276	– 143	18	22,988	– 233
Burton Corporation	Aug. 1	292	– 17	18	4,753	– 151
Bury Corporation	„ 1	1,032	– 168	†18	21,073	...
Calcutta Tramways Co.......	July 31	R47,450	+ R1,482	4	R201,652	+ R19,606
Camborne-Redruth	„ 31	120	– 20	31	3,765	– 110
Cardiff Corporation	„ 24	2,429	+ 93	17	36,338	– 910
Cavehill..........................	„ 23	122	+ 10	29	2,433	– 165
Central London Railway ...	„ 31	5,215	– 1,288	4	21,545	– 7,762
Charing C., Euston & H'stead	„ 31	3,670	+ 470	4	15,430	+ 2,470
Chatham & Dist. Lt. Rys....	„ 29	855	– 81	30	23,499	+ 1,265
City & South London Rly....	Aug. 1	3,176	+ 329	4	12,436	+ 966
City of Birmingham	July 23	2,812	+ 41	29	81,309	+ 739
Colchester Corporation	„ 28	219	– 18	4	834	– 75
Cork Electric Trams Co. ...	„ 29	502	– 12	30	12,747	– 876
Croydon Corporation	„ 30	1,457	– 109	17	26,119	– 29
Devonport & Dist. Trams...	„ 23	382	– 78	29	10,571	– 2,381
Dover Corporation	„ 31	258	– 78	18	3,680	– 478
Dublin & Lucan Railway...	„ 30	146	– 15	4	652	– 9
Dublin United	„ 30	5,486	– 331	4	21,426	– 352
Dudley-Stourbridge	„ 23	863	– 29	29	22,731	– 605
Dundee Corporation	„ 23	1,277	– 77	†11	12,090	– 524
East Ham Council	„ 31	865	+ 60	§17	17,949	+ 2,676
Exeter Corporation..........	„ 30	340	+ 30	18	6,212	+ 511
Gateshead & Dist. Trams...	„ 23	1,043	+ 22	29	25,7[illegible]	– 294
Glasgow Corporation.........	„ 31	14,095	– 802	19	145,3[illegible]	– 4,035
Glossop Trams................	...	...	...	...	...	...
Gravesend—Northfleet......	„ 23	316	+ 86	29	5,837	– 133
Great Northern & City Rly..	„ 31	1,237	+ 12	4	5,206	– 12
Gt. Northern, Piccadilly, &c	„ 31	5,180	+ 365	4	21,615	+ 875
Greenock & Port Glasgow...	„ 23	713	– 30	29	15,282	+ 163
Hartlepool Tramways	„ 23	291	– 6	29	6,492	– 166
Hastings Elec. Trams Co....	„ 29	1,160	– 189	4	4,665	– 201
Hong Kong	„ 31	$8,811	+ $1,022	4	$32,690	+ $1,653
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation..............	„ 31	2,651	+ 203	17	43,650	+ 612
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council....	„ 28	135	– 29	17	2,255	– 192
Ipswich Corporation	„ 31	471	– 37	18	7,107	– 20
Isle of Thanet Co.	„ 31	1,219	– 210	§35	19,058	– 75
Jarrow	„ 23	132	+ 13	29	3,327	+ 295
Keighley Corporation	„ 29	178	– 20	17	2,987	+ 47
Kidderminster & District...	„ 23	112	... 7	29	2,894	– 203
Kilmarnock Corporation ...	„ 31	236	– 7	11	1,748	– 86
Lanarkshire Trams Co. ...	„ 23	1,202	+ 107	30	37,404	– 1,591
Lancashire United...........	„ 23	1,269	– 127	30	39,275	– 18
Leamington	„ 23	219	– 1	29	4,800	+ 163
Leeds Corporation	„ 31	5,203	– 86	18	118,903	+ 341
Leicester Corporation	„ 31	2,277	– 197	4	8,994	– 518
Leith Corporation	„ 31	656	+ 69	11	7,038	+ 603
Lincoln Corporation	„ 31	124	– 1	18	2,240	+ 92
Liverpool Corporation	„ 24	11,088	– 315	‡29	311,294	– 3,362
Liverpool Overhead Rly. ...	Aug. 1	1,452	– 29	‡5	7,278	– 72
Llandudno & Colwyn Bay Ry	July 30	534	– 8	30	7,544	+ 1,628
*London County Council ..	„ 17	36,003	+ 991	§15	558,780	+ 19,339
London United	„ 31	6,393	– 1,939	‡32	178,5[illegible]	– 18,259
Lowestoft	...	...	...	...	...	...
Maidstone Corporation......	„ 31	192	– 41	17	3,235	– 295
Manchester Corporation ...	„ 31	14,874	– 1,550	18	266,825	– 2,477
Mersey Railway	...	...	...	...	...	...
Merthyr.........................	„ 23	217	– 9	29	6,122	+ 47
Metropolitan Dist. Railway	„ 31	9,763	+ 912	4	41,033	+ 4,197
Metropolitan Elec. Trams...	„ 23	7,232	+ 931	29	174,262	+ 14,377
Middleton......................	„ 23	385	– 76	29	9,618	– 785
Nelson Corporation	„ 31	141	– 18	§17	2,583	– 127
Newcastle-on-Tyne Corp. ...	„ 31	3,860	+ 10	17	63,231	– 1,416
Newport (Mon.)...............	„ 31	672	– 41	13	11,874	– 382
Northampton Corporation.	„ 30	407	– 30	§18	8,498	+ 117
Oldham, Ashton & Hyde...	„ 23	606	– 10	29	16 101	– 1,038
Oldham Corporation	Aug. 1	1,740	– 435	18	34,938	– 2,635
Perth (N.B.) Corporation ...	July 28	135	– 9	§10	1,717	– 56
Perth (W.A.) Elec. Trams...	„ 30	1,273	– 5	30	42,649	– 33
Peterborough	„ 23	134	– 4	29	3,295	– 254
Portsmouth Corporation ...	...	...	...	...	...	...
Potteries	„ 23	1,743	– 223	29	51,189	– 1,469
Preston Corporation.......	„ 28	713	– 35	4	2,992	– 98
Rotherham Corporation ...	„ 29	516	– 78	17	10,263	– 401
Rothesay	„ 23	862	– 190	29	4,975	– 260
Salford Corporation	Aug. 2	4,554	– 825	‡18	82,622	– 3,017
Sheerness	July 23	60	+ 18	29	1,397	– 185
Sheffield Corporation........	Aug. 1	5,452	– 322	§18	103,788	– 1,618
Singapore Trams	July 31	$8,850	+ $124	4	$36,862	+ $1,457
South Metropolitan	„ 23	915	+ 13	29	22,153	– 289
South Staffs...................	„ 23	826	– 33	29	23,964	– 1,322
Southend Corporation	„ 28	827	+ 196	17	9,118	+ 1,679
Southport Tramways........	„ 23	355	– 27	29	7,974	– 275
Stalyb'dge, Hyde, &c., Jt. Bd.	„ 31	702	– 174	§17	13,625	– 727
Sunderland Corporation ...	Aug. 1	1,234	– 197	18	20,561	– 1,014
Sunderland District	July 28	507	– 62	39	17,547	– 793
Swansea Trams	„ 23	1,016	– 14	29	26,888	+ 475
Swindon Corporation	„ 23	128	– 22	...	...	...
Taunton	„ 23	42	– 2	29	1,073	– 78
Tynemouth and District ...	„ 23	530	+ 140	29	6,145	+ 186
Tyneside Trams Co..........	„ 28	422	– 27	4	1,842	+ 125
Wallasey District Council...	„ 31	998	– 61	§17	16,725	+ 413
Walsall Corpn.	„ 31	530	– 14	39	15,200	– 1,150
Warrington Corpn.	„ 29	375	+ 8	17	6,609	+ 25
West Ham Corporation......	„ 22	2,475	+ 287	16	38,626	+ 2,449
Weston-super-Mare	„ 23	293	– 24	29	3,085	+ 140
Wolverhampton Co.	„ 23	409	– 32	29	11,932	– 1,203
Wolverhampton Corpn......	„ 28	788	– 55	4	3,321	– 211
*Worcester	„ 23	322	+ 11	29	7,703	– 117
Wrexham	„ 23	101	– 14	29	2,763	– 139
Yorkshire W.R. Trams	Aug. 1	1,132	– 175	31	35,803	...
Yorkshire Woollen District.	July 23	968	+ 19	29	25,632	– 487

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed. Aug. 4	Rate % Yield-ed. £ s. d.	Dividend Due.	Business Week to [illegible]: Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord...	9⅞ –10⅜	[illegible] 1[illegible] 9	Mar, Sep	[illegible]	–
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞ –10⅜	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10¼ –10¾	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	[illegible] –1[illegible]	4 7 6	Jan, July	..	..
5	3 6	Bromley (Kent) El. Lt. & Power Shares	4½ –4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 –96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 –[illegible]	[illegible] 17 [illegible]	March....	[illegible]	–
5	3 6	Do. 7 per Cent. Pref........	[illegible] –5¾	[illegible] 2 6	Mar, Sept	.	–
St.	4%	Central Elec Sup. Co.4% Guar. Db. Stock	97 –100	4 [illegible] [illegible]	June, Dec	..	–
5	2 6	Charing Cross (W. End & City) El. Sup. Co.	4 –4[illegible]	5 1[illegible] [illegible]	Feb, Aug	..	–
5	2 3	Do. 4½ per Cent. Pref.	4[illegible] –5	4 1[illegible] 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)......	[illegible] –[illegible]	4 1 0	Jan, July	..	..
St.	4½%	Do 4½ per Cent Deb. Stock (red) ..	9[illegible] –1[illegible]1	4 9 9	..	[illegible]	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ –4¼	5 2 6	Jan, July	-	..
5	2/6	Chelsea Electric Supply Ord.	3¾ –4¼	4 [illegible] 3	March ..	4	.
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	10[illegible] –103	4 7 [illegible]	June, Dec	.	..
10	5 0	†City of London Electric Lighting Ord...	10[illegible] 1[illegible]	5 1[illegible] [illegible]	Feb, Aug	1	..
10	6/0	†Do. 6 per Cent. Cum. Pref.	1[illegible] –12[illegible]	4 11 [illegible]	Jan, July	12[illegible]	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)......	121 –124	4 0 [illegible]	June, Dec	.	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	9[illegible] –102	4 [illegible] [illegible]	Jan, July	[illegible]	–
5	..	County of Durham Elec. P.D. Ord..........	1¾ –2		April, Oct	..	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3¼ –3[illegible]	3 17 6	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord......	[illegible] –[illegible]	[illegible] 3 [illegible]	Feb, Aug	[illegible]	..
10	6/0	† Do. 6 per Cent. Cum. Pref..............	1[illegible] –11[illegible]	5 9 [illegible]	Mar, Sept	1[illegible]	..
St.	4½%	Do. 4½% Deb. Stock (red.)	1[illegible] –106	4 5	Jan, July	1[illegible]	..
St.	4½%	Do. Second Deb. Stock....................	10[illegible] –103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅞ –[illegible]	5 9 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 –5¼	4 11 0	Mar, Sept	..	.
St.	4½%	†Do. 4½ 1st Deb. Stock (red)......	97 –100	4 1[illegible] 0	Feb, Aug	..	..
5	4 6	Hove Electric Lighting Ord.	7½ –7¾	5 11 6	April, Oct	.	..
5	4/0	Kensington & Knightsbridge Ord..........	6¾ –7¾	5 2 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝ –6⅞	4 14 6	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)......	[illegible] –95	4 2 0	..	-	–
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 –101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co....	83 –87	5 3 6	Jan, July	..	..
3	1 9⅜	London Electric Supply Ord.	1⅞ –2¼	3 6 8	Mar, Sept	.	..
5	3/0	Do. 6 per Cent. Pref....	5½ –5[illegible]	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 –97	4 2 [illegible]	Jan, July	..	–
5	3 0	Metropolitan Electric Sup. Ord.	4¾ –4[illegible]	5 1[illegible] [illegible]	April, Oct	[illegible]	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ –5	4 1[illegible] [illegible]	Jan, July		..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 –108	4 2 6	June, Dec	.	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	[illegible]3½ –36½	4 1 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	94 –97	4 12 6	June, Dec	..	–
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4¾ –5	4 2 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	84 –88	5 5 11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4⅞ –5	2 10 5	Feb, Aug	..	–
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞ –5	5 1 3	Feb, Aug	.	–
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 –99	4 1 8	Jan, July	.	.
100	5%	North Metro. Elec. Power Sup. 5 Morts	99 –101	4 19 0	..	..	–
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 –91	5 0 0	Jan, July	–	–
10	6 0	Notting Hill Electric Ord.....................	11½ –12½	5 14 6	March ..	–	–
5	4 6	Oxford Electric Ord.	[illegible] –5½	5 8 0	March ..	–	–
St.	4%	Do. 4 per Cent. Deb. Stock	95 –9[illegible]	4 2 0	Jan, July	..	..
5	5 0	†St. James' & Pall Mall Elec. Ord..........	8½ –9	5 11 0	Feb, Aug	9[illegible]	..
5	3 6	†Do. 7 per Cent. Pref.	7[illegible] –7½	4 13 4	Feb, Aug	–	–
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	84 –85	3 19 6	Jan, July	–	..
5	..	Smithfield Markets Electric Sup. Ord...	[illegible] –1[illegible]	..	Feb	..	..
5	4 0	South London Electric Supply Ord.......	2¼ –3½	6 8 0	April	..	..
St.	5	Do. 5% 1st Mort. Stk. Red.	101 –1[illegible]3	4 17 0	–	..	..
1	0/0	South Metrop'n Elec. Lt. & Power Ord.	[illegible] –[illegible]	4 14 0	..	..	–
1	0 8⅜	Do. 7 per Cent. Cum. Pref................	1[illegible] –1[illegible]	5 7 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red..................	100 –104	4 6 9	April, Oct	–	–
5	2 6	Urban Electric Supply Ord.	[illegible] –1	–	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	1⅝ –2⅛	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.........	78 –80	5 12 0	April, Oct	..	–
5	5 0	Westminster Elec. Sup. Ord.	8⅞ –9⅜	5 1[illegible] [illegible]	Mar, Sept	9	–
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜ –[illegible]	4 8 0	Jan, July	..	–
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	97 –99	4 1 0	Jan, July	9[illegible]	[illegible]
1	..	Bath Elec. Trams Pref. Ord.	¼ –[illegible]	..	April....	..	-
1	0/6	Do. 6 per Cent. Cum. Pref..............	[illegible] –[illegible]	7 5 0	Jan, July	..	–
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	8[illegible] –91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	[illegible] –91	4 19 [illegible]	Jan, July	..	..
10	6%	†Bristol Tramways & Carriage Ord.	3⅝ –[illegible]⅛	7 2 6	Feb, Aug	..	–
10	4%	Do. Cum. Pref. (fully paid)...............	7¼ –[illegible]	4 14 0	..	..	–
St.	4%	Do. 4 per Cent. Debs.	10[illegible] 1[illegible]1	3 19 0	Feb, Aug	..	–
10	..	British Electric Traction Ord..............	½ –⅞	.	June, Dec	..	–
10	3/0	Do. 6 per Cent. Cum. Pref..............	2 –2½	12 0 0	Feb, Aug	..	–
St.	5%	Do. 5 per Cent. Perpetual Debs.	86 –90	5 11 0	April, Oct	8[illegible]	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	64 –68	6 12 .	May, Nov	.	[illegible]
St.	3½%	Central London Ordinary Stock	60 –62	5 13 0	Feb, Aug	[illegible]	[illegible]
St.	4%	Do. 4 per Cent. Pref. Stock	83 –85	4 14 0	Feb, Aug	[illegible]	..
St.	2½%	Do. Deferred Stock	4[illegible] –45	5 11 0	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	10[illegible] –102	4 1[illegible] [illegible]	Jan, July	..	
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	92 –94	4 5 0	Jan, July	9[illegible]	9[illegible]
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4[illegible] –[illegible]	4 1[illegible]	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs	97 –101	3 1[illegible] 0	April, Oct	..	..
St.	1¾%	†City & South London Rly. Con. Ord. ...	31 –32	4 14 0	Feb, Aug	[illegible]	[illegible]
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	10[illegible] –110	4 1[illegible] [illegible]	Feb, Aug	..	..
St.	5%	Do. (1896)	104 –107	4 13 6	Feb, Aug		..
St.	5%	Do. (1901)	100 –103	5 2 [illegible]	Feb, Aug	..	–
St.	5%	Do. (1903)	9[illegible] –95	5 5 0	Feb, Aug		–
St.	4%	Do. 4 per Cent. Perpetual Debs.	9[illegible] –1[illegible]1	3 19 [illegible]	May, Nov	...	.
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾ –1[illegible]	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	[illegible] –1	..	Feb, Aug	.	..
10	..	G. Northern, Picc. & Brompton 4% G. Pf.	8 –8½	–	Feb, Aug	.	–
St.	4%	Do. 4 per Cent. Deb. Stock	93 –95	4 4 [illegible]	Jan, July	9[illegible]	–
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1[illegible] –[illegible]	.	Mar, Sept	..	–
St.	4½%	Do. 4½ Db. St.	7[illegible] –8[illegible]	5 12 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 –4½	13 0 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 –6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	82 –84	5 7 0	Jan, July	..	–
5	1 3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ –1[illegible]	..	Mar, Sept	..	–
St.	4%	Do. 4 per Cent. Deb. Stock..............	58 –6[illegible]	6 7 0	Jan, July	..	–
10	6/0	Lanarkshire Tramways	9[illegible] 1[illegible]	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	8[illegible] –[illegible]	5 10 6	Jan, July	.	.
10	..	Liverpool Overhead Railway Ord.	4 –[illegible]	..	Feb, Aug	..	–
10	5%	Do. 5 per Cent. Pref.	[illegible] –[illegible]	8 6 8	Feb, Aug	..	–
St.	4%	Do. 4 per Cent. Deb.	82 –84	4 15 3	Jan, July	–	..
10	2 6	London United Trams. 5% Cum. Pref. ...	[illegible] –2½	..	Jan, July	2[illegible]	[illegible]
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68 –71	5 12 6	Jan, July	7[illegible]	69
St.	–	Mersey Con. Ord. Stock	1 –2	–	Feb, Aug.	–	..
1	10⅜	Metropolitan Elec. Tramways Ord.	[illegible] –[illegible]	–	..	..	..
1	–	Do. Deferred	[illegible] –[illegible]	..	April.. .	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible] –[illegible]	5 15 0	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 –97	4 12 [illegible]	Jan, July	[illegible]	[illegible]
St.	1%	†Metropolitan Railway Consolidated	40[illegible] –40[illegible]	1 1 6	Feb, Aug	4[illegible]	[illegible]
St.	2½%	†Do. Surplus Lands Stocks.................	[illegible] –67	4 0 3	Feb, Aug	[illegible]	..
St.	3½%	†Do. 3½ per Cent. Preference...	87 –89	3 18 6	Feb, Aug	..	..
St.	3½%	†Do. 3½ per Cent. "A" Preference	82 –84	4 3 6	Feb, Aug	–	..
St.	3½%	†Do. 3½ per Cent. Convertible Pref......	82 –84	4 3 6	Feb, Aug	[illegible]	[illegible]
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 –94	3 14 6	Jan, July	92[illegible]	[illegible]

In calculating the yield allowance has been made for accrued interest but *not* for redemption
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre.	Last Dividend	Name.	Price Wed., Aug. 4.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Aug. 4 Highest.	Lowest.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.	17½—17¾	—	Feb, Aug	17¾	17½
St.	..	Do. Extension Pref. (5 per Cent.)	45 —47	..	Feb, Aug	46¾	46⅜
St.	3½%	†Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	63 —65	5 8 0	Feb, Aug	..	..
St	3%	Do. 3 per Cent. Consoldtd. Rent-charge	76 —78	3 17 0	Jan, July	77¼	76½
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	95 —98	4 2 0	Mar, Sept	97	95
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	139 —141	4 5 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	93 —95	4 4 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅝	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	82 —86	5 16 0	Jan, July	..	..
..	...	Undergd. E. Rys. Lon. 6% Inc. Bds with coup. 3	36 —38	..	June, Dec	37½	..
..	5%	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	102⅜	..
—	4½%	Do. 4½% Bonds with coup. 8	87 —89	5 1 0	..	89	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	—	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅜—½	..	..	—	..
1	1/4½	Do. 6% Cum. Pf.	¾—⅞	6 17 0	April, Oct	..	—
1	2/4¼	Babcock & Wilcox Ord.	4¼—4⅜	4 15 9	April, Oct	4 5/16	..
1	0/7½	Do. Pref.	1⅜—1½	4 0 0	..	..	—
5	6/0	British Insulated & Helsby Cables Ord.	7⅛—7¼	6 9 6	July, Feb	..	..
5	3/0	†Do. 6 per Cent. Pref.	6⅜—6½	4 12 0	Jan, July	6 7/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	[illegible]	—	Feb, Aug	¼	—
100	6%	Do. 6 per Cent. Prior Lien Dbs. rd.	97 —99	6 1 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	..	..
St.	4½%	Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	10 —10½	6 19 6	Jan, July	10⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	104½—106½	4 5 6	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	1⅞—2	6 6 0	May, Nov	1 15/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb, Aug	..	..
1	1 0½	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	6 11 9	March ..	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/8½	Consolidated Electrical Co.	⅜—½	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1⅛—1¼	5 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	½—1	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	90 —93	5 7 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1 1/16—1½	8 0 0	Sept ...	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	4 16 9	Sept ...	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	¼—⅜	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1½—2½	5 0 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	3/16—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 5 0	Jan, July	60	—
2	..	Electric Construction Co.	7/16—11/16	.	Jan, July	9/16	—
2	2/9⅜	†Do. 7 per Cent. Cum. Pref.	[illegible]	9 0 0	July	..	..
St.	4%	Do.* 4 per Cent. Perp. 1st Mort. Debs.	63 —67	5 19 0	Jan, July	..	..
St.	5%	Ferranti Ltd. 5 per Cent. 1st Mt Db. St.	71—77	6 10 0	...	..	...
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	12½—12⅝	5 18 0	Feb, Aug	12½	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 2 0	Feb, Aug	—	—
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14½—15½	6 10 0	Feb, Aug	15¼	14 13/16
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—10¾	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	—	—
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	[illegible]	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	81 —84	5 7 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1½	..	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	—
12	12/0	†Telegraph Construction & Maintenance	34 —35½	5 3 0	Mar, July	34	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99½—101½	3 18 0	Jan, July	..	..
1	1 0	Vickers, Sons & Maxim, Ltd., Ord.	[illegible]	4 11 0	..	[illegible]	[illegible]
1	1/6	Do. 5 per Cent. non-Cum. Preference	[illegible]	3 11 6	..	[illegible]	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	111	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.	101½—102½	3 17 6	June, Dec	..	102
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	106	106¼
10	5/-	J. G. White & Co. 6% Cm. Pref.	9 —10	6 0 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅝—3⅛	9 12 0	Apr, Oct	—	—
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	..	—
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3¼	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.	95 —96	5 4 0	June, Dec	..	..
St.	15/0	†Anglo-American	68 —70	5 8 0	F,My,Ag,N	68¾	..
St.	3/0	†Do. Preferred	101 —102	5 18 0	F,My,Ag,N	101⅛	101
St.	5/0	Do. Deferred	17⅛—18	2 5 0	F,My,Ag,N	17¾	17⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	89 —91	4 8 0	Jn,Ap,Jy,O	89½	..
10	6/0	Cuba Submarine Ord.	[illegible]	6 15 0	Feb, Aug	..	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
	2/0	Direct Spanish Ord.	2⅞—3⅛	5 15 0	April, Oct	..	..
	5/0	Do. 10 per Cent. Cum. Pref.	8⅝—[illegible]	5 12 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. Deb.	99 —101	4 9 0	Jan, July	..	..
	5/0	†Direct United States Cable	12⅝—13½	5 12 6	Ja,Ap,Jy,O	[illegible]	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.	99 —101	4 9 0	June, Dec	..	..
St.	[illegible]	Eastern Ordinary	125 —128	5 9 6	Ja,My,Jy,O	126	125
St.	17/6	Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,Jy,O	[illegible]	85½
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	105½	104½
St.	2/6	Eastern Extension	11½—12	6 0 0	Ja,Ap,Jy,O	[illegible]	11½
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 18 0	Feb, Aug	..	.
	4%	Eastern & S. Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	..	..
	[illegible]	G. N. of Copenhagen, with Coupon 76	26½—27½	6 0 0	Jan, July	26½	—
100	[illegible]	Halifax & Bermudas 4½% 1st Mt. Db. (red.)	99 —101	4 9 0	June, Dec	..	..
	[illegible]	Indo-European Tel.	61½—62½	5 15 9	May, Nov	..	..
100	$1	Mackay Companies Common	80 —84	4 15 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April	16	..
1		Pacific & European Tel. 4% Guar. Dbs. (red.)	99 —101	3 19 0	June, Dec	—	—
	1/3	West Coast of America	1⅝—1⅞	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	.	West India & Panama	½—⅝	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8 —8½	7 1 0	May, Nov	8	..
10	[illegible]	Do. 6% 2nd Pref.	8 —9	6 15 6	May, Nov	—	—
100	5%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
10	6/0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	13¾	13 9/16
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102½—104½	3 18 0	June, Dec	103	102¾
...	4%	Western Union Telegh. $1,000 4% Bonds	97 —99	4 1 0	..	99	—

Shre.	Last Dividend	Name.	Price Wed., Aug. 4.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week Aug. 4 Highest.	Lowest.
		TELEPHONES.					
100	$2	Amer. Telephn. & Telegh. Cap. St.	146½—147½	6 8 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	—	—
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103 —105	4 15 0	Mar, Sept	—	—
5	5/0	‡Chili Telephone	8 —8½	4 14 6	August ..	..	—
1	0/7½	Monte Video Telephone Ord.	13/16—15/16	6 8 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾—⅞	5 14 3	May, Nov	..	—
St.	6%	†National Co. Pref. Stock	106½—107½	5 11 6	Feb, Aug	107	105½
St.	6%	†Do. Def. Stock	122½—124½	4 16 0	Feb, Aug	123½	122½
10	6/0	†Do. 6 per Cent. Cum. 1st Pref.	10 —10¾	5 11 6	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. 2nd Pref.	10 —10¾	5 11 6	Feb, Aug	..	..
5	2/6	†Do. 5 per Cent. non-Cum. 3rd Pref.	5 7/16—5 11/16	4 8 0	Feb, Aug	5 17/32	5 7/16
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —101	3 9 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	Jan, July	100⅛	99⅞
1	1/0	Oriental	1 5/16—1 7/16	5 7 6	April, Oct	1 13/32	..
1	0 7½	Do. 6 per Cent. Cum. Pref.	1 11/16—1 [illegible]	5 1 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85 —87	4 12 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 —101	4 9 0	Jan, July	100⅜	..
5	5/0	†United River Plate	6⅞—7⅛	5 12 0	July	7⅛	6 15/16
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5½	5 10 6	June, Dec	..	..
St	4½%	Do 4½ Deb. St. Red.	103 —105	4 6 0	Jan, July	—	..
		FINANCIAL INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..	..
10	5/6	Globe Telegraph & Trust	10¼—10¾	6 7 0	Sp De Mr Ju	10½	10⅜
10	3/0	Do. 6 per Cent. Pref.	13⅝—13⅞	4 6 6	Sp De Mr Ju	13¾	13⅝
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	...	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	5/0	Anglo-Argentine 10% Cum. 2nd Pref.	9 5/16—9 [illegible]	5 3 6	April, Oct	9 7/16	9 11/16
5	1/2[illegible]	Do. 5% Non-cum. 3rd Pref.	4 7/16—4 11/16	5 7 0	Jan, July	4 9/16	—
St.	4%	Do. 4% Deb. Stock	90¼—91¼	4 7 0	June, Dec	91½	91
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 6	Jan, July	103½	103
5	3/6	Brisbane Electric Trams. Invest. Ord.	6½—6¾	4 9 0	May ...	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	[illegible]	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100½—104½	4 4 0	Jan, July	..	..
St.	8%	British Columbia El. Ry. Df. Ord.	144 —148	5 8 0	Mar, Sept	147½	146½
St.	6%	†Do. Pref. Ord. Stock	119 —123	4 17 6	May, Nov	123	122¼
St.	5%	Do. 5% Cum. Perp. Pref. Stock	107 —110	4 11 0	Jan, July	105½	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	101½—103½	4 7 0	—	102⅞	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99½—101½	4 18 6	Mar, Sept	100⅜	..
St.	6%	†Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	92 —96	6 5 0	Feb, Aug	..	..
5	2/0	Calcutta Tramways (1 to 137,610)	4½—4⅞	4 2 0	Mar, Sept	4⅞	[illegible]
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	..	—
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	—	—
St.	—	Cape Electric Tram Shares	⅛—⅜	..	..	9/32	—
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 11/16—5 15/16	4 4 0	F,My,A,N	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	—
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	—
1	5%	‡Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	—	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	90 —93	5 7 6	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	64 —68	8 16 0	Jan, July	67½	..
5	1/0	Lisbon Elec. Trams. Ord.	[illegible]—1 1/16	4 14 0	July	[illegible]	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1 1/16	6 1 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	97 —101	5 1 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	92 —95	5 2 0	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	96 —98	5 2 0	Feb, Aug	..	..
100	$1½	‡Mexico Trams Co. Com. St.	124 —127	3 18 9	..	127½	118
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	93 —95	5 10 6	..	94½	93
St.	4½%	‡Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	104	103
1	0/6	Perth Elec. Trams Ord.	⅜—⅝	8 0 0	May	..	—
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅝—5¾	5 4 8	..	—	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	88 — 90	..	..	89	86
..	5%	Do. 30 yr. Gold Bnds.	92 — 94	5 6 0	..	93½	9[illegible]
100	5%	Do. 50 yr. Mt. Bnds	84 — 85	5 17 0	..	84½	83¾
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	148 —149	6 14 0	..	149	147
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	97 —99½	5 0 6	June, Dec	99½	98
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 12 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅝	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93½—95½	4 18 6	Jan, July	94⅛	..
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	[illegible]—95½	..	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	5¾—6¼	6 8 0	April, Oct	6¼	6⅛
100	$1¼	Canadian Gen. Elec. Co. Com. St.	121 —125	5 15 6	..	124½	122½
100	$3½	Do. 7% Cm. Pf. Stock	116 —118	6 3 6	..	119	117
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	84½—86½	5 16 [illegible]	..	85½	85
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	.
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	..
10s	4	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	6 18 3	April, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	82 —84	5 10 0	..	[illegible]	83
St.	$1	Mexican Lt & Power Co. Com. St.	63 —70	6 9 6	—	69½	67
500	5%	‡Do. 5% 1st Mort. Gold Bnds.	85½—87½	5 14 0	..	[illegible]	[illegible]
100	$1½	‡Montreal Lt. Ht. & Power Co. Cap. St.	126 —130	4 16 3	F,My,A,N	..	.
1	1/7½	River Plate Electricity Co. Ord.	[illegible]	5 11 0	April	..	.
1	1 2⅜	Do. 6 per Cent. non-Cum. Pref	[illegible]	6 1 6	May	..	—
St.	5%	Do. 5 per Cent. Deb. Stock	102 —105	4 15 0	Jan, July	..	.
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	[illegible]	5 7 6	April, Oct	..	.
5	3/0	Do. 2nd Pref.	5⅞— 6	5 0 0	..	[illegible]	.
100	$1	Shawinigan Water & Power Co. Ca	92 —94	4 7 3	—	94	9[illegible]
..	5%	Do. 5 per Cent. Bds.	104 —106	4 11 3	Jan, July	105⅛	[illegible]
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 —98	4 12 0	—	97¾	.
St.	4½%	Toronto Power Co. 4½% Db. St.	[illegible]—99½	4 10 6	..	[illegible]	9[illegible]
..	6d.	Victoria Falls Power Co. Pref.	[illegible]	5 14 0	Jan, July	—	.
1	..	Do. 10/- paid	[illegible]	.	..	..	.

* In calculating the yield an allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote the

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NOTES.

Electricity Tariffs.

WITH his accustomed energy, Mr. A. H. SEABROOK has taken up his new position under the St. Marylebone Council, and has issued a report, which has been adopted, advising a simplification of tariffs for the various classes of consumer. The principle of paying a lump sum per annum, depending upon the kilowatts of maximum demand, plus a low charge per unit consumed, is one that has been applied with satisfactory results to many power consumers. As detailed in our last issue, Mr. SEABROOK proposes to extend this principle to lighting consumers, and he designates the tariff the "telephone system of charging," as it is very similar to the system now generally adopted in charging for telephones, and is, therefore, familiar to most electricity consumers. The object Mr. SEABROOK has in mind is the encouragement of electric heating and cooking, and with this end in view he evidently intends to keep a sharp eye on flats, the supply to which is very commonly "farmed out" by flat owners. Obviously, the business of the flat owner is not the extension of electricity supply, and, therefore, he troubles little about tariffs. Consequently, the flat holder may have to pay for his electricity on some system that by no means encourages the use of electric heating and cooking apparatus, which are, nevertheless, so essentially well adapted to flats.

WE are glad to see that Mr. SEABROOK wishes to avoid duplicate wiring, but we are not quite clear how the maximum demand is to be ascertained in the case of consumers taking both light and power if duplicate wiring is to be avoided. The charges for heating and cooking should differ essentially from those for lighting, as is indeed clear from the suggested tariff, and that being so it is necessary to distinguish between the maximum demand for both these classes of service, unless some device is adopted by which the difficulty is altogether avoided. We notice that some mention is made of assessing apparatus for electric heating and cooking, but although this is easy if the total possible maximum demand is all that is required, it gives no clue to the actual maximum demand. In the lighting part of an installation there is, however, less difficulty. As Mr. SEABROOK mentions that consumers on this tariff must give facilities for inspection, possibly he intends to extend this principle. At all events we are glad to see an effort at simplification, and we think it is decidedly a move, though not quite far enough, in the right direction.

IN our last issue there also appeared a letter from Mr. R. S. HALE, Superintendent of the Sales Department of the Edison Electric Illuminating Co., of Boston, giving particulars of the tariff employed by his company. It certainly cannot be considered a very simple one, as there are innumerable rates and discounts. The point of his letter, however, is that it is undesirable to give secret preferential terms to large users. It will be remembered that the view was expressed during the last Convention of the Incorporated Municipal Electrical Association that municipal electricity departments should not be forced to disclose the terms on which they give a supply. Many managers may feel that it is desirable to give special terms to large consumers or those of particularly good load factor. Mr. HALE mentions that this policy has been given up at Boston for the last five years, and that, although sometimes it might be more easy to get business if special

rates could be quoted, yet on the whole it is preferable to say that every prospective consumer can have the same price as any existing consumer under the same circumstances. Very possibly in the long run this policy will pay; at all events prospective consumers can then find out at once what terms they can get, and they will cease to ask for something better, which certainly should be a relief to the supply manager.

Accuracy in Photometry.

APART from being a record of the comparisons forming the basis of the agreement between America, France and this country as to an international unit of candle power, Mr. C. C. PATERSON's Paper, which appears in another column, is interesting as showing the possibilities of photometry as a branch of accurate measurement. Mr. PATERSON mentions that, although it is usual in giving photometric results to write down the fourth figure, under the most favourable circumstances the results are liable to an error of + or − $\frac{1}{10}$ per cent., which must be attributed chiefly to want of constancy in the individual who is making the photometric observations. The highest precision is obtainable in comparisons between properly seasoned electric glow lamps of the same coloured light, and with a good set of sub-standards, the accuracy then obtainable is such that the fourth figure is almost definite. In the case of flame standards, however, it is altogether a different matter. Atmospheric conditions then play an important part, and a large number of observations are necessary for the same degree of accuracy. Further, the estimation of the height of the flame in some lamps and the exact reproduction of the standard conditions may not be identical with different observers. Consequently results are more variable, and, as Mr. PATERSON puts it, "a flame standard needs to be 'interpreted' when its absolute value is desired to a high accuracy." Undoubtedly, photometry is an art the accuracy of which depends essentially upon the observer, and it is this fact which renders it distasteful to many who are accustomed to accurate work in other branches. It is something like working with an electrical appliance that needs to be coaxed (as also the observer) before it will give a correct result, but fortunately electrical measurements are practically free from this trouble.

Commercial Value of International Exhibitions.

A QUESTION which comes up for periodical discussion in engineering circles is whether the international exhibitions that are held throughout the world, from time to time, are of any real value to the industry. It has been stated by those in favour of displays that the Milan Exhibition, held in 1906, had an exceedingly good effect on the exports from this country to Italy; but this was thought by others to be a merely isolated case, and that to exhibit at international exhibitions, especially for British manufacturers, was not, in general, worth the trouble entailed. There can be no doubt that up to the present time English manufacturers, unlike those in other countries, have been discouraged rather than encouraged to exhibit on such occasions. The subsidy granted by the Government has been too small to be of any great use, and even this has been obtained only after a hard fight with the Treasury. The recent appointment by the Government of a Board of Trade Committee specially to deal with the questions of international exhibitions, has given rise to the hope that the disadvantage under which this country has up to now been placed in the matter, owing to the meagre Government support, would shortly be a thing of the past. That this optimism is not altogether justified is pointed out by Mr. H. GREVILLE MONTGOMERY, M.P., in a pamphlet which he has recently issued dealing with the subject. He shows that although a certain amount of assistance will be given to exhibitors by the Committee in providing them with a position at the exhibitions and with show cases and light and power, no information appears to be available for manufacturers as to whether they are likely to obtain any commercial benefit from so exhibiting. In fact, the policy seems to be first to pledge the country to official representation at a certain exhibition and then to get into touch with possible exhibitors.

THE danger of this "cart-before-the-horse" policy is fully recognised by Mr. MONTGOMERY, who shows that participation of the Government in such matters from a political point of view will give rise to great dangers. He points out that in spite of the fact that German manufacturers were informed by their Government that the benefits accruing to them at the St. Louis Exhibition would be great, this hope was not realised. The remedy for such a state of affairs appears to be the appointment of a committee of manufacturers to consider the whole question of exhibiting at any given exhibition, as has been done in France for over 20 years, while the same course is also being followed in Switzerland and Germany. The advantages of such a committee are many. It would tend to prevent the harmful multiplication of exhibitions. For no less than six of these have been held since 1900, and three more are now under weigh, and will be held during the next few years. A committee of manufacturers could determine whether a proposed exhibition was worth considering from a commercial point of view, and political questions would scarcely come into the matter at all. It therefore seems a pity that, now the Government have at last recognised the benefits of supporting the enterprise of our manufacturers at such exhibitions, there should yet be a tendency to place the organisation under political rather than manufacturing control. Such exhibitions are primarily intended for the good of the manufacturer individually and for the good of the industry generally; and if a country is represented it should rather be for the benefit of the industry than in the hope of political advantage.

Electric Plant for Discharging Cargo.—The British Vice-Consul at Spezia, Italy, in a recent report describes some of the electrical appliances now in course of erection at that port. Four electric cranes will raise coal, or ore, in buckets from the holds of ships, transport it horizontally, and discharge it into wagons or on the wharf at the rate of 2,000 tons of coal or ore per day of 10 hours. Two electric cranes are also being fitted with grain-discharging apparatus, each being capable of handling about 36 tons per hour. It is believed that the electric appliances will do away with the long delays suffered by boats discharging at Spezia.

Cable Interruptions.	Date of Interruption.
Tangier—Cadiz	May 19, 1909
Tourane—Amoy	June 17, 1909
Assab—Perim	July 8, 1909
Gibraltar—Tangier	Aug. 7, 1909
Cueta—Tangier	Aug. 7, 1909
Melilla—Chafrinas	Aug. 7, 1909

"The Electron."—With the July issue of this journal its career is opened anew. As will be remembered, in our notice of the last issue we mentioned that a reconstruction of the management was to take place, and that a committtee of three was to be substituted for a single editor. To the outward eye the number under notice does not appear to differ very much from its predecessors. The technical articles contained therein include one on "The Electric Motor Drive for Weaving Sheds," a similar subject being dealt with in another article describing the "Weaving Sheds and the Jute Spinning Mills of Messrs. Blutchen & Sons at Vetchau." On the scientific side we may mention an article by Dr. Kloss on "The Starting Torque of Three-Phase Motors with Squirrel Cage Rotors," to which we hope to return later. Another interesting article is that on "The Origin of Siemens," in which we note that Werner Siemens is given the credit for inventing the self-exciting dynamo. Other names have also been mentioned in connection with this invention, but, perhaps, the present article could not be expected to be of a very general kind. The issue concludes with an article on the cottages which have been built by the firm for the housing of their staff at the Stafford works, while the doings of the various athletic clubs connected with Siemens' are also chronicled. Since the first number of "The Electron" we have viewed with great interest its rise and progress, and we only hope that it will continue to increase and multiply in the future as it has done in the past.

Coal Consumption in Small Stations.—The following notes on this subject are taken from a recent number of the "Electrical World": Although small central stations operating with high-speed, simple, automatic cut-off steam engines are more numerous than any other class, probably less is known about their actual coal consumption per kilowatt hour than about that of larger and more economical stations. Stations of the small high-speed engine class which employ watt-hour meters for measuring the total output, and keep actual records of coal consumption, are the exception. Frequently also these stations, even though provided with total output meters, are carrying on steam-heating or ice business, which makes it impossible to separate the coal required for electrical operation from that required for other purposes. Nevertheless, we have obtained a few figures recently from the stations operating simple, high-speed engine units of less than 200 H.P. They are instructive as showing what fairly well-maintained small plants are doing. One of these plants, in south-eastern Missouri, uses southern Illinois slack from the Carterville district, which is a coal of good heating value. In this plant the consumption of coal is 10 lb. per kilowatt hour, covering everything in the operation of the plant for a considerable period. In another plant located in south-western Illinois, using Hillsboro' slack, special tests for 24-hour periods have shown a consumption of 9 lb. to 10 lb. per kilowatt hour. In another plant in southern Illinois, burning Centralia slack of low grade, the consumption is 14 lb. per kilowatt hour. All these plants are well maintained, but nearly all operate engines considerably under-loaded during much of the day.

Electric Railway Conditions in Austria.—An article by an "Austrian Engineer" in a recent number of the "Electric Railway Journal," gives some details on this subject. The first single-phase railway in the world, the Stubaitalbahn, was built in the Tyrol, and the absence of coal and the large amount of water power have given great impetus to the construction of electric railways. Recent statistics indicate that there are about 5,500,000 H.P. available in the water-power of Austria, or 187 H.P. for each 1,000 inhabitants. This amount is surpassed only in Switzerland, where there are 454 H.P. for each 1,000 inhabitants. The figures showing the percentage of utilised to available power are in Switzerland, 25 per cent.; Germany, 20 per cent.; France, 18 per cent.; Italy, 14 per cent., and Austria, only 9 per cent. A commission appointed by the Government is now systematically studying the subject of utilising all the available water-power for electric traction. As the majority of the railroads are owned by the State, there is a tendency to reserve the water-power for governmental use until after the report of the commission shall determine how much will be required by the Government railways. While the general electrical industry is being seriously handicapped in the meantime, this plan will ensure efficient utilisation of the water-powers and a uniform voltage. The first step in the conversion of steam railways to electric traction will probably take place in the Tyrol, where several large water-power stations are to be built with capacities from 2,000 H.P. to 12,000 H.P. The longest existing electric line in the Tyrol is that between Trient and Malè, 38 miles in length. This line will be opened on July 1, and is operated by direct-current at 800 volts. A more interesting line for the railway engineer is the Maria Zell road, now nearing completion in lower Austria. This is the longest single-phase railway on the Continent (57 miles). Water-power is used and the working pressure is 6,000 volts. The overhead line is equipped with a catenary similar to that of the Hamburg-Blankenese Railway, with strain adjustments every mile or mile and a-half. For the present service 14 locomotives, each equipped with two single-phase, 250 H.P. motors will be used. Owing to the narrow gauge the motors are located above the trucks, and are connected to the wheels with connecting rods.

Royal Institution.—We have received an interesting pamphlet, written by Prof. H. E. Armstrong, giving an account of the work of the Royal Institution during the seven years 1900 to 1907. It is issued in connection with the Hodgkins trust. From the present pamphlet the terms of the trust are not quite clear, but it appears that Mr. Hodgkins emigrated when a young man to America, obtained wealth by establishing a confectionery business in New York, and, although the scientific sequence is not clear, he left a sum of $100,000 to the Royal Institution shortly before his death, the income to be devoted to purposes of scientific investigation. We only wish there were many more such enlightened confectioners. The present pamphlet is one of the results of this bequest, and gives a very interesting account of the work carried on during the period mentioned. It is largely devoted to the remarkable action of charcoal at low temperatures in producing high vacua, and, indeed, the period in question is named the "charcoal vacuum septenate" by the author. As an off-shoot of the subject, molecular constitution of gases receives some discussion, as also do the properties and structure of carbon. After some account of chemical interactions under reduced pressure, the modifications of matter at low temperatures are referred to, as also are calorimetric studies and low temperature thermometry. Naturally, the properties of radium and the liquefaction of helium receive attention. Finally Prof. Armstrong says a few words on the future of scientific work at the Institution, and asks whether genius is not too often maimed, instead of made, by education. He is evidently depressed at the comparatively low average quality of the scientific output at the present time. As to whether this is due to want of genius we are not quite clear. Is it not possible that the path to research cf a kind is so much more easy in these days that the quality of the worker is necessarily lower than 100 years ago? The pamphlet concludes with some quotations from Faraday, whose writings always appear to have the remarkable characteristic of freshness notwithstanding their age, and we do not think we can do better than to end this brief *résumé* with the following short quotations from Faraday's lecture on Mental Education :—

It is necessary that a man *examine himself* and *that* not carelessly. On the contrary, as he advances, he should become more and more strict, till he ultimately prove a sharper critic to himself than anyone else can be; and he ought to intend this, for so far as he consciously falls short of it he acknowledges that others may have reason on their side when they criticise him. A first result of this habit of mind will be an internal conviction of *ignorance in many things respecting which his neighbours are* taught and that his opinions and conclusions on such matters ought to be advanced with reservation. A mind so disciplined will be *open to correction upon good grounds in all things*—even to those it is best acquainted with—and should familiarise itself with the idea of such being the case. . . . .

Because the education is internal, it is not the less needful; nor is it more the duty of a man that he should cause his child to be taught than that he should teach himself. Indolence may tempt him to neglect the self-examination and experience which form his school, and weariness may induce the evasion of the necessary practices, but surely a thought of the prize should suffice to stimulate him to the requisite exertion: and to those who reflect upon the many hours and days devoted by a lover of sweet sounds to gain a moderate facility upon a mere mechanical instrument, it ought to bring a correcting blush of shame, if they feel convicted of neglecting the beautiful living instrument wherein play all the powers of the mind.

MANCHESTER CORPORATION ELECTRICITY DEPARTMENT ACCOUNTS.

The electricity undertaking of the Manchester Corporation has always possessed considerable interest for electrical engineers ; at first, on account of the system of distribution adopted, and of late years on account of the magnitude of the undertaking, which is always regarded as one of, if not the, most important electric supply systems in the United Kingdom.

In view of the general trade depression, it is, perhaps, not surprising that the number of units sold during the year ended March 31 last, viz., 66,924,864, shows a smaller increase compared with the number recorded a year ago—63,437,088—than has been experienced for the last seven years. The "falling-off" is, of course, partly accounted for by the curtailment of tramway progress during the last year or two ; but it is very striking to observe that whereas a year ago an increased sale of over 11 million units to private consumers was recorded, the increase shown on the present occasion is only a little over three million units. In view of the results achieved in other towns, however, the progress made at Manchester is nevertheless encouraging.

In general the cost of working, as shown by the analysis below, differs only very slightly from the figures for the previous year, but a small increase is recorded in the total cost per unit sold, which is now 0·66d., excluding capital charges. The importance of capital costs, even in an undertaking of such a diverse character as that of Manchester, is indicated by the fact that these charges increase the cost per unit by over ½d., and bring the total inclusive cost to 1·20d., which is, nevertheless a very satisfactory figure. The reductions made in the charges for lighting in December, 1907, whilst somewhat affecting the revenue for the year ended March, 1908, very slightly, have, of course, come into greater prominence in the present accounts ; and notwithstanding increased sales to private consumers of over 3,000,000 units the revenue obtained for lighting and power shows a decrease—viz., £231,648, compared with £238,266 last year. When it is remembered, however, that the reduction in the price per unit amounted to ¾d. on the flat rate, and was equivalent to £16,341, the above decrease loses its importance, and the additional consumers attracted by the lower rate are likely to cause a substantial increase in the revenue of the next financial year. In any case next year's figures will be invested, from the cost per unit standpoint, with more than usual interest, since engineers are eagerly awaiting the effects of the installation of the large Tudor battery, which marks an important development in this country.

In regard to the sales of energy, private consumers required 37,150,022 units, public lighting 99,593 units, and the tramways 29,675,249, whilst no less than 6,791,020 units were used on the works. It is interesting to notice that the energy lost in distribution or unaccounted for only amounted to 16·96 per cent. of the units generated, a much smaller figure than that for several years past. The maximum supply demanded was 20,956 kw. on the lighting and power mains, equivalent to a load factor of 20·3 per cent., and 10,162 kw. on the traction system, the latter load factor being 33·3 per cent., whilst the load factor for the whole undertaking works out at 24·6 per cent., compared with 25·39 per cent. in the previous year. The plant capacity amounted to 39,300 kw. on March 31.

Over 14 miles of new cables have been laid during the year, and the total length of main conductors at March 31 was 352½ miles, whilst the additions to the consumers' register amounted to 606, the total number of consumers now being 8,125.

We give below an analysis of the expenditure during the past financial year, together with the cost of working per unit sold for the year and for 1907-8 :—

		Cost per unit sold. 1908-9.	1907-8.
Generating Costs.			
Coal, &c.	£67,219	0·24d.	0·25d.
Oil, waste, water, &c.	6,927	0·03d.	0·02d.
Salaries and wages at station	18,129	0·07d.	0·06d.
Repairs and maintenance	15,284	0·05d.	0·07d.
Total Generating Costs	£107,559	0·39d.	0·40d.
Distribution Costs.			
Wages	£15,493	0·06d.	0·05d.
Repairs and maintenance of mains, fuses, &c	12,489	0·04d.	0·06d.
Miscellaneous	2,339	0·01d.	0·01d.
Total Distribution Costs	£30,321	0·11d.	0·12d.
Management Costs, &c.			
Salaries	£8,073	0·03d.	0·03d.
Printing, stationery, &c.	1,251	0·00d.	0·00d.
General establishment charges	2,376	0·01d.	0·00d.
Law and Parliamentary charges	308	0·00d.	0·00d.
Special charges (plus bad debts)	1,690	0·01d.	0·01d.
Total Management Costs	£13,698	0·05d.	0·04d.
Rents, rates and taxes	£32,461	0·11d.	0·11d.
TOTAL COSTS (*ex* Capital Charges)	**£184,039**	**0·66d.**	**0·68d.**
Capital Charges.			
Interest	£67,966	0·24d.	0·26d.
Sinking fund	81,944	0·29d.	0·29d.
Total Capital Charges	£149,910	0·53d.	0·55d.
TOTAL COSTS (including Capital Charges)	**£333,949**	**1·20d.**	**1·23d.**
TOTAL RECEIPTS (from all sources)	**£367,847**	**1·32d.**	**1·45d.**
BALANCE	**£33,898**	**0·12d.**	**0·22d.**

Of this balance of £33,898, a sum of £21,495 is placed to the Renewals Suspense Account, £403 to the Reserve Fund Account, and the remainder, £12,000, is paid over to the City Fund in aid of rates. The Renewals Suspense Account now amounts to £135,252, whilst the Reserve has decreased to £6,358 owing to amounts charged on it for wages of permanent employés engaged on capital account and for land adjoining Stuart-street station.

The generating costs given above refer to Dickinson-street, Bloom-street and Stuart-street stations taken together. The generating costs at these stations may be separated as follows : The Dickinson-street and Bloom-street stations generated 12,293,134 and 14,398,848 units respectively at a total works cost of £43,741—*i.e.*, 0·393d. per unit generated, whilst 62,074,250 units were generated at Stuart-street station for a total cost of £63,818 or 0·247d. per unit generated, the combined costs of generation thus working out at 0·29d. per unit generated, or 0·39d. per unit sold, as shown in the analysis above. It is interesting to notice that the full costs work out at 0·23d. per unit generated at the two older stations, whilst at Stuart-street the figure is only 0·16d.

During the year the capital expenditure amounted to £79,271, mains accounting for £29,056, Stuart-street generating station £23,394, and distributing stations £19,205. The various items of total capital expenditure, which now amounts to £2,521,871 are given in the following table, together with the cost per kilowatt installed :—

Capital Account.		Per kw. installed.
Land and buildings (Dickinson-street)	£99,301	
,, ,, (Bloom-street)	72,961	
,, ,, (Stuart-street)	212,186	
Total	£384,448	£9·7
Machinery and plant (Dickinson-street)	174,204*	
,, ,, (Bloom-street)	127,331†	
,, ,, (Stuart-street)	359,632‡	
Total	£661,167	16·8
Stuart-street railway	81,380	2·1
,, water supply	649	0·0
Distributing stations	346,111	8·8
Mains	918,524	23·4
Meters	59,232	1·5
Motors	29,795	0·7
Electrical instruments	3,186	0·1
Cables, stores and workshop	30,520	0·8
Miscellaneous	6,859	0·2
Total Capital Expenditure	£2,521,871	£64·1

* £18·1 per kilowatt installed. † £17·7 per kilowatt installed. ‡ £15·6 per kilowatt installed.

DEVELOPMENTS IN ELECTRIFICATION OF RAILWAY TERMINALS.*

BY H. H. EVANS.

Summary.—The author considers in a general way the causes tending to the electrification of railway terminals, and gives brief particulars of a number of existing electrified lines.

Steam railroad electrification may be expected to come from three directions. An electrification may be decided upon because the continued operation of steam locomotives through a tunnel or through a city is deemed to be a public nuisance. It may be decided upon because of the savings which can be made by electrical operation instead of steam operation, or it may be decided upon as a matter of larger policy on the part of the railroad company, either for the purpose of attracting more traffic or to get more movement over congested track. In any of these, the density of traffic is the dominating factor; and as density of traffic is the characteristic of terminals, terminal working presents the most fertile field for electrical development.

Electrification receives its largest consideration, from the public at large, owing to its obviating the major part of the nuisance incident to the operation of steam railroad trains through cities, viz., smoke, smell, dust, noise and cinders, whilst steam operation through tunnels and over constricted trackage may constitute a public danger. It was because the operation of trains by steam through their tunnel was considered a menace to public safety, that the New York Central R.R. was required by legislative act to operate its New York terminal electrically. In the steam operation of the St. Clair tunnel there were cases of asphyxiation of the train crew through the parting of a train in the tunnel filled with gases. Although trains were never operated therein by steam, it was because steam operation would be a nuisance, that the Paris-Orleans line electrified their tunnel entry into their Paris terminal and the Baltimore & Ohio R.R. its terminal entry into Baltimore. The working of trains by electricity in such places removes the obscuring of signals by smoke, admits of the installation of efficient lighting and mechanical devices, provides a much more certain controlling of the train at danger points and provides physical comfort, and good vantage point for the operator in the cab of the electric locomotive or motor car, which tends to increase his alertness.

The saving which may come from electrical working may be looked for at a number of points: In the first place the absence of dust, dirt and smoke leads to longer lived furnishings and less wear and tear on the rolling stock, and also to a lessened cleaning expense. It is probable that the coaches under electrical working will require cleaning at the end of the run just as they do at present with steam power, but while there is as frequent a cleaning there is not so laborious a one. Dusting off parts of the cars or wiping them lightly with a rag will take the place of a hard scrubbing, the latter not only costing more in that it takes more time and labour, but also having an extra expensive effect in that the hard rubbing removes paint work and varnish and otherwise damages the cars. The absence of smoke should result in longer lived steel work in bridges, viaducts and other metallic structures adjacent to the track. These are rapidly eaten away because of the sulphur contained in the coal burned in the locomotives.

A greater annual mileage capacity is available from the equipment by electrical working than by steam working. This comes, first, because of the higher speeds obtainable by electrical working, and second, by reason of the fewer repairs necessary for the electrical equipment and consequent larger number of days available for service throughout the year. There should be lessened switching and added movement under electrical than steam working. This is particularly true in the case of suburban trains. Compared with trains hauled by steam locomotives, in some cases, there will be saved the trip of a train to the storage yards for cleaning and back again and the trip of the locomotive to the water tank or to the roundhouse. This has been found, for instance, in the operation of the New York Central R.R. terminal, where an electric locomotive from an incoming train, on arriving, switches immediately to the head of an outgoing train and in a few minutes is bound out on another trip.

Electrical working, of course, would mean a greater economy in coal consumption. This is partly due to the even load imposed on the power house boilers and prime movers against the violently fluctuating load imposed upon a locomotive in terminal service. It is found, approximately, that on terminal operation the fuel consumption by electrical working, despite the losses of transmission, conversion and distribution, is one-half that of steam working. Chicago, however, is an exception, and the costs would be about equal; but in California, where coal is £1·12 to £1·16 per ton, electrical working may be adopted solely because of the coal saving.

There are also large savings to be expected by electrical working from a lessened repair bill. A good many of the derangements which come to electrical motor vehicles may be repaired where they occur out on the road, instead of requiring a trip to the roundhouse. Electric motor vehicles are relatively free from the aggregation of small troubles which are responsible for a good deal of the repair bills of the steam locomotive, and these small derangements will keep small, whereas in a steam locomotive they magnify themselves. Repairs would also be cheapened because of the greater standardisation of electrical parts, and because a good many of such repair parts permit of easy installation without fitting. There are fewer danger points for derangements on the individual electric locomotive than on the steam locomotive, that is, there are fewer points the derangement of which disables the machine. The uniform load and the even torque on the motors tends to reduce strains and failure. The result is, we may predict, a maintenance charge of about 1·5d. a mile for electrical locomotives against 4 to 5·5d. for steam and about 0·6d. per car-mile for multiple unit suburban cars.

Electrical working will cut out a great deal of the dead time; will shut off the consumption of power, or rather the consumption of coal, at the individual motor during stops; by its higher speeds will reduce the cost of train labour per train-mile; will reduce somewhat the shrinkage of coal between the coal pile and the grate bars; will permit the use of the cheapest kind of coal; will remove a great many of the roundhouse expenses and remove altogether the expense of keeping up water stations; will allow the substitution of cheaper roundhouse labour and reduce the fixed charges for the plant for the handling of terminal rolling stock. With electricity, trains can be operated at a less weight per passenger or a less weight per horsepower at the draw bar, than steam locomotives. A 95-ton electrical locomotive will more than do the work of a 160-ton steam locomotive and thus save on locomotive hauled trains, 60 to 70 tons on a 300 to 600-ton passenger train. In the case of suburban trains operated by multiple unit motor cars, the weight of the locomotive is replaced by a much smaller weight for the motor equipment, and here on a 200-ton train we can save 30 to 40 tons. With electric and steam locomotives of equal power, the entire weight of the tender is saved and in some cases, part of the weight of the locomotive; in addition to which the entire weight, or a large portion of the weight, of the electrical locomotive may be driver borne. Electrical operation allows a higher mileage capacity of equipment, so that although the electric equipment costs somewhat more than the steam equipment, the additional mileage power may serve in a measure to bring down the fixed charge for electrical motive equipment per train-mile closer to that for the steam trains than is apparent at first sight. Some lessening in the track maintenance may be expected, although whether appreciable or not is somewhat in question, and there will be lessened derangements to traffic because of the easier control of an electrical train.

The third of the general reasons we have advanced for terminal electrification is, perhaps, the one which at the present time will receive the greatest consideration from railway officials; that is, ability to attract more traffic or to get a greater train movement over terminal tracks. Electric street cars offer many advantages and have attracted many passengers from the railways, so the latter must offer an equally good or more attractive service. This has been recognised particularly by the British railroads. In many of the English cities, a large part of the local transportation field is occupied by the suburban service of the steam railroads. The communities in general are much more dependent upon steam suburban trains than they are in the United States. The movement towards electrical equipment of surface car lines, and in particular the building of interurban lines, has been much slower in Great Britain than in the United States. In consequence, the British railway managers have been able to see a lesson in the United States in the building of numerous interurban lines, and so have set about to bring their facilities to such a high standard that the building of competing lines in their territory would not be undertaken. As a result several of them have electrified their suburban service and put on a fast and frequent schedule of trains made up of multiple unit cars. They have met with a greater response from the public because of their improved service, and have met with financial returns because, in the first place, they have secured a large increase in their patronage, and in the second place, economies in working which enabled them to haul the individual passenger at a lower, yet a profitable rate.

The use of higher speeds on suburban service does not appear to be economy at first. As a matter of fact, the increased power consumption due to high acceleration adopted is only one factor with

* Abstract of a Paper read before the Western Society of Engineers.

several others in making up the total cost per train-mile: the saving in these by higher speeds will offset the increased cost of the power, the total power charge being somewhere around 10 per cent.: thus the train labour per train-mile decreases with the increased speed, as does the cleaning and other charges which amount to so much per day rather than so much per mile. The higher speed may even result in cheaper working until we consider the interest on the extra investment for the higher power equipment, the extra cost of feeders, &c., when the saving may be offset. In turn the interest charges on certain parts of the investment, which will be a constant gross amount over a somewhat wide variation in the size of plant provided, will be spread over a greater mileage and the charge per mile consequently brought down; thus, for instance, the investment in car sheds, in power house building and terminal platforms will be rendered more efficient. The demand on steam railroad suburban operation is for provision of stops at shorter and shorter intervals as the patronage increases. This requires quick acceleration in order to get an acceptable mean running speed. For this character of service, electrical equipment is eminently adopted because of the rapid acceleration it provides and because of the ready control afforded over the motive power, together with the characteristic of the electric motor that it holds its efficiency over a wider range of speed than does a steam engine. The absolute elasticity of multiple unit equipment is highly desirable. From the point of view of the railroad management, the substitution of numerous light trains for occasional heavy ones has its advantages in that the added convenience to the public will cause the coaches to be generally filled instead of only partially, as is too often the case in present steam suburban trains.

When we come to the question of capacity we find that it is here electrification is most likely to appeal to those who direct the policy of railroads. Terminal property is becoming increasingly expensive, whilst as a terminal becomes busy, junction points, crossovers, turnouts, and other disturbers of traffic multiply. Electrification provides a system of working which gives efficient control, quick acceleration, allows us to get past disturbing points with a minimum of delay, does away with a lot of dead time for equipment, makes less switching, gives a higher speed and a lessened time of passage over busy tracks, allows of almost any train load being handled without much loss in speed, and, in general, allows us to work a terminal at about double the capacity it possesses under steam operation.

With the use of electric locomotives about the terminal warehouses, it becomes possible to use them not only for receiving and delivering freight, to build them many stories in height—even to carry them on columns and cover the tracks with them—and utilise the upper stories as warehouses. With the danger from fire gone and the possible damage from soot and dirt removed, the storage will commend itself to merchants. The New York Central R.R. is planning to cover its entire yard and right of way at its New York City terminal, since electrification, with large office buildings. An electrified terminal also presents the opportunity (because of cheap handling of varied train weights and ready starting and stopping) of affording a local freight service analogous to the suburban passenger service.

Examining the terminal electrifications which have been made, we find that electrifications have been decided upon for each of the three general reasons we have advanced for electrification. The New York Central electrically equipped its New York terminal because the continued operation of steam trains through the tunnel entry into the terminal was held by legislative enactment to constitute a public danger. The Paris-Orleans (on its Paris terminal), the Long Island Railroad (on a Brooklyn terminal), and the Baltimore and Ohio (on its Baltimore terminal) all electrified their terminals because of the construction of new terminals with tunnel entries in which the operation of steam locomotives, would be deemed distasteful or dangerous to passengers. The new Pennsylvania terminal into New York City is to be electrified for a similar reason. The New Haven and the North shore electrifications have been carried out, it was announced, to secure operating economies. To secure capacity the various tunnel electrifications, as the Grand Trunk, the Great Northern, the Michigan Central, and the Simplon tunnels have been carried out. To gain additional patronage is the avowed purpose of several British electrifications.

Particulars are then given in the paper of the various electrifications which have been carried out. The New York Central electrification of its New York terminal is said to be the largest scheme yet carried out. The electrification is intended to be extended to Croton on the Hudson Division, 34 miles out, and to North White Plains on the Harlem division, 24 miles distant. The part so far completed comprises an initial zone extending over 17 miles. In the zone there are electrified 73 miles of main track and 12 miles of yard track and sidings, or 85 miles in all. The extension of the electrification is under way and eventually the whole electrification will comprise 224 miles of main track and 68 miles of other tracks, or 292 miles total. Secondary tracks and freight tracks have not yet been electrified.

The New York, New Haven & Hartford Railroad, in addition to sending its trains from Woodlawn Junction to the Grand Central Station (12 miles) over the electrified New York Central zone, has electrified its line from Woodlawn to Stamford, Conn., a distance of 21·5 miles; the electrification extends over rather more than 100 miles of equivalent single track. It is the intention to eventually electrify the entire line from New York to Boston. This railroad is also gaining control of the street railway systems throughout its territory and working them in unity with the railroad. These systems will act as feeders for the road, and their power houses, with the provision of the necessary additional units, will be able to supply the main line with current at different points along its route. The president of the New Haven road advocates running the local street cars of adjacent towns over the electrified steam road.

The Long Island Railroad has an electrified terminal in Brooklyn in addition to one worked by steam locomotives. The conditions are similar to New York, although the trains leaving the terminal are entirely suburban. The electrified zone comprises about 100 miles of track.

The West Jersey and Seashore is properly not a terminal electrification. It extends from Camden, New Jersey, to Atlantic City—a distance of about 65 miles. It was probably electrified to prevent the building of competing interurbans. There are about 150 miles of track electrified.

The Pennsylvania Railroad is building a new terminal in the heart of Manhattan Island, New York City. Their route, under Jersey City, under the Hudson River, across Manhattan Island into and through their terminal, under the East River and Long Island City to their storage yard lies in tunnels. Electrical operation is the only kind to be considered in such a case. Contracts were recently let for the electrical equipment. It is presumed that the system will be single phase.

The Baltimore and Ohio was the first terminal electrification to be undertaken in the world. A section extending over 3·4 miles of double track was electrified in 1895, a direct-current equipment being provided. The service is hardly a terminal service, but really a pusher service on a grade through tunnels.

The North Shore Railroad has over 13·69 route miles of electrified double track with spurs and branches, on the third-rail system, whilst the Southern Pacific has under construction the electrification of its suburban lines out of Oakland across the harbour from San Francisco. About 50 miles of track are to be electrified, a 1,200 volt direct-current overhead trolley being adopted.

The British terminal electrifications concern themselves principally with the suburban traffic. Suburban traffic in Great Britain is more important than in the United States, many communities relying upon steam suburban trains for the greater part of their local transportation. Take the case of London. Out of 8,000 trains per day entering the city, but 500 are long distance trains. The building of electric interurbans is backward and the railroad managers are preventing the construction of these competitors by electrifying their suburban lines. In addition, the cost of conducting this traffic has risen 25 per cent. in the last decade, while the receipts have remained stationary. Consequently it is necessary to attract more traffic in order to pay dividends. Brief descriptions of the British electrified lines are given by the author.

In Italy the Mediterranean Route has electrified its suburban terminal on the Milan–Varese–Porto Ceresio line, adopting a direct-current equipment with third rail. The initial equipment was over about 80 miles of track—it has been extended from time to time. The electrification now extends to a maximum distance of 30 miles. The traffic is said to be the most dense in Italy. It was electrified in 1901 as a part of an experiment by the Italian Government looking to a general electrification of the Italian roads. Direct-current working was applied to this terminal, while three-phase equipment was applied to the Valtellina over a stretch of 67 miles—the latter being a road through a sparsely populated district chosen to represent the other extreme.

The Paris-Orleans Railroad in 1900 inaugurated electrical service into its Paris terminal. This road is one of the most important in France. To get closer to the centre of Paris a new terminal station was built at the Quai d'Orsay and connected with the old Austerlitz terminal by a tunnel, electrically equipped with a third rail. Later the electrification was extended to Juvisy, 14 miles distant, in order to secure expected profits from suburban traffic, to spread the fixed charges over a greater train mileage, and to secure a more even load at the power house.

The French Western operates an electrified line for its Paris-Versailles suburban service. This line runs through a tunnel for a little over two miles and has an underground station. The electrified line extends over 11 route miles. Third rail direct-current equipment has been provided.

Finally, as regards Chicago and the Illinois Central. The railroad operates a suburban service of 262 trains per day to Flossmoor, 25 miles distant, and to intermediate points, to Blue Island, 19 miles distant, and to So. Chicago, 12·92 miles distant, the two latter being on lateral branches. In addition the terminal trackage handles the large through passenger and freight traffic of the Illinois Central, together with that of the Michigan Central, Wisconsin Central, Big Four, and Chicago, Cincinnati and Louisville. There are over 60 through passenger and freight trains daily. The maximum load upon the power house under electrical operation is estimated at 12,000 kw. Not including a power house but including substations we have estimated that an electrical equipment (with a third rail multiple unit equipment for the present suburban coaches, and electric locomotives for through trains), could be provided for about £800,000. The Illinois Central has in hand an extended inquiry into the possibilities of electrification, and has announced its intention to electrify.

DISCUSSION.

Mr. P. Junkersfeld referred to the arrangement come to in England between competing roads as to the time of "through" trains. A scheme like that would be a much better load-factor for the electric locomotive and power equipment. Another thing which would improve the load-factor would be the forming, perhaps, of terminal associations, or at least the operation of those electrical equipments centring in one depot under a single management. If the several loads would get together and have an arrangement whereby the equipments could be kept more constantly in use instead of lying idle, much benefit would result. A still further step would be, as proposed by Mr. Delano, to place back from the centre of the city a terminal for quite a number of railroads entering Chicago; have them all build their terminals side by side at Twelfth-street. That would make, probably, a still further improved load-factor for the electric equipment and the power.

Mr. E. N. Lake mentioned that the locomotive investment of all the railways of that country was only about 5 per cent. of the total valuation of their operating properties, so that the element that was affected by electrification was in value only a small percentage of the total value of the railroad properties. He also referred to some figures given by Mr. Wilgus before the American Society of Civil Engineers, in connection with the operation of the New York Central R.R.; viz., the actual effective work which could be secured from an electrical locomotive was about 25 per cent. more than from a steam locomotive, so that with a system requiring 50 steam locomotives, 40 electric locomotives would do the work. The steam locomotives of the New York Central R.R. were given at £3,000 each, and 50 of them would cost £150,000. The electric locomotives cost £6,000 each, and 40 of them represented an investment of £240,000. The annual charges, as given by Mr. Wilgus, including interest, depreciation, repairs, &c., were: for a steam locomotive, £900, or 30 per cent. of the first cost; for an electric locomotive, £740, or 12½ per cent. of the first cost. On the basis of this equipment of 50 steam and 40 electric locomotives, there was an annual saving shown of £15,400, which would pay approximately 12·8 per cent. upon the difference in cost between 40 steam and 40 electric locomotives.

Mr. W. B. Story, Jun., did not agree that the smoke or dust nuisance was due to the suburban railways, but to the consumption of soft coal by the entire city. As to the supposed saving from electrical working by absence of dust, dirt and smoke leading to longer lived furnishings and less wear and tear on the rolling stock, and also to a lessened cleaning expense, these things were very small, and if the cars and motors were not kept clean there would be a protest from the passengers. Again, there was not much injury to steel work due to the coal smoke from locomotives. He admitted that a greater annual mileage capacity was available from the equipment by electrical working than by steam working, but there were no figures to show what the saving would be. It did not as yet justify the installation of an electrical terminal. The railways terminating in Chicago would be perfectly willing to start in and do the work if it was proved that it was the best thing to do, but it could not be shown that electrification was justified. The author stated that there were also large savings to be expected from electrical working from lessened repair bills, but no one knew what the repair bill would be. The electrical installations were not old enough and the types of locomotives were not determined definitely enough, to enable one to give correct figures. After the electrical installation had been in service 10 or 15 years figures more nearly correct could be obtained. The author predicted a maintenance charge of about 1½d. a mile for electrical locomotives, against 4d. to 5·5d. for steam locomotives. On account of the absolute lack of knowledge, no one was justified in making such a prediction. As to the saving due to less dead weight to be taken from place to place, possibly there would be some saving, but it would be hard to measure. The only saving would be in the locomotive itself. In the Paper there was some uncertainty as to exactly what was being spoken of. In electrical terminals all the through trains would have to be handled by electric locomotives and one could have no multiple units, and the multiple unit arguments did not pertain to locomotives. The subject should be differentiated. Admitting that for a service purely suburban, with nothing but local trains coming and going within a radius of 25 miles, if one was building the railroad in the first place, the electric railroad was the proper one, but from that standpoint one was not justified in saying that the present terminals should be electrified. A further argument given was the facility with which freight could be handled at electrified terminals, but the author did not state that the same method of handling freight was available now. The author's remarks about [illegible] local freight service were entirely impractical. As to where electrification was justified, there seemed to be no question but that it was justified in the New York Central installation [illegible] the New York Central [illegible] the Pennsylvania Railroad. Several other cases were cited by the author, such as the Baltimore station. All of those [illegible]. But those situations did not apply to Chicago or any city situated as Chicago was at the present time. In Chicago they had a plain spreading out 25 miles in every direction, and it was going to be a long time before electrical installation was justified. In looking over the history of electrical installation it seemed to be shown that the only places where these installations had been put in were where there were tunnel conditions or where the financial conditions would warrant. In conclusion, he referred to the figure given by the author for electric locomotive maintenance, and pointed out that sufficient experience had not been obtained to justify this figure. A slight alteration would change the whole saving shown.

Mr. W. E. Symons pointed out that the dust in railway trains was caused by air currents due to the train's movement, and was not in any way due to the use of a steam locomotive. Less than 3 per cent. of the foreign matter in railway trains came from the steam locomotive burning soft coal. The wear and tear of rolling stock was largely a question of track conditions. Track that was in poor condition was hard on rolling stock. It was also due to some extent to the character or capacity of the motive power and the manner of handling it, and if, as the author stated, they were to have electric locomotives of largely increased capacity (25 per cent., he thought), then they might look for a larger percentage of the freight and passenger equipment being in the shops for repairs than at present. The claims for damage to contents of cars had increased largely during recent years because of the violent handling of cars by heavy locomotives while "switching" in the yards. In regard to the author's figure of 4d. to 5·5d. per mile for repairs to steam locomotives, for three prominent railway companies running out of Chicago (two of them the largest trunk lines) the costs for repairs last year were 2·21d., 1·77d. and 2·82d., or an average of 2·27d. per mile. These companies owned and operated the heaviest locomotives running out of the city. Again, Mr. J. E. Muhlfeld, of the Baltimore & Ohio Railroad, who had had both steam and electric locomotives in his charge for several years, stated before the New York Central Railroad Club that the entire working expenses of locomotives of similar tractive power, which had been operated in similar service during a 2½ years' period, showed the cost per 100 miles actually run to be approximately £16. 16s. for the electric and £8. 4s. for the steam locomotives. These figures were comparative for electric and steam locomotives of corresponding ages, but did not take into consideration the interest, depreciation, taxes or insurance, nor did they include the maintenance of feeders, third rail, bonding wires, insulation, cut-out switches and auxiliaries, which were required only in connection with electric locomotive operation. As to track maintenance, a fact sometimes overlooked was that the total expense of track maintenance was not entirely governed by the kind of locomotives, but perhaps 80 per cent. was due to deterioration through the action of the elements, and about 20 per cent. to wear in service. The reduction in cost of track maintenance by the use of electricity in place of steam would be rather questionable if the number of trains were not materially reduced, which was not usually contemplated.

Mr. W. L. Abbott stated that within 100 miles of, and including, Chicago, there was more electric railroading done now than there was steam railroading. The prohibitive expense which would be entailed in changing from steam to electrical equipment had been dwelt upon, but no reference had been made to the elevated railroads, which changed their entire equipment in a single night, as it were, and scrapped a complete equipment of steam locomotives.

Mr. W. M. Camp thought that for tunnels at terminals of cities, where trains were liable to follow one another at close intervals, the blowing of sufficient currents of air through the bore to keep it clear of smoke was not practicable. In such situations the steam railroads would be compelled to electrify their terminals, whether or not it was economical from an operating standpoint, and regardless of the cost. That did not lead to the conclusion, however, that the electrification of all steam railroad terminals on the surface in large cities would be economical and logical. As to the smoke nuisance, careful study showed that all the alleviation possible in this direction would be too small in comparison with existing conditions, which the public seemed to have no disposition to correct. As to the idea, which seems to be entertained by some electrical engineers, that a change to electrical operation of any existing steam railroad was a very simple problem, he believed that electric locomotives for any requirements of steam road service—either suburban or through traffic—were, as yet, largely experimental. If the electrician thought that he had solved the problem as soon as he had applied motors that were powerful enough for the contemplated locomotive unit and reliable in operation, he had only to tell him that the development of a satisfactory locomotive machine was at that stage only begun. After referring to maintenance, he mentioned that very serious doubt was entertained as to whether an electric locomotive, designed on any of the plans now in existence, with a big, heavy armature on the axle, or with the very slight spring connection such as could be interposed, would not be so severe on the track as to result in heavy cost for repairs. Also,

whether track maintenance would be anything like as small under electrical operation as under steam operation.

Mr. H. H. EVANS, in reply, said criticism had been raised that data was not afforded as to the cost of maintenance of electrical rolling stock. While the working of electrical locomotives on a large scale was somewhat recent and comparatively infrequent, those in charge had been glad to publish such figures as there were, and to let them stand for comparison against similar figures for steam locomotives. For multiple unit coach equipments more complete data was afforded from the performances of the elevated railroads and of the suburban and interurban equipments. In connection with the unfavourable comparison between the electric and the steam locomotives of the Baltimore and Ohio Railroad made by Mr. Muhlfeld, the comparison was hardly a fair one. The installation was the first heavy electric locomotive installation in the world. The machines could not be other than experimental. To compare the earliest type of electric locomotive with the latest type of economical freight engine was hardly fair. Further, these electrical locomotives were operated within tunnels, on a run only 3·5 miles long, up-grade, with seven curves in the distance, and with two intermediate stops. As to the criticism that electric motive equipment had not been in service long enough to test its durability, the various elevated railroads had in service equipment that was provided upon their electrification 10 to 12 years ago, and the original Baltimore & Ohio Railroad locomotives (built 1895) were still in service. The first electric locomotive built by the General Electric Co. (in 1894) was still in service by the Fonda, Johnstown & Gloversville Railroad. Except the Central London locomotives (scrapped in favour of motor coaches to reduce vibration over a tube road) little heavy electric motive equipment had required to be scrapped. That this equipment was still good for service after 12 to 14 years' use was reassuring as to its durability. As to the criticism of his proposition for working of freight terminals, loading the freight into cars and removing it to outer yards as fast as the waggons delivered it, he pointed out that the largest railroad freight terminal in the city of London, in point of freight handled, was so worked and very successfully. He also pointed out that the £6,000,000, given as the cost of the New York Central electrification, included more than the electrification proper. Extensive terminal changes were carried out at the same time. The purely electrical work probably came to a third of this sum.

MODERN INCANDESCENT ELECTRIC LAMPS.

BY A. C. JOLLEY.

Although a considerable amount of attention has been directed to the behaviour and properties of metallic filament lamps, most of the observers have confined themselves to comparatively narrow limits of voltage, whilst many of the early communications contain results for lamps which were issued before the various processes involved in their manufacture had been thoroughly standardised, and such results can, therefore, only be applied to the more modern lamps with considerable caution. There is also a curious lack of information concerning the behaviour of the metallised carbon or Howell filament, which undoubtedly deserves a place among metallic filaments. The following tests were, therefore, undertaken in the photometric laboratory of the Northampton Institute in order to obtain a fair comparison on a common basis between the carbon filament and its more modern metallic modifications, and for this purpose the following four types of lamps were selected as representative, and were purchased in the ordinary way in the open market. They were respectively :—

(*a*) A nominal 16 c.p. 100 volt carbon lamp by Lyell.

(*b*) A nominal 55 watt 100 volt Osram lamp by the General Electric Co.

(*c*) A 100 volt tantalum lamp by Siemens Bros. Dynamo Works.

(*d*) A nominal 16 c.p. 100 volt Gem lamp by the British Thomson-Houston Co.

These lamps (together with others of the same class) were compared against suitable sub-standards by means of a high-grade Lummer-Brodhun contrast photometer, the sub-standards being in turn frequently checked against Fleming-Ediswan standards certified by the National Physical Laboratory. The horizontal candle-power, power consumption and resistance of each lamp was thus determined, and is plotted against the voltage in Figs. 1 to 4.

By plotting logarithm curves the law for the variation of candle-power with voltage has been found in each case, and may be expressed as follows. For the carbon lamps we have

$$\text{C.p.} = 3{\cdot}2V^{5\cdot4} \times 10^{-10} \text{ for values above 85 volts}$$

and

$$\text{C.p.} = 1{\cdot}26V^{7\cdot2} \times 10^{-12} \text{ for values below 85 volts.}$$

In the case of the Gem filament we have

$$\text{C.p.} = 1{\cdot}91V^{4\cdot45} \times 10^{-8} \text{ for values above 95 volts}$$

and

$$\text{C.p.} = 1{\cdot}66V^{5\cdot5} \times 10^{-10} \text{ for values below 95 volts.}$$

For the purely metal filaments there is no break in the law, which for the tantalum lamp is $\text{C.p.} = 1{\cdot}59V^{4\cdot00} \times 10^{-7}$, and for the Osram (tungsten) filament $\text{C.p.} = 4{\cdot}79V^{3\cdot92} \times 10^{-7}$.

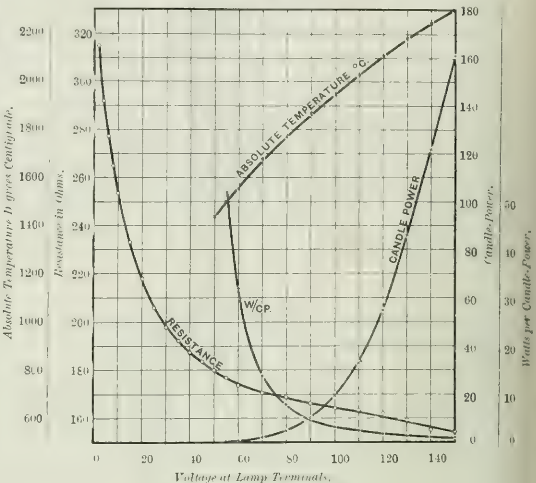


FIG. 1.—CARBON LAMP.

The resistance curve for the metallised carbon filament is interesting, showing at first the characteristic of carbon, but rapidly assuming the form of the metal curves as the temperature increases.

The question as to how far the greater efficiency of the modern lamp is dependent upon the attainment of high temperatures has led to renewed attention being directed

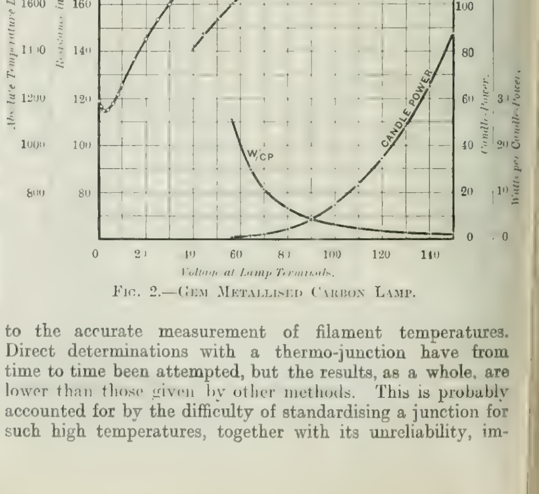


FIG. 2.—GEM METALLISED CARBON LAMP.

to the accurate measurement of filament temperatures. Direct determinations with a thermo-junction have from time to time been attempted, but the results, as a whole, are lower than those given by other methods. This is probably accounted for by the difficulty of standardising a junction for such high temperatures, together with its unreliability, im-

perfect thermal contact and tendency to produce local cooling if the wires are sufficiently large to prevent burning off.

The bolometer has been employed by Lummer and Pringheim* with some success; but probably the most practical of direct methods is that employed by Waidner and Burgess,† Grau‡ and others, in which a direct photometric balance is obtained between the glowing filament and a calibrated black body, or other radiating surface, by viewing the lamp filament superposed upon a background of the glowing surface with an arrangement similar to the Kurlbaum pyrometer.

In all cases the statement as to the actual temperature requires careful consideration. If black-body temperatures are used they will depend upon the wave-length at which they are measured, and will, therefore, be somewhat different from the true temperature and require correction.

Of recent years great advances have been made in our knowledge of the laws which express the relation between the temperature and emissions of a radiating body, and by a careful application of these laws it should be possible to arrive at an estimate of the filament temperature.

If we could regard the filament as radiating like a truly black body (as some observers claim it does), then its temperature

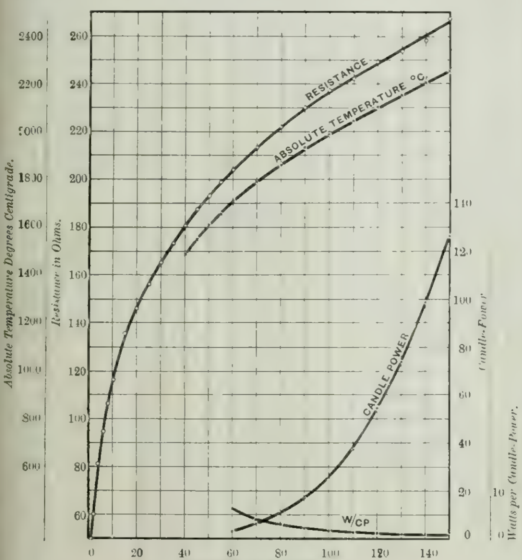


Fig. 3.—Tantalum Lamp.

is at once given by a simple application of the Stefan law, providing we measure the area of the radiating surface and the power expended in the lamp. Thus, if we assume that the loss by convection and conduction is negligible, we have

$$W=\sigma(T^4-t^4),$$

where W are the watts expended per unit surface of the radiating body and T and t the absolute temperature of the body and its enclosure. Ordinarily t is taken as the air temperature about the bulb, and hence t^4 may be neglected in comparison with T^4. Prof. Féry has, however, suggested that the value of t in the above formula is not that of the air about the bulb, but something much higher, and therefore not negligible, for, he points out, the filament is surrounded by a highly reflecting enclosure, which, therefore, should have a much higher *virtual* temperature.

The constant σ has been determined by Kurlbaum,§ who gives the figure $5{\cdot}32\times10^{-12}$ watts per square centimetre as its value for a black body at 100°C., radiating to an enclosure at 0°C.* There is, however, good reason to believe that the improved efficiency of modern lamps is by no means entirely attributable to increase of temperature, but is largely dependent upon the fact that many of the metals of high melting point are better *light* radiators than a black body—that is, the energy curve of their emissions is steeper for short wavelengths—and the area enclosed by the energy curve is less than for a black body at the same temperature, and, under these circumstances, black-body laws in their simple form do not apply.

Thus J. E. Petavel,† in the course of his invaluable researches upon light standards, comments upon the remarkable light emissions from iridium at its melting point.

He finds that platinum at its melting point radiates 19 c.p. per square centimetre, while iridium emitted 290 c.p. at a temperature some 500°C. to 600°C. higher. Still more recently Nernst has obtained the figure 12·1 hefner per square millimetre for iridium melting at 2,400°C., a value much greater even than that given by Petavel.

However, assuming for the moment that Petavel's figures represent the true values, then, if these substances are radiating according to Stefan's law, we find by reference to curves given

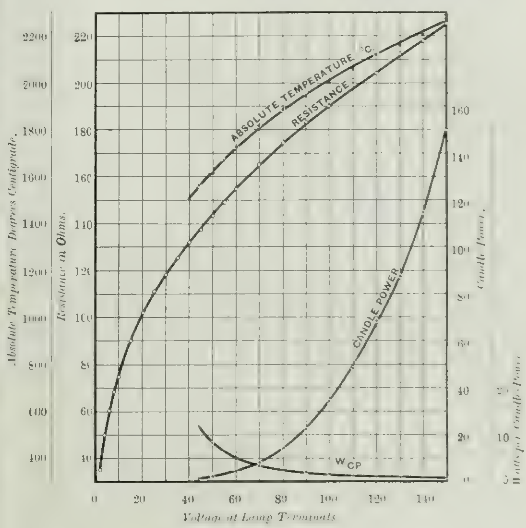


Fig. 4.—Osram Lamp.

by Dr. Drysdale‡ for the light emissions from a black body, that the light energy should be 1·25 watts per square centimetre for platinum and 13·6 watts per square centimetre for iridium under the above conditions. If now we take the lowest value of recent determinations for the mechanical equivalent of white light—viz., 0·08 watt per candle§—we have that at its melting temperature platinum should emit 15·6 c.p. per square centimetre and iridium 170 c.p. per square centimetre if they behaved as black bodies.

It is at once obvious that the light emitted by these substances is greatly in excess of the theoretical amount, and, therefore, the law of Stefan must give results which are too low. Petavel‖ has given the relation between the intrinsic bright-

* "Verhand lungen der Deutschen Phys. Ges.," Vol. I., 1899.
† "Electrical World," Vol. XLVIII., 1906.
‡ "Elecktrotechnik und Maschinenbau," April, 1907.
§ "Ann. Phys. Chem.," LXV., 4, pp. 746-748, 1898.

* Quite recently Prof. Féry has shown that, owing to the reflection from the absorbing surfaces used in Kurlbaum's determination, the constant σ given above is too low and is probably more nearly $6{\cdot}3\times10^{-12}$ watts per square centimetre.
† The Electrician, Vol. L., p. 1012, 1903.
‡ "Luminous Efficiency of Black Body," "Proc." Phys. Soc., London 1909.
§ C. V. Drysdale, "Proc." Roy. Soc., A, Vol. LXXX., 1907.
‖ *Ibid.*, also "Phil. Trans.," Vol. CXCI., p. 515.

ness (b) in candle-power per square centimetre and the Centigrade temperature (t) of a glowing body in the empirical formula

$$t=400+889{\cdot}6\sqrt{b}.$$

and Lummer and Kurlbaum* have also studied this relation for bright platinum and expressed it in the form

$$\frac{\phi_1}{\phi_2}=\left(\frac{T_1}{T_2}\right)^x,$$

where ϕ_1 and ϕ_2 are the intensities at the absolute temperatures T_1 and T_2; the exponent x varies with temperature having the value 30 at 900°C. absolute, and falling to the constant value 12 at temperatures above 1,900°C. absolute. E. Rasch† has, however, disputed the above conclusions, and he shows that from Lummer's expression given above we may deduce the fundamental equation underlying the physiological conception of brightness—viz.,

$$\frac{d\phi}{\phi}=\xi\frac{dT}{T^2},$$

where ϕ is the sensibility of the eye for light and T is the absolute temperature of the radiating body. Starting from this, by integration he obtains the expression

$$\log_e \phi = c - \xi/T.$$

Now, by selecting as the unit of light that intensity (ϕ_1) which is emitted normally from 1 sq. mm. of an ideal black body at an absolute temperature (θ), the integration constant c becomes $\frac{\xi}{\theta}$, and the above equation may then be written

$$\log_e \frac{\phi}{\phi_1}=\xi\left(\frac{1}{\theta}-\frac{1}{T}\right).$$

Rasch then deduces from the experimental results of Le Chatelier and Boudouard that the value of $\frac{\xi}{\theta}$ is 13·02, while from an analysis of Nernst's experiments he arrives at the value of 12·943 for the ratio and 2,068·4 for the value of θ.

From Lummer and Pringsheim's results $\theta=2{,}073$°C. absolute, and Nernst‡ has obtained the value 2,092°C. absolute for the temperature at which a black body emits 1 hefner per square millimetre, and he proposes this as a definition of the unit of light. Taking the value employed by Rasch of $\frac{\xi}{\theta}=13{\cdot}02$, and putting θ equal to the mean value of the two former figures—viz., 2,071°C. absolute—we have

$$\log_e \phi = 13{\cdot}02 - \frac{13{\cdot}02\times 2{,}071}{T}$$

or

$$T=\frac{26{,}965}{13{\cdot}02-\log_e \phi}.$$

I have attempted to check this expression by using it to determine the melting points of such metals whose luminous emissions are known and find it gives very fair results when one takes into consideration that the actual experimental determinations of these melting points by direct means are in considerable disagreement.

We may also use the formula to estimate the crater temperature of the open arc. Thus, if we assume the intrinsic brilliancy of the crater to be 175 hefner per square millimetre, we have

$$T=\frac{26{,}965}{13{\cdot}02-\log_e 175}=3{,}630\text{°C. absolute}$$

Prof. Féry§ has measured this temperature, and givesfi gures ranging from 4,100°C. to 3,490°C., but has given preference to the lower figure.

(To be concluded.)

* "Deutsch Phys. Ges. Verh.," 2, 8, pp. 89-92, 1900.
† "Ann. der Physik," 14, 1, pp. 193-203, 1904.
‡ "Phys. Zeit.," 7, pp. 380-383, 1906.
§ "Comptes Rendus," 134, pp. 1201-1204, 1902.

COMMUTATION IN DYNAMO-ELECTRIC MACHINES.*

BY R. RUDENBERG.

Summary.—The present article is an advance on the usual theories of commutation in so far as it considers the important part played by the paths in parallel with the armature coils as they leave short-circuits. A criterion is deduced which shows the conditions under which these shunt circuits may prevent a serious rise of pressure or dangerous current-density at the leaving brush tip, and at the same time the excellent influence exerted by the equalising connections during short-circuit is emphasised.

Owing to the complexity of the electric and magnetic phenomena which occur during commutation, assumptions have to be made which render only approximate calculations at all possible. The best procedure is not to try to follow the process of commutation in all its various phases, but to limit the investigation to the determination of a criterion by means of which the danger of sparking can be estimated.

The current passing from the commutator to the brush can in general be divided into two parts—the *useful* part, which produces a constant current density at all points under the brush, and the *harmful* part which is superposed on the useful part, and leads to a variable current distribution under the brush, causing possible local heating and sparking. Experience proves that this disturbance reaches its greatest magnitude at the end of a commutation period when a commutator segment leaves the brush tip. We shall, therefore, confine our attention to this instant and examine when these additional currents can give rise to a dangerous overloading at the brush tips. Limiting the problem in this way makes it possible to bring into the calculation all the conditions which affect commutation, without encountering any great difficulties. We shall assume the brush to cover several segments, and consider only what takes place under *one* brush. The variation of the specific contact resistance will not affect us since we are only concerned with its value at the last instant.

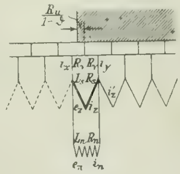


FIG. 1.

Special attention, however, will be paid to the fact that the *whole* current in the short-circuited coil is not compelled to flow from the leaving segment into the brush, but there are also other paths along which a part may flow. For example, one part may flow along the non-short-circuited coils in the armature—shown dotted in Fig. 1—and return either through the symmetrically disposed coils on the other side, or even through the brush and the external circuit; also in multipolar machines, through other like-named brushes. If equi-potential connections are present these offer an excellent auxiliary path to the current in the leaving bar. For the purposes of calculation all these branches can be supposed combined in a common circuit in parallel with the short-circuited coil, and having the constant resistance R_n and constant reactance L_n (*see* Fig. 1).

The introduction of this shunt circuit forms the chief difference between the present considerations, and most of the theories of commutation. This parallel circuit has two effects on the commutation of the current—first we see that its presence increases the loss due to heating, owing to the total resistance of the short-circuit being decreased, whilst the E.M.F. is unaltered. This increase in the total loss, however, is also accompanied by a decrease in the contact losses, which must be reckoned as an advantage. In the case of normal commutation and moderate resistance and reactance of the shunt circuit, these variations which occur during the commutation period, are not considerable. They only become important when—with strong over- or under-commutation—the pressure in the leaving coil towards the end of the short-circuit rises so much as to make sparking highly probable. During the time a bar leaves the brush the contact surface decreases rapidly, whilst the inductance of the short-circuited coil only allows a very slow falling off of the current. The result of these two actions is to cause a large increase in the current density at the contact surface on the one hand, which may lead to inadmissible heating, and also owing to the necessarily rapid change of current, a large rise of pressure at the ends of the short-circuited

* Abstracted from the "Elektrotechnische Zeitschrift."

coil, and between the leaving bar and the brush may be set up which can eventually give rise to sparking.

If now, in addition to the leaving segment, the coil undergoing short-circuit is also connected to a second circuit, the influence of the self-induction will enable a current to be maintained in the latter, even when the contact surface diminishes very quickly, consequently no great increase of pressure and current density can be set up. This action, of course, is only effective when the inductance of the parallel circuit is not too large, otherwise it will not be able to take this sudden rush of current. The resistance is only of secondary importance, owing to the very rapid rate of change of the current, the time of this variation being of the order of a 1/10,000th of a second, if we assume that the large current changes at the end of commutation take place during one-tenth of the whole period of short-circuit.

To examine these quantities numerically, we can build up the differential equations for the circuits connected with the coil leaving short-circuit (Fig. 1). Denote the apparent self-induction and the effective resistance of the short-circuited coil by L_s and R_s, the similar quantities of the equivalent shunt circuit by L_n and R_n, the resistance of the commutator lug by R_v and the resistance of the contact surface—corresponding to the contact resistance at the last instant—by R_u. Further let i_x and i_y denote the currents in the commutator segments, i_z and i_z^1 the short-circuit currents in the last and last-but-one coils undergoing commutation, and i_n the equivalent shunt current. Then for the E.M.F.s of the short-circuited coil e_z and of the shunt circuit e_n we get the two equations :

$$\left.\begin{aligned} e_z &= \frac{L_s}{T}\frac{di_z}{d\delta} + R_s i_z - \left(R_v + \frac{R_u}{1-\delta}\right) i_x + \left(R_v + \frac{b}{\beta}R_u\right) i_y \\ e_n &= \frac{L_n}{T}\frac{di_n}{d\delta} + R_n i_n + \left(R_v + \frac{R_u}{1-\delta}\right) i_x - \left(R_v + \frac{b}{\beta}R_u\right) i_y . \end{aligned}\right\} \quad . \quad . \quad . \quad (1)$$

where b/B is the ratio of brush width to width of commutator bar, whilst the ratio of the time passed t to the time of short-circuit T is δ, e_z and e_n are assumed to contain all the E.M.F.s not represented in the form of self-induction. The mutual effect between i_z and i_n is negligibly small ; also the capacity of the commutator bars need not be taken into account.

It may be repeated that these equations only represent the relations between the *additional* currents and pressures, which must be superposed on those necessary for constant current distribution under the brush, in order to obtain the actual values. The E.M.F. e_n is due to the action of the teeth, want of symmetry and such-like causes, which set up internal pressures in the armature.

The current density in the leaving segment at the last instant of short-circuit is—

$$s_z = \frac{1}{F}\frac{di_x}{d\delta} \text{ for } \delta = 1. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where F is the surface of the brush. The corresponding *transition* pressure is

$$e_z = R_u \frac{di_x}{d\delta} . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2\text{A})$$

Now from Fig. 1 we have

$$\left.\begin{aligned} i_x &= i_n - i_z \\ i_y &= -i_n - i_z^1 \end{aligned}\right\} . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Multiplying the second equation in (1) by L_s/L_n, and subtracting it from the first, we get—

$$\frac{L_s}{T}\frac{di_z}{d\delta} + R_s i_z - \frac{L_s}{L_n} R_n i_n - \left(1 + \frac{L_s}{L_n}\right)\left(R_v + \frac{R_u}{1-\delta}\right) i_x$$
$$+ \left(1 + \frac{L_s}{L_n}\right)\left(R_v + \frac{b}{\beta}R_u\right) i_y = e_z - \frac{L_s}{L_n} e_n . \quad (1\text{A})$$

Now when $\delta = 1$

$$i_x = o ; \quad \frac{i_x}{1-\delta} = -\frac{di_x}{d\delta} ; \quad i_n = -i_z ; \quad i_y = i_z^1$$

whence

$$\left\{ R_u\left(1 + \frac{L_s}{L_n}\right) - \frac{L_s}{T} \right\}\frac{di_x}{d\delta} + \left(R_s - \frac{L_s}{L_n}R_n\right) i_z - \left(1 + \frac{L_s}{L_n}\right)$$
$$\left(R_v + \frac{b}{\beta}R_u\right) i_z^1 = e_z - \frac{L_s}{L_n} e_n .$$

The pressure at the leaving tip will then be (*see* equation 2A).

$$e_z = \frac{e_z - \frac{L_s}{L_n} e_n + \left(\frac{L_s}{L_n}\frac{R_n}{R_s} - 1\right) R_s i_z + \left(1 + \frac{L_s}{L_n}\right)\left(R_v + \frac{b}{\beta}R_u\right) i_z^1}{\left(1 + \frac{L_s}{L_n}\right) - \frac{L_s}{TR_u}} . \quad (4)$$

For calculating the pressure and current density this formula is not sufficient, because the short-circuit currents i_z and i_z^1 are unknown, and cannot be determined without a complete integration of the whole problem. It is quite sufficient for our purpose, however, to see that pressure and current density are increased, at the last instant, by these short-circuit currents. Whether the action of e_n will be favourable or otherwise depends entirely on its direction, about which nothing general can be said. Its influence is larger the smaller the self-induction L_n of the shunt circuit.

The most important effect of this parallel circuit, however, lies not in the numerator, but in the denominator of equation (4). *A moderate pressure only can be safely assumed when the condition* $\frac{L_s}{TR_u} < 1 + \frac{L_s}{L_n}$ *is fulfilled*, and the greater the difference between these two terms the better the commutation. In addition, then, to the inductance of the short-circuit being small, a low self-induction of the equivalent shunt circuit is also advantageous for good commutation.

It is not difficult to estimate the value of L_n in given cases. Consider a *bipolar* armature. The chief part of the circuit in parallel with the short-circuited coil consists of the remainder of the armature winding. Now here it must be remembered that the total current volume per slot is zero for internal currents, so that only the lines passing between the several conductors in a slot can exert an inductive effect. Hence it is seen that the co-efficient of self-induction L_n may easily attain a value of the same order as that of the short-circuited coil L_s. Another path for the shunt currents, after passing through half the armature winding, would be through the other brush, and return through the external circuit. Since the inductance of this circuit, however, is comparatively high, not much of the current will take this path, except in the rare case when both brushes commutate at precisely the same instant, in which event the shunt currents in the two halves of the armature winding neutralise one another and the commutation conditions will be less favourable owing to the larger value of L_n. In every case these two currents will tend to neutralise one another to some extent, which causes the actual current density to be higher than would be the case if the other brush were absent. In the danger limit, however, when the denominator in equation (4) becomes very small, the influence of the second brush does not appreciably affect the distribution of the current rushes, because these are then very large, and take place very quickly, and consequently cannot be interfered with by the slow changes occurring in this brush. Consequently *we can regard the above condition as the criterion for good commutation in all cases.*

Coming to *multipolar* armatures the case is more complicated because there are several parallel paths along which the pulsating shunt current can flow. It is not easy to find how the current will distribute itself, because the circuits are closely interlinked magnetically with one another, and the total magnetic energy must be a minimum. It is possible, however, in any given case to find the path of least inductance, so that an idea of the magnitude of the same can be obtained. Of course, the currents connected with any particular short-circuited coil do not traverse the whole winding, but partly return through the like-named brushes, and set up pulsating currents in the connecting leads.

Since the conductors traversed by the additional currents to a great extent do not lie in the same slots in the case of multipolar windings, and their magnetic fields therefore cannot weaken one another very much, the inductance L_n will be considerably larger than in two pole machines, and cannot assist commutation so well. Hence with the same conditions of brush resistance, short-circuit inductance and time of short-circuit, *multipolar machines will reach their sparking limit before bipolar machines*, a statement which is borne out by actual experience.

To ensure good commutation in multipolar machines, equalising connections in the armature winding are often used. In addition to their other advantages, they play an important part at the last instant of short-circuit. Taking for example a four-pole winding with equalising connections on every commutator bar, then it is easily seen that as each coil leaves short-circuit, there is another coil connected in parallel with it by means of the equi-potential connections. This latter coil may either be passing through short-circuit itself or may have completed the same. In the latter case L_n equals the inductance of the short-circuited coil L_s, assuming both are magnetically independent, and the above condition for commutation becomes $L_s/T R_u < 2$. If, however, the coil in parallel is still undergoing short-circuit, then L_n only consists of the extremely small inductance of the connecting leads, since the currents prefer the path through the brush to that through the coil. In this case $1 + L_s/L_n$ will assume very large values. When only part of the possible equalising connections are provided, the shunt to the leaving coil usually consists of several coils, so that the conditions are not so favourable. In any case it is seen that *the equi-potential connections always exert a good effect on commutation, and may occasionally suppress sparking in a machine that would commutate badly without them.*

P

In cases where the equipotential connections are not used for equalising the current distribution, but only to avoid large pressures and current densities as the coils leave short circuit, another means may be employed which can be applied even to bipolar machines, such as turbo-dynamos. This consists in connecting a second "resistance winding" in parallel with the armature winding in such a way that each coil is permanently short-circuited through a high resistance, which should have as low an inductance as possible. It is true there will always be a current flowing in these resistance coils, but since the resistance can be made very large without interfering with their action on commutation, the energy consumed can be kept small.

It is interesting to examine what happens when the condition for good commutation, viz., $\frac{L_s}{TR} = 1 - \frac{L_s}{L_r}$ is not satisfied.

Equation (4) shows that with both these terms equal the transition pressure assumes an infinite value, whilst a further mathematical investigation proves that also for all other values of the self induction which do not satisfy this condition, the pressure and likewise the current density at the leaving bar become infinite. This, however, takes for granted that the conditions are as represented by equation (1). Actually this is not the case, for as soon as the pressure exceeds a certain value currents other than those in the metallic conductors will flow. Even if this were not so, we have but to turn to equation (2), where we see that an infinite current density would require an infinitely rapid variation in the short-circuit currents; this, however, on account of skin effect and the eddy damping of the flux in iron would make the effective inductance very small; but the effective resistance infinitely large, making impossible an infinite pressure at the brush-tip.

The above condition, therefore, must be regarded as giving a limit within which the current density and pressure at the leaving brush tip do not exceed moderate values.

A HIGH VACUUM MERCURY PUMP.

Where a high vacuum is required, the rotary pump designed by Dr. Gaede is worthy of consideration. This pump, of which an exterior view is given in Fig. 1, consists of an iron vessel, half filled with mercury, in which a porcelain drum rotates. During the rotation the chambers into which the drum is divided are filled alternately with air and mercury. These chambers at first suck the air

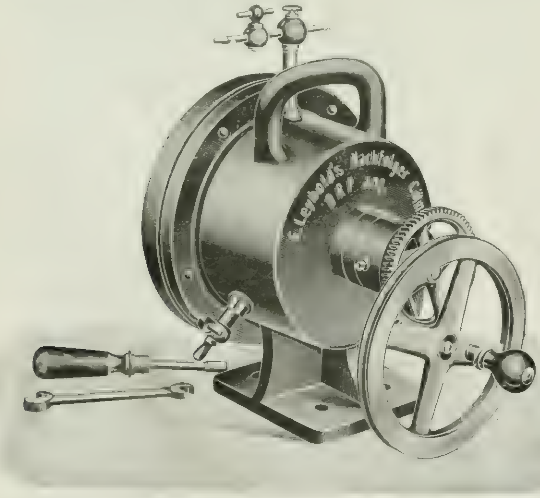


Fig. 1.

from the receiver and during further rotation expel it. The action is somewhat similar to that of a gas meter, only in the latter the motion of the gas causes the rotation whilst in the pump the rotation is effected by external means and imparts motion to the gas.

Fig. 2 shows a side view of the pump, and Fig. 3 a section from the front. G is the cast-iron casing with the handle G_1, and a strong base G_2. The front of the casing is closed by the glass plate B, 2 cm. thick, which is fastened to the casing by means of the cast-iron ring P and five bolts and nuts. The U-shaped tube R passes through the central hole in the glass plate and connects the front space V of the drum with a receiver attached to R. The pump is filled with mercury up to the line q. The axis A passes through a mercury stuffing box into the casing and carries the drum T; r is a steel tube screwed into the casing and fitted with the ends s_1 and s_2 adapted to take rubber tubing, and with the steel cock h. The

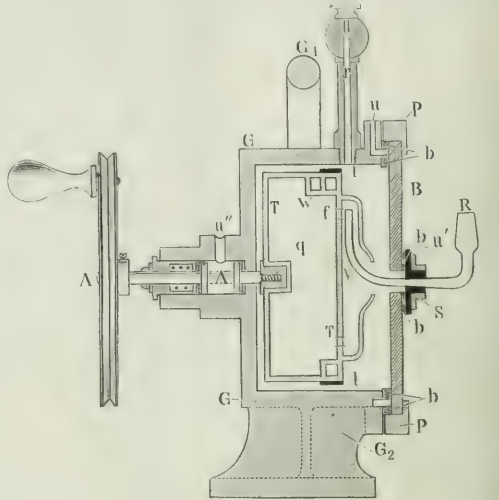


Fig. 2.

glass disc B is made air-tight against the casing and the tube R by means of two concentric rubber rings b, the space between which is filled with mercury poured in at u and u'.

On turning the drum the space W (Fig. 2) increases, so that air is sucked through the opening f in the partition wall from the front space V, and through the tube R out of the receiver attached to the

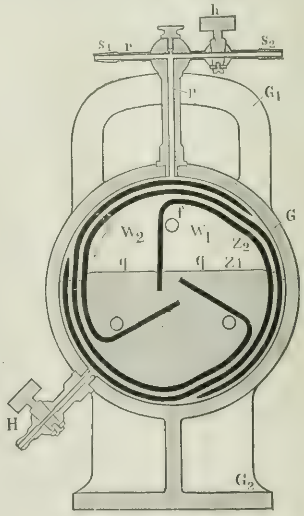


Fig. 3.

pump. Fig. 3 shows the mode of action of the pump. On turning the drum in the direction of the arrow, the space W is filled through the opening f with air from the receiver; as the turning continues, the orifice f comes beneath the level of the mercury. The air in the space W_2 shut off in this way from the receiver, is forced into the channel lying between the walls Z_1 and Z_2 of the drum and, as the turning continues, into the space between the drum and casing. From here it is removed by means of an auxiliary pump attached at s_2, which must give so good a vacuum (at least 20 mm. of mercury)

that the level of the mercury q outside the drum does not fall below the upper edge of the central opening.

Fig. 4 shows the glass apparatus attached to the steel tube R by means of the ground end L (compare Fig. 2). At E, the receiver, furnished with a normally ground connection is attached. The use of this connection offers the great advantage that the number of pieces of apparatus that can be connected with the pump is unlimited. The glass attachment is connected with a manometer H and a drying vessel P, which can be filled with phosphorous pentoxide. The manometer H serves at the same time as an automatic valve, the orifice O being free at atmospheric pressure. As the side piece a is connected by rubber tube with s_1, the auxiliary pump attached at s_2 is in direct connection with the receiver by the steel tube r and the opening O. When a vacuum of about 20 mm. is reached the mercury in the right limb sinks and, by rising in the left limb, closes the opening O. At this instant the drum is started rotating. The

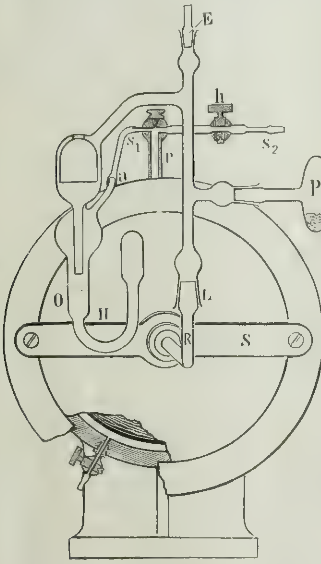


Fig. 4.

opening of R inside the pump is covered with wire gauze, which allows air to pass freely but prevents, by capillary depression, the passage of mercury, which otherwise might stop up the tube R when violent movements occur, such, for instance, as that due to the sudden admission of air.

The average power of a pump is such that commencing with a vacuum of 10 mm. the flask is exhausted down to 0·004 mm. in five minutes, to 0·0001 mm. in 10 minutes and to 0·00001 mm. in 15 minutes. Almost any auxiliary pump can be used, including the ordinary water injector pump. In the first pumps made the porcelain drum cracked when air was suddenly admitted into the high vacuum, but this difficulty has been removed by the adoption in the later forms of the new valve-drum in which a rubber band, l (Fig. 2), closes a number of safety valves. The introduction of these safety valves allows the use of porcelain which is superior in many respects to such metals as iron, since although the latter is stronger it is at the same time oxidisable and therefore unsuitable for high vacuum work.

We may mention that the Gaede pump is manufactured by Messrs. E. Leybold's Nachfolger, of Cologne.

THE ELECTRIC WELDING OF RAIL BONDS.

In considering the question of the return circuit on electric tramways there are several problems which must be faced and overcome, in order that the working of the line may be carried on as efficiently as possible. One of the most prominent of these problems is undoubtedly that of obtaining a satisfactory bond when a rail return is used; the rail return being, naturally, the most economical way of conveying the return current back to the station if a good circuit over the joints between the rails can be satisfactorily obtained.

In the early days of electric traction, trouble was experienced owing to the high resistance at the contact between bond and rail, due to the corrosion which arose from the unsatisfactory methods adopted in fixing the bonds to the rails. This difficulty has been overcome in late years by the design and use of flexible bonds, and as regards tramway service, this type of fitting is quite adequate for the work. But on electric railways the case is otherwise, though as regards the conductor part of the bond everything is quite satisfactory. The point of contact between bond and rail, however, often gives rise to a good deal of trouble. Moisture is a great enemy to a good contact, and it may well be said that no method of fixing

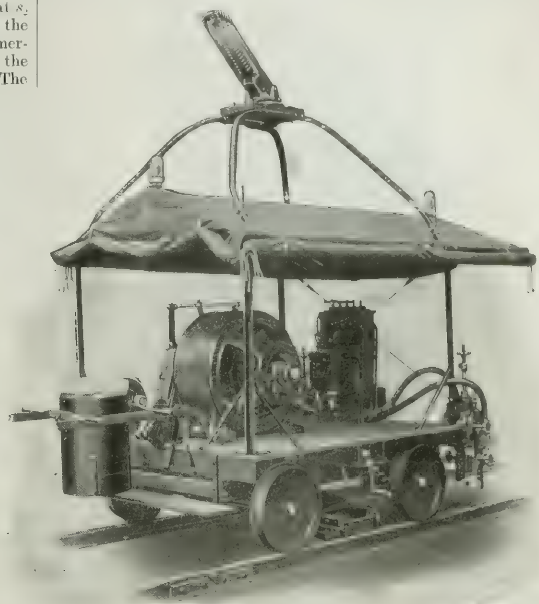


Fig. 1.—Car for Electric and Copper Welding (Forest City Electric Co.)

is satisfactory in which the contact resistances of the bonds increase with the length of time they are in service. Such an increase in resistance is unfortunately, the property of a number of rail bonds now in use.

Quite a rational way of overcoming these difficulties is by electric welding; and one method of doing this, which we describe in this article, is due to the Forest City Electric Co., of Salford. Such welding can be effected by two entirely different processes, viz., electric welding and copper welding. The machine used for effecting the former is shown in Fig. 1, an alternating current of about 2,000 amperes at 5 volts being employed. The electrical apparatus

Fig. 2.—Bond Wires in Mould for Copper Welding.

is placed as shown on a small trolley and consists of an 18 kw. converter and transformer equipped with the necessary switches for the operation of the set. The converter is provided with a clutch, and is used as a motor for the propulsion of the car through the streets, a chain drive being used between motor and road axle. The car is provided with an adequate brake, and a speed as high as 30 miles an hour can be safely obtained. Means are provided whereby the car can be raised from the rails for the purpose of turning it or rolling it from the track to avoid interference with the traffic.

The current for working this apparatus is taken from the trolley wire and is converted by means of the apparatus described above to single-phase alternating current at 5 volts. The secondary of

the transformer terminates in a bonding clamp, the terminals of the clamp being the electrodes of the electrical circuit. One electrode is copper and the other carbon. This arrangement is shown in Fig. 3.

When the surface of the rail has been cleaned, the brass covered bond terminal is placed in position and held there by the carbon electrode, the copper electrode being in contact with the opposite side of the rail. The current is then switched on and quickly

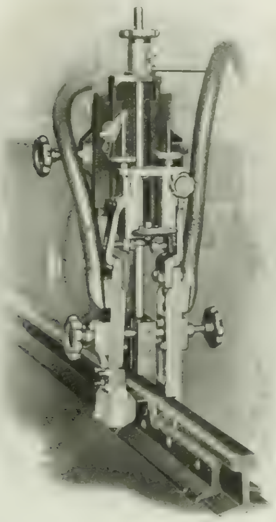


FIG. 3.—ELECTRODES IN POSITION FOR WELDING.

generates sufficient heat to make the weld, the time required being about a minute when 2,000 amperes at 3 volts is used on a 4/0 B.S. bond.

The second process of welding bonds to the rail used by the Forest City Electric Co. is effected by molten copper. A mould of suitable refractory material (Fig. 2) is employed in which the ends of the bond are placed. A short channel connects the terminal

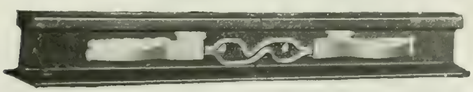


FIG. 4.—BOND AFTER POURING MOLTEN COPPER.

mould with another chamber. After the rail has been properly cleaned the mould and all the wires are clamped in position, and the molten copper on being poured into the mould welds up with the steel of the rail, thus making an excellent contact. This arrangement is specially designed for use when bonds of large carrying capacity are required. Figs. 4 and 5 show the finished bond before and after cutting away the surplus metal.

FIG. 5.—FINISHED BOND WITH SURPLUS METAL CUT AWAY.

The Forest City Electric Co. claim a number of advantages for these bonds. The weld with the rail is said to be perfect, while the resistance is permanent and does not increase with the life of the bond. The bonds cannot be removed from the rails unless they are cut off, and they are quickly and conveniently installed.

NOTE ON THE HEATING OF MAGNET COILS.

BY G. TREVOR WILLIAMS, B.SC.

Summary.—The author has separated the heat losses experimentally and finds that about one-half is dissipated by convection, the remainder being removed by radiation and conduction. One-half of that removed by convection is accounted for by the fanning action of the armature.

The maintenance of the magnetic flux in any electrical machine requires the expenditure of a certain quantity of energy due to the passage of the exciting current through the field winding. The heat produced is dissipated by the combined action of radiation and convection, and by conduction to the iron of the magnetic circuit. The temperature of the windings reaches a steady state when the rate of generation of heat is the same as the total rate of dissipation.

From a comparison of the behaviour of machines of different types, Profs. Arnold * and S. P. Thompson † have deduced the following formula. The work of Messrs. R. Goldschmidt,‡ G. A. Lister § and others has in general confirmed its applicability. The formula is of the type

$$T = \frac{W}{A} \cdot C,$$

where T = the final temperature rise,
A = the area of the cooling surface,
W = the total watts consumed,

and C is a coefficient for which various values are given depending on the units employed and the general conditions of the case: amongst these latter are the character of the armature surface and its peripheral speed, and the condition of the air either circulating or still.

Lister has shown what values may be taken for the heating coefficient for various types of machines and coils, when the armature is stationary and when it is revolving at normal speed. Reference to his figures shows that these values are not the same for the two latter conditions, because of the fanning action of the armature. The heat generated by the exciting current is then carried away from the surface more quickly, the heating coefficient is smaller, and the final temperature rise is reduced. This increased removal of heat is due to direct convection.

The respective influence of radiation, conduction and convection has, however, not been determined practically, and the experiment to be described was undertaken in order to find the relative value of convection, as distinct from radiation and conduction, with regard to the dissipation of heat energy.

The term convection here includes both the steady convection from the surfaces of the coils and the influence of the fanning action of the armature, whether the latter effect acts directly upon the coils or indirectly through the removal of heat from the iron faces of the poles.

Radiation may be assisted by suitably preparing the outer surfaces of the coils; the heat removed by conduction depends on the method of supporting the coils, but perhaps the best prospects for improvement lie in increased convection.

In order to directly separate the convection effect from that of radiation and conduction, a 6½ B.H.P. Westinghouse motor of the four-pole semi-enclosed type (Fig. 1) with barrel winding, was enclosed in a large cast-iron case (Fig. 2) and driven at its normal speed by a thin steel shaft, [illegible] in. diameter, connecting it through a stuffing box to an external motor. The tank could be closed and exhausted at will. The test machine was wound for shunt excitation at 240 volts. The armature normally made 1,500 revs. per min., giving a peripheral speed of 3,700 ft. per minute. The commutator end connections were covered with varnished canvas. The dimensions are given in Fig. 1.

* Arnold: "Die Wechselstromtecknik," IV. Band, 5 kapitel.
† S. P. Thompson: "Dynamo Electric Machinery," p. 182.
‡ Goldschmidt: "Journal" of Inst. Elec. Eng., Vol. XXXIV., 1905, p. 669.
§ Lister: "Journal" of Inst. Elec. Eng., Vol. XXXVIII., 1906, p. 414.

The value of the convection effects was determined in the experiment by a comparison of the power absorbed for a certain mean temperature rise under three conditions :—

1. Running light at normal speed in air.
2. Stationary in air.
3. Stationary in vacuo.

The conditions when running in vacuo were found to be identical with (3).

The power dissipated for (1) was found directly by applying the normal exciting voltage (240 volts) to the winding and measuring the final resistance and power. From the increase of resistance the mean rise of temperature is calculated on the basis of a rise of 0·002378 ohms per ohm per degree Fahrenheit.

For (2) and (3) two methods were adopted. The first depends on the assumption that for any given coil in position

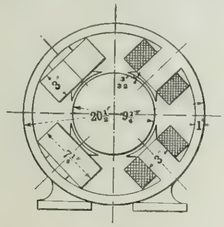


Fig. 1.

the final temperature rise is proportional to the watts dissipated. Mr. Lister, in his Paper, referred to previously, gives in Figs. 1, 2 and 4, curves which show this assumption to be approximately correct. Readings of the final resistance and power were taken with standard instruments, and the values of the power were reduced to the mean temperature rise (or increase of resistance) under condition (1).

The second method is direct and involves the experimental determination of the power which will give a final constant increase of resistance, or mean temperature rise, under the new conditions, identical with that obtaining under condition (1). The voltage across the winding was considerably reduced below that in (1), and after time had been allowed for the heat emission to become nearly steady the resistance was measured and the voltage adjusted to bring it nearer the required value. The process was repeated until finally the resistance, and

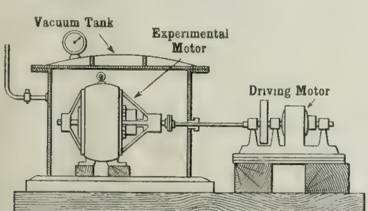


Fig. 2.

therefore the mean temperature, remained constant for some 16 hours. And, since the radiation and conduction remain constant, whether air is present or not, it follows that in condition (3) the value obtained is the power dissipated by these two factors at the specified rise of temperature, and therefore the excess of power in case (1) over that in case (3) represents the action of convection.

Thus, if W_1 be the total power dissipated for (1),
W_2 ,, ,, ,, (2),
W_3 ,, ,, ,, (3)
we have W_1=heat dissipated by radiation, conduction, and total convection ; W_2=heat dissipated by radiation, conduction, and convection without fanning ; W_3=heat dissipated by radiation and conduction alone.

Whence the proportion of heat dissipated due to the total action of convection is

$$\frac{W_1 - W_3}{W_1},$$

and that due to the fanning action of the armature is

$$\frac{W_1 - W_2}{W_1}.$$

The observations taken are given in the following tables :—

Table I.—*Resistance of Shunt Field Winding. Machine running at 1,500 revs. per min. in air at atmospheric pressure.*

Time, hours.	Voltage.	Current, amps.	Resistance, ohms.
...	232·0	1·126	206·0
0·5	232·5	1·065	218·5
1·0	232·5	1·000	231·3
1·5	231·5	0·965	240·0
2·0	231·5	0·950	243·8
3·0	232·0	0·944	245·8
4·0	231·0	0·938	246·2
6·0	231·5	0·940	246·3
8·0	231·5	0·940	246·3

Final power=217·6 watts.

Table II.—*Method 1. Machine stationary in air.*

Time, hours.	Voltage.	Current, amps.	Resistance, ohms.
...	232·0	1·125	206·0
0·5	228·5	1·050	217·5
1·0	227·8	0·980	231·0
1·5	233·2	0·955	244·1
2·0	230·8	0·932	247·7
2·5	232·2	0·923	251·4
4·0	230·6	0·905	255·0
6·0	231·2	0·903	255·9
8·0	231·2	0·904	256·0

Final power=209·0 watts.

Table III.—*Method 1. Machine stationary in vacuo.*

Time, hours.	Voltage.	Current, amps.	Resistance, ohms.
...	232·0	1·126	206·0
0·5	230·5	1·030	224·0
1·0	227·5	0·950	239·0
2·0	226·5	0·905	250·4
3·0	226·5	0·900	252·0
4·0	232·5	0·905	256·9
6·0	228·5	0·860	265·7
8·0	229·5	0·860	267·0

Final power=197·4 watts.

Table IV.—*Method 2. Machine stationary in air.*

Time.	Hours.	Voltage.	Current, amps.	Resistance, ohms.
4:30 p.m.	...	162·7	0·790	20
10:30 a.m.	18·0	165·5	0·701	236
11:0 ,,	18·5	191·5	0·800	239
12:30 p.m.	20·0	193·5	0·795	244
6:30 ,,	26·0	196·5	0·805	244·5
7:30 ,,	27·0	197·5	0·804	246·0
11:30 a.m.	43·0	198·0	0·804	246·3
12:0 ,,	43·5	198·0	0·804	246·3

Final power=159·2 watts.

Table V.—*Method 2. Machine stationary in vacuo.*

Time	Hours.	Voltage.	Current, amps.	Resistance, ohms.
4:0 p.m.	...	178·5	0·866	206·0
4:30 ,,	0·5	203·5	0·930	219·0
5:0 ,,	1·0	205·5	0·880	234·0
11:0 a.m.	19·0	164·5	0·675	244·0
12:0 ,,	20·0	166·5	0·683	244·0
2:0 p.m.	22·0	166·5	0·680	245·0
4:0 ,,	24·0	168·5	0·685	246·2
5:0 ,,	25·0	169·5	0·689	246·2
11:0 a.m.	43·0	165·5	0·672	246·3

Final power=111·0 watts.

Table I. shows the readings taken for the conditions of normal running, namely, (1).

Tables II. and III. show the same for conditions (2) and (3) by the former of the two methods described. The average vacuum maintained under (3) was 28½ in.

Table VI.—*Collected Results.*

Conditions.	Final resistance.	Mean rise of temperature.	Corresponding power, watts.	Power reduced to a temperature rise of 82·2 deg.	Power at final temp. rise of 82·2 by second method	Convection, expressed as a percentage of power.	
						By first method.	By second method.
						Per cent.	Per cent.
1. Machine running in air	246·3	82·2°F.	217·6	217·6	217 6	40·0	49·0
2. Stationary in air	256·0	102·0	209·0	168·5	159·2	22·6	26·7
3. Stationary in vacuo ...	267·0	124·5	197·4	130·5	111·0	...	...

Tables IV. and V. give the results of the second method for the same conditions (2) and (3) respectively.

In Table VI. are collected the final values and the results calculated from them, viz. :—the mean temperature rise from increase of resistance, the powers reduced by direct proportion in the ratio of the final temperature rise to the normal rise when running light, and finally the proportion of the total heat lost which is dissipated by the convection of the air adjacent to the coils, together with the air currents set up by the armature, and by this fanning action alone.

The figures given by the first method are low, as is to be expected from a consideration of the shape of Mr. Lister's curves, but they approach the more accurate values arrived at by the second method.

As an example of the way the figures are arrived at, the calculation of the total convection from the results of the first method is appended.

Resistance of coil when cold	=206·0 ohms
Final resistance of coil under (1)	=246·3 ..
Rise of resistance of coil under (1)	= 40·3 ..
Power absorbed under W_1	=217·6 watts
Final resistance of coil under (3)	=267·0 ohms
Rise of resistance of coil under (3)	= 61·0 ..
Power absorbed under (3)	=197·4 watts

$$\text{Reduced power} \quad W_3 = \frac{197{\cdot}4 \times 40{\cdot}3}{61{\cdot}0} = 130{\cdot}5 \text{ watts.}$$

$$\text{Total convection} \quad \frac{W_1 - W_3}{W_1} = \frac{217{\cdot}6 - 130{\cdot}5}{217{\cdot}6} = 40{\cdot}0 \text{ per cent.}$$

And similarly for the total convection by the second method we have

Final power absorbed under (1) $W_1 = 217{\cdot}6$ watts.

Final power absorbed under (3) at same temperature rise $W_3 = 111{\cdot}0$ watts.

$$\therefore \text{Total convection} = \frac{W_1 - W_3}{W_1} = \frac{217{\cdot}6 - 111{\cdot}0}{217{\cdot}6} = 49{\cdot}0 \text{ per cent.}$$

The final result is that very nearly one-half of the heat expended in exciting the field coils is dissipated by the total action of convection, while the remaining half is removed by the combined action of radiation and conduction. And, further, that one-half of that due to convection, that is one quarter of the total heat dissipated, is accounted for by the fanning effect of the rotating armature.

The machine was driven mechanically throughout.

The work was carried out in the Electrical Engineering Laboratory at Armstrong College, Newcastle-upon-Tyne, and the best thanks of the writer are due to Prof. Thornton for his valuable advice.

THE RELIGHTING OF THE CARBON ARC.

BY J. A. POLLOCK, D.SC., E. M. WELLISCH, M.A., AND A. B. B. RANCLAUD, B.SC.

Summary.—The relation between the potential difference across the carbons and the maximum time of interruption of the circuit within which the arc will re-form, is here investigated. The effect of the relative positions of the carbons is also dealt with.

When the arc between fixed carbons in a hand-fed lamp, burns itself out, it may be restarted if too great an interval of time is not allowed to elapse, by lessening the distance between the carbon terminals, but without bringing them into contact. Again, if the circuit is broken and reclosed after a short time, the arc may re-establish itself without the carbons being moved. Mr. Upson* has given observations of the maximum times of interruption of the circuit within which the arc will restart for various arc lengths and currents. The relighting of the arc after a given time of interruption depends, however, also on the potential difference established between the electrodes at the moment of reclosing the circuit, and investigations on this point are here described.

The maximum time of interruption of the circuit, under given conditions, within which the arc will re-form on remaking the connections, is astonishingly well-defined, and could in our observations be determined to 0·002 sec. If the interval exceeds what may be called the critical time for the given circumstances, after reclosing the circuit a small non-luminous current passes between the carbons; the heating effects associated with this current are not sufficient to maintain the electrodes at their high temperatures, and the current

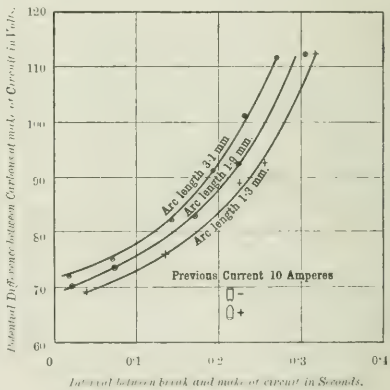


FIG. 1.—RELATION FOR CRITICAL RELIGHTING. CARBONS IN NORMAL POSITION, POTENTIALS REVERSED.

soon dies away as the temperatures diminish. From considerations advanced in a previous paper,† one is led to think that, on reclosing the circuit, this smaller current always precedes the larger one of the fully formed discharge.

In the relighting of the arc both carbons are at a high temperature, and the conditions are complicated by the presence, at the moment of reclosing the circuit, of ions at the anode surface as well as near that of the cathode. Simpler conditions are associated with the change of current régime when only the negative carbon is incandescent. In the present experiments, the flow of negative electricity at the moment of reclosing the circuit is not always from a hot to a cooler carbon; the conditions of the change from the non-luminous to the luminous discharge are, therefore, in some instances, more complicated than those in the case previously considered, and the explanation of the development of the arc suggested in the Paper just mentioned is not sufficient to account for all the features observed in this investigation. Further data are required before a complete description can be given.

The conditions associated with a change from the non-luminous to the luminous discharge, in the case of the ordinary carbon arc, are seen in the wave-forms of current and potential difference in

* Abstract from the "Philosophical Magazine," of a Paper read before the Royal Society of New South Wales.

* "Observations on the Electric Arc," THE ELECTRICIAN, Nov. 1, 1907, p. 91.

† Pollock and Ranclaud, "Phil. Mag.," March, 1909.

connection with alternating-current arc lamps. Reference is made in this connection to curves given by Mr. Duddell and Prof. Marchant.*

For all the experiments Conradty carbons, Marke C, were employed; both positive and negative were solid, each 13 mm. in diameter, the lamp being hand fed. A heavy pendulum, operating two switches when allowed to swing, opened and again closed the circuit; the distance between the switch levers could be readily altered. The time interval between the opening and the reclosing of the circuit for different lengths between the levers was carefully determined by separate experiments carried out as follows:—The switches were arranged to open and close the circuits of two electromagnetic scribers which marked a smoked plate fixed to the pendulum; the records for various distances between the switch levers were then compared with that on the same plates of a style attached to the prong of a standardised tuning fork. A third key, also worked by the pendulum, enabled the battery connections to be reversed in the interval between the break and the make of the circuit if desired. The observations were made in all cases with "normal" arcs.† The lengths of the arc were measured, on images of the carbons, vertically from the point of the negative to a horizontal line passing through the edge of the crater, the values obtained being reduced according to the magnification of the image.

Carbons in Normal Position.—When the connections from the battery are reversed during the interval between the opening and closing of the circuit, so that at the re-make of the circuit the still existing crater becomes negative to the previous cathode, the crater being on the upper carbon, the phenomena are simpler than in other cases, and are first described.

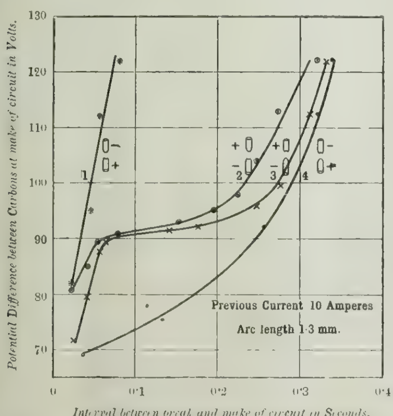


FIG. 2.—RELATION FOR CRITICAL RELIGHTING AS AFFECTED BY CHANGES IN THE RELATIVE POSITIONS OF THE CARBONS.

In Fig. 1 is shown the relation between the minimum potential difference for relighting and the interval between the break and the make of the circuit, under the condition of the reversal of the potentials of the carbons, for a previous current of 10 amperes. In this instance, on reclosing the circuit, the hot is negative to the cooler carbon; the conditions under which the arc is formed are, therefore, nearly allied to those in the simple case previously investigated. The longer the interval between the break and make of the connections, the lower are the temperatures of the carbons at the moment of reclosing the circuit; taking the fall of temperature of the carbons after the arc is extinguished as nearly proportional to the time, the curves in Fig. 1 may be considered as giving, approximately at least, the form of the relation between the critical potential for relighting and the temperature of the hot negative, the temperature of the other electrode being of less importance in this particular case.

Under the conditions of the experiment, the first effect of reclosing the circuit is no doubt a small current of negative ions flowing from the hot to the cooler carbon, and from this non-luminous current the arc may be considered to develop. In the fully formed arc the cathode fall of potential indicates an accumulation of positive ions near the cathode surface. These positive ions, in the growth of the discharge from the non-luminous current, must come in the first instance from the anode, and the potential difference between the carbons, at the instant of closing the circuit, must be sufficient to cause the energy reaching the anode surface to raise a portion of that surface to a temperature at which positive ions are freely emitted.

Change in Position of Carbons.—With the carbons in a vertical plane they may be situated with the crater above or below the negative electrode; also the connections to the battery may be reversed during the interval between the break and the make of the circuit, or left unaltered. In Fig. 2 are shown the relations between the minimum potential difference for relighting and the time interval of interruption of the circuit for these four cases, the current having been 10 amperes and the arc length 1·3 mm. The diagrams of the carbons drawn beside each curve indicate by their shape the relative positions of the electrodes before the circuit was opened, while the signs of the potentials, on the reclosing of the circuit, are shown by the usual symbols. All the observations were taken with the same pair of carbons, so the curves are strictly comparable.

Case 4 is the one just discussed. It is seen that for small time intervals between the break and the make of the circuit, it requires greater potential differences to restart the arc in the cases 1, 2 and 3, than in that of 4, and that cases 2 and 3 approximate to that of 4 for large intervals of time. In searching for a cause of the differences between the curves it has to be noticed that in some cases the negative electrode, on the re-make of the circuit, is hotter than the positive, in others the reverse; it is also essential to recognise that in some instances the negative stream of ions is opposed by the convection current of hot gas, while in others it is helped by it.

The feature of the relations is the evidence, shown by the curves

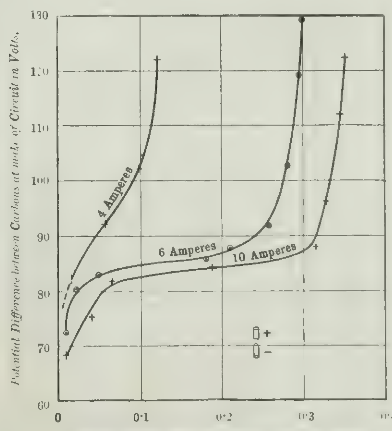


FIG. 3.

for cases 2 and 3, of a critical change in the conditions for relighting occurring when the potential difference attains the value of 90 volts. After reaching this value the minimum potential difference requisite to start the arc remains for some time practically constant in spite of the fact that for increasing time intervals between the break and the make of the circuit the temperatures of the carbons are diminishing.

Effect of Arc Length and Previous Current.—Further observations have been made in connection with case 3, in which the carbons are in the normal position and the battery connections remain unaltered during the interval between the break and the make of the circuit. Some of the measurements are given in Fig. 3, the currents previous to the break of the circuit being marked on the curves. These show that the characteristic bend is more pronounced the higher the previous current. Greater currents mean larger masses of heated carbon with consequent higher temperatures for equal intervals between the break and the make of the circuit. It is also seen from the curves in the Paper that the greater the arc length, the higher the potential difference at which the characteristic bend occurs.

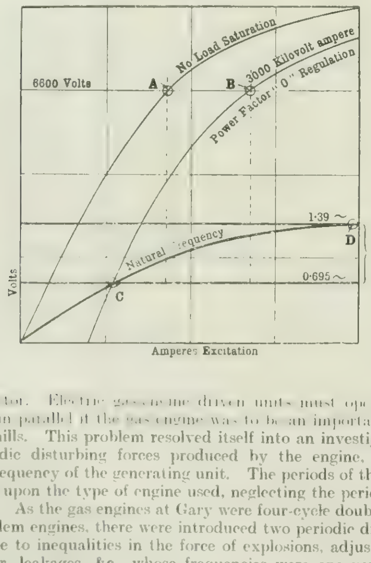
By arranging an additional lever, in connection with the pendulum apparatus previously described, to open the shutter of a photographic camera at a short interval after the remaking of the connections of the arc circuit, photographs showing stages in the development of the arc have been obtained, and a few are reproduced in the Paper.

* "Experiments on Alternate-Current Arcs by aid of Oscillographs," "Journal" I.E.E., 1899; also THE ELECTRICIAN, April 14, 1899, p. 857.
† Mrs. Ayrton, "The Electric Arc," p. 104.

THE INDUSTRIAL APPLICATION OF THE ELECTRIC MOTOR.

We give below a short account of the discussion in connection with the Paper on this subject read before the American Institute of Electrical Engineers. An abstract of this Paper appeared in our issues of April 16 and 23, 1909.

Mr. B. A. Behrend, as the designer of the 17 generators constituting the 40,000 kw. gas-engine power plant at Gary, added a few words regarding some special problems which arose in connection with the plant, for a better understanding of the fundamental conditions which must be met in power plants utilising alternating-current generators for direct connection to gas-engines, a problem of the greatest importance in steel mills. The choice of the right flywheel effect was intimately bound up with this question. The gas-engine power plant at Gary consisted of 17 four-cycle double-acting cross-tandem gas-engine units of 2.500 kw. capacity each. Two of these engines were direct connected to 2,000 kw. 250 volt direct-current generators, while the remaining 15 engines were direct connected to alternating-current generators of 3,000 k.v.a. each at 6,600 volts and 25 cycles. The engine speed was 83½ revs. per min. As the load on the plant was composed chiefly of induction motors of large capacity and slow speed, the amount of lagging current under average operating conditions was likely to be equal to, or even greater than, the amount of watt current required by the motors. The power factor was not likely to exceed 70 per cent., and the generators, therefore, were designed for a large ampere rating at low



power factor. Electric gas-engine driven units must operate successfully in parallel if the gas-engine was to be an important factor in steel mills. This problem resolved itself into an investigation of the periodic disturbing forces produced by the engine, and the natural frequency of the generating unit. The periods of the former depended upon the type of engine used, neglecting the period of the governor. As the gas engines at Gary were four-cycle double-acting cross-tandem engines, there were introduced two periodic disturbing forces, due to inequalities in the force of explosions, adjustment of valve gear, leakages, &c., whose frequencies were one per revolution, and one-half per revolution, of the engine. It was the latter frequency which was absent in steam engines, and which introduced a complex factor of the greatest importance into the problem of parallel operation of gas engines. Following the terminology used in dynamics, he called the results of these periodic disturbing forces "forced oscillations." For the Gary units the frequencies of the forced oscillations, which were likely to be dangerous, were 1·39 and 0·695 cycles per second. The determination of the natural frequency by calculation as carried out by Blondel, Boucherot, and Kapp 10 years ago was based on a knowledge of the angular displacement of the revolving field per unit torque. The short-circuit current was used for this determination, but experimental investigations which he had carried out with his former assistant, Mr. A. B. Field, had demonstrated that other methods must be resorted to if serious error was to be avoided. Supposing they knew the natural frequency of the generator units when operating on 'bus bars of constant frequency, then they could readily obtain, by the methods of dynamics, the increase in the mechanical displacement produced by resonance between the forced and the natural frequencies, or the "magnifying factor," as it had been called by Messrs. Görges and Rosenberg, who had done such excellent work in the theory of parallel operation. This "magnifying factor" was infinite when the natural frequency equalled the forced frequency, provided there was no damping. Under this condition, even with damping, however powerful, it was not possible in practice to obtain satisfactory parallel operation. Turning now to the Gary units, before calculating the moment of inertia of the units, or the flywheel effect, extensive experiments were carried on to determine the natural frequency of oscillation of generators of similar design. The generators were run in parallel when the circuit-breaker was opened and closed again immediately. The number of complete oscillations per second could be counted and the natural frequency was thus actually measured. These investigations, carried on with a number of different machines over the entire range of the saturation, made it possible to determine beforehand the natural frequencies at all excitations of the Gary generators, and, therefore, under all conditions of load and power factor. The curve herewith marked "natural frequency" showed the average result. The straight lines showed the two forced frequencies of the gas engines. The points of intersection C and D marked conditions of instability, the range between them marking the range of stability. The operating range of the generators on the saturation and regulation curves lay between A and B, and, therefore, was well within the range of stability. Very light wheels had to be used to comply with the condition described. With light wheels dampers were efficient, and they had been provided on the Gary generators. A flywheel effect of four times the flywheel effect used would have reduced the natural frequency below that of the lowest forced frequency, and the conditions would thus have been similar to those obtaining in steam engines. Such large flywheel effects on gas engines required the use of steel wheels of large diameter, which were not at all impracticable. In point of fact, the question was carefully considered whether large wheels, reducing the natural frequency, should not be installed. It was, however, finally decided to bear up with the greater fluctuations, and to instal light wheels working between the two forced frequencies. These remarks sufficed to indicate that the problem of parallel operation of gas engines had been reduced to accurate scientific method based on careful experimental and practical data.

Mr. G. Dunn felt, without the slightest exaggeration, that the Gary plant was one of the wonders of the world. It was the advantages of generation and distribution that had brought the induction mill motor to the front, not good qualities in the motor itself. The low power factors, the necessarily small air-gaps, the complexity attending the use of three phase with at least two sets of controlling apparatus, the great reduction in capacity for a given weight of motor—all were bound to indicate that the problems of distribution ought not to be controlling to too great an extent, and ought not to cause the locating at every point around the mill where power was used, of the complications that attended an induction motor, but should rather lead to the collecting of such complications into a substation or power house where a motor generator taking power from the main alternating distributing system would transform it into simple and powerful direct current to be sent out for local service. In his opinion the steel mills would not be supplied throughout with alternating current, but would find themselves equipped with mixed systems of distribution—alternating for the great powers and big motors, and direct for the cranes, reversing motors and other motors of similar service. When the mill men first started electrical equipment they were not in touch with the electrical men, and many mistakes were made; but when he saw how completely the steel industry had capitulated to the electrical engineer in the Gary plant he was filled with joy, remembering the attitude of the steel men toward electric motors not long ago.

Mr. W. T. Dean said that the author had spoken very briefly on some of the problems which had been met—*i.e.*, whether the mill should be two high or three high. A three-high mill was one having three rolls, each of which rotated constantly in one direction—*i.e.*, the upper and lower roll rotated in the same direction, while the middle roll rotated in the opposite direction. So that a piece of steel passed through the lower set of rolls, the table was then raised, and it passed back through the upper set. On the two-high mill, where the steel must pass back and forth through the rolls, it was necessary to reverse the direction of the rolls, and therein came the difficult problem in electrical drive, especially when large motors were used. The mill must reverse quickly to prevent delay, and in this very serious problems were encountered. The previous speaker had mentioned the use of direct-current motors on the rolls which, in some instances, might be as large as 6,000 H.P. Such a motor would be extremely difficult to design, but if it could be designed it would be a very expensive machine. A plan worked out in Europe, where direct-current motors of large sizes were used on reversing rolls, was to put three armatures on a common shaft, thus reducing

the inertia on account of the diameters being smaller than if only one armature of large diameter were used. If now it were possible to use a three-high mill instead of the two-high mill the system became considerably simplified, inasmuch as the direct-current motors and generators could be omitted, and the induction motor could be directly connected to the rolls. The induction motor with its fly-wheel would do the work on any equipment, and the difference in first cost was just about one to three. This was one of the problems which had been solved in connection with the study of the Gary plant, it being first proposed to instal a two-high mill, but after careful study it was found that the three-high mill could be used at about one-third the cost of the two-high equipment and with a large elimination of troublesome features.

Mr. B. Wiley said, regarding the question of surplus gas power over and above that required by the furnace auxiliaries, a review of data obtained from several of the principal blast furnace plants abroad showed that the capacity installed per 100 tons of pig iron produced in 24 hours did not exceed 1,500 H.P. The average pressure was approximately 8 lb. and the amount of coke burned per ton of iron produced was approximately 2,400 lb. The author gave a surplus of 3,000 H.P. per 100 ton of pig iron produced per day. The principal point of the universal application of electric power in the steel industry was the commercial value. The advantages of the electric drive were: (1) More reliable, less breakage of couplings, pinions, &c., with a correspondingly less maintenance cost; (2) low power cost; (3) less space on account of absence of boilers, pipes, &c.; (4) easy adaptation to mill machinery; (5) easy distribution by means of cables, instead of steam or gas pipes; (6) easy and simple handling with reliable protective features of control; (7) less labour; (8) less oil and other stores; (9) ease of obtaining power indications and records; (10) constant and regular torque; (11) increased output due to higher and more uniform speeds. Taking these items into consideration, the results were decidedly favourable to the electric drive, especially for new plants; and it would be found that there were comparatively few cases of existing plants where the conversion from steam to electric drive was not worthy of the fullest investigation. This point was emphasised by the very active interest taken in exhaust steam turbines by a majority of the large steel companies. The exhaust steam from the existing mill steam engines was used to drive a low-pressure turbine connected to a generator, which in turn furnished electric power for the mill motors. Within the past two years the steel companies of the United States had installed more than 200,000 H.P. of gas engines and turbine electric station equipments to drive approximately 15 motor units aggregating 20,000 H.P., exclusive of 13 units of the Indiana Steel Co. now operating and on order, and aggregating 51,700 H.P. Within a year or so the data obtained from the above installations should give a conclusive analysis of the electric drive from both an actual and comparative cost standpoint.

Mr. D. B. Rushmore considered the installation the beginning of a new era in electrical work. Under no other conditions of service were the requirements of the electric motor so severe as they were in rolling mills. The load curves shown indicated a load condition not met with elsewhere. This necessitated in the motor a very unusually strong mechanical construction and an interesting mechanical device mentioned by the author; it necessitated a comparatively large air-gap in the large machines, and also in smaller machines, making the design of the machinery, electrically and otherwise, with the idea of reliability first. The author had very interestingly brought out the point that what a steel mill desired was nothing but the maximum output of steel, and the incidental features of the design must all be kept with this in view. That meant that the electric motors had a considerably larger air-gap than was necessary from any other consideration; that the factor of safety, electrical and mechanical, very much exceeded the figures that would be used for any other class of service. This was illustrated in the new type, where all the mills operated continuously in the same operation, and all the motors were equipped with flywheels.

The President said the subject of industrial power, not only as applied to steel mills, but to all practice, was very important. It was not quite so pyrotechnic as the electrification of railways, for instance, but there was a great deal of work which was being done very quietly in the application of electricity for power purposes, but not nearly as much as should be done. It was with the idea of bringing out the possibilities of the use of electricity for power purposes generally that this year he had appointed a committee on industrial power.

Mr. Shover, in reply, mentioned that they had had some slight difficulties in paralleling the gas engines; the trouble, however, existed only at times of light load. The operation of the alternators in parallel under three-quarter load or more was in the main as steady as any reciprocating steam engine driven alternators. On lighter loads there was always some inclination to hunting, due to the inherent characteristics of the gas engine, in that there was always one cylinder which was a little stronger than the other—*i.e.*, one end of one cylinder. Therefore at light load a point might arrive where the weak cylinder missed fire. They did not know what their power factor was going to be when plant was put down, but at present it varied according to the conditions in the mill, from 35 to 85 per cent.

SOME PECULIARITIES OF ELECTRICAL CONDUCTIVITY EXHIBITED BY POWDERS AND A FEW SOLID SUBSTANCES.

BY R. H. GODDARD.

Summary.—A description is given of investigations on three phenomena of conduction through loose powders and certain solid substances: (1) Change of conductivity with time; (2) the development of asymmetry of conduction, *i.e.*, difference of conductivity in the direction of and opposite to the current; and (3) deviation from Ohm's law. Finally a theory depending on slow diffusion of ions in heated contacts between particles is offered in explanation of the facts.

The resistance of the powders examined was very high, thus the conductivity could only be measured by using a thin wide layer of the powder, a high E.M.F. and a sensitive galvanometer. The powder was sprinkled over a flat copper disc 6 in. in diameter to a depth of about 1 mm. Then a similar disc, on which was a lead weight, was placed on this layer. This resistance, or bridge, was placed in series with a sensitive Broca galvanometer, the sensibility being $7{\cdot}156 \times 10^{-8}$ amperes per millimetre of the scale. An E.M.F. was applied by a battery of 40 small storage cells, so that the E.M.F. could be varied by steps of about 2 volts from 0 to 80 volts. A reversing switch was also provided. The substances studied were the sulphides of calcium, barium, zinc and mercury, sulphate of calcium and of mercury, calcium fluoride, barium carbonate, magnesium oxide, mercuric oxide, mercurous oxide, litharge, zinc dust, mercuric iodide, solid silver iodide, borax, zinc perborate selenium and molybdenite.

Change of Conductivity with Time.—In most cases, when an E.M.F. was applied, the conductivity fell very rapidly at first, then more and more slowly, approaching a limiting value many times less than the original conductivity. If, after this exposure had continued for some time the circuit was broken, the conductivity slowly regained its original value, the increase being most rapid at first. When the exposure was long enough to make the conductivity constant, the state of the substance seemed fairly steady—that is to say, if the circuit were opened for a short time and then closed the conductivity soon regained the steady value before the interruption. It was found, in this way, that a momentary breaking or even reversing of the current did not change appreciably the conductivity of this steady state. Thus it may be assumed that, in studying the rise of conductivity after exposure to the steady E.M.F., momentary application of the E.M.F. to get a deflection did not change the conductivity of the substance appreciably.

This change of conductivity with time differed both as regards magnitude and direction with various substances. Of the powders used, calcium sulphide gave the greatest change in magnitude. On one occasion, after an exposure to the E.M.F. for three days, the conductivity rose sixty-fold in 21 hours. The initial changes produced in calcium sulphide by the E.M.F. were too rapid to be recorded. A curve is, however, given (Fig. 1, A) showing the effect of application of the E.M.F. to a specimen of calcium sulphide 40 minutes after a previous long application. The first part of the curve shows the effect of the steady application; the second part, the effect after the E.M.F. was removed, it being applied then only long enough to take readings. The substances which exhibited a decrease of conductivity on continued passage of a current were—arranged in the order of magnitude of the effect—calcium sulphide, barium sulphate, borax, zinc sulphide (Fig. 1, B), magnesium oxide (Fig. 1, C), mercurous sulphide, mercuric sulphide, zinc dust, calcium sulphate, solid silver iodide, strontium sulphide (Fig. 1, D) and lithage. Those exhibiting an increase were solid molybdenite, barium carbonate, powdered barium sulphide, solid barium sulphide (Fig. 1, D) and red iodide of mercury. Barium fluoride, zinc perborate and selenium, all powdered, showed neither increase nor decrease to any appreciable extent.

Effect of a Vacuum.—All the powders that were examined, except selenium, and even the solids (silver iodide and barium sulphide) showed a marked effect when the vessel in which they were con-

* Abstract from the "Physical Review."

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tained was exhausted by an air pump. The effect in nearly all cases was the same—a great decrease in conductivity, the change persisting until air had been re-admitted, following which there was a gradual rise. With magnesium oxide the conductivity was reduced to one-ninth the initial value by the vacuum, and with other substances the change was comparable with this. For all other substances, except solid barium sulphide and molybdenite, the curves are similar. With barium sulphide the rise on admitting air was somewhat abrupt. Solid molybdenite appeared to give a rather sudden fall in conductivity of about 15 per cent. on producing the vacuum, and a corresponding rise on admitting air. The effect seemed to be more or less independent of the current. An E.M.F. was applied steadily to CaS until the deflection had reached a fairly steady value. The E.M.F. was then removed and a vacuum produced. On re-application of the E.M.F. the deflection was found to be only 20 per cent. of that just before exhaustion. When the conductivity was at its lowest, under the influence of a vacuum, jarring the bridge caused a rather feeble rise, but after the air had been re-admitted and the conductivity had risen jarring caused a considerable rise. Later experiments have indicated that the proportionate drop in deflection, after a one-minute application of the vacuum, is the same whether the E.M.F. has been applied for a very short time, immediately before producing the vacuum, or for five minutes.

The powders differed markedly as regards fineness. The calcium sulphide, barium fluoride, magnesium oxide and the carbonates and sulphates were all very fine. The zinc sulphide was somewhat coarse, while the selenium was the coarsest of all. The other powders were nearly, if not quite, as fine as those first mentioned. No polarisation or back E.M.F. could be observed at any time. Copper electrodes were used, but no apparent change was produced when the electrodes were tin, zinc or platinum.

The action of a powder, as regards the time-conductivity change, is not always the same. In many trials, at different times, calcium sulphide and borax showed a decrease of conductivity with time. Once, however, for each powder, there was an exception, for no apparent reason. The rise with time in the case of calcium sulphide was almost linear, the curve being slightly convex toward the time axis, while the curve for the borax resembled the hysteresis curve for iron, being S-shaped. These cases could not be repeated. A peculiar time-conductivity effect was noticed with barium sulphide which might be called a spontaneous rise of conductivity. It was found that when the barium sulphide was freshly powdered the conductivity rose to three times its initial value in 3·5 minutes, the E.M.F. being applied only long enough to take readings.

Asymmetric Conduction. It will be convenient to call A the conductivity in the direction of the initial current and B the conductivity in the opposite direction. The relation between A and B for calcium sulphide is shown by Fig. 2. The current was kept constantly in the direction A, and brief reversals for B were made at intervals of two minutes—only long enough to take a reading. The current was then reversed, and it will be noticed that here A rose steadily while B fell. This illustrates the steady increase of conductivity in the direction opposite to that in which the current is flowing, characteristic of calcium sulphide. On opening the circuit, and taking readings for the conductivity at intervals of two minutes—applying the current for as short a time as possible—A fell, while B kept rather constant. It is to be noticed that the deflection for A reached a steady value quickly. For B, however, the initial throws grew larger and larger, falling rather rapidly to the same scale division each time. The resistance, then, *increased* in one direction on opening the circuit. The specimen of powdered calcium sulphide used in this experiment had been previously subjected to reversals. Two fresh bridges of calcium sulphide were then prepared. One was exposed to the E.M.F. for 18 minutes. When the circuit was opened A fell slightly, then rose, while B rose, as it had been doing before the E.M.F was removed. The other bridge was exposed to the E.M.F. for 1 hour 22 minutes. Here the increase in resistance on opening the circuit was clearly marked (Fig. 2, II.).

The behaviour of coarsely powdered selenium was peculiar. At first the difference between A and B was not marked, but on reversal of the current the conductivity in the direction of the current then flowing fell slightly, while that in the opposite direction rose considerably. The effect on opening the circuit was similar to that of calcium sulphide after a long exposure to the E.M.F. The conductivities, on reversing, appeared to reach a steady state after a short time.

A bridge of solid silver iodide showed the asymmetry markedly. The current fell in the initial direction and rose in the opposite direction. This was true on reversal. It should be noted that with this substance the curves for A and B are of the same shape, one of them being inverted. With this substance, when a vacuum was produced, A dropped to one-fourth its value, while B dropped to two-fifths its value before the production of the vacuum.

The mineral molybdenite behaved differently from the other substances examined in that A increased with the time while B fell.

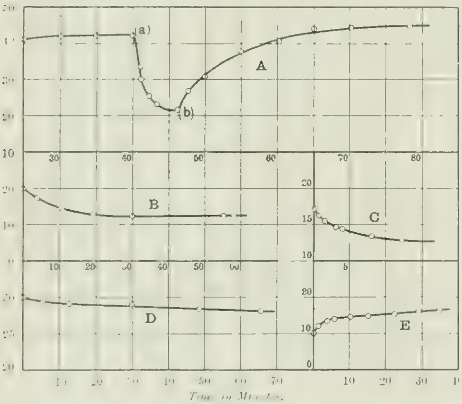

Fig. 1.

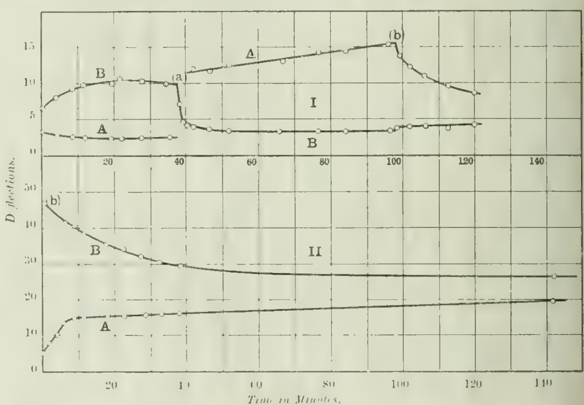

Fig. 2.

After applying the E.M.F. the conductivities soon reached a steady state. The phenomenon was here complicated by the fact that a given state in the molybdenite tended to persist. In other words, with a perfectly fresh specimen, the E.M.F. produced a state which persisted for a considerable time—the conductivity for this initial direction being permanently above that in the reverse direction. The effects of subsequent reversals were superposed upon this permanent effect. The state could be obliterated, however, if the specimen were split into laminæ, and some of these were reversed. This state was, curiously, influenced by sparks from an induction coil several feet away from the apparatus. After a spark had passed the state was often reversed, and the conductivity in general was higher. Such sparks had no apparent influence on the other substances examined.

Asymmetry was found with a coherer of the ordinary form, made of nickel silver filings. A state of asymmetry would appear more or less suddenly, remain rather constant, and persist even if reversals were made rapidly. The tendency seemed to be for A to remain steady and for B to rise, and B could stay permanently twice A.

When reversals were made, in studying asymmetry, a certain sluggish action was noticed with selenium which was not shown with the other substances. When the current was flowing in the direction A, in selenium, and a steady deflection had been reached, for both A and B, a reversal gave immediately the larger deflection for B, but a reversal back to the original direction did not give the original deflection at once, but the deflection fell rather slowly from the higher.

Deviation from Ohm's Law.—All the powders and the three solids

examined showed deviation from Ohm's law, except powdered zinc perborate. Arranged in the order of magnitude of the effect—*i.e.*, the magnitude of the curvature—they were molybdenite, calcium sulphide, solid barium sulphide, powdered barium sulphide, mercuric oxide, zinc dust, magnesium oxide, borax, strontium sulphide, mercuric iodide, barium carbonate, barium sulphate, barium fluoride, zinc sulphide, solid silver iodide, calcium sulphate, litharge, mercurous oxide and zinc perborate, which last gave no sensible deviation whatever. The curves given in the article show that those substances which deviate but slightly do so most strongly at low voltages. The deviation from Ohm's law was present under all conditions, except when great pressure was applied. Even in a vacuum the deviation was present. Also, the deviation did not disappear with current-densities many times greater than those ordinarily used in the experiments.

An electric discharge had a marked defect on the conductivity of zinc dust, but did not change the deviation from Ohm's law to any appreciable extent. As the conductivity of zinc dust was better than that of the other powders used, it was possible to make a bridge of it in the form of a tube coherer. The tube of the coherer was placed 1 in. from the spark-gap of a small induction coil, parallel to the axis of the gap. It was found that sparks caused the conductivity of the zinc dust to increase about a hundred-fold, but when steady readings were possible the deviation was still present. After the sparking the conductivity of the zinc dust coherer fell, whether the current were on or off. A peculiarity of the deviation is that, with the same substance, the upper part of the E-I curve is more or less straight. Here, again, there seems to be a general tendency, which is followed except in a very few cases.

The above phenomena, in general, may reasonably be considered as contact phenomena—*i.e.*, changes taking place at the junctures between particles. It is evidently so for powders, and is more or less so in the case of solid silver iodide, barium sulphide and molybdenite, if it be assumed that, in the first two bodies, there is point contact between the interlocking crystals, and, in the last, line contact between thin laminæ. This being so, there should be some

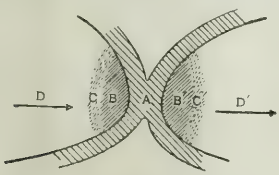

Fig. 3.

resemblance between the behaviour of powders and of the coherer. Such a resemblance is shown by the author by considering what has been already found concerning coherer phenomena.

Conclusions.—It seems improbable that the change of conductivity with time is due to a decohering action, such as breaking of the chains of particles by heating produced at the junctions. Cooling a coherer produces no change, warming produces expansion and fracture of the junctions, hence decoherence. This point was tested with calcium sulphide. Because the deviation from Ohm's law is always in the same direction, it must be due to some condition which holds for all powders. It may be explained most easily by supposing that, as the E.M.F. increases, particles that were loose now take part in the conduction, either by movements or by forming temporary chains of particles. The phenomenon may, however, not be so simple. Since the study of a coherer shows that a surface film is necessary, it seems safe to assume that, with all substances which show change of conductivity with time or deviation from Ohm's law, a surface film is also necessary. The spontaneous rise is difficult to understand, unless it has to do with ionisation on fresh surfaces that may be acted upon by the air, as suggested by the following consideration of asymmetry.

The phenomena connected with the asymmetric conduction of powders are very complex, and it is difficult to give any satisfactory explanation of them. It may be explained by considering conduction to take place by means of ions in motion. Suppose in Fig. 3, which represents a contact between particles, greatly magnified, A to be the part of the film between the particles. This film is necessary in order to have coherence phenomena, as there must be something which separates the particles, prevents fusion, and hence causes currents of great density at the points of contact. Suppose B and B′ to be the respective parts of the two particles that are most highly heated, C and C′ to be regions where the heating is less intense.

It will be necessary to make certain assumptions. (*a*) Owing to the high temperatures at contacts between particles, due to great current density, there should be marked changes of the resistance to motion of electrons, or negative ions, which move across the contact. Hence assume the resistance to motion of the ions in the more heated regions, B and B′, to be greater or less than in C and C′, depending on the material of the particles. (*b*) Also assume that the film A, though it may have considerable resistance, has small resistance, as a rule, compared with B and B′.

This will help to explain asymmetrical conduction in which the conductivity in the direction of the current decreases with time, while that in the opposite direction steadily increases. If the hotter parts B, B′ impede the negative ions more, then, if the current flows from D to D′, the ions produced in C will move slower as they approach B. Thus there will first be considerable movement of the ions until there is a kind of opposing assemblage in B. Ions will still pass through and beyond B, but at B′ they will be neutralised by positive charges there, as B and B′ are charged oppositely, and will not pass to any extent into B′ and C′. If, now, the current be reversed, the ions will move back *at a higher rate*, since they are all now moving in the direction of decreasing resistance, and this increased rate means a high initial current. Such a state of asymmetry is found with calcium sulphide and solid silver iodide.

On the other hand, if the regions B, B′ and A offer less resistance to the motion than C and C′, which are cooler, then, when a current is sent from D to D′, ions from C will cross B to B′, where they will be neutralised as before. In this case they pass through a region in which they move constantly faster—*i.e.*, the current increases. A steady state is reached when the velocity at any point in the course remains the same. If the current be now reversed the condition will differ from that which initially held, in that the ions in B will all be moving in the direction of increasing resistance, and hence the current, depending on the rate of motion, will be small. It will increase, however, if time is given for the ions in C′ to pass into B′. This is the case of molybdenite.

It is to be observed that this explanation of asymmetry takes care of the question of the change of conductivity with time. There are, however, certain weak places in the theory. When the circuit is broken, the heated contacts should cool very rapidly, and the resistance should return promptly to its initial value. To account for the facts, it must be assumed, then, that the ions can diffuse, more and more slowly, in the solid substance of the cold particles, as the asymmetric condition changes for some time after opening the circuit, thereafter remaining constant for hours. It is difficult to account for the re-coherence of two copper wires, unless there is initially a semi-solid film on the surface of the copper, and ions become more or less permanently entrapped in this film—which, in part, constitutes B and B′ in the figure—and only slowly diffuse therefrom. With balls of different metals the critical voltage is independent of the direction of the current, but may be less or greater than the critical voltage of either. This is difficult to explain, unless it is supposed that the atoms of the two metals cross the film and combine during the transit to form a single ion.

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"Science Abstracts." July, 1909. Vol. XII. Part 7. Section A—Physics; Section B—Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

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THE ENGINEER AS HIS OWN ARBITRATOR.

It has been the custom of some engineers in drawing up general conditions of contract to insert an arbitration clause and to appoint themselves as sole arbitrator. Fortunately, such a procedure has practically disappeared as far as the consulting engineer is concerned. Many local authorities, however, issue specifications in which the borough engineer, or some other engineering officer of their staff, is responsible for supervising the work, and is at the same time sole arbitrater in the event of dispute. It is a curious idea that a dispute should be decided by one of the parties concerned, and still more so that the process of settlement should be given the high-sounding name of "arbitration." However desirous of impartiality the engineer may be, he cannot well avoid some bias in such a position, particularly when he may have to sit in judgment upon himself. The very natural consequence of such methods has been much discontent on the part of the contractor who, nevertheless, prefers to tender for work under these disadvantageous conditions than to lose it.

If a remedy could be sought in the Law Courts less dissatisfaction might be the result, but as a rule no action can be brought when the parties have agreed to arbitration. Occasionally, however, the condition of affairs is so unsatisfactory that the Courts may think fit to intervene when called upon to do so. A case in point is that of R. W. Blackwell & Co. *v.* the Mayor, Aldermen and Burgesses of the Corporation of Derby. The contract was for the laying down of a tramway, and the general conditions of contract contained a clause of inordinate length giving the

Borough Engineer every conceivable power, and making any award by him final and binding on both parties. The date of completion was fixed, with a penalty of a certain sum per week failing completion at the time named. Although the time for completion was extended by about three months the work was not complete at the expiration of this time, and consequently a deduction of £1,500 was made as liquidated damages for delay. The plaintiffs alleged that there was constant changing of plans from the time the contract was signed; that the Corporation delayed its decisions as to certain interlacing lines and other important matters; that the order in which the work had been agreed to be carried out was subsequently altered, thus rendering the material to hand useless, and necessitating the obtaining of other material before the work could proceed; that a reasonable amount of material was not allowed to be placed on the footpaths ahead of the work; and that an unusual number of samples of sand were rejected, apparently in an unreasonable way. With the truth of these and other allegations we are not concerned, as they will no doubt form the subject of enquiry in due course. They are, however, sufficient to show that the engineer was so far involved in the complaints of the contractor that he could not act well as arbitrator in the matter. This view has been taken by the Court of Appeal, with the result that the arbitration clause has been set aside.

In giving judgment, Lord Justice FLETCHER MOULTON expressed the view that any case of this kind must be decided on the facts, and that, where the nature of the dispute arising from the facts which were subsequent to the contract was such that the tribunal was not likely to be able impartially to deal with the dispute, it was open to the Court, and would usually be their duty, to refuse to enforce the arbitration clause. In the present case the dispute was as to whether the engineer had not from the first acted unreasonably towards the contractor. It could not be said that the arbitrator was an unfit judge merely because he was an officer of the Corporation, but if facts subsequent to the signing of the contract had given rise to a substantial dispute involving allegations of continued unreasonableness on his part, the Court would not be acting in the spirit of the law if the dispute were referred to arbitration. In the opinion of Lord Justice FLETCHER MOULTON, Corporations were often too fond of putting their officers in the position of engineers under a contract. Lord Justice BUCKLEY, in giving judgment, remarked that the matter to be determined was whether the contractual referee was an unreasonable person. The worst possible referee on the question of unreasonable conduct was the person who was accused of being unreasonable. It was not human nature to suppose that he could properly determine whether he himself was an unreasonable person.

We trust that this action of the Court of Appeal will act as a deterrent in future, and that general conditions of contract in the case of local authorities will in future contain an arbitration clause of a more satisfactory kind. If the engineer is a thoroughly competent man he will not fear the risk of arbitration by some disinterested person, whereas if he is afraid of this risk the contractor should certainly not be placed at his tender mercies, and the sooner the engineer ceases to be responsible for such work the better for all concerned.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Dynamobau. By K. PICHELMAYER. Vol. V. of "Handbuch der Elektrotechnik." (Leipzig: S. Hirzel.) Pp. xxiv.+745. M 36.

This is doubtless one of the most important treatises on the calculation and design of electric machinery and transformers that has appeared for some time past, and will certainly rank as a standard work on this subject for some time to come. The author, though now Professor of Electrical Engineering at the Technical University of Vienna, was for several years the chief designer, and afterwards works manager, of the Austrian branch of the Siemens & Halske firm before its amalgamation with the Schuckert Company. Thus from every side, technical and practical, commercial and academical, Herr Pichelmayer is able to write with authority obtained from the best of all sources—experience.

Needless to say, this is scarcely a book for students, or, at least, for young students—it is intended rather for those to whom the underlying principles of electromagnetism have become a second alphabet. This does not mean to imply, of course, that a student has nothing to learn from the book, but it is doubtful whether anyone without practical experience could properly appreciate the vast amount of information here placed before him. On nearly every page of the book instances occur where the practical engineer betrays himself, so to speak; details are given which, to a pure physicist or to one unacquainted with practical requirements, would often have no meaning, but which, to an engineer, are real information. Though scientific, the treatment is by no means involved, whilst the mathematics used are such as one who has passed through a full course of engineering can easily follow. Throughout the book the style is clear and generally concise, though at times the author becomes discursive. This is rather a disadvantage in such a handbook where the subject under treatment has attained such vast dimensions at the present day, as it may easily lead to incompleteness; yet there are few really serious omissions. Of course, it is only to be expected that the present volume is somewhat heavy and bulky, as indeed any complete one-volume treatise of such a matter must of necessity be—even the price would lead a buyer to expect something substantial for his money. But our chief objection to the book is not so much its size, but the fact that it is written in German. Though doubtless this latter language is gradually becoming as important for the English engineer as English is for the German engineer, yet we can well imagine much genuine grumbling at this seemingly unnecessary increase of labour. Surely it will not be long before some of our own technical men—than whom none are better fitted—will take the trouble to record their experience for the benefit of others, so that it will no longer be necessary for specialists to turn continually to outside sources.

Coming now to review more closely the several chapters—of which there are but 10, excluding the introductory matter, which, however, occupies but 32 pages out of the 745—the first thing which strikes the reviewer at a casual glance is the uniform treatment followed throughout. In this way the essential differences of the various kinds of machines are strongly brought out, whilst the many points of similarity do not lead to repetition. On the other hand, this arrangement of the material frequently makes it difficult to find what one wants. The first three chapters include the introduction, a description of the various materials used in construction and a short statement of the fundamental laws on which all electromagnetic apparatus is based.

Chapter IV. deals with windings. Armature windings for continuous-current machines follow Arnold, the pioneer writer on this subject. The section on alternating-current windings is much shorter, but most standard methods are included. In the next chapter the E.M.F.s induced in the several kinds of windings are calculated. A short method is given for finding the E.M.F. of an alternator with a given

field distribution, by replacing the latter by a rectangle, trapezium or sine curve, as the case may be.

Commutation occupies the whole of Chapter VI. The treatment of this difficult matter is simple, though in no way superficial, whilst the contents include most of the results, in a condensed form, which have appeared from time to time in the technical press. Possibly the different types of carbons might have received more attention, for it is just here where experience is of so much assistance.

Two very important chapters then follow. The one deals with the characteristics of the machine when only one winding is active, and the magnetisation curves are found for the several types of winding—concentrated and distributed. The other chapter considers the resultant excitation due to the combined effect of the several windings and constitutes by far the longest, and possibly the most important, in the book, for it contains the theory of the continuous-current machine, the synchronous machine, the converter, the asynchronous machine and transformer and of alternating-current commutator motors. Doubtless many designers will here find several points on which they will not agree with the author, or will prefer other ways of looking at the matter, but throughout the author is quite fair and often criticises the formulæ he deduces as thoroughly as his readers will. Moreover, numerous test results and examples are given from time to time—the former to confirm and the latter to illustrate; this, indeed is one of the most pleasing sides of the book. The section on the method of working of synchronous machines is very complete, whilst the theory of the compensated series motor and the compensated repulsion motor—each supplemented by a practical example—will be welcomed by the ever-increasing number now beginning to study electric traction seriously.

Chapter IX. deals with the losses occurring in electric machines, especial attention being paid to the eddy current losses set up in the copper. The whole of the next chapter is occupied with the temperature rise and cooling of electric apparatus, and much interesting matter on the effect of radiation is brought to bear on the subject. Unfortunately, theory is not of much use to the designer in enabling him to predetermine the heating of his machine. So much depends on the cooling facilities offered by the particular design in question, that it often becomes almost impossible to apply conclusions deduced from other types. Yet this problem is probably the most important the designer has to face, for on it largely depends the minimum amount of active metal which can be used for a given temperature rise.

A long chapter then follows in which the main features in the design of machines and transformers are brought out. In determining the relation between the main armature dimensions and the speed and output, the author shows how the latter can be expressed either electrically or mechanically. He prefers the latter method and proceeds to deduce the output coefficient from the mechanical interaction of the field on the current. We notice the curves of output coefficients obtained agree well with standard practice. Most of the sections in this chapter conclude with a fully worked out example of an actual machine. Following this is chapter XI. on the *mechanical* design and construction of dynamo machines; whilst the book closes with a description of 29 machines and transformers built by various firms. These last two chapters occupy some 170 pages and contain much useful information on what may be chiefly regarded as modern Continental practice, though certain classes of machines, for example, continuous-current machines with commutating poles, &c., might well receive more attention in future editions.

Naturally, in going through a book of this description, there is much the reviewer might criticise, and in places even find fault, but to attempt this on anything like a just scale would need far too much space. Moreover, the fact that the work covers such a large field makes it impossible to review it in the same way as less ambitious treatises. It would be unreasonable to expect all sections to be treated with equal skill, and it must be left for the individual reader to find out those parts that please him best, just the same as with all other works of reference.

But we think enough has been said about the book to indicate the nature of its contents and also their quality. It might be added that the text is excellently illustrated and the diagrams well drawn, though we should have been much better pleased to see explanations placed under the figures—an improvement that we hope will not be lost sight of in future editions. At the beginning of the book besides a detailed list of contents, there is also a convenient table of formulæ and a reference list of authorities quoted, which probably accounts for the somewhat meagre index at the end of the book. We rather think the publisher will already have received complaints about the binding—after a few weeks' rough usage in an office, the present light cardboard covers would afford little protection to a book of this weight and bulk. Surely one who is willing to pay 36s. for a book would willingly pay two or three shillings more and have it properly bound.

This book ought to have a place in the technical library of every firm and college in the country. STANLEY P. SMITH.

Electricity in Factories and Workshops. By A. P. HASLAM. (London: Crosby, Lockwood & Son.) Pp. xvi.—306. 7s. 6d. net.

This publication deals, in a very practical manner, with the costs, advantages and disadvantages of the electric drive in factories, discussing at length the pros and cons of public and private supply.

Chapters I. to III. give descriptions of the different types of motors and accessories available for factory installations. In dealing with the polyphase squirrel-cage motor, the author points out that the arbitrary rule made by some supply authorities in limiting the size of squirrel-cage motors to 3-5 H.P. is not altogether to their (the authorities') advantage, and expresses the now generally accepted view that the installing of squirrel-cage motors in the larger sizes is most desirable, from the "supply" point of view; the low first cost of this type of motor, its simplicity and negligible maintenance, being one of the best advertisements "supply" could devise for reliability of the electric drive. The great extension of power business by the Newcastle-on-Tyne Electric Supply Co. is attributed to the encouragement of the installation of squirrel-cage motors. Mention is made of single-phase variable speed commutator motors, but it is stated in error that commutator motors cannot, at present, compare in price with induction motors for equal output.

Considerable stress is laid on the necessity of starters and regulators being as carefully chosen as the motors themselves, it being pointed out that insufficient attention paid to the buying of these accessories is a most fruitful cause of the breakdown of the electric drive. A minute description of the various kinds of controllers and starters is given.

Chapter IV. takes up the important question of motor rating and efficiencies, and motor buyers would do well to study it carefully. The author is particular to point out that the British manufactured motor is well able to hold its own against foreign competitors, a fact recently demonstrated by several large contracts placed during the last year.

The cost of energy (generated in the factory) receives attention next. The small power user is dealt with by himself, and comparisons of cost in relation to plant load factor are well and clearly put. The comparative figures given for the cost of large power users are somewhat open to criticism. For instance, a figure of 13½ per cent. per annum is given as sufficient to cover interest, depreciation and repair charges on a generating plant using suction gas as a source of power, thus crediting the plant with a life of 12 years (interest at 5 per cent.) a figure yet to be reached even under the best conditions. The fuel cost, namely, 0·4d. per unit, given for such a plant again is open to criticism, considerably lower figures being quite common in practice.

Chapter IX. takes up the matter of power station tariffs, explaining the various charges and the reason for their existence in a clear and concise way. Close comparisons from the factory owner's point of view are made between the cost of energy taken from an outside supply, and the cost for home

generation. The figures for the latter again appear, however, to err slightly on the high side.

Passing on, a long account is given of the electric driving of textile mills, the application of the motors to the different machines being dealt with in considerable detail. Other particular descriptions are given of the electric drive, special notice being given to printing and engineering workshops.

This work should prove a most useful addition to the library of the commercial supply engineer. The way in which supply costs are set forth should be instructive to power users and *some* power sellers; a number of the former are prone to count their fuel and labour costs as the total expenditure for power. One would imagine that it would pay power sellers to circulate copies of this book among the works managers of the factories they are anxious to supply. It should lead to business.

A. Hugh Seabrook.

THE PROPOSED INTERNATIONAL UNIT OF CANDLE POWER.*

BY C. C. PATERSON.

The intercomparison of light units between the National or other standardising laboratories of America, France, Germany and Great Britain has been proceeding at intervals since 1905. The values which have been obtained for the ratios between the different units are now found to be in sufficiently close accord to warrant the establishment of a working basis of agreement between this country, America and France in the matter of a common unit of candle power. The possibility of agreement between the British and French units was demonstrated by Dr. Glazebrook in a Paper on light standards read before the B.A. at Dublin in 1908.† The chief factor in the present movement has been the desire of the authorities in the United States to establish one unit for both gas and electrical industries in that country, and the possibility of their adopting a unit which should be identical with those existing in Great Britain and France led them to take the initiative in an attempt to obtain international co-operation. The agreement which has resulted has the approval of the Metropolitan Gas Referees, and now forms the subject of an announcement which is reproduced as an appendix to the Paper (*see* The Electrician, Vol. LXIII., p. 215).

Dr. J. A. Fleming discussed the question of light standards very fully in his Paper before the Institution of Electrical Engineers.‡ Some facts, however, connected with the units in question have a more especial bearing on the experimental results, and should be borne in mind in connection with the table of ratios given (*loc. cit.*).

The British Unit.—As defined in the above-mentioned recommendation, the unit of candle power in this country is the Harcourt 10 c.p. pentane lamp burning in an atmosphere at normal barometric pressure and containing 8 litres of water-vapour per cubic metre as measured by a ventilated hygrometer. A difficulty arises in the use of all flame standards in connection with the method to be employed for measuring the humidity. When flame lamps are burning in a closed room it is well known that their candle power diminishes, due probably to the vitiation of the air in the immediate neighbourhood of the flame.§ Two standards will not necessarily diminish in candle power at the same rate, and it is therefore necessary to take readings after the air of the room has been changed and before the candle power of the lamps has had time to be affected. The method of measuring humidity must therefore be a rapid one, and it is now generally agreed that from considerations of accuracy and quickness of reading the ventilated hygrometer is the best instrument to use.‖ In the German and French comparisons this has been used, but in the English comparisons (as reported to the Photometric Commission meeting in Zurich in 1907) (*see* The Electrician, Vol. LX., p. 6) the unventilated hygrometer was employed,¶ and in the tables published in the proceedings of the Commission the author's results are given in terms of humidity measured by this instrument. The ratios tabulated in the present Paper are corrected so as to be in terms of the ventilated hygrometer. In each case values are taken for the humidity at which each lamp, in the country where it forms the standard, is considered to give its nominal candle power.

The Unit of the United States of America.—In the initial adoption of a unit of candle power the United States of America endeavoured to make its value as nearly as possible the same as that accepted at the time in this country.* This was before Prof. Vernon Harcourt and the Metropolitan Gas Referees (London) had established the 10 candle pentane lamp on the present definite basis. The American Institute of Electrical Engineers recommended the derivation of their unit from the Hefner lamp by increasing its value in the ratio of 0·88 to 1. This seemed at the time, from different observers' work, to be the most probable ratio between the Hefner and British units. The gas industry in America, however, did not follow this course but developed their unit along the lines of the 10 candle pentane lamp.† The result is that there has been, up to now, an appreciable difference between the units adopted in the two industries in that country. The Illuminating Engineering Society and other bodies took the matter up energetically, and the Bureau of Standards, Washington, now has the support of the leading institutions in America, in defining the value of a common standard, to be accepted throughout the States. This Institution has ascertained by means of electric intercomparisons the ratio of their present unit to those of Germany, France, and Great Britain respectively,‡ and has arranged to adjust the value of the American unit as already indicated.

German Unit.—The unit accepted in Germany is the light given by the Hefner lamp burning in an atmosphere at normal barometric pressure and containing 8·8 litres of water vapour per cubic metre. The researches of Liebenthal§ at the Reichsanstalt on the Hefner lamp and the variation of its candle power with atmospheric change were the earliest systematic experiments undertaken of this nature and are too well known to require more than passing mention.

French Unit.—The Candle Power Unit adopted by the electrical industry in France is the Bougie Decimale. This is the 20th part of the light given out by a square centimetre of platinum at the temperature of solidification. The unit was suggested by M. Violle and adopted by the Congrès International des Electriciens in 1881. This standard has been found very difficult to reproduce, and the French authorities still use the Carcel lamp, burning colza oil, as the standard for all photometric work. A determination of the value of the Carcel lamp in terms of the Violle platinum standard has only been made once. This was by M. Violle himself in 1884.‖ Measurements were made by him using two or three photometric methods, and all his values except one showed the bougie decimal to be a little less than 4 per cent. greater than the Carcel unit. A multiplying factor of 1·04 for the Carcel unit was therefore given by him, and has been adopted ever since for reducing the values in terms of one standard to those of the other. As no account was taken by M. Violle of the pressure and humidity of the atmosphere in which the Carcel lamp was burning, the accepted figure of 1·04 must be regarded as liable to a certain inaccuracy due to this cause. It should be remarked, also,¶ that no correcting factor has as yet been determined for the variations in the candle power of the Carcel lamp due to atmospheric changes. Hence, in the table given later on in the Paper a correcting factor has had to be assumed in cases where the Carcel lamp is corrected for a difference of humidity.

Accuracy of Comparisons.—It is well to explain in giving the results of experiments that different limits of accuracy must be attributed to photometric measurements of different types of standards. It is usual in giving photometric results to write down the fourth figure, but even in the most favourable circumstances this must be written small and the value considered liable to an error of + or − 0·1 per cent. In the case of the best comparisons of electric sub-standards this inaccuracy should not be occasioned by imperfection in the bench or photometer head nor yet to the electrical measurements, but must be attributed, in the author's opinion, chiefly to want of constancy in the individual who is making the photometric observations. In some of the comparisons which are tabulated the electrical measurements are probably not so accurate

* Paper read before the Physical Society, June 11, 1909. The appendix is omitted owing to previous publication.

† B.A. Report, 1908, Dublin, "The Photometric Standard of the National Physical Laboratory": The Electrician, Vol. LXI., p. 983.

‡ Fleming, The Electrician, Vol. L., p. 438. See also Paper by the author, The Electrician, Vol. LVIII., p. 560.

§ Report Amer. Gas Inst., "Methods of taking C.P. of Gas," Illum. Eng., 1909, p. 203.

‖ "Proc." Roy. Soc. Edinburgh, Vol. XLIII., 1905; also "Zur Kenntniss des Ventilierten Psychrometers," Akademische Abhandlung der Fakultat der Universitat zu Upsala, by Aron Svensson, 1898.

¶ *See* B.A. Report, Dublin, 1908.

* "Bulletin" of the Bureau of Standards, Vol. III., No. 1, p. 65; Report to the American Gas Institute on "A Unit of Light," Journal of Gas Lighting," Vol. CIV., 1908, p. 426.

† "The Working Standards of Light and their Use in the Photometry of Gas," Ch. O. Bond, Franklin Inst., 1908.

‡ Ref. cit.

§ "Zeitschrift fur Instrumentenkunde," Vol. XV., 1895, p. 157.

‖ Séances of the French Physical Soc., May to July, 1884.

¶ "Rapport de Trois Lamps," Laporte and Jouaust, Bull Soc. Inst. des Elect. 2nd série, tome VI., No. 58.

Table *giving determinations of the Ratios of National Candle Power Units from 1903 to 1908.*

Pentane British. Bougie Decimale French. Hefner German. Bureau of Standards U.S.A.

	Electric Comparisons.									Direct Comparisons.			
Column............	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Tests conducted by	Sharp 1903.	Paterson, 1905.	Fleming, 1905	Hyde, 1906.	Laporte and Jouaust, 1907.	Laporte, 1907.	Rosa, 1908. Spring.	Rosa. 1908. Autumn	Laporte, 1908.	Paterson.	Liebenthal.	Perot and Laporte.	Photometric Commission, Zurich,* 1907.
Number of Lamps.........	...	6	3	12	6	2	12	6	11	...	...	...	...
A { Hefner / Pentane Unit }	...	0·89$_5$	0·88	0·89$_3$	0·90$_8$	...	0·89$_6$	...	...	0·90$_2$	0·90$_4$	0·92$_1$	0·90$_2$
B { Bougie Decimale / Pentane Unit }	...	...	...	0·99$_8$	1·01	1·00	1·00$_8$	...	1·00$_8$	1·00$_6$	1·00	1·01$_9$	1·00
C { Bur. of Standards / Pentane Unit }	...	...	...	1·01$_6$	...	...	1·01$_5$	1·01	...	...	...	...	...
D { Pentane Unit / Hefner }	...	1·12	1·13	1·12$_0$	1·10$_1$	...	1·11$_6$	...	...	1·10$_5$	1·10$_6$	1·08$_6$	1·10$_1$
E { Bougie Decimale / Hefner }	1·11	...	...	1·11$_6$	1·11$_8$	...	1·12$_4$	...	...	1·11$_8$	1·11$_6$	1·11$_7$	1·11$_6$
F { Bur. of Standards / Hefner }	...	...	...	1·13$_8$	...	...	1·13$_1$	...	...	...	...	...	...
G { Pentane Unit / Bougie Decimale }	...	...	...	1·00$_2$	0·98$_7$	0·99	0·99$_2$	...	0·99$_2$	0·99$_1$	0·99$_4$	0·98$_1$	0·99$_2$
H { Hefner / Bougie Decimale }	0·89$_4$	...	...	0·89$_6$	0·89$_8$	...	0·89$_0$	...	...	0·89$_4$	0·89	0·89$_5$	0·89$_4$
I { Bur. of Standards / Bougie Decimale }	...	...	...	1·01$_8$	...	...	1·00$_6$	...	...	...	...	...	...
J { Pentane Unit / Bur. of Standards }	...	...	...	0·98$_4$	...	...	0·98$_5$	0·98$_4$	...	...	...	...	...
K { Hefner / Bur. of Standards }	...	...	...	0·87$_8$	...	...	0·88$_4$	...	...	...	...	...	...
L { Bougie Decimale / Bur. of Standards }	...	...	...	0·98$_2$	...	...	0·99$_4$	...	...	...	...	...	...

* Pentane values corrected to a humidity of 8 litres of water vapour per cubic metre of air.

as in others. The fuller appreciation, however, of the exact values of the national and international electrical units which has recently resulted from the labours of the International Conference, makes it possible now to attain an accuracy which leaves nothing to be desired from this point of view.

As matters stand now, undoubtedly the photometric comparisons in which the highest precision is attainable are those between properly seasoned electric glow-lamps of the same coloured light. With a potentiometer which is accurate to 1 part in 10,000 and a substitution method of photometric comparison * on a bench which can be read to 0·5 mm., an accuracy is attainable with a set of good sub-standards in which the fourth figure is almost definite. When, on the other hand, comparisons are made against or between flame standards, the probable inaccuracy is greater. How much the inaccuracy is must depend largely on the flame adjustments and the consistent behaviour of the standard in question. It also depends upon the accuracy of measurement of atmospheric conditions and the precise knowledge which we have of their effect on the light of the standard lamps. It follows from this that a relatively large number of observations must be made, when using a flame standard, if the same order of accuracy is to be attained that is possible with a much smaller number of electric comparisons. It must further be remembered when considering the question of photometric measurements to two or three parts in a thousand that the estimation of the height of the flame in some lamps, or the exact reproduction of the standard conditions, may not be identical when carried out by different observers. Hence it is conceivable that owing to this cause the observations in one laboratory on some flame standard may differ consistently by a small amount from those in another on the same standard. This, however, is not the case when electric sub-standard comparisons are made, if the electrical measuring apparatus is accurate. To a certain extent, therefore (in some cases more than others), a flame standard needs to be "interpreted" when its absolute value is desired to a high accuracy.

The value of electric sub-standards comparisons thus becomes apparent. If (as is generally the case) a laboratory has sets of electric sub-standards which have been compared at intervals for years with the primary flame standard whose value they represent, an opportunity is given for realising the absolute value of this unit to an accuracy which could hardly be attained with certainty by others who might endeavour to reproduce it in a single set of observations, however carefully made. When these electric sub-standards are intercompared through the medium of a travelling set of lamps, there is no reason why we should not obtain accurate knowledge of the relative values of the different units as each is interpreted in the country where it is the recognised standard.

The ratios between the four units of light given in the table are the results of measurements which have been made at the specified laboratories in the four countries concerned. Other determinations were made previous to these,* but the standards used for obtaining the British unit were of several different forms and the atmospheric conditions have not always been taken into consideration. I have deemed it desirable, therefore, to insert only the more recent determinations, in all of which the 10 candle Harcourt pentane lamp has been used and atmospheric changes have been allowed for.

The table is divided into two portions. Columns 1 to 9 give the various ratios obtained through the medium of electric lamps which have been measured at some or all of the laboratories. These have been chiefly initiated by the Americans, who have from time to time sent sets of lamps to Europe to have values assigned in London, Paris, and Berlin. It is not suggested that all the results given in the Table should receive equal weight. In some of the electric comparisons the conditions allowed of a greater accuracy than in others, when fewer lamps were employed and time only allowed a single set of measurements to be made. Columns 10, 11 and 12 contain the values which resulted from the intercomparison of flame standards undertaken at each of the laboratories. These were initiated by the International Commission on Photometry and gave a set of ratios which brought the knowledge of the relative values of the candle power units to within an accuracy of about + or − 1 per cent. As in the case of the electric comparisons, the conditions in some cases probably allowed of a higher accuracy than in others —but the results of all the measurements have been tabulated in order that the bearing may be seen of each on the agreement which has been established.

* See "Photometry of Electric Lamps," by Dr. J. A. Fleming, M.A., F.R.S., "Journ." Inst. Elect., Eng., Vol. XXXII., p. 144, and The Electrician, Vol. L., p. 438.

* For a discussion of these, see J. A. Fleming, "The Photometry of Electric Lamps," ref. cit.

The first series of ratios (columns 1 to 9) may therefore be regarded as representing the ratios of the standards as they are interpreted in the countries to which they belong, whilst in the second series we have the interpretation of the values of the standard lamps by experimenters who are not so accustomed to their manipulation. Lines marked A, B, C, give the values of the standards in terms of the pentane unit. D, E, F, give them in terms of the hefner and similarly other sets are in terms of the Bougie Decimale and the Bureau of Standards candle.

Without going into detailed comments upon the experiments from which each ratio in the table is derived it will suffice to say that as far as the electric lamp comparisons are concerned, greatest stress should be laid on the results in columns 4 and 7. This is partly on account of the large number of lamps employed, and also because of the more prolonged measurements made. Line J illustrates the high accuracy it is possible to secure in comparisons of this nature. In the certification of glow lamps in terms of the hefner unit the Reichsanstalt only give candle power values to the nearest 1 per cent. If the average of 10 or 12 lamps is taken the error thus introduced is probably not great, but when the number is small, appreciable inaccuracies may be introduced into the mean, and the rather low value obtained by Fleming in 1905 may be attributed to the fact that only three lamps were tested.* As regards the flame lamp comparisons, it will be noticed that Perot and Laporte (Column 12) found a value for their pentane lamp which was appreciably lower than that obtained by other observers. Except for this difference the agreement between the ratios is fairly close. The exceptionally close agreement shown in columns 10, 11 and 12 for the ratio Bougie Decimale/Hefner can only be attributed to a coincidence, since in the experiments from which two of the three ratios were determined the observations varied between 3 and 4 per cent. from the mean. The chief point of interest in these comparisons is the near coincidence of the value of the Bougie Decimale with that of the pentane unit as indicated by lines B and G. An inspection of these values indicates that the Bougie Decimale, as interpreted by the Laboratoire Central, may be slightly larger than the pentane unit—but the amount is less than 1 per cent. When we remember that, at present, the value of the Bougie Decimale depends on the interpretation of the Carcel lamp and the ratio between it and the platinum unit, determined by Violle in 1884, it must be admitted that this small apparent difference is well within the limits of the errors of experiment.

The second point to notice is the difference of 1·6 per cent. between the units of the Bureau of Standards and the National Physical Laboratory. It is generally recognised† that the unit at present adopted by the gas interests in the States is about 4 per cent. smaller than the Bureau of Standards unit. It will then be seen that by lowering the value of their unit by 1·6 per cent. the Bureau comes into exact agreement with this country, and approximately halves the difference between the units employed by the gas and electrical industries in the States.

A further point of interest and importance which results from the comparisons (*see* line A in the table) is that the Hefner unit is in the ratio 9/10 to the new candle. The French authorities have for some time taken the ratio Hefner/Bougie Dec. as 0·895. It is of interest, therefore, to see from lines A and H how nearly the value for the Hefner unit in terms of both Pentane and Bougie Dec. units approaches the figure 0·90. The mean of all the ratios Hefner/Pentane comes to $0{\cdot}90_0$, and those of Hefner/Bougie Dec. to $0{\cdot}89_5$, so that, although the comparisons between the Pentane and Bougie Decimale units indicate a difference of 0·8 per cent., the same units compared through the Hefner standard only appear to differ by 0·5 per cent.

DETERIORATION OF LEAD CABLE SHEATHS.‡

BY T. G. SPENCER.

The causes for the deterioration of cable sheaths can be divided into six general groups: (1) Mechanical injury, (2) chemical decomposition, (3) electrolysis, (4) vibration, (5) lightning, (6) impurities in the lead. The famous cable bug of Australia, whose work has been found also in the south-eastern portion of the United States and in southern California, might be added as a seventh. Mechanical injuries are the most frequent in occurrence, being responsible for much more than half of the cable troubles. Too great care cannot be exercised in the placing of aerial and underground cables.

The second and third causes—chemical decomposition and electrolysis—can best be taken together. The theory of electrolysis most familiar is that cables picking up stray currents become a part of the return circuits. Where the current enters the cable no damage is done, but when the current leaves the cable in a moist spot, as is usually the case, the water is decomposed and free oxygen is liberated, which readily attacks the lead sheath, decomposing it. When water is absolutely pure it has no action by itself, but in the presence of the free oxygen in the air the lead is quickly attacked with a formation of hydrated oxide, which is appreciably soluble in water and forms an alkaline liquid. When carbonic acid is present, or nitrate of ammonia, the action is intensified. In ducts which are not properly drained this is particularly noticeable. The water percolates from the surface, and in traversing through the ground picks up the sulphur and nitrogen compounds that are in the coal gas with which the ground is permeated. As a rule, it also gathers some chlorine; then while working into the duct, through the ordinarily poor cement joint, it gathers up carbonate from the cement. The water also takes up a certain amount of tannin from the leaves, grass, twigs, &c. Therefore, when the water finally reaches the inside of the conduit it is ready to begin the attack on the lead and convert it into a poor species of white lead—an action otherwise called electrolysis. For the protection of cables from electrolysis there are but three things to do: (1) Build the conduit so that no water will ever lie in it—*i.e.*, with a slope from the middle of the duct both ways to the manholes; (2) try and make absolutely watertight joints; (3) continually make electrical surveys, and earth the cable whenever necessary.

Sulphur dioxide also causes trouble. This gas comes from the burning of coal, and is especially bad for cables near railroad yards and under railroad bridges. Sulphur and nitrogen compounds in coal gas are also a source of much annoyance and tend to corrode lead very fast. Certain factories produce gases which are highly injurious, and smelters have been known to cause much trouble in their vicinity. The application of an asphalt paint to the exposed cables is suggested, but it is not certain that this would be entirely successful in preventing this trouble.

Vibration, although undoubtedly responsible for the loss of many cables, usually operates in conjunction with some of the other causes mentioned. Too little slack in a cable is a serious defect in construction, because when the messenger gradually elongates there is no provision for the greater arc of the span and the lead sheath must stretch, and, consequently, thin out and draw apart. Lead has rather a high coefficient of expansion and contraction with changes of temperature, so that where a cable has been strung in summer with insufficient slack the natural result is a stretching of the lead with the coming of winter. The use of long spans merely intensifies all of the phenomena just mentioned. Cables suspended from vibrating structures are frequently in danger.

The last cause to be considered here is impurities in the lead. The impurities most commonly found in lead are iron, antimony, sulphur, zinc, arsenic, silver and tin. For the most part these foreign substances are removed at the refineries, but that some remain when received at the factory is shown by the dross on the surface of the molten lead in the kettles. This dross is removed until only a thin film of lead oxide (litharge) remains on the molten surface, showing that no impurities are left. In very rare instances in pressing the sheaths it happens that a lump of dross or an accumulated bit of litharge is imprisoned in the cylinder and is run out as a part of the sheath. This foreign substance is soft and breaks up easily, allowing moisture to enter the cable. Possibly the litharge is occasionally, by further oxidation, converted into red lead.

There is no way to preserve cables other than to avoid, where possible, the dangerous conditions pointed out. The presence of 1 to 3 per cent. of tin in the lead sheath is of great service in the work of construction, particularly in case of underground cables, helping to maintain the shape of large cable. Tin hardens the sheath, making it less subject to mechanical injury, and in that way adding to its life. It is doubtful, however, if the use of tin will lessen chemical action or crystallisation. The use of sheaths heavier than the so-called standard is advocated by many, but no thickness of lead will render cables indestructible.

The Spark-gap of an Induction Coil.—In a recent communication to the Royal Society of Edinburgh, Dr. Dawson Turner describes the results of introducing a solid dielectric between the electrodes of an induction coil when these have been placed at such a distance apart that a spark will not pass easily. Mica, sulphur, glass, ebonite, &c., will facilitate the sparking if placed near or against the positive pole, but will not have this effect if placed against the negative pole.

* *See* Discussion by Dr. Fleming of the Author's Paper on "Investigation of Light Standards, &c.," THE ELECTRICIAN, Vol. LVIII., p. 641.

† Report of Committee on Nomenclature and Standards, Annual Conv. Illum. Eng. Soc., Oct. 5, 1908, Dr. A. C. Humphreys.

‡ Abstract, from the "Mining World," of a Paper read before the Conference Committee of Representatives of Independent Telephone Operating Companies.

CORRESPONDENCE.

FEEBLY DAMPED OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the article "A Method for Producing Feebly Damped High-Frequency Electrical Oscillations for Laboratory Measurements," by L. W. Austin, in THE ELECTRICIAN of July 30th, I should feel obliged if you will allow me to remark that the principle of the arrangement designed by Austin, which, according to the foot-note of the article, is also employed in the wave-meters of the Telefunken Company and the Amalgamated Radio-Telegraph Company, is not a new one, but was first designed and published by me in my former patents (German Patent 157,056, English Patent No. 28,166, &c.). This principle is simply that by the sudden interruption (in a shunt-circuit, and best by a vacuum-interrupter) of the current and through this by the sudden disappearance of the current in the self-induction coil, an extra current is generated, which is then oscillating (with correspondingly increased potential amplitude in comparison with the ordinary amplitude of the condenser oscillations) in a thoroughly closed and therefore very feebly damped circuit.

When I offered at the time my patent to the Telefunken Company, and later on to the Amalgamated Company, it was said by the former company to be absolutely worthless, and the latter company declared that they would not make use of it. Now that the patents have been allowed to expire this arrangement is universally employed as the so-called "Eichhorn arrangement for feebly damped oscillations," and is considered essential for exact measurements in wave-meters and station controllers (Stationsprüfer).

Trusting that you will be kind enough to allow this statement to appear in one of the next numbers of THE ELECTRICIAN, I am, &c.,

Zürich, Aug. 7. DR. GUSTAV EICHHORN.

THE NEW TELEFUNKEN METHOD OF WIRELESS TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 30, 1909, I notice that Dr. Eccles refers to the stranding of the conductors carrying high-frequency currents as one of the chief improvements introduced by Count Arco and the Telefunken Company into their new apparatus.

Moreover, when speaking of the methods adopted by various experimenters for reducing the ohmic losses in conductors, he refers to this stranding as the "German method," and, mentioning no other system employing the said means, he seems to imply that it is the invention of the Telefunken Company and is used solely by them.

This, I may say, is hardly correct, as the reduction of ohmic losses in conductors by stranding is strongly advocated by Sir Oliver Lodge himself, and is employed in the Lodge-Muirhead apparatus; in Sir Oliver Lodge's words, "Another precaution that must be taken to keep the tuning sharp—that is to say, not to damp out the oscillations at these very high frequencies—is to have the conducting wires so composed that they shall offer plenty of surface to the æther. To this end they must be *finely subdivided into insulated strands*, because otherwise, if they were solid conductors, only their exterior surface would take part in conducting the current, and therefore the resistance would be very high, and the oscillations would be killed. But by using as conductors a bundle of a *very large number of excessively fine insulated copper* wires of high conductivity, sufficient total surface is exposed to give admirable conducting power even to disturbances of the highest frequency used."

In view of the above, it seems scarcely justifiable to attribute the "extreme stranding of the conductors carrying heavy oscillatory currents" entirely to the German system, and at least the name of the Lodge-Muirhead Syndicate should have been mentioned in this connection.—I am, &c.,

Muswell Hill, N., July 31. PHILIP R. COURSEY.

We have submitted the above letter to Dr. Eccles, from whom we have received the following reply:—

SIR: The fact that the conductance for high-frequency currents of a finely-stranded cable is proportional to the square root of the number of strands has been well known more than 20 years. I did not mean to suggest that the Telefunken engineers are the first to advocate the utmost application of this principle; I rather wished to say that so far as is known to me they are the first to carry extreme stranding into practice on the large scale, and to demonstrate publicly its feasibility and advantages.—I am, &c., W. H. ECCLES.

Battersea, Aug. 6.

THE HIGH-PRESSURE SPARK-GAP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Prof. Fleming's interesting and excellent book, "Hertzian Wireless Telegraphy," which first appeared in the "Popular Science Monthly," January—December, 1903, he kindly mentions some experiments made by me, with a high-pressure spark-gap, in connection with a Tesla induction coil ("Phil. Mag," 1902, 6th series). In a foot-note the professor adds that Mr. Marconi, in his patent 12,039, 1896, includes the use of compressed air round the spark-gap. As the mention of insulated balls separated by compressed air or gas occurs in the provisional but not in the final specification, or in the claims of this patent, I conjecture that it was not at the time thought to be of very great importance. Respecting this form of spark-gap, I was, I regret to say, at the time quite ignorant. There is, no doubt, much yet to be done by experimenting with a spark-gap under pressure, not only with air, but with different gases, and probably the results following the use of CO_2 will be found of some interest; also the behaviour of a spark-gap of the disc type, subjected to gas pressure of considerable magnitude. Recently, while searching through the "Phil. Mag." on another subject, I found the following references to early work on the pressure spark-gap: Wolf, Vol. XXXVII., "Ann. der Phy."; by Macfarlane, in (5) 10, 1880, "Phil. Mag." ("Air and Liquid Dielectrics"); Baille, from "Ann. de Chim.," (5) 29, 1883, "Phil. Mag."; Liebig (5) 24, 1887, "Phil. Mag." These may possibly be of use to those working on this subject.—I am, &c.,

Lymington, Aug. 6. F. JERVIS-SMITH.

THE "C.M.B." AUTO-CONVERTER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to Mr. Murphy's reply, published in your issue of July 30th, we must again say that all his statements regarding the "C.M.B." machine are incorrect. We, however, agree with the principle that for the greatest efficiency and economy of material a transformer should have approximately equal losses in primary and secondary sections, and from the following table, which has been made up from three machines recently despatched, it will be seen we are quite alive to this fact:—

Transformation ratio.	Ratio of primary losses to secondary losses.
4 : 1	1 : 1·17
3·7 : 1	1 : 1·01
4·5 : 1	1 : 1·03

It will be noted there is a great difference between these figures and those attributed to the "C.M.B." machine by Mr. Murphy.

We again repeat (and perhaps Mr. Murphy will very carefully consider this statement) that the chief reason why this type of machine can show such a high efficiency is that the whole of the armature conductors are common to both motor and generator fields, and in this respect the "C.M.B." machine is the exact equivalent of the double-wound machine and not, as stated, the equivalent of two separate machines mechanically coupled together. Also, all the copper is fully utilised and never overloaded.

In conclusion, we may state that because of the economic applicability of the principle involved, the "C.M.B." machine is more efficient than any other split voltage machine yet designed, but we await Mr. Murphy's design with considerable interest. Let us suggest that this design be equivalent to the 480/65 volt 5 kw. converter with the efficiency of 88 per cent. Also let us suggest that it has the same regulating properties as the "C.M.B." pattern.—We are, &c.,

J. C. MACFARLANE.
Chelmsford, Aug. 11. H. BURGE.

REPULSION MOTOR WITH VARIABLE-SPEED SHUNT CHARACTERISTICS.*

BY E. F. W. ALEXANDERSON.

Although the advantages of alternating current for industrial plants are generally recognised, it is often necessary to recommend the use of direct current because many machines require a motor with adjustable speed. The direct-current shunt motor is the only one on the market which fills this requirement. The author first presents a theory of the alternating-current machine in such a way as to indicate the possibilities of developing an alternating-current motor with the required characteristics. The subject can be made clearer by departing from the theory of the rotating field; the latter will be treated as if it were composed of two alternating fields at right angles to each other. In an ordinary induction motor, the two fields are of equal strength, and the E.M.F. of rotation will be completely neutralised by the E.M.F. of alternation when the motor has reached synchronous speed. The armature has a tendency to run at a speed at which the induced currents are a minimum. All motors of this kind have only one free running speed, which is that of synchronism. This is true with motors of the commutator type, as well as the squirrel-cage and collector type, provided that the brushes are short-circuited.

The condition which determines the speed of an alternating-current motor may be stated briefly as: The motor tends to run at a speed at which the sum of all the E.M.F.s in each of the armature circuits is zero. The two sets of brushes in a repulsion motor of the compensated type may be classified as the main brushes and the exciting brushes; the main brushes carrying the energy current of the armature, the exciting brushes carrying the magnetising current.

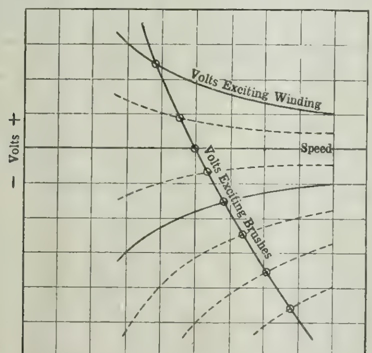


FIG. 1.

If the main brushes as well as the exciting brushes are short-circuited, the motor will act like a single-phase induction motor. The equilibrium of voltages that exists at synchronous speed, when both sets of brushes are short-circuited, can be disturbed by introducing a voltage from the outside into either the circuit of the main brushes or the circuit of the exciting brushes; and it can be shown that in doing so another equilibrium can be established by changing the speed of rotation.

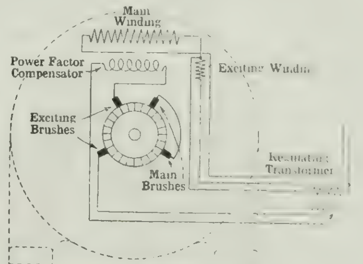
The relation between speed and field strength and the impressed voltages can be expressed as follows:—

Speed = synchronous speed $\sqrt{(E \pm e)/e}$ and F_1/F_2 = speed/synchronous speed, where E is the voltage impressed on the stator winding reduced to number of turns in the armature, and e is the voltage impressed on the armature. F_1 and F_2 are the two components of the field in the axis of the exciting brushes and the axis of the main brushes respectively. The voltage which is impressed on the armature may be either positive or negative, and consequently the speed can be regulated below synchronous speed as well as above synchronous speed. This method for speed variation described can be classified as armature control, because the functions correspond to those of a direct-current shunt motor when the speed is varied by raising and lowering the line voltage.

The second method for varying the speed of the repulsion motor follows logically. The short-circuit is maintained on the main brushes, while an external voltage is impressed upon the exciting brushes. In order to make the impressed voltage effective for speed variation, it should be in phase with the voltage of alternation and the voltage of rotation of the same circuit. These voltages in the exciting circuit are out of phase with the line voltage and consequently, the line voltage cannot be used for varying the speed; however, if the motor has an exciting winding, like a plain repulsion motor, in addition to the exciting brushes, a voltage is found on the terminals of the exciting winding which has a suitable phase to be used for speed variation by field control. The equilibrium of voltages is reached by a combined change of field strength and speed, for the same reason as in the case of armature control.

The relation of voltages which gives the equilibrium in the two-brush circuits is not quite as simple to calculate as is the case of armature control; because the voltage impressed upon the brushes for the sake of speed variation is not derived from a constant source of potential, but from a winding which delivers a voltage that is in itself a function of the speed. However, the relations become comparatively simple by returning to the theory of the plain repulsion motor and plotting curves for the voltage that would naturally occur at the exciting winding and the exciting brushes at different speeds. The voltage of the exciting winding is always positive, but varies inversely with the speed; while the voltage of the exciting brushes is positive below synchronous speed and negative above synchronous speed. Fig. 1 shows curves of these voltages plotted on the same sheet. Only one curve is shown for the voltage of the exciting brushes, while the voltage of the exciting winding is plotted on the positive as well as on the negative side. The dotted curves indicate different voltages that may be derived from the exciting winding by the use of a step-up and a step-down transformer. The points marked in the intersections between the curves indicate equilibrium of voltages that may be obtained at different speeds by impressing on the exciting brushes the different voltages derived from the exciting winding.

The tests, which have been made on a 30 H.P. 25-cycle motor and a 3 H.P. 60-cycle machine in order to demonstrate the possibilities of the alternating-current shunt motor, confirm entirely the theory given above. A practical control diagram for the motor with field control is shown in Fig. 2.



Shunt Repulsion Motor with Field Control
FIG. 2.

The power factor of any commutator motor with shunt characteristics, single-phase as well as three phase, can be regulated in a manner similar to that of a synchronous motor. The power factor regulation consists in superimposing a wattless current upon the current that would otherwise be taken by the motor. It is known from the theory of the synchronous motor that the power factor can be maintained practically at unity between no load and full load with one fixed excitation provided the excitation has been adjusted for the average load. The same is the case with the commutator motor. The regulation of the field for the purpose of adjusting the power factor is accomplished in the commutator motor by a transformer or a coil in the stator winding, connected so as to introduce a fraction of the line potential in the exciting circuit.

The author finally refers to the possibilities of the three-phase motor with shunt characteristics. The possibility of such a motor was demonstrated theoretically by Georges about 10 years ago, and tests of such a motor were made several years ago by Eichberg and Alexander. The speed variation of the Georges three-phase shunt motor is obtained by maintaining a constant field and adding or subtracting voltage to the armature circuit. The power-factor of the three-phase shunt motor can be regulated as described above.

In conclusion, speed variation by armature control is particularly applicable to those cases in which the torque increases with the speed, and field control to those cases in which the torque decreases with the speed. With armature control a speed variation can be obtained of 3 to 1; whereas with field control the variation is limited to a range of from 1·5 to 1. It is not attempted to compare the merits of the three-phase and single-phase shunt motor; however, the impression of the author is that the single phase shunt motor will be preferred on account of the gerater simplicity of control.

* Abstract of a Paper read before the American Institute of Electrical Engineers.

RECENT IMPROVEMENTS IN ELECTRIC RAILWAY APPARATUS.*

BY J. I. DAVIS.

Two years ago, before this association, the advantages of the interpole construction for railway motors were set forth. After an experience covering a year and a half of operation we find all the claims for the interpole motor fully realised. On a large elevated system using 200 H.P. motor equipments the commutators have maintained a very high degree of polish from the start, the wear on the commutators can hardly be detected, and the average life of brushes is found to be from 100,000 to 150,000 miles. On another large system, where motor flashes averaged at times 300 per month, and proved a most serious source of trouble and interruption to the service, the use of interpole motors entirely stopped the flashing. Records show inappreciable wear on the commutators, with a resulting brush life of over 100,000 miles. Motors are free from copper and carbon dust. Under these conditions electrical troubles have been practically eliminated. The same good reports come from small motors in city service, and indicate that the saving in the wear on commutators, brush-holders and brushes, together with increased reliability of service, will many times over pay for the extra cost of the interpole construction. Operating records show a brush life of 60,000 to 70,000 miles with the softer grades of carbon brushes.

The general troubles from commutation on the non-interpole motors have been enormously reduced by the expedient of slotting out the mica in the commutator below the surface and by the adoption of a softer brush with a larger graphite content and somewhat lower brush tension. Many operating companies which have been led to adopt this method are most enthusiastic over the results obtained. Operating records show that where 10,000 miles was a good mileage without slotting, the brush life runs from 20,000 to 30,000 miles with slotting, and the commutators do not have to be turned down more than one-third as often. Great improvements have been made in the quality and strength of carbon brushes. Operating engineers are finding out that there is economy in the use of a high-grade carbon brush.

Motors.—The increasing use of larger cars with heavy motor equipments and the rapidly extending practice of overhauling equipments at regular periods are bringing the solid-frame motor more and more into general favour. Of great importance in increasing the length of time between general overhaulings is the use of higher grade and longer life material in the pinions and gears. For a small additional cost the steel of the pinion can be put through special processes and treatments which will add to its life 33 to 50 per cent. The solid cast-steel gear is coming more and more into favour, and with the general introduction of the annealed and specially treated cast-steel gears the principal objection to the use of solid gears should be overcome. The annealing of the casting toughens the fibre, makes it finer of grain, and at the same time eliminates shrink strains and other weaknesses. On heavy equipments, where the design is limited, the material must be carefully selected for strength, wear and toughness. In such gears wrought-tyre steel rims specially treated are shrunk on annealed cast-steel centres.

The improper meshing of gears and pinions due to wear in them, and in the armature and axle bearings, is recognised as being the cause of rapid deterioration of the motor armatures under the excessive vibration, and means are taken to increase the life of the gearing and armatures by the use of higher-grade materials, the protection of bearings by proper dust shields and allowing less wear on the teeth.

An attempt to make the armature windings more compact and resistant to vibration has led to the introduction of the two-turn strap winding for the smaller armatures. This winding packs very solidly in the slot and on the ends, and the straps are moulded side by side around the whole coil. This type of winding marks as distinct an improvement over wire windings as has been given by the substitution of flat strap windings in the field coils of smaller motors for wire windings. Interpole motors of recent design from 50 H.P. to 100 H.P. capacity are provided with windings of this two-turn strap-wound type.

Control Apparatus.—It is desirable to remove the possibility of arcing in the platform controller. The controller can be so arranged as to break the arc on a separate auxiliary contactor under the car. In a recent design this contactor is an electro-pneumatic switch, operated from a storage air tank and controlled by a valve magnet, energised through a high resistance from the trolley circuit. The storage air tank has a capacity sufficient to provide enough air pressure after standing several days to operate the switch. This system can only be applied on cars with air brakes.

Locomotives.—While the connecting rod has been a long-established and favourite method of transmission with the steam railway engineer, the electrical engineer has exploited to the greatest degree the advantages of a uniform torque produced by the motor and gearing. There is a general tendency toward two-motor equipments rather than four-motor equipments, on account of the lower first cost, higher efficiency and less weight and maintenance. At the same time it is desirable to utilise the full tractive effort of all the wheels for acceleration and braking. A large city system, after experimenting with the side-rod method of drive, has recently placed in service a large number of equipments of this type. While this device has been often proposed in the past for heavy high-speed locomotives, the development of the electric locomotive has been along the lines of the electric car with the motor on the axle. The dangers of having a heavy motor or armature pounding at the rails from a low position over the track were not fully realised until recently. The use of connecting rods enables the motor to be mounted up in the cab, where it is easily accessible and provides a high centre of gravity with as light and unrestricted running gear and wheels as possible—two essential requisites for heavy high-speed operation.

Single-phase Systems.—The author finally refers to the economies in first cost and the saving in power and sub-station attendance which can be effected in the case of interurban and other heavy electric railway lines by the use of the single-phase system. Accurate figures are now available. Thus, the Warren & Jamestown Street Railway Co. operates 22 miles of road and owns six cars, each equipped with four 50 H.P. single-phase motors, with hand-operated controllers and weighing complete, but without load, approximately 29 tons. The line was started in 1905, and during the year ended June 30, 1907, a total of 284,886 car-miles were run, which was increased during the year ended June 30, 1908, to 296,804. The accounts are kept upon the standard association basis, and showed a total operating expense for 1907 of 7·4d. and for 1908 of 6·95d. per car-mile. These costs are remarkably low for a small interurban railway, and would have been considerably greater had the direct-current system been used.

The second single-phase line for which operating costs are available is that of the Indianapolis & Cincinnati Traction Co., which operates 24 cars over 108 miles of line. This line was the first single-phase railway in the world to be started on a large commercial scale. The cars weigh approximately 50 tons complete, without load, and are equipped with four 100 H.P. motors with multiple-unit control. Certain cars on the line make the run of 58·3 miles between Indianapolis and Connersville in $1\frac{1}{2}$ hours, or at an average speed of approximately 39 miles per hour between terminals. About 30 minutes of this time is required, moreover, for covering about 6 miles in Indianapolis, Rushville and Connersville, so that a little over 52 miles is covered in the remaining hour. During the year 1908 the entire number of cars of this road averaged nearly 65,000 miles each, and eight of the cars averaged nearly 99,000 miles each. The entire cost of operation on the standard Street Railway Association basis was approximately 7·75d. per car-mile for the year 1908, and that of maintaining the electric equipment of the cars approximately 0·36d. The economies which have been effected in the operation of this road by the single-phase system are clearly indicated by comparing its cost of operation with that of several direct-current interurban lines also operating out of Indianapolis, which show costs per car-mile of 10·2d., 10·4d., 8·6d., 9·6d. and 9·2d. respectively, in spite of the fact that the Indianapolis & Cincinnati Traction Co. operates larger and heavier cars equipped with more powerful motors and gives a considerably higher speed service.

THE WEST STANLEY COLLIERY EXPLOSION.

A report by Mr. R. A. S. Redmayne, Chief Inspector of Mines, and Mr. R. D. Bain, Inspector of Mines, on the cause of this disastrous explosion, has now been issued. After an exhaustive inquiry it was found impossible to arrive at any definite conclusions owing to the very conflicting evidence. Consequently the facts are only briefly stated and criticised. The possibility of electricity playing a part in the disaster is the most interesting point for readers of THE ELECTRICIAN. Prof. W. M. Thornton, who was called by the Durham Miners Association, committed himself to the opinion that the explo-

* Abstract, from the "Electric Railway Journal," of a Paper read before the Street Railway Association of the State of New York.

sion was electric in its origin, and mentioned the following three possible points of origin :—

1. A lamp which hung in front of the large pumping tank in the Busty seam, and which was found smashed.

2. The breaking of a fuse in the pump house in the Busty seam.

3. A short circuit set up by a train of coal dust between the terminals in any of the junction boxes or gateway end switches.

He mentioned the third as being the most probable, but after the inquest three of the fuses which were in the junction box to which Dr. Thornton particularly referred were examined, and were found to be intact and showed no sign whatever of heat. Another theory is that some electric cables were injured by tubs getting off the way, that an arc was formed, and so caused the explosion. No marked sign of electrical damage or of fusing was found.

On the assumption that the explosion did originate in the Busty seam the inspectors are of opinion that electricity is a more likely first cause than any of the other alternatives discussed. Owing to the great uncertainty as to what did occur, no useful purpose would be served by going into all the details of the electrical installation. The following, however, which concludes a memorandum by Mr. R. Nelson, Electrical Inspector of Mines, is of interest :—

The suspected area was defined as lying between the curve on Busty West haulage way, about 40 yds. from the downcast shaft, and a point in the roadway adjacent to the 5 H.P. motor-driven centrifugal pump, above referred to as the Busty Straight West pump. The electric plant in this area consisted of three 7/20 rubber-covered cables supported from the roof and side timbers, a six-way fuse box, a starting switch and the pump motor itself.

The three latter items—namely, the fuse box, the switch and the motor —were close together and at the extreme in-bye end of the suspected area. The mining experts were, however, unanimous in saying that the indications of force in the neighbourhood of the pump were so great as to preclude the possibility of the pump having been at, or even very close to, the actual point of origin—the damage to pipes being specifically instanced. In these circumstances, the cables only remain for consideration, though it must be said that Dr. Thornton, professor of electrical engineering at the Armstrong College of Science, Newcastle, who was called to give expert evidence from an electrical point of view, stated, in reply to a question, that he thought it "quite possible" that the explosion had originated in the fuse box. Dr. Thornton argued from the condition of the box after the explosion, in conjunction with the mining expert evidence above referred to, rather than from direct evidence: but other boxes in the pit were damaged as badly, and there was no evidence to show that the box in question was other than it purported to be—namely, a gas-tight box with its cover properly bolted down. At the same time, Dr. Thornton drew attention to one important point: the danger of allowing an accumulation of coal dust on motor or switch terminals—and the verdict of the jury—namely, that the explosion was a coal-dust explosion pure and simple—lends point to Dr. Thornton's warning.

With regard to the cables, the possibility that the accident was the result of mechanical damage to them is, in my opinion, less remote than either of the alternatives more particularly suggested for the jury's consideration—namely, sparks from the running set or arcing due to coal dust in the fuse box. It has not been possible since the accident to completely examine the cables within the suspected area due to heavy falls of roof, but in any event the difficulty of discriminating between cause and effect in examining such a small cable as a rubber-covered 7/20 wire would have been very great. There can be no doubt that a heavy fall of stone on a cable might result in an arc appearing external to that cable, and an instance was indeed quoted in evidence as having happened at this very colliery about four months before the explosion. In the event of such an arc the presence of gas or coal dust in sufficient quantity is all that may then be required to cause a serious explosion, but it must be added that no evidence exists of an occurrence of the kind in the present case.

To sum up, though electricity cannot be acquitted of suspicion in the absence of other positive cause, there is no direct evidence against it, any more than against any one of the dozen safety lamps, which the evidence showed to be still unrecovered from the pit. A review of the evidence suggests one or two general considerations :—

1. The use of cables with earthed metallic outer sheathing wherever possible.

2. Attention to the mechanical details of gas-tight apparatus, with the idea of ensuring that the apparatus shall be gas and dust tight in fact.

3. The proper protection of cables during shot-firing operations.

4. The use of oil-break switches with overload trip coils wherever possible in substitution for or in series with ordinary fuses.

5. The use of apparatus without exposed live metal terminals.

6. The importance of frequent inspection and cleaning where exposed live metal terminals are in use.

COMMERCIAL CABLE CO. AND NEWFOUNDLAND GOVERNMENT.

Friction has arisen between the Newfoundland Government and the Commercial Cable Co. in regard to the contract under which the company recently laid a cable to that island, and on July 31 the vice-president and general manager of the company (Mr. Geo. G. Ward) addressed the following letter to the Hon. Sir Edward P. Morris, Premier of Newfoundland :

Your official notice of July 3, 1909, that the Newfoundland Government declines to recognise the validity of the contract of Feb. 18, 1909, between that Government and the Commercial Cable Co., was duly received. In reply, we would say that the Commercial Cable Co. has invested over a million dollars on the faith of that contract, the contract having been executed and delivered by the Newfoundland Government to the Commercial Cable Co. under the Great Seal of Newfoundland, and signed by His Excellency Sir William MacGregor, Governor of the Island of Newfoundland, the direct representative of His Majesty King Edward VII. The contract by its terms is final and complete, and does not contain any provision requiring the approval of the Legislature. In this respect it does not differ from the previous two contracts between the same parties, one of which never was approved by the Legislature and yet was carried out to the letter. The other contract was approved by statute, but the statute expressly stated, not that approval was necessary, but that "it is desirable." Moreover, the statute enacted in that instance contained an additional provision which did not appear in the contract—namely, power to the Governor in Council to grant the fee simple of land to the Commercial Cable Co. We would also call attention to the fact that by this contract of February, 1909, the Newfoundland Government practically gives up nothing, nor does it confer anything, not even the right to the company to do business in Newfoundland ; in fact, it expressly prohibits the company from doing business in Newfoundland. The important features of the new contract are as follows :—

First : The company is to pay the Government $4,000 annually as a tax on the cable, and if the company lay and operate a second cable, as it intended to do and still intends to do, if this contract is observed, this tax will be $8,000 annually. It is true that by the contract the Government is to pay $4,000 annually to the company as compensation for the company's expenditures in extending its cable from the landing point into the city of St. Johns and maintaining a profitless office there without any expense whatsoever to the Government. But if this new contract had not been made this company would not have extended its cable at all to Newfoundland, and, hence, would not be under obligation to pay the $4,000 or $8,000 annually as mentioned above, so that it is clear that the Government loses nothing.

Second : The waiver of import duties on supplies, especially original supplies, is a common and usual privilege accorded by Governments to new cable enterprises. It does not cost the Government anything, because if the new contract had not been made the company would not have extended its cable to Newfoundland. The contract expressly provides that "The company shall have entry duty free for all cables, instruments and batteries, tools, utensils, furniture and supplies necessary for the establishment of its said cable station and installation of its cable." We relied on that provision of the contract, and after purchasing in St. Johns such articles as were obtainable there, we purchased electrical apparatus and other supplies elsewhere, but when these arrived at St. Johns you compelled us to pay an import duty of $4,322.60 in violation of our contract.

Third : Under the new contract the Government receives the same proportion of the tolls on cable messages as before, and, hence, the Government losing nothing in revenue, gains largely in facilities.

Fourth : The advantages to the Newfoundland Government are that the cable messages collected by the Government on its land line system may, under this new contract, be handed to the Commercial Cable Co. at St. Johns instead of those messages going from St. Johns the whole length of the Island by the land lines and thence by the Government's submarine cable to Nova Scotia, and thence by the Commercial Cable Co.'s lines to Europe and America. Continuous service with continuous income to the Government is thus assured, even if the land lines or cable of the Government are interrupted, and it also ensures much quicker service, because the new cable of the Commercial Cable Co. extends from St. Johns in the one direction to Europe and in the other direction to New York. If it is of any advantage at all to the Government to own its land line telegraph system, it certainly is an advantage to the Government to have this new connection direct from St. Johns to Europe and America. There is another fact which is not to be forgotten. For over twenty years the people of Newfoundland have had the benefit of the reductions in Atlantic cable rates brought about by the Commercial Cable Co. After a two years' cable war, this company caused the Atlantic cable rates to be reduced from 50 cents to 25 cents a word, and immediately the Newfoundland cable rate fell from 50 to 25 cents a word. We estimate that the reduction in rates, brought about by the Commercial Cable Co., has saved to the public, during the past 25 years, over $140,000,000.

Fifth : The Commercial Cable Co. by running its cable into Newfoundland and establishing a station there would bring considerable trade to St. Johns without anything being taken away. In fact the company has already purchased a plot of land in St. Johns and let a part of the contracts for the construction of a cable office and station. It did this before your Government repudiated the contract. The annual expendi-

Sums of the Commercial Cable Co. in maintaining such a station under the contract would be very substantial, and in addition, if the company should station its cable steamship, the "Mackay-Bennett," in the harbour of St. Johns an expenditure of over $50,000 a year would be involved. Is it the policy of the Government to drive away such trade?

For 50 years the Anglo-American Telegraph Co. and its predecessors had a monopoly of cable landings in Newfoundland. That monopoly was created by a statute enacted in Newfoundland in 1854. The Anglo-American Co. also had and still has a land line telegraph system in Newfoundland, and that system has always competed and still competes with your Government's land lines. The monopoly having expired in 1904, and your own land line system being established, you approached us with the request that we should make some connection with that system in order that your land lines might be put into communication with other parts of the world, as you had not been able to make arrangements satisfactory to yourselves with the Anglo-American Telegraph Co. In consequence you entered into an agreement with us in 1905 and the desired connection was made by way of Canso and Port au Basque in that year. As, however, your long land lines between St. Johns and Port au Basque were subject to interruption, especially during the winter months, your Government asked us to lay one of our cables into St. Johns, so that you would not be dependent upon your single line for your communication and so that you would thus be enabled more successfully to compete with the Anglo-American Co. Whereupon another contract was entered into in February last, between your Government and ourselves, and this is the contract which you now repudiate. The contract prohibits our doing business in Newfoundland except to transmit such messages as your Government collects or delivers. Your Government takes a part of the toll and we get only the remainder, while the Anglo Co., which competes with you, gets the entire toll, although that company does no more cabling than we do in the handling of Newfoundland cablegrams. Your action in embarrassing us doubtless pleases our competitor, the Anglo-American Telegraph Co., but that company is your competitor as well as ours, and since 1905 we think you have found that your alliance and connection with us has been profitable to your Government, in competition with the Anglo-American Telegraph Co., and we regret that a change of administration should cause a change of policy in this respect.

Under these circumstances we fail to understand your action. The good name of a government, the same as of an individual, is something to be cherished and preserved. If repudiation were a characteristic of the British Government or of its dependencies we would not have entered into contract relations with Newfoundland at all, and we think this is the first time, in the history of Great Britain or its dependencies, that a contract made with a responsible Government has been repudiated by a succeeding administration of the Government itself. The Commercial Cable Co. has always studiously refrained from taking part in politics or party questions, and has done so in Newfoundland, and will continue to do so. It regrets, however, that the change of administration which has taken place should cause the Government to repudiate a solemn contract which was executed only a few months ago, and which has caused the Commercial Cable Co., as stated above, to expend over a million dollars, and the company denies your legal right to repudiate it.

LEGAL INTELLIGENCE.

Devonport Tramway Dispute.

On July 28 and 29 Devonport Magistrates heard 155 summonses issued by Devonport Corporation against the Devonport & District Tramways Co. in connection with the discontinuance by the latter of the service on certain lines of the Devonport tramway system. One set of summonses, numbering 71, was for failing to run at least four carriages each way in the morning and in the evening, at the hours thought by the Corporation most convenient for artisans, mechanics, &c., in pursuance of certain agreements between the parties; and the second batch (84) were for failing to comply with the terms of a certain lease, &c., by not providing upon certain tramways in the borough (leased by the Corporation to the Company), such cars as were reasonably required by the Corporation in the public interests.

In support the town clerk (Mr. R. J. Fittall) said the summonses were issued to compel the Company to perform their obligations; and he suggested he should only proceed on the summons for the first day in respect to the ordinary service, and in respect to the workmen's cars, and he asked their worships simply to impose a nominal penalty in respect of those two days if the Company would undertake to perform their obligation, and to run either the same service which they ran previous to the discontinuation, or the service which the Corporation had required them by notice to run, or any other service which was a reasonable one, and which might be agreed upon by the Company and the Corporation.

Mr. Eustace Hills, for the Company, said there was a question of principle involved, and the summonses had to be taken separately. He should ask them to find that the service required was not a reasonable one.

Mr. Fittall said these lines belonged to the Corporation, who had expended £62,000 in constructing them, and they were leased to the Company, who on March 10, 1908, wrote to the Corporation that there had been a decline in their prosperity, and suggested certain concessions; and they also asked the Corporation to give up their veto so far as the running of Plymouth cars into Devonport was concerned. In return for those concessions the Company suggested that they would run a universal 1d. fare except to St. Budeaux. If the proposals did not commend themselves to the Corporation, the Company would be prepared to negotiate for the sale of the Devonport tramways to the Corporation, on the terms at which they were authorised to purchase by the Tramways Act. Further correspondence followed. On Dec. 17th last the Company wrote that they found it impossible to carry out the terms of the lease, and the trams were discontinued on Jan. 16. The Company's undertaking was to provide such a service of cars as might be reasonably required by the Corporation in the public interest. If the Company were not disposed or unwilling to run a service on those lines, and if the magistrates agreed that the requirements of the Corporation were reasonable in the interests of the public, he would ask them to impose the maximum penalty of £5 a day.

Ald. J. C. Tozer, chairman of the Tramways committee said it was impossible for the committee to recommend the Corporation to grant the concessions demanded by the Company, as it would mean a loss in five years of £1,678 per annum. The Company did not submit any proposal for the sale of their undertaking until a conference, which proved abortive, was held.

Mr. Hills said the Company were summoned for not running (amongst other services) a 60 minute service from and to three places. In taking over the extensions, the Company had to pay a rent amounting to £3,900 a year in round figures. The Company not only had to pay the rent, but also, as part of the bargain, to take their energy from the Corporation at a price which was certainly a higher price than the Company could have generated for themselves. The price was 1·66d. per unit, and the Company could provide it themselves for 1d. Under no circumstances could the Corporation recover more than a nominal penalty, because, in fact, they had suffered no damage.

Mr. Walter G. A. Bond (chairman of the Company) stated that in 1902 the Company's revenue was £6,090; in 1904 (the first complete year of the extensions), the gross revenue was £8,636. The extra revenue against those extensions was £1,646, against the rent £3,900, so that the deficiency on the extensions was £2,254. The deficiency had distinctly increased from 1904 to the present time. It was financially impossible to give the service required in the notice of Jan. 4, 1904. There was not sufficient traffic on the leased lines to pay charges.

Replying to Mr. Fittall, Mr. Bond said the Company were ready to sell their undertaking to the Corporation. The discontinuance of the service was not done by the Company with the object of trying to force the Corporation to buy.

The second set of 71 summonses were then proceeded with, and after evidence had been taken, the chairman said the Bench would reserve their decision.

On the 4th inst. the Chairman (Dr. G. A. Rae), in giving judgment, said the Bench found against the defendant Company in both cases, and fined the Company £5 (the maximum) and costs for the first day in the first set of summonses. On the other 83 summonses of the same character the fine was 2s. 6d. and costs for each day. Of the second set there were 71 summonses; and the Company would be fined £2 and costs for the first day for non-running of workmen's cars, and for the subsequent dates 1s. and costs in each case.

On 6th inst. Mr. Gill applied, on behalf of the Company, for a special case to be stated for the determination of the High Court, as the Company urge that the decision was erroneous in law.

Post Office Telephones.—In the City of London Court on Tuesday the Postmaster-General sued Mr. W. H. Russell, to recover 15s. 7d. for the rent of an extension telephone line. Defendant had several other lines, about which there was no dispute. Defendant's manager, Stevens, said that the extension line was absolutely useless from beginning to end. They never could get connected, although he tried to do so over 50 times. At last they asked the Postmaster-General to take the intermittent away. Mr. W. Brignall, for Sir Robert Hunter (solicitor to the Post Office), said that the extension worked all right at first, but there was no responsibility on the Postmaster-General to maintain it or to keep it efficient.

Judge Lumley Smith said that the contract was a very tight one, and he had had similar complaints before. The fact that the extension was out of order was no answer to the claim, and the contract precluded defendant claiming damages. Judgment must be for plaintiff, with costs.

PARLIAMENTARY INTELLIGENCE.

Glasgow Corporation Bill.—This bill has now been allowed to proceed by the Standing Orders Committee, but the local railway companies have been allowed a locus to appear against clauses 20, 29 and 30, which would make the tramway undertaking part of the Common Good.

Oldham Corporation Bill.—This Bill was read a third time in the House of Lords last week, but the clause empowering the Corporation to let out for hire and fix electrical motors and fittings was dropped. In Watford and Heywood Bill similar clauses have been struck out.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the post of lecturer and assistant in the department of electrical engineering of the Glasgow and West of Scotland Technical College. Commencing salary £175. Applications by Aug. 17 to Prof. Magnus Maclean, D.Sc. See advertisement

The Governing Body of Northampton Polytechnic Institute. London, invite applications for the appointment of practical instructor in electric light wiring and cable jointing. Two evenings per week. Particulars and forms of application (to be returned by Sept. 1) from the Principal, Dr. R. Mullineux Walmsley. See an advertisement.

A capable electrician is wanted for a colliery in the Wigan district. Must be accustomed to electric pumping, hauling, lighting and coal cutting and have had experience of concentric cables. Wages 35s. per week and free house. See advertisement.

Llandilo Council require an engineer to take charge of electrical installation. Applications to the Clerk by Aug. 31.

Applications are invited for the position of head of the electrical engineering department at the Technical College, Sunderland. Salary £250, rising to £300 per annum by two equal annual increments. Applications to the secretary, Mr. T. W. Bryers, Education Offices, 15, John-street, Sunderland, by Aug. 23.

Applications are invited for the Professorship of Physics in the Royal College of Science, Dublin. Applications by Aug. 16 to the Secretary, Department of Agriculture and Technical Instruction for Ireland, Upper Merrion-street, Dublin.

The lectureship in electrical engineering at University College, Galway, is vacant. Salary £120. Applications to the Secretary, Mr. Robt. Donovan, Royal University-buildings, Dublin, by Aug. 31.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

There is a vacancy for a lecturer and demonstrator of physics at the Sir John Cass Technical Institute, London. Commencing salary £150. Applications to the Principal by Aug. 28.

Wolverhampton Electricity committee have appointed Mr. E. Stubbs as technical and general assistant at £160 a year; Mr. J. S. Dudley as maintenance engineer at £156; and Mr. F. C. Platt as junior assistant at £78.

Mr. G. W. King, manager of the Greenock Tramways Co., has also been appointed manager of the Airdrie and Coatbridge tramways

Mr. S. Hann, superintendent of the Stoke Newington electricity works, has been appointed borough electrical engineer.

Keighley Council have appointed Mr. E. Murgatroyd manager of the tramways.

Mr. R. Fulton has been appointed electrical engineer of the Mount Bischoff Mining Co., Waratah (Tasmania) in the place of Mr. W. Behrend, who has vacated the position and is proceeding to Germany to study the developments of electrical engineering in that country.

Major H. G. K. Wait, R.E., has been selected for the position of chief instructor in the Electric Light School, Portsmouth.

Mr. W. C. Houston has been appointed head of the mechanical engineering department at the South Western Polytechnic Institute, Chelsea, in succession to Mr. W. F. Pullen.

EDUCATIONAL NOTICES.

University of London (University College).—Prof. J. D. Cormack has been elected Dean, and Prof. J. A. Fleming Vice-Dean of the University College Faculty of Engineering for the session 1909-10. The Chadwick scholarship and medal has been awarded to F. L. Thompson, and A. M. Sims, who was declared proxime accessit, has been awarded a silver medal.

The next session will begin on Monday, Oct. 4. Special and post graduate courses have been arranged to meet the needs of the following classes of students: (*a*) Postgraduates and engineers in practice; (*b*) others whose qualifications are, in the opinion of the lecturer, such as to enable them to follow the courses. Each course will include lectures and exercises, and the numbers admitted will be strictly limited. The following are some of the special courses for next session: Steam turbines, by Mr. W. J. Goudie and Mr. E. G. Izod; railway engineering, by Mr. H. Deans (of the G. W. Railway); roads, street paving and tramways, by Mr. W. N. Blair; and electrical design, by Mr. H. M. Hobart.

King's College, London.—The session 1909-1910 commences on Oct. 6. Prospectuses and information relating to the courses of instruction in the Faculty of Engineering and Applied Science and Division of Architecture may be obtained from the Secretary, Kings College, Strand, W.C. Evening classes are held in electrical and mechanical engineering drawing, mathematics, physics, &c.

University of Birmingham.—The full course in engineering extends over four years and students who enter after matriculation and who pass the examinations at the end of each year will be entitled to the degree of B.Sc. in the branch of engineering to which they devote themselves. Some particulars of the instruction given in the technical engineering classes, engineering laboratory, &c., are given in an advertisement. The session, 1909-1910, commences on Oct. 4, and detailed syllabus with full particulars of University Regulations, lecture and laboratory courses, fees, &c., may be obtained from the Secretary.

University of Manchester.—A complete theoretical and practical training is given at this University to students preparing for the higher positions in the electrical engineering profession. This subject may be taken as part of the courses preparing for the B.Sc. degree in both the honours classes of engineering and physics. A special course has also been arranged extending over three years and preparing for the certificate in electrical engineering. The John Hopkinson laboratories and dynamo house are fitted with modern electrical machinery and offer excellent facilities for educational and research work. The session commences on Oct. 5. Prospectuses from the Registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27 Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

Glasgow and West of Scotland Technical College.—The session 1909-10 commences on Sept. 23 for the evening classes and Sept. 28 for the day classes. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, and the courses of study for the diploma usually extend over three sessions. Holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. There are new and well equipped laboratories in the departments of physics, chemistry, electrical engineering, mechanics, metallurgy, &c., and facilities for research are afforded. Calendar (price 1s. 4d.) and prospectus (free) can be obtained on application to the Secretary.

Aberdeen.—On the recommendation of the Electricity committee it has been decided to purchase a stock of electric heating and cooking apparatus for hiring out.

It has been decided to abandon ½d. fares and to introduce a universal 1d. fare.

Alvaston (Derby).—The Council have assented to the proposed application of Derby Corporation for a provisional electric lighting order.

Australasia.—The "Australian Mining Standard" says the electric signalling apparatus for mines, patented by Mr. O. Reigelehuth, of Ballarat, is to be tested at the New Moon mine.

The Prahran and Malvern (Victoria) Tramways Trust reports that contracts for rails, fishplates, steel poles, &c., have been let at £9,854, tenders for overhead construction and car bodies are to be in by Aug. 27 and Sept. 17, respectively, and tenders for permanent way construction are about to be invited. A 10 years' agreement (terminable on agreed conditions after four years) has been entered into with the Melbourne Electric Supply Co., and the maximum charge for current is to be 1½d. per unit. It is expected that the tramways will be in operation by May next.

Melbourne Electric Supply Co. propose to construct tramways to Geelong West, Newtown and South Geelong, subject to the satisfactory settlement of the dispute with the Railway Commissioners regarding the Moorabool street crossing.

The South Gippsland Creamery and Butter Factory (Ltd.) have been authorised to engage in the supply of electricity for lighting in the Yarram Yarram district. The Council of Alberton have decided to enter into a contract with the Company for lighting Yarram for five years at £150 per annum.

Mr. C. St. John David (city engineer), and Mr. R. J. Strike (city electrical engineer) have submitted to Launceston (Tasmania) Council a report on means for more fully utilising the hydraulic power obtainable

from the South Esk for generating electrical energy. The cost of the works under the scheme suggested by Messrs. David and Strike is estimated at £82,438, made up as follows: Dam at third basin, £7,700; hydraulic equipment including intake, dam, completely lined tunnel, [illegible], steel pipes and receiver, &c., £55,554; lands and buildings, £2,365; electrical equipment (including removal of four 300 kw. generators and switchboard and exciters from existing station, new turbines for same, and four new 600 kw. generators, turbines, switchboard, transmission line, &c.), £16,819.

As alternatives to the above scheme (which includes an entirely new tunnel and new plant) projects of a less expensive character have also been submitted for (1) installing auxiliary heat engines at a convenient site in the city, and improving the existing tunnel; (2) increasing the size of the present tunnel and hiring steam auxiliary while this work is being done; (3) driving new tunnel parallel to, but a short distance from, the existing one.

Electric pumping plant has been purchased for the New Zealand Crown Mines, at Karankahake, in the Hauraki district. The plant, which comprises a 550 kw. three-phase alternator, motors and duplex pumps, will pump 1,135 gallons of water per minute from a depth of 1,000 ft.

Barnes.—A sub-committee has been appointed to organise an electrical exhibition.

Barnsley.—An inquiry was held on Tuesday into the Council's application for sanction to borrow £3,000 for extensions of the electricity mains, &c., and £308 for the electric lighting of the May Day Green Market.

Bishop's Stortford.—Messrs. May & Hawes are to prepare a report for the Council on the question of electricity supply.

Burslem.—By agreement the assessment of the electricity works has been reduced from £1,180 to £1,000.

Caldy (West Kirby).—The electricity supply works were formally inaugurated last week.

China.—The report of Acting-Consul John Fox states that the principal imports at Canton during 1908 included electrical material to the value of £6,799 (compared with £16,307 in 1907).

The Canton electric light works, erected by the Chinese Light & Power Co. of Hong Kong, are equipped with up-to-date plant, all of British make, with the exception of one engine. The plant comprises three Diesel oil engines (burning crude petroleum) of a total horse-power of 600, five steam engines (total 730 B.H.P.), four Babcock water-tube boilers, and one Green's economiser. Induced draught is used, and Contraflo and Worthington condensers. Alternating current is supplied to the city of Canton by means of overhead high-pressure mains on iron and wood poles, the transmission voltage being 2,000 and the voltage at consumers' terminals 100. The supply to Shameen from the same works is c.c. The consumers in Shameen number 167 and in Canton 2,642.

Consul John Fraser says imports to Hankow in 1908 included electrical materials to the value of £60,267 (against £12,106 in 1907).

Acting-Consul W. P. Ker (Tientsin) says the tramway system of the Belgian Compagnie de Tramways et d'Eclairage Electriques de Tientsin has been extended so as to traverse a route between the foreign settlements and the Chinese city, and the total length is now between 8 and 9 miles. Receipts were £19,400 in 1908, compared with £13,120 in 1907. The company's electric lighting business has also increased from £4,680 in 1907 to £6,240 in 1908.

Acting-Consul Phillips (Chungking) states that the Chungking Electric Light Co. (a Chinese company) started operations on a small scale in June, 1908. They are supplying current for 220 16 c.p. lamps. They have obtained tenders for a larger plant to light the whole city, and land has been bought on which to erect a new station.

Dundee.—Lochee substation was opened on Monday. High-tension current is supplied from the Carolina Port station and the capacity of the substation is about 300 kw.

Exhibitions.—H.M. Consul Mr. W. Keene reports that the Genoa Lighting and Optical Exhibition (referred to on p. 683 of our last issue) is to be postponed till next year.

In connection with the Turin Exhibition in 1911 the Turin Chamber of Commerce propose to award a prize of 50,000 fr. (about £2,000) to the owner of "an invention or discovery which will prove in practice advantageous to the national economy." Inventions discovered or published prior to 1908 will not be admitted. Particulars from the Commissione per il concorso a premio, Camera di Commercio, Torino, Italy. Applications (in Italian or French) by March 31, 1911.

Fatality.—Last week the Press reported that a man named Lennard had been "electrocuted" while trimming an arc lamp in Battersea. At the inquest, which was held on Tuesday the evidence showed that deceased had suffered from heart disease. On Friday evening he was engaged at an electric lamp standard in Bolingbroke-grove, when he suddenly fell and died immediately. It was stated on behalf of Battersea Council that it was almost impossible for a man to receive a shock; in any case the shock would not be stronger than 230 volts, which would not harm a healthy man.

France.—Consul R. Macdonald reports that electric power was brought to Bordeaux in 1908 from Tuilières on the Dordogne. A dam has been constructed across the river, raising the water to a height of 39 ft. 5 in. and giving 10,000 H.P., and auxiliary steam plant of 12,000 H.P. has been installed as a stand-by. The voltage of the alternating current leaving the generating station is 50,000, and transforming plant at Cenon converts this to 550 volts c.c. for tramways and 110 volts for lighting. Besides supplying current for power and lighting in Bordeaux, the Soc. Electrique du Sud-Ouest propose to supply all the districts between Bergerac and Bordeaux by branches from the main transmission line (which is supported on nearly 3,000 iron columns at intervals of from 50 to 60 yds.) and also Périgueux and Limoges and other towns.

Mr. Consul Trillot (St. Nazaire) says the Société des Usines de la Basse Loire, formerly known as Forge de Trignac, propose to greatly increase their works. The manufacture of material for naval construction, armaments and railways, from Spanish and Algerian minerals, will be maintained and developed. Electric power will be substituted for steam.

Consul C. Clipperton says 18 electric capstans for moving railway trucks and shore cranes have been placed in service at the port of Rouen, and as soon as the quays now in course of construction are completed eight additional capstans and eight electric cranes will be installed. The two tramway companies will shortly be combined and extensions to the suburbs carried out. Tenders will doubtless be invited for supply of rails and for cars.

Germany.—Consul-General Schwabach says experiments are being made in Berlin with a new type of electric omnibus, which carries 36 passengers over 60 miles with one charge of batteries, but it is stated that working expenses are very heavy, and it is believed that the 'buses could only be run at a profit on lines with an excess of short-distance traffic.

Herr Schwabach's report includes a table showing the numbers and horse-power of electric motors used in various trades in Berlin in 1908, compared with 1907 and 1906, including dynamos but not traction motors. The totals are:—19,193 motors (64,021 H.P.) in 1908, 16,966 motors (55,453 H.P.) in 1907 and 14,911 motors (47,419 H.P.) in 1906.

On the Basle to Zell railway ($12\frac{1}{2}$ miles), which the Baden Government have converted to electric traction, an a.c. system has been adopted.

In Berlin and suburbs the expansion of the electric underground and elevated railways has proceeded apace. 90 per cent. of the 2,330 miles of tramway in Germany were worked entirely electrically at the end of 1908, 2·5 per cent. by steam, 3 per cent. by horses and the remainder by electricity and steam or horses combined.

The consumption of electrical energy for all purposes in Berlin in 1908 was 155,115,135 units, compared with 142,921,816 and 128,103,848 in 1907 and 1906 respectively. Germany's imports of "electrotechnical products" in 1908 were valued at £451,000 (against £411,000 in 1907). The exports in the same class were £9,107,000 (against £8,227,000). Exports of cables in 1908 were valued at £2,558,000 (against £2,778,000). This class does not appear amongst the imports.

Honduras.—Consul Campbell says electric lighting was inaugurated in the streets of the city of Tegucigalpa two years ago and has since been extended to many private houses. The local undertaking is in a fairly satisfactory condition.

India.—The "Indian and Eastern Engineer" says the War Office has sanctioned the erection of a power station in Colombo, and the Royal Engineers have commenced the work.

It is understood that the Secretary of State has sanctioned the Electricity Bill and that it will be introduced at an early date to the Viceroy's Legislative Council.

"Indian Engineering" says the introduction of electric lighting into Mussoorie has made some progress.

Messrs. Turner, Hoare & Co. have put in an extensive installation of electric "punkah" fans at the Civil and P.W.D. Secretariat buildings, Lahore. Each room has at least one "punkah" and some of the large halls five or six, and there are also a number of portable table fans. Messrs. Turner, Hoare & Co. have established a permanent branch at Lahore.

Electric lighting and fans are being installed at the new General Post Office, Bombay, at a cost of R.62,000 (about £4,133).

Japan.—The imports of electrical machinery to Japan (says Mr. E. F. Crowe, commercial attaché to H.B.M. Embassy, Tokyo) were valued at £209,200 in 1908 (compared with £180,900 in 1907), including £37,700 (£55,000) British, £141,000 (£101,000) American and £30,000 (£22,300) German.

Electric light is now to be found in most towns and many villages, and the cost in some cases is quite trifling. Cheap electric tramways have prevented the cycle dealers from doing so good a business as they anticipated. Extensive reclamation works are being carried out at Yokohama, including the erection of numerous buildings, cranes, elevators, &c., and the construction of 11 miles of railways. Electric power will be used on a large scale in the handling of cargo. A fixed electric crane to lift 50 tons is being erected, and there will be more than 30 electric travel-

lers and 32 electric capstans alongside the quay walls. A power house is being erected, and will contain four generating sets, each of 210 kw.

Japan-British Exhibition. It has been decided to hold a Japan-British Exhibition in London in 1910, and the Committee announce that H.R.H. Prince Arthur of Connaught has been appointed Honorary President and the Duke of Norfolk President.

Kilrea (Ireland). A public meeting of ratepayers will be held to-day (Friday) to consider a proposal to form a company for the erection of electricity works in this district. Mr. W. J. Bolton is promoter of the scheme.

Light Railway.—The Light Railway Commissioners have granted the application of Southend Corporation for an extension of time for constructing tramways from Southend to Shoeburyness.

Lowestoft.—A very short trial has sufficed to convince the Tramways committee that the remedy for poor traffic returns is not to be found in increased fares. The receipts at the higher fares showed such a serious falling off that the new scale has been abandoned and the old fares are again in force.

Luton.—An inquiry was held here last week into the Council's application for sanction to a loan of £11,707 for the electricity undertaking. In regard to £4,500 for future extensions the matter was adjourned sine die for the inspector to examine the financial condition of the undertaking.

Madeira.—Capt. J. Boyle, H.M. Consul, again points out that telephones are badly needed in Madeira, and if properly managed and financed would probably be a success.

It was rumoured at the beginning of 1908 that a British company was to take over the present electric lighting undertaking and erect an up-to-date installation; but the scheme seems to have fallen through on account of financial difficulties. There is room for improvement in the electric lighting of Madeira.

Marriage.—At Glasgow on 7th inst. Mr. James Edmund Sayers, M.I.E.E., was married to Miss Margaret Wilson Robertson, of Glasgow.

Mexico.—Consul John Stringer says the town of Mazatlan is well lighted by electricity and a good but expensive service is offered to householders, 10 16 c.p. lights costing £1. 16s. per month.

Middlesbrough.—The electric street lighting in Corporation and Newport-roads was inaugurated on Saturday last. Twenty arc lamps, which have been supplied by Crompton & Co., are employed. If the results are found to be satisfactory, the Corporation propose to extend this system of lighting.

Oulton Broad.—The Council are to invite offers for taking over their provisional electric lighting order.

Peking Telephone Service.—The Western Electric Co. of Chicago are stated to have secured the contract for a telephone service in Peking at $150,000.

Personal.—Sir H. Babington Smith, Secretary to the Post Office, has, at the request of his Majesty's Government, accepted the post of President of the National Bank of Turkey, which is now in course of formation. He will resign the secretaryship of the Post Office and proceed to Constantinople in September.

Mr. E. H. W. Westwood, consulting engineer, of Old Exchange, Collins-street, Melbourne, has been appointed secretary of the Electrical Association of Victoria, in succession to Mr. J. H. D. Brearley.

Presentations.—On 5th inst. Mr. Harold Dickinson, city electrical engineer of Leeds, was presented by the members of the Leeds section of the Institution of Electrical Engineers with a silver table centre, on the occasion of his approaching marriage. This presentation is an acknowledgment of Mr. Dickinson's services in founding the Leeds Section of the Institution, of which he was the first chairman.

At the Bradford electricity works recently Mr. Chas. W. Salt, chief assistant to the city electrical engineer and manager (Mr. Thomas Roles), was presented by the staff and employés with a brass-mounted oak clock and a calabash pipe on the occasion of his marriage with Miss Ida Potts, of Bradford. Mr. Roles made the presentation on behalf of the subscribers.

Mr. H. A. Howie, chief assistant at Wolverhampton, who was recently appointed to the position of deputy manager and chief assistant engineer of Sheffield Corporation electric supply department, has been presented by his late colleagues with a carved oak escritoire.

Mr. C. T. Linney, resident engineer of the Kent Electric Power Co., has been presented with a silver salver and silver cigarette case on his retirement from the company's service.

Mr. H. Wilson, mains superintendent at Maidstone, has been presented by the staff with a marble clock on the occasion of his marriage.

Rand Power Scheme.—Mr. W. A. Harper (of Harper Bros. & Co., joint consulting engineers with Prof. Klingenberg for this scheme) states that all the engineering details of the scheme have been settled, and the machinery and plant are being manufactured.

The Rand Mines Power Co. has already contracted to supply 270,000 units per annum, but this figure is likely to be greatly exceeded. The plant that will be necessary in the stations to supply this quantity will be 10 turbo-generators of 12,000 k.v.a. capacity and air compressing plant of 40,000 H.P. The supply of compressed air at 100 lb. pressure direct to the consumers is stated to be an entirely new departure in power supply engineering.

Rhyl.—The Council have decided to spend £3,000 in extensions of the electricity works, including a Diesel oil generating set, at £3,000.

Russia.—Consul-General C. S. Smith (Odessa district), in his report for 1908, states that the tramway company have not been able to begin work on the construction of the electric tramways at Odessa, although the Government's sanction has been given. The tender of the Soc. Anonyme des Tramways d'Odessa was accepted for the erection and equipment of an electricity supply station.

Vice-Consul P. Bagge says that, although Nicolaieff Town Council decided in May to grant a concession for the electrification of the existing horse tramways, nothing definite has yet been settled. The Government has assigned a sum of money for the improvement of telegraphic and telephonic communication between Nicolaieff and Odessa.

Vice Consul Chas. Blakey says Kharkov municipality laid an electric tramway to the goods station of the South-Eastern Railway some years ago, but in the rest of the town, and to the fine Central Railway station, a Belgian company runs dilapidated horse tramways. A proposal by the company to introduce electric traction, provided they are given an extension of their concession of 31 years, is likely to be refused, although the municipality cannot provide the funds for the improvement.

Acting Vice-Consul E. W. Carnana says Kherson municipality are discussing the terms of a concession to French capitalists for electric tramways $11\frac{1}{2}$ miles in length. The electric lighting of the town and port was commenced in March, 1909.

Vice-Consul W. S. Walton says the bulk of the machinery imported, into Mariupol in 1908 was for electrical purposes, and was of Belgian German and French origin. He suggests that Great Britain might compete in the supply of electrical machinery and of tools. During 1908 Mariupol municipality completed the installation of electric light in the principal streets.

Acting Vice-Consul K. Ringeling (Sevastopol) says the question of the construction of an electric railway to Yalta and the south coast has come more to the front. Estimates of the cost for three different routes vary from £1,055,000 to £1,583,000. A society has been formed in St. Petersburg with the object of forming a company to construct electric railways in the Crimea, but the capital seems hard to find.

Sheffield.—At the meeting of the City Council on Wednesday it was reported that on the past year's working of the tramway there was a net profit of £36,635, of which £15,000 was voted to relief of rates.

South Africa.—The "British and South African Export Gazette" states that the Howick Falls (Natal) are being harnessed for industrial purposes, and the Pretoria Power Co. (Ltd.) are preparing a scheme for using the waters of the Crocodile river and its tributaries, for the generation of electricity.

Amongst prospective orders for plant for South Africa are telegraph and telephone material for Natal Government, transformers and cables and a quantity of tramway material for Johannesburg Corporation, motors for Village Deep (Ltd.), and rails and track material, poles and fittings, overhead equipment, trolley wire and cables, cars and equipments, switchboards, steam-driven generating set, water-tube boiler, &c., for Pretoria Corporation.

Orders have been placed in England for three 600 H.P. motors and one 100 H.P. motor for the Robinson Gold Mining Co. and one 100 H.P., one (about) 400 H.P. and one (about) 630 H.P. motors for the Robinson Central Deep.

The following orders have been placed for motors of 100 H.P. each for various South African mines, mainly in connection with the Rand Mines power scheme: Five for New Modderfontein, three for Geldenhuis Deep, four for Rose Deep, two for Jumpers Deep, three for Crown Deep, four for Langlaate Deep, three for Crown Reef, four for Ferreira Deep and two for Nourse Mines.

Stretford.—18 street lamps are to be adapted for incandescent electric lights at a cost of £1 per lamp, and the annual charge per electric lamp is to be reduced from 45s. to 42s. 6d. each.

Venezuela.—The Director-General of National Telegraphs has authorised the Municipalities of Libertad (State of Trujillo) to make arrangements for the provision of a telephone line between Libertad and Betijoque.

Walsall.—It has been decided to adopt electric driving at the new sewage disposal works.

Warrington.—Application has been made for sanction to borrow £500 for transformers.

Wetterhorn Electrically Operated Cableway.—In reference to the description of this cableway which appeared in our last issue (pp. 667-669), we should have stated that the ropes were supplied by the Felten & Guilleaume Lahmeyerwerke, of Mulheim-on-Rhine, Germany.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Aberdeen. The accounts of the municipal tramways for the year ended May 31 show passenger traffic revenue of £70,325, against £70,754 in 1907-8, but owing to increase in revenue from other sources, the net decrease in the total revenue was £251.

Total working expenses were £40,791, against £38,666. The cost of electrical energy increased from £8,971 to £9,561. The gross profit was £31,485, compared with £33,261. Capital expenditure during the year was £1,5[illegible], bringing the total to £318,592.

Barnstaple. The capital expended on the electricity undertaking for the year ended March 31 was £181, bringing the total to £31,729.

Total income for the year was £4,506, including £4,086 from the sale of current and £250 from public lighting. Total expenditure was £3,081 and gross profit £1,425. Capital charges came to £2,101. 3s. 2d., and the net deficit (after crediting £200 pupils' premiums) was £476. Units sold were 221,079; 94,172 for public lighting and 126,887 for private lighting, and the total maximum supply demanded was 195·5 kw.

Bradford. The annual report of the electricity department for the year ended March 31 was presented to the Electricity committee last week.

There was a surplus on the year's working of £2,146, compared with £1,135 in 1908. Against this has to be set £1,491 for adjustment of liabilities on March 31, 1908, and £1,200 rebate made to the Tramways committee in consequence of failure to provide sub-stations for transforming high-pressure current. The surplus on the department from 1890 to date is £78,127. On the general supply of current for the year there was a decrease of £217, but there was an increase of £4,064 in the bulk supply. The cost of coal was £11,910, an increase of £510. The total income showed an increase of £3,972 and the expenditure of £2,960.

Consideration of the accounts was adjourned.

Burnley.—The report of the borough electrical engineer (Mr. Jas. E. Starkie) states that 3,148,875 units of electric current were sold during the year ended March 31, a decrease of 286,104 units compared with 1908.

There was an increase of 32,965 units sold for private lighting, and also a small increase in the traction units, but power units showed a decrease of 326,087, owing to the stoppage of the temporary supply to Scar Top mill motors. The department has been affected by the increasing use of metal filament lamps, as the lamps connected show an increase of 10 per cent., but the increase in consumption is only 5 per cent. The capital expended is £100,594, an increase of £5,833. Total net income was £21,686, against £22,390, and total costs were £11,456, against £10,222, while interest and sinking fund came to £5,835, against £5,699, and the net profit was £4,170 (against £6,255), of which £3,000 has been devoted to relief of rates and £1,170 to depreciation. The load factor was 22·75 per cent., against 23·61 per cent.

Chesterfield. The traffic receipts of the tramway departments for the year ended March 31 were £11,633. 11s. 11d. and the total receipts were £12,157, or 9·94d. per car-mile.

The total costs were £7,256 and gross profit £4,901. Sinking fund and interest came to £4,338 and net profit (£600) has been placed to reserve. 2,481,321 passengers were carried and 293,380 car-miles run. The traffic expenses decreased from 2·4d. to 2·33d., and general expenses from 1·4d. to 1d. per car-mile. The capital expended is £70,464, an increase of £743.

Devonport. The total income of the electricity department for the year ended March 31 was £17,705, including £16,470 from sale of current.

Working expenses were £10,414, leaving gross profit £7,291. Interest and sinking fund charges came to £6,504, leaving a net surplus of £790, which has been transferred to reserve. The outstanding capital expenditure is £113,777. Total works costs were 1·279d. per unit sold, and the total costs (including capital charges) were 2·186d. 2,140,047 units were generated; 1,178,815 were supplied for traction, 187,669 for private and 26,722 for public lighting. There are 397 consumers (against 351 in 1908), with the equivalent of 32,482 8 c.p. lamps connected (28,519 8 c.p.).

Eastbourne.—The accounts of the electricity undertaking for the year ended March show capital expenditure £170,987 (increase £2,706).

Revenue was £25,109, gross profit £13,592, net profit £1,938. £2,000 has been transferred to depreciation during the year, bringing that fund up to £11,487, and the accumulated surplus stands at £8,017. Coal cost 0·90d. per unit (against 1·09d. in previous year), works costs were 1·40d. (1·57d.), total costs 1·98d. (2·11d.), and capital charges 2·23d. (1·99d.). The average prices received per unit were, for lighting, 4·90d. (4·92d.), power 2·26d. (2·26d.), public lighting 2·56d. (2·23d.). There are 111 (99) motors installed on consumers' premises, with an aggregate horse-power of 296 (279½), and the equivalent 30 watt lamps connected (for lighting) are 96,105 (90,406). The total maximum load was 1,096 kw. (1,056 kw.), and the load factor 13·13 (13·55) per cent. 1,670,300 (1,664,243) units were generated, 986,028 (983,365) sold for private lighting, 123,154 (84,505) for power, and 151,717 (185,469) for public lighting.

The borough electrical engineer (Mr. J. K. Brydges) attributes the small increase in units sold for lighting to the use of metal filament lamps. Of the saving of £977 in cost of coal, £190 is due to reduction in price and £787 to economy obtained by use of the new turbo-alternator, compared with the old non-condensing reciprocating plant.

Eccles. The electricity department accounts for the year ended March show capital expenditure £19,202 (increase £3,344). Revenue was £8,738, gross profit £3,470, and net profit £860. Sales of current included 267,585 units to private consumers, 685,774 for tramways and 96,000 for public lighting.

Govan.—For the year ended May 15 the electricity department sold 2,356,367 units of electric current, against 2,161,494 last year.

Total revenue was £16,072. 16s. 2d., and total expenses (including interest and sinking fund) £15,544. 7s. 2d., leaving a net profit of £528. 9s., a decrease of £100. 19s. 1d. of which £78. 17s. 6d. was due to bad debts.

Hornsey.—The capital expended on the electricity undertaking for the year ended March 31 was £9,423, bringing the total to £147,478.

Total revenue for the year was £15,504 and expenses £6,119, leaving £9,385. £371 was employed in purchasing meters and £50 set aside for bad debts; the gross profit was, therefore, £8,964. Interest absorbed £4,587 and instalments of principal £4,238, and, after taking into account £49 from 1908, there was a balance of £189 to be carried forward. 1,258,595 units were generated; 798,309 were sold to private consumers and 80,173 were supplied for public lighting, for which there are 58 arc, 126 incandescent and 12 tantalum lamps.

Huddersfield.—The tramway accounts for the year ended March show capital expenditure £412,902, or £408,326, after taking into account £4,576 transferred from reserve or renewals fund account for Whitestone-lane extension and for cars.

Revenue was £84,357, working expenses £45,745, interest £14,241, sinking fund £9,922, and net profit £14,449, of which £12,387 has been placed to reserve or renewals fund and £2,062 applied to aid of borough rate. Car-miles run were 1,789,274 and coal truck miles 8,911. 17,434,724 passengers were carried and 4,500,051 units used. Total revenue per car-mile was 10·13d., working expenses (exclusive of power) 4·50d. per unit. Power cost 1·50d. Average fare per mile was 0·78d. and per passenger 1·12d.

Ilford. The accounts of the electricity department for the eighth year of working (to March 31) show a capital expenditure of £181,326, increase £26,725 on the year.

The annual income was £28,721 (including £15,239 from sale of current to consumers, £4,786 from the tramways department and £7,354 for public lighting), against £27,637 in 1907-8. Total working expenses were £17,977, and after allowing £65 for bad debts the gross profit was £10,679 against £9,671. Interest required £5,676 (against £5,682) and repayment of debt £5,002 (against £4,364), and the net profit was £1 against a deficit of £375. 3,235,076 units were sold (1,433,711 for private lighting, 1,020,960 for traction and 780,405 for public lighting), against 3,046,728 in 1907-8. There are 3,302 consumers (against 3,045); the maximum load in kilowatts was 1,675 (1,604), the load factor was 22·05 per cent. (21·68). The works costs were 0·84d. (including coal 0·62d.), a decrease of 0·05d. per unit sold, and the total costs 1·11d. per unit, a decrease of 0·06d.

The total income of the tramways department for the year ended March 31 was £24,802, including £22,984 from passenger traffic. Working expenses were £18,038, leaving £6,764 to meet interest (£4,516) and sinking fund (£4,236), and after crediting £557 paid by the electricity department as interest and sinking fund on capital expended on machinery used wholly in generating electricity for traction, there was a deficit of £1,431.

Perth.—There was a deficit of £1,500 on the past year's working of the tramways, against £1,200 in 1907-8. A proposal to reduce the price of current for the tramways from 1⅙d. to 1d. per unit has been remitted to the Council.

Stockton-on-Tees.—The capital expenditure of the electricity department at March last was £54,018, an increase of £295 compared with 1908.

The year's revenue was £8,175, working and general expenses £4,291 and gross profit £3,884, of which £626 has been placed to reserve, the remainder being required for interest and redemption of loans. 871,16[illegible] units were generated, 784,228 sold (719,471 to private consumers and 64,757 for public lighting).

FORTHCOMING BOOK.

"The Shot-Firer's Guide."—The deplorable accidents which so frequently occur in mines call particular attention to the importance of being fully informed as to the best and most up-to-date methods of shot-firing. The probability that deputies and shot-firers will be required to produce evidence of their knowledge and experience gives additional topical interest to a new book by Mr. Wm. Maurice, F.G.S., M.I.Min.E., M.I.E.E., who is a specialist in all that pertains to mining, and who, as manager of the Hucknall Collieries, is intimately acquainted with modern practice. The book will cover the entire field of mining work in collieries, quarries, &c., where shot-firing is an essential part of the operations. The new book will be fully illustrated, and will be ready for the autumn market. It will be published by "The Electrician" Printing & Publishing Co., London, price 3s. 6d. net.

Stoke-upon-Trent.—The capital expenditure of the electricity department for the year ended March last was £6,230, making a total of £35,044.

Revenue was £4,949, working and general expenses £2,828, gross profit £2,101, and net profit (after payment of interest and sinking fund instalment) £146. Total costs (exclusive of capital charges) were 0·98d. per unit sold. 898,965 units were generated (compared with 518,754 in 1907-8). 214,848 (195,931) were sold for lighting and 481,519 (178,160) for power. There are 438 (354) consumers, with the equivalent of 41,203 (34,802) 8 c.p. lamps connected. 765 (623) H.P. of motors are connected.

The receipts of the destructor department, which included £400 for steam supplied to the electricity department and £84 for sale of clinker, &c., and steam for disinfector, fell £679 short of the expenses, which amounted to £1,164.

Taunton.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £70,764, an increase of £653 during the year.

Annual income was £9,663 and expenses £5,593, leaving gross profit £4,070. After meeting interest and sinking fund charges there was a net profit of £19. 7s. 3d. 899,912 units were generated; 169,430 were supplied to the public lamps, 378,562 sold to private consumers and 83,620 to the local tramway company. The maximum supply demanded was 570 kw.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1909 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in handy book form. These are included in the 1909 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

Tenders are invited by LEEDS Corporation for supply of paper-insulated cables required during one, two or three years (at the option of the Corporation, to be declared on the acceptance of the tender), commencing Jan. 1, 1910. Copies of specification, conditions of contract and form of tender from the manager of the electric lighting department, Mr. H. Dickinson, 1, Whitehall-road, Leeds. Tenders to the town clerk, Mr. Robt. E. Fox, by 10 a.m. Tuesday, Sept. 7. An advertisement contains further particulars.

The Cleansing committee of DUBLIN Corporation invite tenders for supply of one electric water sprinkling car, fitted with electrically-driven air compressor or "Roturbo" pump. Specification, form of tender, &c., from the secretary, Mr. Fred. J. Allan, 3, Cork-hill, Dublin, where tenders must be delivered by noon Tuesday, Aug. 31. See also an advertisement.

LONDON County Council invite tenders for the manufacture, delivery and laying of about 6½ miles of 0·075 sq. in. three core lead-covered h.t. cables, &c., and about 46 miles of single core lead-covered l.t. cables, telephone cables, &c.; manufacture (but not erection) of 50 tramway feeder pillars; laying about 16 miles of stoneware cable ducts, including necessary manholes, repaving, &c., and manufacture and delivery of 440,000 ducts of glazed stoneware for electric cables. Drawings, &c., at the County Hall, Spring Gardens, S.W. Tenders to the Clerk to the Council, by 11 a.m. Sept. 14.

EDINBURGH Corporation invite tenders for the supply at the McDonald-road electricity supply station of a motor-alternator. Specification, form of tender, &c., can be obtained at the engineer's office, Dewar-place. Specification, general conditions and drawings can be seen at (but not obtained from) the office of the consulting engineer, Sir A. B. W. Kennedy, 17, Victoria-street, London, S.W. Tenders to the Town Clerk, City chambers, Edinburgh, by Sept. 4.

EDINBURGH Corporation also want tenders by Sept. 4 for the electric lighting installation at the new slaughter houses. Specification from the Engineer, Dewar-place, Edinburgh.

The Committee of Management of the ENNISCORTHY district Asylum invite tenders for lighting Kilcarberry House from existing plant, according to specification, which can be obtained from the Clerk, District Asylum, Enniscorthy, co. Wexford. Tenders to the Asylum Office by 10 a.m. Aug. 18.

BATTERSEA (London) Council want tenders by noon, Aug. 24, for supply and erection of (1) d.c. motors and controlling gear; (2) d.c. flame and enclosed arc lamps, and (3) motor and arc lamp installations. Forms of tender from the Electrical Engineer, Lombard-road, Battersea, S.W.

Tenders are required by Sept. 10 for supply and erection of overhead cables in connection with the electric lighting of BALLINASLOE District Lunatic Asylum. Specifications from Mr. G. B. Meenan, 5, Charleville-road, Rathmines, Dublin.

TODMORDEN Corporation want tenders by noon, Aug. 14, for supply and erection of 150 kw. generator and engine, switchboard extensions, condensers and steam piping, and steam pump. Specification from the Borough Electrical Engineer.

RHYL Council want tenders by Aug. 21 for supply of 125 kw. Diesel oil engine set, and 50 kw. steam dynamo set. Specifications from the Electrical Engineer.

WEST HAM Guardians want tenders by 11 a.m., Sept. 2, for one year's supply of electrical fittings. Forms of tender from the Master of the Workhouse on and after Aug. 19.

YORK Corporation want tenders by 9 a.m. Aug. 27 for supply of 18 double-deck tramcars and one watering car. Specification from the City Electrical Engineer.

The Deputy Postmaster-General, SYDNEY, N.S.W., wants tenders by 2:30 p.m. Nov. 10, for supply and erection of a branching metallic multiple magneto switchboard at the Petersham telephone exchange. Specifications, &c., at 72, Victoria-street, London, S.W.

Tenders are invited for supply of ten 100-number switchboards to the Postmaster General's Department, NEW SOUTH WALES. Tender forms at the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited for the supply of telephone material to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

The GOLDEN BAY (N.Z.) Cement Works (Ltd.) require tenders by noon, Nov. 1, for supply and erection at Terahoke, Golden Bay, of electrically-driven portland cement plant. The cement making plant and the power plant may be tendered for together or separately. Preference will be given to British plant, and foreign machinery is generally liable to duty 10 per cent. in excess of the duty on British machinery. Specification at 73, Basinghall-street, London, E.C.

The Chairman of the Tender Board, Control and Audit Office, CAPE TOWN (S. Africa) wants tenders by noon, Sept. 29 for supply of dry cells for 12 months, from July 1, 1910, to the General Post Office Stores at Cape Town, Port Elizabeth and East London. The estimated number of cells required is 2,500. Form of tender from 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

A further order has been received for two centrifugal pumps manufactured to the designs of Messrs. Jens Orten-Böving & Co. by Messrs. Willans & Robinson. The pumps are to deliver 200 gallons per minute against a head of 535 ft. at 1,440 revs. per min. The consulting engineers are Messrs. Rendel & Robertson. The features of these pumps are an automatic end-thrust balancing device, improved designs of impellers and guide wheels, and casing, &c.

Bury (Lancs.) Council have accepted the tender of Clarke, Chapman & Co. for three water-tube boilers, with superheaters and mechanical stokers.

Stretford Council have accepted the following tenders:—

W. T. Glover, 741½ yds. of 0·2 cable, 3s. 8d. per yard; Bennett & Wightman, 600 yds. troughing, 8¼d. per yard; E. Heron & Son, two 4 in. slide valves for boiler and feed range, £6 each; Callender's Co., 500 yds. of 0·05 cable, £28. 2s. 6d.

The "D.P." Battery Co. have recently received an order for a storage battery of 50 cells for Dundee University College through Steinthal & Boydell, who are supplying the whole of the electrical equipment of the college.

Darlington Corporation have accepted the tender of Ferranti Limited for a switchboard and that of the Whessoe Foundry Co. for pipework.

Wallasey Council have accepted the tender of the Premier Accumulator Co. for a battery of 264 cells, also for booster plant, and for the maintenance of same for 10 years.

Halifax Council have accepted the tender of the British Insulated & Helsby Cables for supply of cables at £2,104.

Tunbridge Wells Council have accepted the tender of W. T. Henley's Telegraph Works Co. for cables.

Eccles Health committee have accepted the tender of Waring & Gillow for wiring 12 houses in Corporation road at £48. 15s.

Wimbledon Council have placed an order with Babcock & Wilcox for chain grate stokers for two boilers at £600.

Maidenhead Council have placed an order with the Diesel Engine Co. for a 150 kw. Diesel oil engine and dynamo at £2,505.

The Robinson Gold Mining Co. (South Africa) have placed a contract for cable with W. T. Henley's Telegraph Works Co.

Hereford Council have accepted the tender of the Blasberg Engineering Co. for the erection of a water cooling tower at £270.

Belfast Tramways and Electricity committee have accepted the tender of Cowans Limited for additional switchboard panels.

Messrs. Jens Orten-Böving & Co. have received an order for two 3,750 H.P. water turbines for the Calgary Electric Power Co. (Canada), and for four "Böving" patent governors for four Francis turbines of 2,750 H.P., each for the Mines Power (Ltd.). The consulting engineers in both cases were Messrs. Smith, Kerry & Chace.

The A.E.G. Electrical Co. of South Africa have orders for four electric hoists for the Ferreira Deep. The equipment will include four synchronous motors of 600 H.P. each at 375 revs. per min. The same contractors have orders for four 50 H.P. motors for Glen Deep, one for Crown Deep and two for Geldenhuis Deep.

An order has been given for five double drum electric winders for the East Rand (S. Africa) Proprietary Mines (Ltd.). The electrical portion of the plant is being supplied by the A.E.G. of Berlin and the mechanical portion by Fraser & Chalmers.

BUSINESS NOTICES.

Enoch Sharpe & Alex. Waters, electrical engineers, 34, Uverdale-road, Chelsea, London, S.W., have dissolved partnership. Debts by Mr. Sharpe.

Messrs. Haes & Eggers, agents for a number of British electrical manufacturers, have removed from 2, Hunter-street to 163, Clarence-street, Sydney (N.S.W.).

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell will sell by auction in lots at the Gramophone Works, 62, Glengall-road, Old Kent-road, London, S.E., on Wednesday, Sept. 8, and following days, a number of modern machine tools, including 30 screw-cutting and other lathes, 10 capstan lathes, milling and shaping machines, &c.; also 13 c.c. motors, three dynamos, shafting, pulleys, belting, &c., 800 Edison electric 200-thread phonographs for Amberol records, 200 electric multiplex phonographs, &c. On view two days preceding sale. Catalogues may be had on the premises or of the Auctioneers, 11, Billiter-square, E.C. An advertisement contains further particulars.

Sale by Tender.—Messrs. Corfield & Cripwell, Balfour House, Finsbury-pavement, London, E.C., invite offers for the plant, machinery, stock in trade, &c., of Casperds Limited. See advertisement.

Telegraph Patents Development.—The owners of certain patents relating to "Improvements in printing telegraphs, typewriters &c.," and "Apparatus for punching strips of paper and like materials, suitable for use in telegraph transmitters, &c.," desire to enter into negotiations with the view of granting licences under same. Information may be obtained from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C. See also an advertisement.

Patents Development.—The owners of patents No. 11,933/1900, for "Improvements relating to the regulation of electric motors," Nos. 19,899/1905 and 26,808/1905, for "Improvements relating to a.c. electric motors," and No. 16,435/1905, for "Improvements relating to transmission systems for wireless telegraphy and telephony" desire to enter into arrangements, by way of licence and otherwise, for exploiting same. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

High Voltage Lamps.—Simplex high voltage lamps can now be supplied suitable for burning direct on circuits from 200-250 volts of 25 c.p.

CATALOGUES, &c.

Battery Signal Machine.—Messrs. Siemens Bros. & Co. have issued a pamphlet dealing with the Siemens battery signal machine the essential feature of which is that only a small primary battery is required for lowering the heaviest signal to the clear position; the efficiency of the apparatus being so high that only a minimum amount of energy is required. A number of other advantages are possessed by this piece of apparatus which makes it specially suitable for signalling work on railways generally. All the mechanism, except the crank, which is attached to the upright rod working the signal, is enclosed inside a cast-iron case, and is, therefore, protected from dust or danger. A battery of 24 Siemens-Obach cells is used for working the signal, the voltage being 24 volts. The time taken to lower the signal is about eight seconds, so that the energy consumed is not excessive. At the present time, when the application of electricity for signalling work is a matter that is engaging the attention of electrical engineers, this pamphlet is of more than usua interest.

Crane Motors and Controllers.—We have received from Messrs. Dick, Kerr & Co. a new edition of their pamphlet bearing this title. It contains a very full description of the details of the crane motors manufactured by this well-known firm, the construction of the various parts being thoroughly gone into; and there is also a schedule of the standard sizes of crane motors made by them showing the rating, horse-power, weight and dimensions generally The second part of the pamphlet is devoted to a description o metallic shield blow-out controllers for crane and hoist work, the various details of these apparatus being given at sufficient length fo their peculiarities to be well indicated. The pamphlet is illustrated throughout with examples of Messrs. Dick, Kerr & Co.'s work a regards cranes generally, and should be in the possession of a manufacturers who are likely to require any of this class of equip ment.

Electro-medical Apparatus.—A firm which has for some year paid particular attention to the application of electricity to medica and surgical purposes is Messrs. Siemens Bros. & Co. Their late pamphlets on this subject describe a clinical temperature-recordin outfit, in which the temperature is measured by a platinum spir placed against the various parts of the body whose temperature required. A continuous record on a chart of the readings th obtained is made by a stylus. Another pamphlet in the same seri gives details and prices of the various radium and radio-active sal which are supplied by Messrs. Siemens Bros. & Co. for medical pu poses. The third pamphlet, entitled the "Application of Electricit to Medicine and Surgery," describes a number of apparatus design for these purposes.

Electric Horns.—Messrs. Siemens Bros. & Co. have also issued leaflet dealing with this subject. The horn described is worked on modified telephonic principle and consumes very little energy. should find a useful application on all types of motor vehicles.

Railway and Tramway Plant.—The latest catalogue of tl Railway & General Engineering Co., Nottingham, gives a goo general idea of the activities of this firm. Their particular specia ties appear to be railway crossings of all kinds, and castings general in connection with tramway and railway work. An interestin piece of apparatus is Brown-Crosta's rail grinder, which can l driven by an electric motor and is quite self-contained. Th machine is made in a number of various types.

Electric Cranes.—Messrs. Neville Kaye & Co., of Thanet Hous London, W.C., who make a speciality of electric lifts, light cran and overhead runways, have ready an illustrated pamphlet whi gives details of various equipments of this kind,

Imports.—The following are official values of electrical macl nery, material and apparatus imported into this country (*a*) durin July, 1909, and (*b*) during the current year from Jan. 1 July 31, with the increases or decreases compared with the corre ponding periods of 1909:—

Electrical machinery (*a*) £57,160 (decrease £13,760), (*b*) £289,9 (decrease £108,002); telegraph and telephone cables (*a*) £10,336 (crease £465), (*b*) £72,811 (decrease £2,501); telegraph and te phone apparatus (*a*) £12,186 (decrease £2,610), (*b*) £105,041 (decrea £9,382); other electrical wires and cables, rubber insulated (*a*) £23,7 (increase £17,234), (*b*) £52,748 (increase £7,019); with other insulati (*a*) £816 (decrease £7,247), (*b*) £54,624 (decrease £10,472); carbons £11,256 (decrease £132), (*b*) £76,833 (decrease £21,326); glow lam (*a*) £30,899 (increase £10,569), (*b*) £248,137 (increase £103,585); a lamps and electric searchlights (*a*) £64 (decrease £467), (*b*) £8,890 (crease £6,516); parts of arc lamps and searchlights (other than carbon (*a*) £5,612 (increase £761), (*b*) £33,339 (increase £2,572); primary an secondary batteries (*a*) £2,553 (decrease £2,496), (*b*) £27,086 (decrea £2,611). Total of electrical goods and apparatus, other than mac nery and telegraph and telephone wire, (*a*) £104,027 (increase £10,78, (*b*) £738,565 (increase £62,947).

Exports.—The exports of electrical machinery, material, &c.,) during July, 1909, and (*b*) during the current year from Jan to July 31, and the increases and decreases compared with e corresponding periods of 1909, are as follows:—

Electrical machinery (*a*) £122,563 (decrease £3,903), (*b*) £830,24

(increase £61,816); telegraph and telephone cables (a) £236,445 (increase £157,892), (b) £434,873 (increase £119,061); telegraph and telephone apparatus (a) £49,950 (increase £36,381), (b) £173,444 (increase £79,883); other electrical wires and cables, rubber insulated (a) £22,648 (increase £1,216), (b) £149,425 (decrease £9,637); with other insulations (a) £27,684 (decrease £175), (b) £175,323 (increase £12,883); carbons (a) £988 (decrease £172), (b) £5,188 (increase £175), glow lamps (a) £5,746 (decrease £1,243), (b) £40,966 (increase £9,196); arc lamps and searchlights (a) £2,366 (increase £65), (b) £11,911 (decrease £1,043); parts of arc lamps and searchlights (other than carbons) (a) £503 (decrease £604), (b) £8,953 (decrease £355); primary and secondary batteries (a) £9,556 (increase £1,487), (b) £66.054 (increase £25,076). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (a) £388,800 (increase £199,453), (b) £1,274,436 (increase £243,104).

BANKRUPTCIES, LIQUIDATIONS, &c.

A second and final dividend (9½d.) will be payable on Aug. 18 at 1, Bank-street, Bradford, to the creditors of Wm. Terrell Garnett (trading as W. T. Garnett's Cable Co.), Barkerend Mills, Bradford.

A dividend of 1s. 8d. has been declared in the failure of Conrad E. Zimdars, pneumatic and electric telegraph engineer.

In the matter of Vaughan & Cook (Ltd.), Mr. Leonard V. Houseman, liquidator, announces that a first and final dividend of 7s. 2½d. in the £ is ready for payment at the offices of Messrs. Marreco & Co., 1, Clement's Inn, London, W.C.

The creditors and contributories of the Ozonisation Synd. (Ltd.), Craig's-court, Charing Cross, London, W.C., meet at 33, Carey-street, W.C., on Aug. 20.

Claims against Thomas Parker (Ltd.) (in vol. liq. for the purpose of reconstruction) by Aug. 28 to Mr. W. A. Nelson, Lichgate, Wolverhampton.

Claims against the General Electric Sign & Engineering Co. (Ltd.) by Sept. 7 to Mr. E. Hayes, 28, Basinghall-street, London, E.C.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

June 24, 1909.

4,790 PEARSON. Ironclad electric switches.
4,803 SIEMENS BROS. & CO. & BRADLEY. Electric searchlights.*
4,826 FESSENDEN. Electric signalling. (Date applied for, 30/7/08.)*†
4,833 HOWGRAVE-GRAHAM. Electric switches.

June 26, 1909.

4,858 BINGHAM. Electric furnace electrodes.
4,873 HOLDEN. Electric clocks.
4,934 REGNART. Electric reflector lamps.
4,937 GRUNWALD. Electrical induction furnaces. (Addition to No. 3,599/09. Date applied for, 2/10/08.)*
4,952 GREINER. Detecting faulty insulators in high-tension conductors. (Date applied for, 20/7/08.)*†
4,960 FARJAS. Permanently active radio-active products. (Addition to No. 14,762/09. Date applied for, 8/5/09.)*†
4,972 WUNDERLICH & HUGHES. Raising and lowering of arc lamps and the like. (Addition to No. 25,398/07.)*
4,980 FASSLER. Rectification of alternating electric currents and devices.

June 28, 1909.

5,006 KELVIN & JAMES WHITE, EVANS & WILSON. Terminals for shunts and other electrical apparatus.
5,032 KOZESNIK. Third rail electric railway systems.*
5,081 DAALEN. Dynamos and motors.*
.084 and 15,085 REES. Centrifugal pumps, turbines or compressors.
.090 HORMBY. Turbine motors.*

June 29, 1909.

.147 COCKSHOTT. Trolley heads of electric tramcars.
.151 LYNESS. Contact finger for electrical controllers, switches, and the like.
.182 SMITH & SMITH. Flame arc lamps.
.192 and 15,193 SOCIETE FRANCAISE D'INCANDESENCE PAR LE GAZ (SYSTEME AUER). Metallic filaments for incandescent electric lamps. (Date applied for, 18/7/08.)*†
194 BLEECK. Primary batteries.*
.208 ZAMBONI & STERLING. Reflectors or shades for electric lamps.*
.210 CANELLO. Attaching filaments of incandescent lamps. (Date applied for, 22/7/08.)*†
.211 FLOOD. Electric switches.
.217 HIGHFIELD. Brush-holders for dynamo-electric machines.

June 30, 1909.

287 JOHNSON & PHILLIPS & BROCHIE. Magazine arc lamps.
.319 POHL & PHŒNIX DYNAMO MFG. CO. Dynamo-electric machines constructed with commutators.
.326 LEITNER. Production of constant potential electric circuits.

July 1, 1909.

.345 FERGUSON. Voltage regulators for dynamo-electric machines.
366 CLARK & JUDGE. Turbines.
370 HODGSON. Radiators.
.371 HOUGHTON, ALLMAN & GRAY. Collector shoes or skates for electric traction systems. (Date applied for, 2/6/09. Comprised in No. 12,937, dated 2/6/09.)
.385 BROWN. Electric telegraphy.
386 K[illegible]. Point switch for tramways and railways.
421 B.T.-H. CO. & DAWSON. Current collecting devices for dynamo-electric machines.

July 2, 1909.

494 CROMPTON & CO., MACFARLANE & BURGE. Rotary electric trausformers and motor-generators.
496 JAHODA. Metallic filaments for electric incandescent lamps. (Date applied for, 10/5/09.)*†

July 3, 1909.

532 WALTERS. Stage arc lamps and other similar lamps.*
554 TUBBS. Magazine arc lamps.
574 PRIESTLEY. Overhead lines for electric traction.*

July 5, 1909.

15,578 KENNEDY-MCGREGOR. Switches.*
15,605 SIEMENS S[illegible] G.M.B.H. [illegible] (Date [illegible])*
15,647 LESSING. Electric carbons.
15,650 B[illegible]VERIE & RA[illegible]. [illegible]
15,659 MAXA[illegible]ER. C[illegible] (Date [illegible])*

July 6, 1909.

15,670 HEURTLEY. Electrical and other recording and measuring instruments
15,672 LUST[illegible]. Controlling [illegible]
15,681 THOMAS & THOMAS. Switches.
15,682 THOMAS & THOMAS. Electric collectors.
15,725 WESTINGHOUSE ELECTRIC CO. Braking apparatus for railway [illegible] (Date applied for, 14/7/08.)*†
15,737 BENK. S[illegible] metal [illegible] (Date applied for, 28/12/08. Comprised in No. 28,290, dated 28/12/08.)*
15,771 MIDGLEY & VANDERVELL. Dynamo-electric machinery.
15,790 SLACK. Electric fuses.

July 7, 1909.

15,800 WALLWORK, WALLWORK & SHILL[illegible]. C[illegible] dynamo-electric machine.
15,867 BOURDOS. Manufacture of filaments for electric lamps.
15,880 & 15,881 JABURG, JUN. Arc lamps. (Date applied for, 26/5/08. Comprised in No. 7,471, dated 29/3/09.)*
15,895 KREBS & KREBS & CO., G.M.B.H. Trolley wheel.*

July 8, 1909.

15,929 GAMBRELL & GAMBRELL. Electrical testing apparatus.

SPECIFICATIONS PUBLISHED.

1908 SPECIFICATIONS.

14,852 TRENZEN & POPE. Bodies of metallic titanium.
14,853 TRENZEN & POPE. Metallic filaments for electric incandescent lamps.
14,934 ROSENBUSCH. Switches.
15,047 PECK. Alternating electric current distribution systems.
15,053 WILDERSPIN & HOUGH. Winding machines applicable for winding coils of wire for electrical purposes.
15,054 GRAY. Armoured electric cables.
15,130 B.T.-H. CO. (A.E.G.) Electric motor generator sets for supplying arc lamps for searchlights and for other apparatus. (Addition to No. 4,379/05.)
15,186 STONEHAM & STONEHAM. Coin-controlled mechanism for gas, electricity and other meters.
15,213 PRESTON & HENDRIE. Fusible plugs.
15,268 BIRKETT. Controlling or braking electrically-operated machinery.
15,275 JOHNSON-LUNDELL ELECTRIC TRACTION CO. & PRICE. Regulation or control of electric motors.
15,494 FINNIGAN. Electrical contacts for use in railway signal systems.
15,645 KILBURN. (Oesterle.) Electric furnaces for the treatment of ores and the like.
15,646 KILBURN. (Oesterle.) Magnetic separators.
15,853 RAYMOND-BARKER & ORLING. Electric relay systems and relays therefor.
16,305 CURWEN. (J. G. Brill Co.) Supports for contact plows or electric-current collectors for electric railways.
16,722 B.T.-H. CO. (G.E. CO., U.S.) Arc control mechanisms for projectors, searchlights and the like.
17,048 KINGSBURY. (Western Electric Co.) Telephone current transmitting, re-transmitting and reinforcing apparatus. (Request under sec. 19 not granted.)
17,706 HILL. Shade-holders for incandescent, electric and other lights.

COMPANIES' MEETINGS AND REPORTS.

CENTRAL LONDON RAILWAY CO.—At the meeting last week the chairman (Sir HY. OAKLEY) stated that the receipts for the half-year were £20,000 less than in the corresponding period of 1908. The exhibition this year had not attracted so many people as in 1908. That traffic had fallen off to the extent of 445,000 passengers. For distance equal to three of the underground stations they found that the tramways were charging 1d., and that practically they were depriving the company very largely of passengers travelling that distance. When the board were satisfied of that, and had examined the question all round, they determined to adopt a penny fare for any three stations, on the basis that every station should be a terminus either to the East or to the West, and from the central station a man who paid a penny could go to three stations in either direction. Of course, it involved a loss which gave them much consideration at starting, because, if they got passengers back, those who formerly paid 2d. now only paid 1d. As the average cost per passenger was 1d., there was very little profit, or chance of profit, unless they increased the number sufficiently to repay them for the accommodation given. However, there was no other course open. The loss by the reduction of 2d. passengers represented something like two millions of passengers; the gain by the increased number of 1d. passengers had not quite repaid the whole loss, but it was approaching it. The system of through booking had now been established between their line and the other tubes. They had carried three millions of passengers under that system, an increase of rather more than a million over the corresponding period. Their Bill for the extension to Liverpool-street had passed both Houses and was on the point of receiving Royal assent.

CONSOLIDATED ELECTRICAL CO. (LTD.)—The ordinary income for the year ended March 31 was £6,512. 1s. 6d. and expenses £1,562. 5s. 11d. Of the balance of £11,585. 3s. 9d. standing to credit of revenue the interim preference dividend of 3 per cent. paid on Jan. 1 last absorbed £450, leaving £11,135. 3s. 9d. The final preference dividend paid on July 1 absorbed £450, and the directors now recommend a dividend of 3 per cent. for the year on the ordinary shares, absorbing £3,300, leaving £7,385. 3s. 9d. to be carried forward. Steps are about to be taken for the liquidation of the Consolidated Supply and the Private Wire & Telephone Installation Companies, and the realisation of the company's interest therein. The position of the Anglo-Portuguese Telephone Co. is entirely satisfactory.

GREAT NORTHERN RAILWAY CO.—Lord Allerton stated, at the meeting, that further extensions of electric tramways in the London suburban and Yorkshire districts were responsible for the loss of 650,000 passengers, and £6,000 in money; in Yorkshire they had closed one passenger station. The extension of electric tramways in

North London continually decreased the railway short-distance suburban traffic and, therefore, the policy of the company was to develop the outer suburban traffic. He was sceptical as to the possibility of railways competing with trams for short-distance passengers, and he did not think that the energies of railway companies would be best employed in trying to break tramway companies or themselves for that kind of traffic.

LANARKSHIRE TRAMWAYS CO.—The revenue for the half-year ended June 30 was £32,199. 16s., and expenses £17,686. 12s. After deducting contributions payable to local authorities (£794. 0s. 9d.) and debenture interest (£608) and adding £865. 3s. 3d. brought forward, the balance is £13,976. 6s. 6d. The directors recommend payment of a dividend at the rate of 5½ per cent. for the half-year, leaving £5,282. 18s. 7d. to be carried forward. Owing to continued trade depression the traffic receipts show a decrease of £1,764, compared with the corresponding half-year of 1908, and the expenses show a reduction of £1,306.

METROPOLITAN DISTRICT RAILWAY CO.—During the half-year ended June 30 the gross receipts were £273,318, an increase of £25,419 on the corresponding half of 1908, and the working expenses were £148,096, a decrease of £6,733. After providing for interest and other charges and setting aside £10,000 as reserve for renewals, the balance was £19,10[illegible]. 15s. 6d., and the directors recommend a dividend at the rate of 3 per cent. be declared on the 4 per cent. guaranteed stock. Including workmen and season-ticket holders, 32,949,895 passengers were carried (against 29,526,685 in the same half of 1908), the average receipts per passenger was 1·85d. and the train mileage 1,557,559.

The Chairman (Sir GEO. S. GIBB) stated at the meeting on Wednesday that the traffic receipts were increasing at a very satisfactory rate. The new offices at St. James's Park were now approaching completion. The Underground Company and the three tube railway companies associated with the Underground were becoming the tenants of the additional accommodation provided at St. James's Park. They will pay the District Company £1,900 a year for accommodation, and all the work of the companies, which were under one general administration, would be in one office, which was a considerable advantage. They had carried 32,900,000 passengers, an increase of 3,300,000 (or 11·22 per cent.) over 1908. The local passengers on the District Railway were 15,500,000, or 47½ per cent. of the total number carried. The through passengers (including those exchanged with the City lines undertaking) were 17,500,000, an increase of 12 per cent., and the through traffic was 52½ per cent. of the total traffic. After analysing the various items in the accounts, he said that they were having good increases at present, and he thought that, with some few exceptions, the fares were on a satisfactory basis. The London traffic generally did not show much improvement, and had still many doubtful and unsatisfactory features. They must seek steady progress and stability.

TYNESIDE TRAMWAYS & TRAMROADS CO.—Dr. J. T. Merz stated on Tuesday that the traffic receipts showed an increase of £748, against a decrease of £1,251 last year. The increase was almost entirely due to workmen traffic. The number of passengers carried increased by 147,676; receipts per car-mile were 8·26d., against 7·89d., and expenses per car-mile 5·84d., against 5·79d. They proposed to pay on the ordinary shares a dividend at the rate of 1 per cent., against nothing last half-year.

WESTINGHOUSE ELECTRIC & MFG. CO. (U.S.A.)—The annual report states that the affairs of the company were taken out of the hands of the receivers on Dec. 5, 1908. There was a decrease in the surplus account during the year ended March 31 of $2,992,992. The loss during the year of $918,683, after providing for interest on the debt and all expenses, is chiefly accounted for by a small volume of business, the utilisation of high-priced material, by sales at reduced prices and by very considerable extra expenses incurred in completing the departmentalising of the manufacturing operations and in rearranging the machinery, which work was carried on without interruption by the receivers. The officials estimate that the plants have an annual output capacity of $50,000,000, and that the cash capital provided is ample for conducting a business of that magnitude. While there has been a decided improvement in the business of the company since the beginning of the year, it has not yet nearly reached normal proportions, although the outlook and inquiries indicate that in the near future the full capacity of the various works will be required to meet the demand.

YORKSHIRE ELECTRIC POWER CO.—The directors' report for the half-year ended June 30 states that receipts from the sale of energy and for work charged to consumers, &c., were £11,169. 4s. 2d., against £8,698. 9s. for the corresponding half-year of 1908. Gross profit was £2,598. 12s. 11d., against £1,249. 16s. After paying mortgage interest the net profit was £1,069. 17s. 11d., compared with £363. 6s. 10d.

NEW COMPANIES AND STATUTORY RETURNS.

NEW COMPANY.

DYNAMIC ELECTRICAL CO. (LTD.) (104,436.)—Reg. Aug. 6, capital £100,000 in £1 shares, to acquire all or any of the undertakings, businesses, properties and assets of the Dynamic Synd., the Dynamic (French) Synd. and the Mitcham Electric Fan Co., and to carry on the business of electricians, engineers, makers and manufacturers of and dealers in electric and other motors, fans, dynamos, induction coils and other machinery and electrical apparatus, &c. First directors, [illegible] Simpson T. H. Weguelin and B. H. Weguelin.

STATUTORY RETURNS.

EUROPE & AZORES TELEGRAPH CO. (LTD.) In return to June 23 capital is £200,000 in £10 shares, all of which have been taken up. £144,320 has been received and £55,680 is considered as paid. Mortgages and charges, nil.

EVERSHED & VIGNOLES (LTD.)—The capital in the return to July 2 is £30,000 in £10 shares, all of which have been paid up. Mortgages and charges, £10,800.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—Return to May 28 gives capital as £600,000 in £1 shares (300,000 preference), of which 245,000 preference and 245,000 ordinary shares have been taken up. £423,340 has been received on 178,340 ordinary and 245,000 preference. £66,660 is considered as paid on 66,660 ordinary. Mortgages and charges, £245,000.

ROBERTSON ELECTRIC LAMPS (LTD.)—According to return to June 3 capital is £100,000 in £10 shares, of which 6,750 have been taken up. £66,485 has been received on 6,650 shares, leaving £15 in arrears. £1,000 is considered as paid on 100 shares. Mortgages and charges, £10,000.

SPANISH TELEPHONE CO. (LTD.)—In return to July 17 capital is £61,000 in 3,600 ordinary shares of £10 each and 1,250 preference shares of £20 each, of which 3,600 ordinary and 671 preference have been taken up. £20 per share has been called up on 671 preference, and £10 per share on 2,000 ordinary, and £33,420 has been received. £16,000 is considered as paid on 1,600 ordinary. Mortgages and charges, nil.

WALTERS ELECTRICAL MFG. CO. (LTD.)—Return to June 30 gives capital as £13,000 in £1 shares, of which 10,507 have been taken up. £1 per share has been called up on 507 shares and £507 has been received. £10,000 is considered as paid. Mortgages and charges, £2,600.

J. G. WHITE & CO. (LTD.)—The capital in return to July 12 is £200,000 in 15,000 preference shares of £10 each and 50,000 ordinary shares of £1 each, all of which have been taken up. £10 per share has been called up on the preference and £150,000 has been received. £50,000 is considered as paid on the ordinary. Mortgages and charges, nil.

RECEIVERSHIPS.

BI-CENTRIC INSULATING CO. (LTD.)—Notice of the appointment of E. Taylor, C.A., 71, Temple-row, Birmingham, as receiver and manager, by order of court dated July 27, 1909, has been filed.

BOGOTA TELEPHONE CO. (LTD.)—D. Gibson, C.A., of 4, Kingsmead road, S. Oxton, Birkenhead, ceased to act as receiver or manager on July 23.

LONDON ELECTROBUS CO. (LTD.)—A notice of the appointment of A Riding, 15, Cockspur-street, S.W., as receiver and manager on July 22 1909, under powers contained in a trust deed dated Dec. 7, 1908, has been filed.

WIMSHURST, HOLLICK & CO. (LTD.)—A notice of the appointment of W. Cash, C.A., 90, Cannon-street, E.C., as receiver, by order of court dated Aug. 9, 1905, has been filed.

CITY NOTES.

MEMORANDA (Aug. 12).—Bank rate 2½ per cent. (since April 1909). Price of silver, 23½d. per oz. Consols $84\frac{1}{16}$—$84\frac{3}{16}$ for money 84⅛—84¼ for account. Consols Pay Day, Sept. 1; Stock and Share Continuation Days, Aug. 24 and Sept. 8; Ticket Days, Aug. 25 and Sept. 9; Pay Days, Aug. 26 and Sept. 10; Mining Shares Carry Over Day, Aug. 23.

PRICES OF METALS (London).—*Copper*, cash, 60[illegible]; three months 61⅛. *Lead*, English, 12⅞—13⅛; foreign, cash, $12\frac{9}{16}$; three months 12⅞. *Spelter*, cash, 21¾—22. *Tin*, English, 135—135; foreign cash, 135; three months, 135½—136½. *Iron*, Cleveland, cash, 49/, and three months, 50/4. *Magnet Steel* (price supplied by W. Dennis & Co.), £55.

FORT WILLIAM ELECTRIC LIGHT CO. (LTD.)—The directors have declared a dividend at the rate of 2½ per cent., tax free.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Aug. 18 a special settling day in 77,039 £1 (12s. 6d. paid) preferred ordinary shares of the *National Telephone Co. (Ltd.)*, and have granted quotations to 640,000 £5 fully-paid 5 per cent. cumulative first preference and 500,000 £5 (fully paid) 5 per cent. cumulative second preference shares and £1,732,237 4½ per cent. debenture stock (in lieu of 1st, 2nd and 3rd preference shares now quoted) of the *Anglo-Argentine Tramways Co. (Ltd.)*, and 20,000 £10 fully paid 6 per cent. cumulative preference shares of *Hurst, Nelson & Co. (Ltd.)*. The committee have been asked to appoint special settling days in and grant quotations to scrip (fully and partly paid) for £218,500 4½ per cent. consolidated first mortgage debenture stock of the *Newcastle-upon-Tyne Electric Supply Co. (Ltd.)*, and a further issue of £500,000 4½ per cent. perpetual consolidated debenture stock of the *British Columbia Electric Railway Co. (Ltd.)*; to grant quotations to £150,000 5 per cent. second mortgage debentures (in lieu of scrip now quoted) of the *Bombay Electric Supply & Tramways Co. (Ltd.)*, £1,250,000 6 per cent. 50 year mortgage bonds (in lieu of scrip now quoted) of the *Mexico Tramway Co.*, and a further issue of £50,000 4 per cent. redeemable debenture stock of the *Oriental Telephone & Electric Co. (Ltd.)*

WASTE HEAT & GAS ELECTRICAL GENERATING STATIONS (LTD.)—The directors have declared an interim dividend for the half year ended July 31 at the rate of 5 per cent., less tax.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Amount.	Inc. or Dec. (a)
		£	£		£	£
berdeen Corporation	Aug. 4	1,603	− 36	9	14,142	− 827
irdrie	July 30	181	+ 4	30	6,491	− 138
nglo-Argentine	Aug. 5	38,645	+ 3,376	31	1,206,885	+ 69,073
yr Corporation	,, 7	5 5	− 18	12	4,801	− 231
aker St. & Waterloo Ry.	,, 7	2,770	+ 120	5	15,430	+ 950
arnsley	July 30	169	− 17	30	4,976	− 237
arrow	,, 30	283	− 75	30	6,716	− 568
ath Electric Trams, Ltd.	Aug. 4	1,230	− 60	31	23,505	+ 943
irmingham Corporation	,, 7	6,611	− 152	19	123,210	+ 3,198
irmingham & Mid.	July 23	871	+ 42	29	24,173	+ 374
lackburn Corporation	...	...	...	...	...	...
lackpool and Fleetwood	Aug. 7	2,417	+ 143	5	6,773	+ 95
olton Corporation	,, 8	2,456	+ 119	19	41,614	− 871
ombay	July 8	R35,320	+ R3,697	26	R1,022,665	+ R61,331
ournemouth Corporation	Aug. 4	2,572	− 28	18	30,841	− 221
radford Corporation	July 31	4,703	− 411	17	86,444	− 1,061
righton Corporation	Aug. 8	2,060	− 83	19	19,187	+ 618
ristol Trams & Carriage	,, 6	7,765	+ 870	11	65,956	+ 1,319
urnley Corporation	,, 7	1,383	− 42	19	24,371	− 215
urton Corporation	,, 8	331	− 12	19	5,024	− 153
ury Corporation	...	...	...	...	...	...
alcutta Tramways Co.	,, 7	R15,612	+ R874	5	R250,294	+ R20,180
amborne-Redruth	,, 7	133	− 7	32	3,8.8	− 117
ardiff Corporation	...	...	...	...	...	...
avehill	July 30	92	− 17	30	2,526	− 182
entral London Railway	Aug. 7	4,635	− 2,013	5	26,180	− 9,775
haringC.,Euston & H'stead	,, 7	3,695	+ 180	5	19,185	+ 2,680
hatham & Dist. Lt. Rys.	,, 5	1,126	− 93	31	21,626	+ 1,173
ity & South London Rly.	,, 8	2,986	+ 10	5	15,421	+ 976
ity of Birmingham	July 30	2,794	− 56	30	84,103	+ 683
olchester Corporation	Aug. 4	288	− 40	5	1,1?2	− 115
ork Electric Trams Co.	,, 5	586		31	13,334	− 876
roydon Corporation	,, 6	2,050	+ 152	‖18	28,170	+ 1?2
evonport & Dist. Trams	July 30	368	− 173	30	10,939	− 2,551
over Corporation	...	...	...	...	...	...
ublin & Lucan Railway	Aug. 6	214	+ 2	5	866	− 7
ublin United	,, 6	6,997	+ 96	5	31,123	− 186
udley-Stourbridge	July 30	821	− 56	30	23,552	− 664
undee Corporation	Aug. 4	1,162	− 88	†12	13,802	− 613
ast Ham Council	,, 7	1,132	+ 18	§18	19,081	+ 2,692
xeter Corporation	,, 6	456	− 6	19	6,663	− 608
ateshead & Dist. Trams	July 30	1,011	− 22	39	29,728	− 316
lasgow Corporation	Aug. 7	16,649	− 621	‡10	162,017	− 4,536
lossop Trams	,, 7	130	− 8	32	3,863	− 119
ravesend—Northfleet	July 30	226	− 26	30	6,061	− 159
reat Northern & City Rly.	Aug. 7	1,145	− 15	5	6,351	− 27
. Northern, Piccadilly, &c.	,, 7	4,430	− 50	5	26,015	+ 825
reenock & Port Glasgow	July 30	650	+ 60	30	15,912	+ 222
artlepool Tramways	,, 30	258	− 57	30	6,750	− 223
astings Elec. Trams Co.	Aug. 5	1,851	− 126	5	6,416	− 370
ong Kong	,, 7	$8,174	+ $13	5	$40,864	+ $9,827
uddersfield Corpn.	...	...	...	...	...	...
ull Corporation	,, 7	2,845	+ 72	18	46,196	+ 684
ford District Council	...	...	...	...	...	...
keston District Council	,, 4	161	− 26	18	2,419	− 219
swich Corporation	,, 7	605	− 4	19	7,713	− 41
of Thanet Co.	,, 7	2,051	− 65	§36	21,101	− 130
row	July 30	120	− 5	30	3,417	+ 290
ghley Corporation	Aug. 5	162	− 7	18	3,119	+ 39
derminster & District	July 30	126	− 37	30	3,019	− 210
marnock Corporation	Aug. 7	161	− 4	12	1,903	− 89
arkshire Trams Co.	,, 5	1,395	+ 121	31	38,793	− 1,467
ncashire United	,, 4	1,427	− 207	31	40,702	− 339
mington	July 30	201	− 11	30	5,004	+ 151
ds Corporation	,, 31	6,655	− 193	18	120,355	+ 227
ester Corporation	Aug. 7	2,654	− 60	5	11,648	− 578
th Corporation	,, 7	651	+ 111	12	7,779	+ 713
coln Corporation	...	...	...	...	...	...
rpool Corporation	July 31	11,113	+ 30	‖29	332,407	− 3,331
rpool Overhead Rly.	Aug. 8	1,659	+ 19	§6	8,937	− 53
ndudno & Colwyn BayRy	,, 6	845	− 3	36	8,380	+ 1,635
don County Council	July 24	39,829	+ 3,134	§16	598,600	+ 22,523
don United	Aug. 7	8,950	− 1,817	‖33	187,490	− 20,076
estoft	July 31	298	− 76	...	...	...
dstone Corporation	...	...	...	...	...	...
chester Corporation	Aug. 7	15,251	− 1,177	19	282,793	− 4,557
sey Railway	,, 7	1,936	+ 69	5	9,772	+ 469
thyr	July 30	203	− 3	30	6,330	+ 44
ropolitan Dist. Railway	Aug. 7	8,780	+ 660	5	49,863	+ 4,757
ropolitan Elec. Trams	July 30	6,451	− 358	30	180,713	+ 11,019
dleton	,, 30	329	− 47	30	9,977	− 832
on Corporation	Aug. 7	167	+ 9	§18	2,633	− 118
castle-on-Tyne Corp.	...	...	...	...	...	...
port (Mon.)	,, 7	813	− 40	19	12,717	− 422
thampton Corporation	,, 6	744	+ 6	§19	9,242	+ 122
iam, Ashton & Hyde	July 30	560	− 45	30	16 664	− 1,081
am Corporation	Aug. 8	2 052	+ 15	19	37,051	− 2,650
h (N.B.) Corporation	,, 4	202	+ 9	§12	1,915	+ 15
h (W.A.) Elec. Trams	,, 6	1,307	− 7	31	15,955	− 47
rborough	July 30	131	− 21	30	3,126	− 305
smouth Corporation	...	...	...	...	...	...
eries	,, 30	1,786	+ 25	30	51,976	− 1,443
ton Corporation	Aug. 4	729	− 55	5	3,721	− 153
rham Corporation	,, 5	633	− 79	18	10,902	− 481
esay	July 30	601	+ 30	30	5,578	− 290
rd Corporation	Aug. 9	4,952	+ 221	‡19	87,571	
ences	July 30	56	− 18	30	1,453	− 201
field Corporation	Aug. 8	5,826	− 2	§19	109,671	− 1,630
pore Trams	,, 7	$9,770	+ $229	5	$46,632	+ $1,686
n Metropolitan	July 30	807	− 191	30	22,960	− 480
n Staffs	,, 30	821	− 97	30	24,783	− 1,120
and Corporation	Aug. 4	961	+ 32	18	10,079	+ 1,741
port Tramways	July 31	365	− 13	30	8,310	− 248
b'dge,Hyde,&c.,Jt.Bd.	Aug. 7	819	+ 18	§18	14,494	− 710
erland Corporation	,, 8	1,615	+ 13	19	22,179	− 1,001
erland District	,, 4	750	− 4	40	18,298	− 797
sea Trams	July 30	1,007	− 22	30	27,845	+ 452
don Corporation	...	...	...	...	...	...
ton	...	...	...	...	...	...
mouth and District	,, 30	42	− 4	30	1,115	− 83
side Trams Co.	,, 30	375	− 20	30	6 321	+ 156
ey District Council	Aug. 4	542	− 25	5	2,344	+ 100
ll Corpn.	,, 7	1,263	+ 43	§18	17,988	+ 137
ngton Corpn.	,, 7	645	− 20	31	15,841	− 1,171
Ham Corporation	July 23	2,314	− 37	17	40,910	+ 2,411
n-super-Mare	,, 30	249	− 76	30	3,334	− 61
rhampton Co.	,, 30	424	− 40	30	12,466	− 1,243
erhampton Corpn.	Aug. 4	957	− 78	5	4,278	− 282
ester	July 30	321	− 22	30	8,021	− 111
uth	,, 30	98	− 9	20	2,861	− 146
hire W.R. Trams	Aug. 8	1,902	− 17	33	37,703	
hire Woollen District	July 30	1,119	− 76	30	26,811	− 586

These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	Name.	Price Wed., Aug. 11.	Rate % Yielded. £ s d.	Dividend Due.	Business Week to Aug. 11 Highest	Lowest
		ELECTRICITY SUPPLY.					
10	7/0	Bournemouth & Poole Elec. Sup. Ord.	9½ −10½	[illegible] 9	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	[illegible]	4 [illegible] 0	Feb, Aug	[illegible]	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼ −10¾	5 11 6	Feb, Aug	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	[illegible] −103	4 7 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4¼ −4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 −[illegible]	5 17 [illegible]	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	[illegible] −5½	4 2 6	Mar, Sept	..	—
St.	4%	Central Elec Sup. Co. 4% Guar. Db. Stock	97 −100	4 [illegible] 6	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 −4½	5 16 6	Feb, Aug	4	—
5	2/3	Do. 4½ per Cent. Pref.	4¾ −5	4 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	[illegible]	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 −101	4 9 9	..	100¾	[illegible]
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ −4¼	5 2 6	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3¾ −4¼	4 9 3	March ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	10[illegible] −103	4 7 [illegible]	June, Dec	..	..
10	5/0	†City of London Electric Lighting Ord.	10½ −11¼	5 [illegible]	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. Pref.	1[illegible] −12[illegible]	4 14 [illegible]	Jan, July	12	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4 0 [illegible]	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 −102	4 8 [illegible]	Jan, July	102	—
5	..	County of Durham Elec. P.D. Ord.	2¼ −3½	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 −3½	3 11 9	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.	7⅞ −8½	6 3 0	Feb, Aug	[illegible]	..
10	6/0	† Do. 6 per Cent. Cum. Pref.	10½ −11	5 9 0	Mar, Sept	1[illegible]	1[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	103 −106	4 5	Jan, July	105½	10[illegible]
St.	4½%	Do. Second Deb. Stock	100 −103	4 7 6	May, Nov	101½	10[illegible]
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅝ −[illegible]	5 9 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 −5½	4 11 0	Mar, Sept	..	..
St.	4½%	†Do. 4½ 1st Deb. Stock (red)	97 −100	4 10 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7½ −7¾	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord.	6⅞ −7½	5 7 0	Feb, Aug	—	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝ −6⅞	4 14 6	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	95 −98	4 2 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	83 −87	5 3 6	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞ −2⅛	5 3 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅜ −5⅞	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 −97	4 2 6	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅜ −4⅞	5 16 0	April, Oct	4⅝	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ −5	4 19 0	Jan, July	5	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ −86½	4 1 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	94 −97	4 12 6	June, Dec	..	..
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4⅞ −5	4 2 1	Feb, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	84 −88	5 5 11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4 −4½	2 10 6	Feb, Aug	—	—
5	5%	†Do. 5 per Cent. non Cum. Pref.	4⅞ −5⅜	4 19 0	Feb, Aug	—	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 −99	4 1 8	Jan, July	—	—
100	5/0	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 19 0	..	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	—	—
100	4½%	Do. 4½ per Cent. Deb.	89 −91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	11 −12	5 16 9	March ..	—	—
5	4/6	Oxford Electric Ord.	6 −6½	5 8 0	March ..	—	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 −98	4 2 0	Jan, July	—	—
5	5/0	†St. James' & Pall Mall Elec. Ord.	8½ −9	5 11 0	Feb, Aug	—	—
5	3/6	†Do. 7 per Cent. Pref.	7 −7½	4 13 4	Feb, Aug	—	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 −85	3 19 6	Jan, July	—	—
		Smithfield Markets Electric Sup. Ord.	[illegible] −1½		Feb	..	..
5	4/0	South London Electric Supply Ord.	2⅞ −3	6 16 0	April....	..	..
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 −103	4 17 0	—	1[illegible]	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0		..	..
1	0/3⅜	Do. 7 per Cent. Cum. Pref.	1⅛ −1¼	5 7 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 −101	4 6 9	April, Oct	—	..
5	2/6	Urban Electric Supply Ord.	¾ −1	—	April, Oct	—	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1½ −2	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	76 −80	5 12 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8¾ −9¼	5 8 0	Mar, Sept	9¼	[illegible]
5	2/8	Do. 4½ per Cent. Cum. Pref.	4⅞ −5⅛	4 8 0	Jan, July	..	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	98 −100	4 0 0	Jan, July	99½	[illegible]
1	..	Bath Elec. Trams Pref. Ord.	¼ −¾		April....	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 −91	4 19 0	April, Oct	..	—
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88 −91	4 19 0	Jan, July	..	—
10	6%	†Bristol Tramways & Carriage Ord.	8 −8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8 −8½	4 14 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100 −101	3 19 0	Feb. Aug	..	—
10	..	British Electric Traction Ord.	½ −¾		June, Dec	..	—
10	8/0	Do. 6 per Cent. Cum. Pref.	2 −2½	12 0 0	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Perpetual Debs.	85 −89	5 13 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 −67	6 14 0	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	62 −64	5 9 0	Feb, Aug	64	61¾
St.	4%	Do. 4 per Cent. Pref. Stock	85 −88	4 14 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	43 −45	5 11 0	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	100 −102	4 18 0	Jan, July	102	101⅞
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 −94	4 5 0	Jan, July	92¾	92½
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ −4¾	4 15 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1½%	†City & South London Rly. Con. Ord.	31½ −33½	4 12 0	Feb, Aug	31½	31
St.	5%	†Do. 5 per Cent. Perp. Pref. (1891)	108 −110	4 1 [illegible]	Feb, Aug	..	..
St.	5%	†Do. (1896)	104 −107	4 13 6	Feb, Aug	..	..
St.	5%	†Do. (1901)	100 −103	5 2 6	Feb, Aug	..	..
St.	6%	†Do. (1903)	92 −95	5 5 0	Feb, Aug	1[illegible]	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 −102	3 18 0	May, Nov	[illegible]	[illegible]
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12½ −13½	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	[illegible] −1	..	Feb, Aug	[illegible]	..
10	..	G. Northern, Picc. & Brompton 4% G.Pf.	8 −8½	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	91 −96	4 3 6	Jan, July	..	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	[illegible]		Mar, Sept	..	..
St.	4½%	Do. 4½ Db. St.	[illegible]	5 12 6	April, Oct	..	..
10	0%	Imperial Tramways Ord.	1 −1½	[illegible]	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 −6	5 0 0	Mar, Sep.	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80 −83	5 1 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅛		Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	58 −63	6 7 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	[illegible]	5 18 6	Feb, Aug	..	—
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ −90½	5 10 6	Jan, July	..	—
10	..	Liverpool Overhead Railway Ord.	[illegible]		Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	5 −6	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	..	—
10	2/6	London United Trams. 5% Cum. Pref.	2 −2½		Jan, July	[illegible]	—
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68 −[illegible]	5 12 6	Jan, July	69½	[illegible]
St.	..	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	—	—
1	10⅞	Metropolitan Elec. Tramways Ord.	..	—		..	..
1	..	Do. Deferred	[illegible]		April..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 −97	4 12 [illegible]	Jan, July	[illegible]	..
St.	1%	†Metropolitan Railway Consolidated	40 −40½	[illegible]	Feb, Aug	40½	40
St.	3½%	†Do. Surplus Lands Stocks	61 −65	4 3 6	Feb, Aug	65	..
St.	3½%	†Do. 3½ per Cent. Preference	88 −90	3 17 9	Feb, Aug	88	..
St.	3½%	†Do. 3½ per Cent. "A" Preference	81 −83	4 1 0	Feb, Aug	[illegible]	[illegible]
St.	3½%	†Do. 3½ per Cent. Convertible Pref.	84 −85	4 1 0	Feb, Aug	[illegible]	..
St.	3½%	†Do. 3½ per Cent. Debenture Stock	92 −94	3 14 6	Jan, July	93½	[illegible]

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Divi-dend	NAME.	Price Wed., Aug. 11.	Rate % Yield-ed. £ s. d.	Dividend Due.	Business Week to Aug. 11. High-est.	Low est.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	92	..
St	..	Metropolitan District Railway Ord.	17 —17½	—	Feb, Aug	17½	17⅛
St	..	Do. Extension Pref (5 per Cent.)	48 —50	—	Feb, Aug	49	47⅞
St	3½%	†Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	63 —65	5 8 0	Feb, Aug	65	61½
St	3%	Do. 3 per Cent. Consolid. Rent-charge	76 —78	3 17 0	Jan, July	76½	..
St	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	95 —98	4 2 0	Mar, Sept	97½	96
St	6	Do. 6 per Cent. Perp. Deb. Stock	139 —141	4 5 0	Jan, July	139½	..
St.	4	Do. 4 per Cent. Ditto	93 —95	4 4 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	½—¾	..	April, Oct	..	..
1	0/6	Do. 6 per Cent. Cum. Pref.	⅝—⅞	6 0 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	88	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5%1stMt.Db.	81 —85	5 18 0	Jan, July	..	..
..	..	UndergdE.Rys.Lon.6% Inc.Bds.with coup.8	35 —37	..	June, Dec	36¼	..
..	..	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	..
—	4½	Do. 4½% Bonds with coup. 8	87 —89	5 1 0	..	88½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1—	—	March ..	..	..
6	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼		..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	¼—½	..	..	..	..
1	1/1½	Do. 6% Cum. Pf.	1—1⅛	6 17 0	April, Oct	1⅛	—
1	2/4½	Babcock & Wilcox Ord.	4⅛—4¼	4 13 3	April, Oct	4¼	—
1	0/7½	Do. Pref.	1⅛—1¼	4 0 0	..	..	..
6	6/0	British Insulated & Helsby Cables Ord.	7⅝—7⅞	6 9 6	July, Feb	7⅝	—
5	3/0	†Do. 6 per Cent. Pref.	6⅜—6⅝	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	..	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	33 —42	9 10 0	Jan, July	..	..
St.	4½%	BrushE.Eng Co.4½% Perp. 1st Deb.Stock	43 —48	9 8 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
10	..	Callender's Cable Con.Ord.	10 —10½	6 19 6	Jan, July	10⅜	10¼
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	104½—106½	4 5 6	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	1⅛—2⅛	6 4 0	May, Nov	1½	1⅛
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.).	104 —107	4 4 0	Feb, Aug	..	..
	1/0½	Chadburn's (Ship) Telegraph Ord.	1¼—1⅜	6 11 9	March ..	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/5¼	Consolidated Electrical Co.	⅜—½	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1⅛—1¼	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1	6 0 0	April, Oct	..	..
3	3/9	*Crompton & Co. (Nos. 1 to 85,000)	½—1	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	90 —93	5 7 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1¼	8 0 0	Sept	..	..
	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 9	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛-⅜	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	1⅛	—
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	68 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅛—3⁄16	..	Jan, July	1⁄16	—
6	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 5 0	Jan, July	59	—
2	..	Electric Construction Co.	7⁄16—11⁄16	..	Jan, July	..	—
2	2/9	†Do. 7 per Cent. Cum. Pref.	1⅛—1 9⁄16	9 0 6	July	1 11⁄32	..
St.	4	Do.* 4 per Cent. Perp. 1st Mort. Debs.	63—67	5 19 0	Jan, July	..	..
St.		Ferranti Ltd. 5 per Cent.1st Mt Db.St.	71—77	6 10 0	...	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	7 5⁄32	7 3⁄32
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	16/3	Henley's Telegraph Works Ord.	12½—13	5 17 6	Feb, Aug	12 9⁄16	..
5	2/3	Do. 4½ per Cent. Pref.	5⅛—5½	4 2 0	Feb, Aug	—	—
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c.,Wrks.	14½—15¼	6 10 9	Feb, Aug	15¼	15
10	6/4	Do. 5 per Cent. Cum. Pref.	10½—10¾	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	100⅛	—
1	..	National Elec. Construction Co.	¼—½	..	April......	..	..
1	..	Richardsons, Westgarth & Co., Ltd, Ord.	3⁄16—⅜	..	Nov	3⁄16	..
1	..	Do. 6 per Cent. Cum. Pref.	11⁄16—⅞	..	May, Nov	—	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	81 —84	5 7 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1½	..	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	17/0	†Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	34¾	35
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —101½	3 18 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 5⁄32—2¼	4 9 0	—	2 7⁄32	2 5⁄32
1	0/6	Do. 5 per Cent. non-Cum. Preference	1 1⁄32—1 3⁄32	3 11 6	—	1⅛	..
St	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db.Sk.(red)	101½ —103½	3 17 6	June, Dec	103½	102
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	106½	106¼
1	6	J. G. White & Co. 6% Cm. Pref.	⅞—1⅛	8 6 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—¾	3 15 0	Apr, Oct	..	..
1	3/0	Do. 6 per Cent. Cum. Pref.	2⅞—3⅛	9 12 0	Apr, Oct	2 15⁄16	—
St.	4%	Do 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	78⅜	78⅜
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¾—3½	—	June, Dec	..	..
100	5%	Do 5 per Cent. Debs. (red.)	93 —96	5 4 0	June, Dec	..	..
St.	1/6	†Anglo-American	59 —61	5 7 0	F,My,Ag,N	59	..
St.	3/0	†Do. Preferred	102 —105	5 17 0	F,My,Ag,N	102½	101¼
St.	2/0	Do. Deferred	19⅜—19⅞	2 0 6	F,My,Ag,N	19⅛	18⅛
St	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	90½	..
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	8⅝	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
6	2/0	Direct Spanish Ord.	2⅞—3⅜	5 18 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅞—8⅝	5 12 9	April, Oct	8⅝	..
100	4½%	Do. 4½ per Cent. Deb.	99 —101%	4 9 0	Jan, July	..	..
20	8/0	†Direct United States Cable	12¼—13⅜	6 7 3	Ja,Ap,Jy,O	13	12⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 —101	4 9 0	June, Dec	..	..
St	2/0	Eastern Ordinary	126 —129	5 8 6	Ja,My,JyO	128¼	126
St	17/6	Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,JyO	84¼	81⅞
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	105	..
St	2/6	Eastern Extension	11⅜—11⅞	5 19 3	Ja,Ap,Jy,O	11⅜	11⅛
100	4%	*Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	102¾	102
	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	3 18 0	May, Nov	100⅝	100¼
	3/0	G. N. of Copenhagen, with Coupon 76	26½—27¼	6 0 0	Jan, July	26¾	—
	4½	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 —101	4 9 0	June, Dec	..	..
	2/6	Indo-European Tel. all	61½—63½	5 16 9	May, Nov	..	..
	$1	Mackay Companies Common	80 —84	4 16 0	Ja,Ap,Jy,O	—	..
	$1	Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	..—..	..	April	..	..
1	4	Pacific & European Tel. 4% Guar.Dbs.(red.)	99 —101	3 19 0	June, Dec	..	—
	1/3	West Coast of America	1⅛ —1⅜	4 12 0	May	1⅛	..
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	..	West India & Panama	½—⅞	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref	8 —8½	7 1 0	May, Nov	..	..
10	10/0	Do. 6% 2nd Pref.	8 —9	6 15 6	May, Nov	..	—
100	5%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	13⅞	13½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102½—104½	3 18 6	June, Dec	—	..
—	4%	Western Union Telegr. $1,000 4% Bonds	97 —99	4 1 0	..	..	—

Share	Last Divi-dend	NAME.	Price Wed., Aug. 11	Rate % Yield-ed. £ s. d.	Dividend Due.	Business Week to Aug. 11. High-est.
		TELEPHONES.				
100	2$	Amer. Telephn. & Telegh. Cap. St.	146 —147	5 9 0	..	146¾
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	..
St	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103 —105	4 15 0	Mar, Sept	..
5	6/0	†Chili Telephone	8 —8⅝	4 15 6	August ..	..
1	0/7½	Monte Video Telephone Ord.	1⅛—1⅛	6 8 0	Nov	..
1	0/6	Do. 5 per Cent. Pref.	¾—⅞	5 14 3	May, Nov	.
St.	6%	†National Co. Pref. Stock	106 —107½	5 11 6	Feb, Aug	10
St.	6%	†Do. Def. Stock	123 —125	4 18 6	Feb, Aug	124
10	6/0	†Do. 6 per Cent. Cum. 1st Pref.	10 —10¾	5 11 6	Feb, Aug	..
10	6/0	†Do. 6 per Cent. Cum. 2nd Pref.	10 —10¾	5 11 6	Feb, Aug	..
5	2/6	†Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅛	4 8 0	Feb, Aug	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	98½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	Jan, July	..
1	1/0	Oriental	1 5⁄16—1 7⁄16	5 7 6	April, Oct	1⅜
1	0,7½	Do. 6 per Cent. Cum. Pref.	1⅛—1..	5 1 0	April, Oct	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85 —87	4 12 0	Jan, July	8..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	99 —101	4 9 0	Jan, July	—
5	5/0	†United River Plate	6¾—7⅛	5 12 0	July	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ -5½	5 11 6	June, Dec	..
St	4½%	Do. 4½ Deb. St. Red.	103 —105	4 6 0	Jan, July	—
		FINANCIAL INVESTMENT, &c.				
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..
10	5/6	Globe Telegraph & Trust	10¼—10⅞	6 7 0	Sp DcMrJu	10..
10	3/0	Do. 6 per Cent. Pref.	13½—14	4 5 9	SpDcMrJu	13..
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	...
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.				
5	—	Anglo-Argentine 5% Cum. 1st Pref.	4⅝—4⅞	5 2 6	April, Oct	9..
5	—	Do. 5% Cum. 2nd Pref.	4 7⁄16—4 13⁄16	5 7 0	Jan, July	1..
St.	4%	Do. 4% Deb. Stock	91½—92½	4 6 6	June, Dec	92⅛
St.	..	Do. 4½% Deb. Stock	95 —96	..	—	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —104	4 16 6	Jan, July	..
5	3/6	Brisbane Electric Trams. Invest. Ord.	6⅝—6⅞	4 7 0	May	6..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	.
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	101
St.	8%	British Columbia El.Ry.Df. Ord.	144 —148	5 8 0	Mar, Sept	..
St.	6%	†Do. Pref. Ord. Stock	121 —125	4 16 0	May, Nov	123
St.	5%	Do. 5% Cum. Perp. Pref. Stock	107 —110	4 11 0	Jan, July	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 7 0	Jan, July	102
St.	4½%	Do. 4½% Perp Con. Deb. St.	101½ -103½	4 7 0	—	102..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99½ - 101½	4 18 6	Mar, Sept	10..
St.	6%	†Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	92 —93	6 5 0	Feb, Aug	..
5	2/0	Calcutta Tramways (1 to 137,610)	4½ —4⅞	4 2 0	Mar, Sept	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	..
1	4½%	Do. 4½% 1s. Deb. Stock (red.)	97 —100	4 10 0	Jan, July	—
St.	..	Cape Electric Tram Shares	⅛ -⅜	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904)Sh.	5 11⁄16—5 13⁄16	4 4 0	F,My,A,N	6..
St.	4%	Do. 4 per Cent. Deb. Stock	99 —101	3 19 0	June, Dec	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	9..
1	..	Kalgoorlie Elec. Trams Sh.	1⁄32—3⁄32	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	90 —93	5 7 6	Jan, July	
5	6%	Do. 6 per Cent. "B" Ditto	65 —69	8 11 0	Jan, July	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅛	4 14 0	July	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	5 1 0	Jan, July	—
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	97 —101	5 1 0	Jan, July	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	96 —98	5 2 0	Feb, Aug	.
100	$1½	†Mexico Trams Co. Com. St.	126 —129	3 17 6	..	127⅛
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	95 —97	5 2 6	..	96
St.	4½%	†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	..
1	0/6	Perth Elec. Trams Ord.	⅝ —⅞	8 0 0	May	..
St.	5%	Do. 1st Mt. Db. Stock	100½ -103½	4 16 6	Jan, July	—
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6⅜—6⅞	5 4 8	..	—
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	.
100	..	Rio Janeiro Tram, Lt. & P. Co.	90½ - 91½	..	..	90..
..	5%	Do. 30 yr. Gold Bnds.	92 — 94	5 6 0	..	93..
100	5%	Do. 50 yr. Mt. Bnds	84 — 86	5 17 0	..	84..
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	150 —153	6 11 0	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	99 —101	4 19 0	June, Dec	101½
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 12 6	Feb, Aug	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.				
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 11 0	Mar, Sept	.
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½ —10	6 0 0	..	
St.	4½%	Do 4½ per Cent. Deb. Stk. (red.)	93½ —95½	4 13 6	Jan, July	95
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	93½ - 95½	..		
5	4/9	Calcutta Elec. Supply Ord.	5¾ —6⅜	6 5 6	April, Oct	
100	$1¾	Canadian Gen. Elec. Co. Com. St.	121 —123	5 15 8	..	12..
100	$3½	Do. 7% Cm. Pf. Stock	117 —119	5 13 0	..	11..
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	
500	5%	Elect. Development Co of Ontario	84½ 86½	5 16 ..	—	8..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	
5	..	Indian Elec. Sup. & Trac. Co.	1½ —2	—	..	
10	4	Kalgoorlie Elec. Power & Ltg. Ord.	..—..	..	..	
1	0/7½	Do. 6 per Cent. Cum. Pref.	¼—½	6 18 3	April, Oct	
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83½—85½	5 10 6	..	8..
St.	$1	Mexican Lt & Power Co. Com. St.	71 —75	6 0 0	—	7..
500	5%	†Do. 5% 1st Mort. Gold Bnds.	85 —87	5 15 0	..	
100	$1¼	†Montreal Lt. Ht. & Power Co. Cap. St.	126 —130	4 16 3	F,My,A,N	
1	1/7½	River Plate Electricity Co. Ord.	1⅛—1⅛	5 11 0	April . ..	
1	1 2⅝	Do. 6 per Cent. non-Cum. Pref	..—1..	5 1 6	May	
St.	5%	Do. 5 per Cent. Deb. Stock	102 —105	4 15 0	Jan, July	
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅜—5⅝	5 6 6	April, Oct	
5	3/0	Do. 2nd Pref.	5¾— 6	5 0 0	..	
100	$1	Shawinigan, Water & Power Co. Ca	93 —95	4 4 0	—	
..	5%	Do. 5 per Cent. Bds.	101 —106	4 14 3	Jan, July	
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 —98	4 12 0	—	
St.	4½%	Toronto Power Co. 4½ Db. St.	99 —101	4 9 6	..	
..	6d.	Victoria Falls Power Co. Pref.	..—..	5 14 0	Jan, July	
1	..	Do. 15/- paid	..—..	..	..	

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex dividend ‡ The London Stock Exchange Committee have declined to quote these

THE ELECTRICIAN:

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NOTES.

The Attitude of the Local Government Board.

Recent events seem to show that the Local Government Board is inclined to extend its sphere of authority beyond the limits that have been customary. For example, after holding an inquiry at Finchley into that Council's application for sanction to a loan of £2,200 for arc lighting, the Board inquired whether the Council had carefully considered the relative cost of street lighting by electricity and by gas, and asked for copies of the reports of the Highways and Lighting Committee on the subject. To this request a reply was sent to the effect that the Council considered they were the best judges as to what illuminant should be used in the streets, and they did not feel they could submit to any outside pressure to force upon them an illuminant of which they did not approve and which they considered for the present purpose was not so satisfactory as the one they proposed. The Council also respectfully submitted that the Board was not called upon to decide whether gas or electricity should be used. A somewhat similar incident has occurred at Gravesend in regard to loans. Apparently the Board suggested here that, in projecting any extension of the present system of public lighting by electricity, the Council should carefully consider the comparative cost of lighting by electricity and by gas.

It is a little difficult to understand this new attitude of the Board. Electric lighting has become uniformly cheaper and cheaper during the last few years. Why, therefore, should the Local Government Board be particularly anxious at the present moment to press forward the claims of gas? If there were any good cause for doing so, it would certainly have been much more reasonable years ago than at the present time. Occasionally, no doubt, a Council becomes carried away by some extravagant idea. If, for example, it were proposed to light all the small side streets of a town by means of arc lamps, we should feel that the Local Government Board were justified in suggesting that the claims of gas should be considered; but, generally speaking, a local Council knows best the local needs. For instance, from the point of view of general trade, it may be worth while to light up certain thoroughfares on a somewhat lavish scale, and when such claims have to be considered local knowledge becomes essential. It would seem, therefore, that for the Local Government Board to interfere in such purely local matters as the form of illuminant to be used is unpardonable interference unless the circumstances are very exceptional.

Six Months of Railway Working.

The cycle of operations that is indicated in the various reports on the last half-year's railway working just issued should prove of great interest to electrical engineers. First we have chairmen of the large trunk lines complaining that their whilom suburban traffic has been greatly cut into by the ever-encroaching electric tramways; then the tube railway chairmen complain that municipally-owned tramways tempt away some of their passengers with the bait of lower fares. Meanwhile, the tramways themselves are doing none too well, and although we have not yet been told that their misfortunes are due to a combination of railways and tubes, yet there may conceivably be a connecting link somewhere.

The reports of the London tube railways for the year ended June 30, 1909, are, in spite of many troubles, encouraging in tone. In nearly every case increased re-

ceipts are accompanied by decreased working expenses: but a notable exception is the Central London Railway, the Shepherd's Bush Exhibition proving to be less attractive this year than last. We fear the worst of the diminution in receipts from this cause has yet to be experienced. The problem of the best fares to charge is still receiving attention, and in this connection it is interesting to note that the experiment made some months ago by the Central London Railway, by introducing 1d. fares for short distances, in place of the uniform 2d., has been almost, if not quite, justified. The increase in passengers has, in fact, nearly repaid the loss sustained in halving the fare. The Great Northern & City Railway retains its unfortunate financial position, which is unlikely to improve except by judicious extension of the line. On the City & South London Railway the question of reducing the fares with the hope of regaining those passengers who have deserted the tube for the tramways is under consideration. The case of this railway is peculiarly hard. Over a considerable section of its route it "finds itself" in direct competition with the County Council tramways, on which, as is well known, the penny stages are of enormous length. It is difficult to see how this state of things can now be avoided, but it is only one of the many examples of the folly of allowing the London traction undertakings to be put together in a piecemeal fashion, and without the control of any proper central revising authority.

THE good results which have been obtained from co-operation as regards the interchange facilities for passengers between the various tubes are very satisfactory, and this is a direction in which the companies should be able still further to develop their traffic. It is surprising how many, even of the regular residents in London, are ignorant of the best way to reach some part of the metropolis remote from their own district. If they are once impressed with the idea that the nearest way is by "tube," much will have been accomplished. There is no doubt that the use of the "Underground" for "across London" journeys is increasing, and this is a branch of travel which the companies should encourage by providing even greater interchange facilities than are available at present.

MOST of the trunk railways seem to be undecided how to regain their lost suburban traffic. To adopt electric traction would seem the obvious way, but a certain not altogether unjustifiable timidity is noticeable, and a tendency to await the results of the electrification on the London, Brighton & South Coast Railway before attempting anything on their own account is also apparent. The new line on the London & North-Western Railway from Euston to Watford is, however, under construction, and makes one more example of the adoption of electric traction on a railway not purely urban in character.

Cable Interruptions.

Cable	Date of Interruption.
Tangier—Cadiz	May 19, 1909
Tourane—Amoy	June 17, 1909
Assab—Perim	July 8, 1909
Gibraltar—Tangier	Aug. 7, 1909
Cueta—Tangier	Aug. 7, 1909
Melilla—Chafrinas	Aug. 7, 1909
Corfu—Trieste	Aug. 16, 1909

High-Tension Disaster.—It is announced that a serious disaster has occurred at Olginate, near Lecco, in Italy, due to a high-tension wire coming into contact with the low-tension wires supplying light. Details are not to hand, but it appears that, as a result of the accident, 10 persons were killed.

The Tramways and Light Railways Association.—The "Official Circular" of this Association for August contains a copy of the recently-published Board of Trade Regulations, while various Association matters also receive attention.

Electric Traction in Brazil.—According to the "Electric Railway Journal" an electric railway 10 miles long has been projected to connect Joinville, the principal trade centre of the State of Santa Cathrina, Brazil, and Lake Sogaussu, an ocean harbour affording good anchorage for the largest vessels. All goods to and from Joinville are at present handled by barges from the port of San Francisco.

Electric Mail Waggons.—"The Times" Engineering Supplement states that the Post Office Department of New York City has been experimenting with electric in place of horse-drawn vehicles. The Motor Delivery Co. has a contract to supply these electric mail waggons, and 14 are in use at present. It is the intention to put an extra number in service during the Christmas holiday season, when there is such an enormous quantity of packages to handle. Of the cars now in use, two have a capacity of 4,500 lb., four of 2,500 lb. and eight of 1,300 lb. It is stated that they have resulted in a considerable saving in time.

Central London Railway Extension.—Parliamentary powers having been obtained, the work of extending the Central London Railway from the Bank to Liverpool-street has begun. The new line will provide for the first time a direct train service from Liverpool-street to the West End. A new subway is to be constructed giving additional access to the Bank station from the street. The work undertaken by the company includes the construction of a moving platform connecting the British Museum station of the Central London Railway with the Holborn station of the Great Northern, Piccadilly & Brompton Railway. These improvements will greatly facilitate London traffic.

Construction of Electrically-worked Main Lines in the United States.—At a recent meeting of the Verein für Eisenbahnkunde a Paper bearing the above title was read by Herr E. C. Zehme, editor of the "Elektrotechnische Zeitschrift." The author describes his visits to the New York Central & Hudson River Railway, the New Haven & Hartford Railway the Long Island Railway, the West Jersey & Seashore Railway and the Rochester & Erie Railway. The principal points of both the stations and plant supplying these lines, and of the equipment of the lines themselves are described and criticised The leading features of all these lines have been described at various times in THE ELECTRICIAN, so that we are not able to deal with them again, but we may congratulate Herr Zehme on having collected into a small space a large amount of very useful information.

New Hydro-Electric Station at Zurich.—The municipality of Zurich is at present constructing a large station near Sils for supplying the town with energy for light and power Details of this station are given in "L'Electricien." A barrage which has been built near Nisellas, will allow a catchment area containing 420,000 cubic metres of water to be obtained. From this the station will be supplied through a number of pipes $6\frac{1}{2}$ ft. in diameter at the top and 6 ft. in diameter at the bottom. The machine room will contain six 2,000 kw. hydro electric sets, while transformers, by which the generator voltage will be stepped up from 7,000 to 46,000 volts, will also be provided. The transmission line will be 85 miles long. It will be made up of two entirely distinct conductors carried for the most part on armoured concrete poles.

New Detector for Wireless Telegraphy and Telephony.—In a note in a recent number of the "Comptes Rendus" M. G. E. Petit describes a detector, due to M. Meunier, which consists of a conducting point resting on natural iron pyrites. This arrangement works without a cell, as do the Peukert and other similar detectors, but has the advantage over these latter, and over those of the electrolytic type, that it is no

harmed by the action of strong discharges or atmospheric disturbances. One of these detectors has been in use since February of this year at the Government stations at Saintes-Maries-de-la-Mer and Alger, and has been found to be as sensitive and as constant as the better known detectors. The pyrites can be displaced in two rectangular directions by micrometer screws, thus ensuring that contact is made at the points of maximum sensibility. The point is placed at the end of a lever, which carries a movable and counterpoising weight to regulate the contact.

Impedance of Telephone Lines.—In a recent number of "La Lumière Electrique," M. Devaux-Charbonnel gives the following results of some experiments he has made on this subject. He states that the impedance is very nearly equal to a simple ohmic resistance for lines with appreciable self-induction, while it is independent of the frequency. The impedance of the double apparatus, receiver and transmitter, is practically equal to the ohmic resistance when the line is aerial, while for underground lines the impedance is equivalent to a capacity in series with a resistance varying very distinctly with the frequency. In another article the same author deals with some interesting practical cases, beginning with lines of short length. He is of the opinion that in urban districts supplied by aerial lines the hearing does not depend on the nature of the line employed but entirely on the apparatus. When underground conductors are used the above is only true when the length of line does not exceed, say, 2½ miles. The author also goes into the question of what occurs on long lines, not neglecting, as is usually done, the effect of the apparatus and the impedance of the line, for the consideration of the attenuation of the line alone is insufficient. Lastly, he attempts to discover whether it is possible to increase the range of lines, and what steps should be taken for this purpose.

Effect of Dampness on Marble Panels.—In a recent number of "La Nature" this question is discussed, it being shown that marble is not a good insulator unless protected against damp. It has, in fact, been noted that on several distribution boards carrying apparatus at 110 volts the leakage to earth is directly due to the marble being in contact with the damp walls. For instance, in an installation where the normal insulation resistance was 300,000 ohms the actual resistance was never more than 25,000 ohms, owing to the presence of a lightning arrester fixed to a damp wall, while the dampness had so impregnated the marble that the loss to earth was easily shown by a galvanometer. In another case a lightning arrester was completely spoilt on account of certain electrolytic phenomena caused by the moisture and by the conductivity of the damp marble. The copper plate of this arrangement, which was connected to the positive pole of the line, was totally destroyed, sulphate and carbonate of copper being formed. These copper salts had deeply impregnated the marble panels, while the fixing screws were also destroyed. It is therefore necessary that marble panels should be insulated from direct contact with the walls. Packing pieces of paraffin-impregnated wood treated with shellac should be used, and porcelain insulators interposed between the wood and marble to allow an air circulation. By this means the harmful effect of moisture can be avoided.

The Engineering of Ordnance.—It will be remembered that at the time of his death M. Gustave Canet was president of the Junior Institution of Engineers, and that in commemoration of this fact his widow presented a gold medal, which was to be awarded every year to the reader of a Paper before the Institution. The first of these medals has been awarded to Lieut. A. Trevor Dawson, R.N., and his lecture on "The Engineering of Ordnance" was delivered on June 30th last. We have now received from the Institution a reprint of this lecture, which is fully illustrated, and which, though not essentially electrical, contains many items of interest to engineers generally. The lecturer, after briefly considering the scope of M. Canet's work and its influence on the development of ordnance, describes this development in an historical manner from the earliest days, and gives at some length the various methods of manufacture, dividing his subject into the influence of metallurgy on guns, the influence of explosives generally on the ballistics of guns, and lastly, the influence of mechanics on ordnance. In this last part, electrical mountings for guns of various sizes are dealt with. An interesting piece of apparatus described in this connection is the Janney controller, which is designed for protecting the motor from those variations in load which are necessarily present in gun work. These especially arise from the large variation of speeds and frequent reversals of direction which are required in manipulating the guns. The details of artillery are of necessity to a certain extent shrouded in mystery, and although, of course, he has not given away any secrets, the author has been able to put before the members of the Institution a good idea of the present state of ordnance, from the engineering point of view, and his paper seeing how seldom we obtain any information on this subject, is doubly interesting.

Municipal History and Works of a Small City.—In his recent presidential address to the Institution of Municipal Engineers, delivered at Durham on August 7th, Mr. J. T. Pegge at once followed in the steps of many of his predecessors and struck out a new line for himself. He dealt with his own work as surveyor of the City of Durham, but, in so doing, gave some most interesting historical information on the development of this city as regards its streets, main sewerage, scavenging, police, lighting and water supply. A perusal of the address shows that, while Durham was probably no worse than other towns at that time, it was certainly no better in these respects and that up to quite a few years ago matters of "public safety" were looked after in an essentially happy-go-lucky style. As regards lighting, the coronation of George III. was celebrated by the Durham inhabitants of those days by placing rushlights and candles in each of the house windows. This method of illumination, together with the time-honoured lanthorn, appear to have been the only lighting provided after sunset. Naturally revellers of all kinds held high court. In 1814, as the result of riotous conduct in certain districts after dark it was decided to instal oil lamps, but this method of illumination did not find favour with the inhabitants who took every opportunity of extinguishing the lamps by means of stones, or even removing them altogether. In 1878 gas was first introduced and the streets are now lighted by modern incandescent burners. Early in 1901 the Council leased their powers for 21 years to the Durham District Electricity Co., and this company's interests were taken up by the County of Durham Electric Power Distribution Co., having their generating station at Carville-on-Tyne, near the source of the coal supply. There is a transforming station just outside this town on the north, from which the current is supplied to the Durham station, now a supply centre only, the Babcock & Wilcox boilers, Chandler engines and dynamos not being used. The Aykley Heads sub-station takes its supply at 20,000 volts, three-phase, 40 cycles per second. Here it is transformed to 5,500 volts, and received at Durham City by means of two separate feeders. The feeders are lead-sheathed cables, laid partly solid and partly drawn in through earthenware ducts, the latter having been originally laid for tramway cables. By using this method the cables, which at this part of the route are armoured, were drawn through without again disturbing the streets. At Durham City sub-station the supply is converted to 480 volts direct current by means of motor-generators. The mains originally laid in the city were three-core vulcanised bitumen cables laid solid in wooden troughing; for later extensions three-cored copper, lead and paper-covered cables have been used, laid solid in earthenware troughing. The low-tension feeders are triple concentric vulcanised bitumenised cables, also laid solid. The parts outlying the city are supplied by means of overhead three-wire lines; in some cases triple-braided cables are used, in others bare conductors with split neutrals. The pressure of supply in the city is, on the three-wire system, at 240 volts for lighting and 480 volts for power, and all motors above 1 H.P. have to be connected across the outers. The number of connections to the company's mains in Durham is about 500. The tariffs are:—

Lighting, 3¾d. per unit less 5 per cent. discount.

Motive power,	1,000 B.T.U. per quarter	1·5d.	per unit.
Next	50,000 ,, ,, ,,	1·25d.	,,
,,	50,000 ,, ,, ,,	1·00d.	,,
,,	50,000 ,, ,, ,,	0·75d.	,,

Heating radiators, 1½d. per unit, if on separate circuit and meter.

TYPES OF ALTERNATING-CURRENT COMMUTATOR MOTORS AND THE BEST FREQUENCY FOR RAILWAYS.*

BY F. EICHBERG.

Summary.—The author investigates the influence of the frequency on the generators, transformers, transmission line, and more especially on single-phase commutator motors.

When single-phase railways began to be projected in the years preceding 1902 and 1903, those engineers who favoured resistance connections as the best means for improving commutation chose frequencies of 15 and 16, whilst others, who resorted to cross-field commutation, were less limited in their selection and adopted 25 as a standard—for it was considered that all extensive railway systems would also be able to supply energy for other purposes than traction. There is still much to be said for this latter point of view. Motors can be economically built for practical speeds at 25 cycles. Incandescent illumination can be successfully carried out at 40-50 volts at this frequency, whilst even arc lamps for outside use can be satisfactorily made. The further below 25 cycles we go, the worse it is for motors and lamps in general. Apart from these general

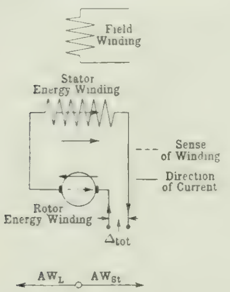


FIG. 1.

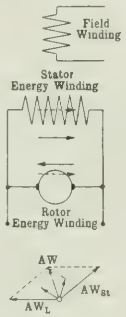


FIG. 2.

considerations, the advantages and disadvantages of the several parts of the installation itself, viz., the traction motors, the transformers—both stationary and transportable—the line and the generators, come into the question.

I. *The Motors.*—In considering the different types of single-phase commutator motors, commutation is the most important factor. Compared with this, weight and efficiency, heating and power factor occupy but a secondary place. Given equal conditions of commutation, the safety of working and maintenance will also depend on the system of construction used.

Let us now see how all these points are influenced by the frequency. In order to commutate the current a "commutating E.M.F." is required to overcome the so-called reactance voltage just as in continuous-current machines. This E.M.F. is directly proportional to the current at any instant, consequently the field producing it must be displaced 180 deg. in phase from that of the armature-current. According to the design, the armature reaction can be either non, partly, totally or over-compensated. The field for inducing the commutating E.M.F. can be produced either by a distributed winding (compensating or energy winding) or a concentrated winding (commutation poles). Also, by merely displacing the brushes the required commutating field may be obtained. This field also has the frequency of the current and does not vary with the speed.

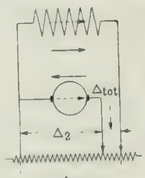


FIG. 3.

In alternating-current commutator motors there is a second E.M.F. set up in the short-circuited coils due to the pulsation of the exciting field F. We will call this the "short-circuit E.M.F." and denote it by e_k. Then

$$e_k = x_1 \sim F, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where x_1 is a constant and $\sim$ the frequency. e_k is displaced from F by 90 deg. in phase, so that if the main current I is in phase with the flux F (which is practically the case in all good machines), then e_k lags 90 deg. behind I. To counterbalance this pressure the coil undergoing commutation must rotate in a field perpendicular in phase to I. To distinguish this field from the commutating field, we will call the former the "cross field," and denote it by Φ. Then, to neutralise the short-circuit E.M.F.,

$$x_2 \Phi n = x_1 \sim F, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where x_2 = a constant and n the speed. Φ must therefore be perpendicular to F and proportional to F and $\sim/n$. Some motors have no cross field while others are provided with a correct cross field over a certain range of speed. It is not possible to have the proper cross field for all speeds, for this would mean $\Phi = \infty$, at $n = 0$; also at low speeds it is not possible for Φ to increase sufficiently on account of saturation. This cross-field can also be produced by a concentrated winding, in which case we shall call it an "auxiliary cross field."

To consider, first, those machines in which the cross field is distributed over the whole circumference, we shall assume for the sake of uniformity that in addition to the compensating winding in series (Fig. 1) there is also a compensating winding in parallel. To these two energy windings in parallel on the stator and rotor let the same pressure be applied, or, as is more generally the case, connect them with two magnetically-interlinked transformer windings, in such a way that the pressure per turn in stator and rotor winding is the same. If, then, a current is caused to flow through one of these windings by some means (*e.g.*, by an E.M.F. due to rotation), then automatically the current flowing in the second winding will neutralise the ampere-turns of the first winding (*see* Fig. 2).

If, however, unequal E.M.F.s per turn are applied at the stator and rotor windings (Fig. 3), the rotor will speed up until the positive or negative additional E.M.F. is induced by rotation in F. The current taken by the energy windings in stator and rotor will be determined by the required torque and the field F. Compensation, however, is always present.

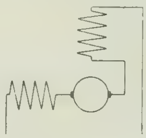


FIG. 4A.

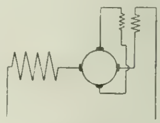


FIG. 4B.

The difference of these pressures per turn—with respect to same direction of winding—is proportional to the effective energy pressure Δ_{tot}, for which the following equation holds:—

$$\Delta_{tot} = x_3 n F. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where x_3 = constant.

For the sake of simplicity assume equal turns in the stator and rotor, then

$$\Delta_{tot} = \Delta_1 - \Delta_2,$$

where Δ_1 = pressure applied to stator energy winding,
Δ_2 ,, ,, rotor ,, ,,

Since only the E.M.F. induced by the cross field Φ can exist in the stationary stator winding, then

$$\Delta_1 = x_4 \sim \Phi. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where x_4 is also a constant.

Substituting equations (3) and (4) in (2) we get the condition for zero short-circuit pressure, viz.:—

$$x_2 n \frac{\Delta_1}{x_4 \sim} = x_1 \sim \frac{\Delta_{tot}}{x_3 n}$$

or

$$\frac{\Delta_1}{\Delta_{tot}} = \frac{x_1 x_4}{x_2 x_3}\left(\frac{\sim}{n}\right)^2 = K\left(\frac{\sim}{n}\right)^2. \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Hence for each ratio Δ_1/Δ_{tot} there is one speed for which the short-circuit pressure becomes zero, and at which the alternating-current commutator motor commutates as well as a compensated continuous-current motor. How this is obtained is theoretically indifferent. In Figs. 1 to 3 it is assumed that the winding sense of the two energy windings is the same and is indicated by the dotted arrows. The direction of the current—which provides the compensation—is shown by the full-lined arrows. Throughout it has been assumed that the exciting flux is in phase with the energy current.

These considerations lead us in a simple manner to a general survey of the various types of single-phase commutator motors. With respect to the energy axis we can distinguish between the following three classes:—

Group I.—Machines where the energy current is only transmitted to the rotor: $-\Delta_1 = 0$. (*See* Figs. 4A and 4B.)

* Lecture given before the Elektrotechnischer Verein. Abstracted from the "Elektrotechnische Zeitschrift."

Group II.—Machines where the energy current is only led to the stator :—$\Delta_1 = \Delta_{tot}$. (*See* Figs. 5A and 5B.)

Group III.—Machines in which energy currents are supplied to both stator and rotor :—$\Delta_1 <$ or $> \Delta_{tot}$. (*See* Figs. 6A and 6B.)

Machines in groups II. and III. possess a cross field. Machines in group I. (to which the ordinary series motor belongs) have a neutralised short-circuit pressure for $n = \infty$, since $\Delta_1 = 0$. Machines belonging to group II. possess a complete cross field. The short-circuit pressure is neutralised at $n = \sim$, since $\Delta_1 = \Delta_{tot}$. In machines of group III. ideal commutation conditions can be obtained over a wide range of speed. There are means for also keeping the short-circuit pressure small over a wide range in groups I. and II.—these are also applicable to group III., when Δ_1/Δ_{tot} is only varied by large amounts at a time. There are three ways of doing this :—

(*a*) We can—independently whether any or no cross field Φ is present—provide a special cross field ("auxiliary cross field"). The pressure δ_1 which is to be applied to the auxiliary winding, to produce this field, depends on the ratio of the auxiliary flux ϕ to Φ and on the number of turns of the auxiliary winding. Within certain limits it will always be possible to find δ_1, so that

$$\frac{\delta_1}{\Delta_{tot}} = K_1 \left(\frac{\sim}{n} \right)^2 .$$

This is only limited by saturation—that is, by low speeds, but no by high. Actually, all speeds from $n = \frac{1}{2} \sim$ onwards can be regu lated.

(*b*) The second method consists in affecting the cross field by altering the reluctance or by shifting the brushes.

(*c*) The third method consists in the use of resistance connections. By this means, the short-circuit E.M.F. is not neutralised but only the current kept down, whilst these connections cause a 2 to 3 per cent. loss. The pressure between segments is also limited in machines with only these connections, for at 15 volts alternating current an arc-over can occur. Thus, when the brushes stand on two segments the maximum pressure between segments must not exceed

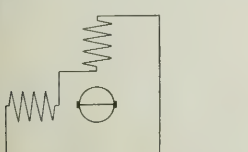


Fig. 5A.

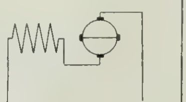


Fig. 5B.

7·5 volts or a mean value of about 5 volts. Since better means are at hand, the use of resistance connections should be avoided.

The limit of cross-field commutation lies below synchronism since the cross flux Φ (or ϕ, as the case may be) depends on saturation. But since Δ_{tot} also comes in the numerator, the range of good commutation can be increased downwards by lowering Δ_{tot}, or, since $\Delta_{tot} = x_3 n F$, by decreasing the flux F, which is accomplished by means of the well-known exciting or variable ratio transformer.

Actually this and the use of resistance connections represent the only means of governing commutation at low speeds and starting, and can be used with machines of all types. When an exciting transformer is used the flux at starting is reduced some 30 to 40 per cent. This forms a very safe method, for the increase in the energy current at these low speeds, where the commutating pressure is very small, is not harmful. This method is much safer than the use of resistance connections. The commutating field and the cross field combine to give the resultant field required for commutation. This provides for ideal commutation from $n = 0{\cdot}3 - 0{\cdot}4 \sim$ to $n = \infty$. Below this limit either the field must be weakened or resistance must be used for keeping the short-circuit losses within desired limits.

Turning now to the actual machines, take the most difficult case: A goods locomotive with direct-coupled motors; these motors to be required to yield a steady pull of 12,000 kg. at low speeds and develop a speed of 70 km. to 80 km. per hour on the level when drawing a train of 400 tons. We shall consider the motors for 15 and 25 cycles respectively, assuming the same conditions of torque and speed and also with respect to the ratio of the maximum pull possible to that limited by adhesion. The active material of each machine is designed for the maximum pull of 15,000 kg. and steady pull of 12,000 kg. at speeds up to 40 km. per hr., and maximum speed of 70 to 80 km. per hr., when exerting a pull of 3,000 kg. The 15-cycle machine will have 12 poles, the 25-cycle machine 20 poles. The pressure between segments is the same, hence the short-circuit losses at starting are the same.

It is immaterial for starting whether the connections shown in groups I., II. or III. are used for normal working. In each case resistance connections could be used—or, still better, a weakened field. Shortly after starting, a good commutating field can be provided either by a compensating winding or commutating poles, quite independent of what system of connections is used. In the designs it has been assumed that the excitation is effected by means of the rotor winding. It could equally well be done by the stator winding—though at the expense of copper and power factor.

	15 cycles, 12 poles.		25 cycles, 20 poles.
Single air-gap	3 mm.	......	3 mm.
Dia. of stator plates (outside)	1,950 ,,	......	2,000 ,,
,, ,, (bore)	1,620 ,,	......	1,720 ,,
Total length of core	430 ,,	......	390 ,,
Diameter of commutator......	1,500 ,,	......	1,500 ,,
Length of ,, ...	330 ,,	......	470 ,,
Total number of brushes......	84 60 24	......	148 160 48
Watt/*dm*, ...	76	......	95·5
Pressure between segments...	5·07 volts	......	5 volts
Active weight of iron	5,400 kg.	......	4,140 kg.
Stator and rotor copper	1,215 ,,	......	885 ,,
Copper in commutator.........	390 ,,	......	550 ,,
Total weight of motor.........	12,900 ,,	......	11,800 ,,

We thus see that the two machines do not differ much in iron, whilst the 15-cycle machine has more copper in its windings but less on its commutator. The total weights, output, heating and power factors are practically the same, and the only real difference is in the larger number of brushes and larger commutator surface of the 25-cycle machine. Both machines give the same torque for the same starting losses and sparking, and can take the same overloads, though experimental results seem to show that slipping occurs earlier with the low-cycle machine.

The machines without armature excitation, either with or without a cross field, are worse for the higher number of poles; consequently their supporters favour low frequencies. For higher frequencies armature excitation becomes necessary.

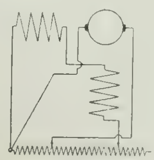


Fig. 6A.

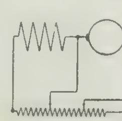


Fig. 6B.

Group II. possesses the simplest construction of motors and switchgear—it has not only the smallest currents but also the least number of leads. With this connection, however, commutating coils are necessary for obtaining a good range of commutation. With group I. commutating poles are essential. In group III. correct commutation is obtained automatically. For perfect starting, machines of all groups require a variable ratio of exciting to energy turns. Armature excitation is preferable in each case. This is best adapted for group II., where the short-circuit E.M.F. under the exciting brushes is always zero. When used with groups I. and III., special means must be employed for keeping down the short-circuit E.M.F. under the exciting brushes.

The limit for frequencies above 25 is soon reached on account of saturation, the prevention of which leads to heavy machines.

II. *The Generators.*—We have to deal with a single phase, or, in any case, with an unsymmetrical load. Also heavy current rushes and short-circuits have to be allowed for. The lower the frequency the more energetic the short-circuit. The unsymmetrical load reacts on the field with double frequency, which effect increases with the pole pitch. Also the larger the pitch, the more sensitive the machine will be against current rushes, owing to the longer coil overhangs, which require to be well supported. Of course, it is possible to build machines with a large leakage and use automatic regulators. In general, however, the 15-cycle generator will be 30 to 20 per cent. heavier and more expensive than the 25-cycle, and steam turbines must often be designed for lower speeds.

III. *The Installation.*—Transformers also have to be heavier for 15 cycles. With 25 cycles we can take $B_{max} = 16{,}000$, whilst at 15 cycles saturation prevents us going much beyond $B_{max} = 18{,}000$. Units of 500 kw. to 2,000 kw. will cost 30 to 35 per cent. more for 15 cycles than for 25. Considerable economy is only obtainable with low frequency in the copper of the transmission line, but not in the network. The saving in the line, however, is outweighed by the extra cost of transformers.

SOME CONSIDERATIONS IN DESIGNING HEAVY CAPACITY FUSES.*

BY L. W. DOWNES.

The conditions to be met in the design of an enclosed fuse are materially different from those imposed by the open link fuse. We not only have to suppress the arc, but we have to handle the tremendous expansive force of the vaporised metal within a comparatively confined space. Further, the radiation of the heat from the metal of the link takes place in an entirely different manner. With the open link the heat dissipation is directly from the surface of the metal. In the enclosed fuse the heat dissipation must take place by conduction through the porous filling to the surface of the tube, so that in enclosing a fusible link and surrounding it with porous material we have modified practically all the conditions of operation. The most serious difficulty that we have to contend with in the design of the larger capacity fuses is that of explosion, and this difficulty becomes greater as the capacity is increased. The problem is largely one of the relation which the volume of the fusible link bears to the volume of the enclosing tube and the distribution of the metal in the filling. It is necessary to devise means which, while tending to reduce the volume of fusible metal to the lowest possible point, will so facilitate the ready escape and condensation of the hot metallic gases as to render the operation of the fuse quiet and reliable under all conditions.

Consider what actually takes place when an enclosed fuse is blown on short-circuit. As the rush of current occurs the metal is raised through its melting point to its boiling point, and the current continues to flow through the fuse for a brief interval on the conducting vapour path of the volatilised metal. It is extremely important that the temperature of these gases should be lowered with the greatest possible rapidity to a point where their conducting power ceases to exist, in order to bring about a reduction in the time of operation of the fuse, which is of tremendous importance in reducing the internal pressures developed and in preventing explosion. These considerations show that as little metal as possible must be used in the link, and, further, its surface must be so extended as to provide

FIG. 1. FIG. 2. FIG. 3.

Length 3 in. Area: Fig. 1, 6 sq. in.; Fig. 2, 12 sq. in.; Fig. 3, 12 sq. in.

every facility for the hot gases to escape and so distribute the metal within the mass of the filling that each particle of it shall be brought promptly into action.

These conditions are effectively met by employing what is known as the "multiple link," or one of its modifications. It is quite a simple matter to obtain an increased link area of 100 per cent. or more by this method, which will permit of a reduction of at least 18 per cent. in the total volume of the metal necessary for a given capacity, according to the design.

Figs. 1, 2 and 3 show end sections through three types of fusible links. In Fig. 1 we have an end section of the widest practical single-strip link which could be used in a given tube. In Fig. 2 is shown how the surface may be readily extended 100 per cent. without occupying a greater width, and with a further advantage that the metal is more widely distributed within the filling, rendering this far more effective and rapid in its action. At the same time, the metal is brought closer to the radiating surface, which will also affect the total amount of metal necessary for a given capacity of a fuse. In Fig. 3 we have another arrangement of the same link which would also be effective.

The author then considers mathematically the effect of a change in position of the conductors within the enclosing casing. It is seen that in order to get the most satisfactory operation of an enclosed fuse, and one of the smallest possible dimensions for a given capacity, all the porous filling should be brought into service when the fuse is subjected to an excessive overload or short-circuit. From this it is clear that the shorter the distance the gases have to pass in order to bring into action the maximum amount of filling the greater will be the rapidity of condensation of the gases and the quicker will the arc be interrupted. This is illustrated by the case of a five-wire multiple fuse and of a flat-strip link of the same capacity, and it is shown that the time which must elapse before all the filling can be brought into action to condense the vapour is nearly double in the latter case, with the result that a larger amount of energy is absorbed by the fuse, the current flows longer through it and the breaking or rupturing of the current becomes far more difficult. This furnishes another reason why an explosion will take place with a single-strip link and will not take place under similar conditions with a multiple link, and that this theory is correct is shown both by oscillograph records and actual test of the fuses themselves. To ascertain definitely the actual reduction in metal volume for any given capacity of fuse, obtained by proper subdivision of the link, an extended series of calibration tests were made on a set of fuses under identically the same conditions. These fuses were all made up in tubes of the same size and fitted with the same size terminals, the lengths of the links being the same. Tabulated results in the Paper show the gain in capacity brought about by the increase in surface of the links and the proper distribution of the metal.

The author next considers the actual operation of the fuse under short-circuit. To permit of a full consideration of the phenomena shown at various intervals during the blowing of the fuse under those conditions an oscillograph was used. The tests consisted in subjecting fuses, similar in every detail of construction, except as relates to the fusible portion of the link, to direct short-circuit across the bus-bars of a 6,000 ampere-hour battery fed by one or more 500 kw. generators. The potential coil of the oscillograph was connected across the fuse rather than across the circuit, in order to show clearly the variations in the volts' drop at different intervals.

Referring to Fig. 4, as typical of the curves given in the Paper, this may be analysed as follows: This curve exhibits the operation of a five-strip multiple link fuse of 1 per cent. volume ratio, 80 amperes capacity. Following the current curve, it will be seen that during the period JA the current is zero. At the instant A, the switch was

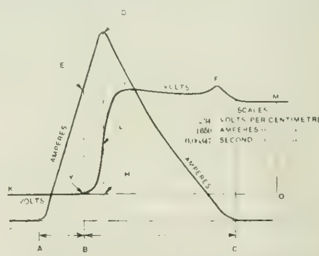


FIG. 4.—FIVE-STRIP MULTIPLE LINK, 0·025×0·125 WIDE.
Capacity 80 amperes, vol. ratio=1 per cent.

closed and the current instantly rushed through the fuse, rapidly increasing in value until at D it had reached its maximum. It then begins to die away until at C it has become zero again, or in other words, the fuse has opened the circuit. Referring to the voltage curve from K to Y, the voltage as measured across the fuse is practically zero, that is to say, it was zero at K, but at the beginning of the current flow, there was of course, a slight rise. This is, however, so small as not to be visible on the curve and for all practical purposes the voltage may be regarded during the interval KY as zero. At the instant Y, the voltage begins to go up with great rapidity until it practically reaches its maximum at I; it then continues at almost even value until just before the rupture of the current, occurring at C, a slight inductive kick is noticed at F, after which it sharply declines and becomes constant at M, MO being the full voltage of the circuit across the fuse. Referring to the current curve, note the rapid rise of the current value from the point A to E. During that period, there was practically no voltage across the fuse. The actual time during which this rise in current was occurring, represented by the distance AB, is 0·0038 seconds. It is during this interval that the fuse link is being raised to its melting point, the total energy impressed on the fuse being extremely small. From the point E on the current curve to its maximum value at D, the metal is being converted into vapour, and a corresponding rapid rise in voltage will be noted, showing the enormous increase in the resistance of the circuit. At D, the vapour begins to condense, or, in other words, lose its conductivity, and as the conductivity of the vapour path diminishes, the current falls. The voltage, however, continues to rise slightly, due to the same cause, but remains practically constant from the point I until just before reaching the point at F. During this period the current is falling rapidly, and the total time or duration of fall is found to be 0·012 seconds. The maximum current which passes through the fuse is found to be 8,415 amperes, and the voltage at the same instant, found by measuring the height HL, was 304 volts, so that the power input into the fuse at the instant G is

* Abstract of a Paper read before the American Institute of Electrical Engineers.

2,558 kw., apparently an enormous amount of energy, but practically an instantaneous value. By integrating, it is found that the average power was 1,925 kw. during the period that power was absorbed by the fuse. This period of energy input, is represented by the distance BC, and is found to be actually 0·0146 second, from which is derived a value of 28,600 watt-seconds. The total period of operation, or the time AC, which elapsed after the switch was closed, until the circuit was opened, was but 0·0184 second.

Referring to Fig. 5, relating to a single flat strip link fuse, it is noted that the time during which the link was being melted as represented by the distance AB, was practically the same as that of Fig. 4, but the significant feature lies in the relatively slow decline of the current value and the prolongation of the period during which energy was being absorbed by the fuse or the period BC. This time is actually 0·0246 second or an increase of 68 per cent. in the period of operation of the fuse during which arcing was going on. By integrating the curve the average power was found to be 2,360 kw., and this value multiplied by the time, gives 58,000 watt-seconds, or more than double the total energy absorbed by the multiple strip fuse.

A similar comparison of the other curves bears out in a most striking manner the important influence which the extension of the link surface and its proper distribution within the filling has in reducing to a large degree the total energy absorbed as well as the duration of the period of energy input. Comparing the results it is found that

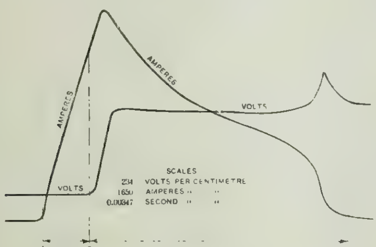


Fig. 5.—Single Flat Strip, 0·028 in. × 0·625 in. wide.
Capacity 80 amperes, vol. ratio=1·12 per cent.

the single link fuses invariably absorb more total energy. Furthermore, in anything like equal ampere capacity the maximum current flow was greater with the single link fuses, the average excess being 15 per cent. This has an important bearing on the tendency to disrupt or burst the cartridge.

The results of other tests are summarised in the chart, Fig. 7. Fig. 6 shows the operation of a single wire link fuse. This curve is particularly interesting as showing the effect of concentrating a mass of metal in as compact form as possible, thereby reducing to a minimum the avenues of escape of the gases within the filling. The rise of the current wave is more pronounced than in any of the other single link fuses, the current here reaching a maximum of 10,642 amperes, while the period of energy input, BC, is relatively short. This is due to the fact that this fuse exploded with great violence and the current was actually ruptured by the explosion. This is indicated by the very pronounced inductive kick shown on the curve, the rise in potential at the instant of rupture being about 450 volts.

The statement may be made in making these comparative tests, that possibly the most efficient form of single link fuse is not used, and that the area might be extended by using a greater width and folding up the edges, &c. In this connection it should be pointed out that such modifications could hardly affect the results, since if such a peculiar form of single link fuse were employed, the same form could, of course, be used in the elements of the multiple strip for comparison, and the gain, both in area and distribution, would remain relatively the same. Further than that, it is difficult to conceive of any arrangement of the single link whereby all the mass of the filling could be so promptly and effectively brought into action.

Two other possible causes contributing towards the explosive action of a fuse have been suggested, one, in the presence within the filling of a certain percentage of moisture and within the casing of a certain amount of air which, it was claimed, was suddenly and rapidly expanded by the heat of the arc. An examination of the filling of the ordinary fuse will show that there can be no material amount of

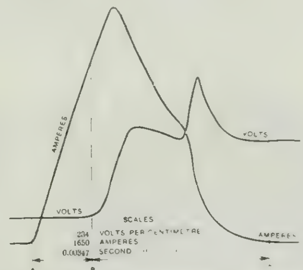


Fig. 6.—Single Round Wire, 0·164 diam.
Capacity 80 amperes, vol. ratio=1·35 per cent.

air, the heating of which would occasion the violent explosions resulting from short-circuit, particularly when it is considered that the metal generally used for the link expands over 2,400 times when converted from its metallic form to vapour. By actual measurement it is found that the total volume of air present in the average enclosed fuse is in the neighbourhood of 19 per cent. of the filling used. The presence of water might cause serious disturbance were there a sufficient amount of it converted into steam, but this would require the heating of the entire mass of filling to a high temperature and to raise it to this temperature in the extremely short interval of time which is required to operate the fuse, would call for the application of a tremendous amount of heat energy. Of course if the arc should be maintained, the filling would rapidly reach such a temperature, but the condition under consideration is one where the fuse explodes when it is short-circuited, and as there can be no prolonged maintenance of the arc under this explosive action, which would affect the filling, it could not be heated in that manner and the only heat which could be applied to that particular purpose is that absorbed by the fuse in converting the metal of the link into its vapour. Actual measurement was made of the percentage of moisture present in the filling, both before and after a fuse had been subjected to a severe short-circuit which it had handled satisfactorily. Starting with an initial amount of 5 per cent., nearly 3 per cent. remained, showing that but a little over 2 per cent. of the total moisture had been driven off—namely, that portion of the moisture present in the filling which was quite close to the metal of the link.

Fuse link construction.	Capacity Amperes. Volts.	Vol. ratio of fuse link. Per cent.	Max. amperes.	Time of melting AB.	Time of arcing BC.	British thermal units.	Operation.
	80 / 500	1	7,600	0·0052	0·0135	16·6	Quiet and satisfactory. Cartridge uninjured.
	80 / 500	1·12	8,910	0·0052	0·0243	36·55	Explosive and dangerous. Cartridge injured at one end.
	70 / 500	1	8,170	0·0045	0·0302	39·88	Explosive and unsatisfactory. Cartridge injured at one end.
	83 / 500	1	...	...	...	...	Quiet and satisfactory. Cartridge uninjured.
	83 / 500	1·19	9,570	0·0059	0·0253	48·78	Explosive and dangerous. Cartridge injured at one end.
	80 / 500	1·35	10,642	0·0055	0·0166	32·8	Explosive and very dangerous. Cartridge burst.
	83 / 500	1	8,420	0·0048	0·0132	22·9	Quiet and satisfactory. Cartridge uninjured.
	78 / 500	1	8,170	0·0052	0·0118	18·9	Satisfactory. Cartridge uninjured.
	80 / 600	1	8,420	0·0034	0·0146	27·0	Satisfactory. Cartridge uninjured.
	80 / 600	1·12	9,390	0·0042	0·0246	54·94	Explosive and dangerous. Cartridge burst.
	80 / 600	1·26	9,650	0·0048	0·0163	35·8	Explosive and very dangerous. Cartridge burst.
	60 / 600	...	6,520	0·0035	0·0243	44·42	Explosive and very dangerous. Cartridge burst. Base broken.
	80 / 600	1	...	...	...	...	Quiet and satisfactory.

Fig. 7.

LEAKAGE REACTANCE.

BY J. REZELMAN.

Summary.—The article deals with the leakage reactance of the stator windings of alternating-current machines, the rotors being removed. The leakage flux is separated into its component parts, for several machines, by means of experiments: the effect of the type of winding upon the overhang leakage, and the relationship between the reactance of the windings in three-phase and in single-phase working are observed. Formulæ are given by means of which the stator reactance can be calculated.

The operation and overload capacity of electric machines depend directly on their reactance. For a long time the determination of the exact value of this reactance has not been well known, and progress in the calculation of machines has undoubtedly been hindered thereby. High-speed alternators and motors have a small number of poles, and a large pole pitch, and hence the overhang coils of the stator winding are very long. An error in the calculation of the reactance of the overhang portion of the winding—of little consequence with a machine having a large number of poles, and small pole pitch, may then become important for these high-speed machines.

In the following article, with the help of simple experiments, the reactances of the different portions of the stator windings are separated, for four machines.

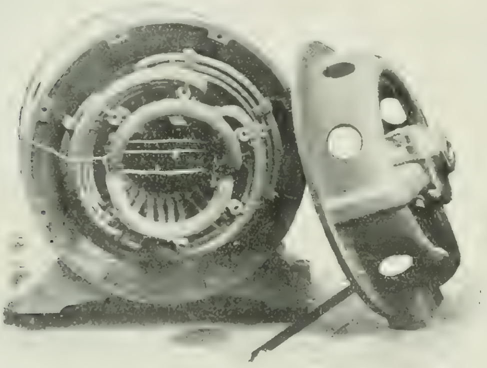


Fig. 1.

In accordance with general custom, we shall subdivide the leakage flux into three parts :—

(1) ψ_n = flux traversing each slot, with a permeance λ_n, for a length l_n.
(2) ψ_k = flux between the tops of the teeth, permeance λ_k, for a length l_k.
(3) ψ_s = the flux embracing the overhang, or "free" portion of the winding, with a permeance λ_s for a length l_s.*

The following symbols will be used :—

s_n = number of conductors in series per slot.
q = number of slots per pole and phase.
p = number of pole pairs.
$w = p \times q \times s_n$ = turns in series per phase.
τ = pole pitch.
l_i = virtual length of stampings.
t_1 = tooth pitch.
r_1 = slot opening.
$z_1 = t_1 - r_1$ = width of tooth at bore.
c = frequency, cycles per second.

The coefficient of self-induction in *single-phase* for *one* phase is given by : $L_1 = 2 \times p \times q \times s_n^2 (l_n \times \lambda_n + l_k \times \lambda_k + l_s \times \lambda_s)$, and the reactance

$$x_1 = \frac{12.5 \times c \times w^2}{p \times q \times 10^8} (l_n \times \lambda_n + l_k \times \lambda_k + l_s \times \lambda_s).$$

It will be seen later how this is applied in certain cases.

* Arnold—"Die Wechelstromtechnik," Vol. IV.

A. *Determination of the Stator Reactance of a three-phase Motor—220 B.H.P., 2 poles, 50 ∽ per second, 3,000 revs. per min., 6,300 volts between phases, the rotor being removed.* Fig. 1.

Dimensions.

Ext. diam. of stator stampings $= \phi_e = 760$ mm.
Int. " " " $= \phi_i = 330$ mm. ; $\tau = 520$ mm.
Total length of stampings $= l = 450 - 7 \times 12$; $l_i = 410$ mm.
Number of slots = 30 ; $t_1 = 34{\cdot}5$ mm.
Slot dimensions $= 26 \times 77$ (Fig. 2A).
Thickness of insulation tubes = 4 mm.
$s_n = 60$ (29/10 insulated to 35/10).
$p = 1$, whence $q = 5$.

The motor has thus an odd number of slots per pole and phase, and an unsymmetrical arrangement of the end connections, there being one coil per pole for each phase. The end connections (a) of three slot coils are bent towards the top, and those (b) of the two others towards the bottom (Figs. 1 and 3). The lengths l_s are different for the three phases :—

I. Phase nearest the rotor : $l_s = 920$ mm.
II. Phase in the middle : $l_s = 1{,}180$ mm.
III. Phase farthest from rotor : $l_s = 1{,}260$ mm.

These lengths are made up of l_{s_a}, l_{s_c}, and l_{s_b}, l_{s_c}.

For phase I. : $l_{s_a} = l_{s_b} = 450$ mm.
For phase II. : $l_{s_a} = l_{s_b} = 710$ mm.
For phase III. : $l_{s_a} = l_{s_b} = 790$ mm.

The periphery $U_s = 2(a + b)$ corresponding to the different parts of l_s is for each phase : $U_{s_a} = 260$ mm. for three slot coils, and $U_{s_b} = 210$ mm. for two slot coils. The length $l_{s_c} = 470$ mm. is the same for all three phases. As can be seen from Fig. 3, the periphery $U_{s_c} = 500$ mm. is determined by the conductors coming out of five slots. In order to separate by experiment the different permeances λ_n, λ_k and λ_s, auxiliary coils

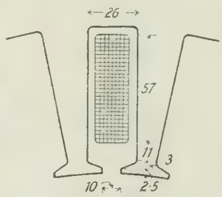


Fig. 2A.

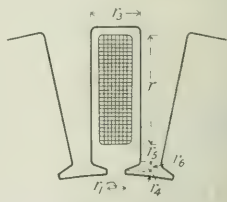


Fig. 2B.

were placed along l_s in phase I., in the middle of the coil, Fig. 1. There were 10 turns between each of the slot coils (a), and 20 turns between each of the coils (b), Fig. 3. By means of these auxiliary coils it was possible to measure the flux ψ_s.*

Experiments.

Very accurate measurements were made on each phase :—

1. In single-phase per phase.
2. In single-phase two phases in series.
3. In three-phase.

Remarks on the Experiments.—The power factor is very low ($\cos \phi \simeq 0{\cdot}06$) ; the voltage readings thus correspond practically entirely to the reactances. The measured watts are 50 to 85 per cent. in excess of the calculated ; the additional losses are in part due to Foucault currents in the copper of the winding, but chiefly to the currents in the masses of surrounding iron ; thus phase III., nearest the iron, shows the greatest additional losses.

The above experiments have been made with the end shields placed on each end ; removing these has a negligible effect (2 per cent.) on the voltages, but the 264 watts measured in phase III. with the end shields in position, is reduced to 231 watts after removing them—that is to say, $1{\cdot}83R_1$ diminishes to $1{\cdot}6R_1$. This experiment shows clearly that part of the additional losses do not occur in the windings themselves, and

* The section of the auxiliary coils must be sufficiently ample, since surprising results may easily be obtained owing to the hot wire voltmeter taking a fair amount of current.

Table of Experiments No. 1.

—		e_{0-1}.	e_{0-2}.	e_{0-3}.	Current I.	Watts. W. 1 ph.	Voltage on auxiliary coils: 10 inside coils.	10 outside coils.	e_a	e_b.	c.	cos φ.	Ohmic Resist per phase R_1.	I^2R_1.	W/I^2R_1.
Readings with a current of 7 amps. in phase	I.	406·0 $a=154$, $b=252$	94·2	86·7	7	164	2·25 + 2·75 = 5·0			3·82	50	0·057	2·21	104	1·57
	II.	94·5	447·2 $a=165$, $b=281$	101·8	7	210	0·73 + 0·79 = 1·52			1·09	50	0·067	2·80	137	1·53
	III.	86·6	101·0	480·0 $a=171$, $b=307$	7	264	0·59 + 0·64 = 1·23			0·98	50	0·0785	2·94	144	1·83

Table of Experiments No. 2.

—		e between phases.	e_{0-1}.	e_{0-2}.	e_{0-3}.	I.	W. 2 ph.	Voltage on auxiliary coils: 10 inside coils.	10 outside coils.	e_a.	e_b.	c.	cos φ.	Ohmic resistance 2 phases in series R_2.	I^2R_2.	W/I^2R_2.
Readings with a current of 7 amps. in 2 phases in series	I.-II.	1,045	498	542	0	7	410	3·05 + 3·65 = 6·7			5·0	50	0·056	5·01	245	1·67
	II.-III.	1,120	0	544	573	7	500	0			0	50	0·064	5·74	284	1·76
	III.-I.	1,060	492	0	567	7	475	2·9 + 3·5 = 6·4			4·95	50	0·064	5·15	252	1·88

Table of Experiments No. 3.

—		e between phases.*	e_{0-1}.	e_{0-2}.	e_{0-3}.	I.	W. 1 ph.	Voltage on auxiliary coils: 10 inside coils.	10 outside coils.	e_a.	e_b	c.
Readings on measuring a current of 7 amps. in phase..................	I.	885	492·5	514	528	7	200	3·0 + 3·6 = 6·6			5·05	50
	II.	937	522·0	543	559	7	240	3·2 + 3·82 = 7·02			5·38	50
	III.	958	532·0	555	570	7	184	3·2 + 3·85 = 7·05			5·42	50

NOTE.—The mutual induction between the overhang coils so disturbs the equilibrium, that the watts measured for each phase have no interest.

$$\frac{W\ \text{total}}{3\times I^2R_1}=\frac{624}{385}=1{\cdot}62.$$

* For each reading the voltage is the same between the three phases.

therefore has not a direct bearing upon their temperature rise. From Table I. it is seen that a larger voltage is induced in phase I. by phase II. than by phase III. In the slots the windings are arranged symmetrically, so that the difference can only be produced by the overhang of the windings, the end connections of phase II. being in fact nearer to those of phase I. than are the end connections of phase III. For the same reason phase II. induces a larger voltage in the auxiliary coils.

It is to be remembered that phase I. induces the same voltage in phase II. as II. in I., when carrying the same current, and the other phases show the same reciprocity. The E.M.F. induced in the 10 outside auxiliary coils of the coil (a)

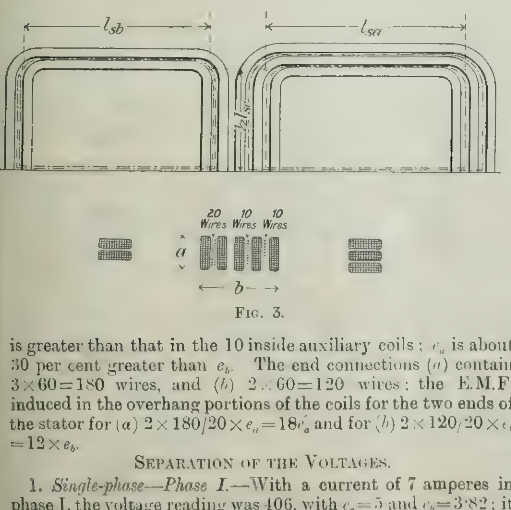


FIG. 3.

is greater than that in the 10 inside auxiliary coils; e_a is about 30 per cent greater than e_b. The end connections (a) contain $3\times60=180$ wires, and (b) $2\times60=120$ wires; the E.M.F. induced in the overhang portions of the coils for the two ends of the stator for (a) $2\times180/20\times e_a=18e_a$ and for (b) $2\times120/20\times e_b=12\times e_b$.

SEPARATION OF THE VOLTAGES.

1. *Single-phase—Phase I.*—With a current of 7 amperes in phase I. the voltage reading was 406, with $e_a=5$ and $e_b=3{\cdot}82$; it follows then that the voltage induced in the overhang of this phase is $18\times5+12\times3{\cdot}82=136$, and the reactance corresponding: $136/7=19{\cdot}45\ \omega$.

The permeance λ_s of the two ends of a coil, in parallel planes, may be approximately calculated from the following formula: $\lambda_s=0{\cdot}46\log 2\pi a/U_s$, where a=distance between the axes of the coil ends and U_s=periphery of the coil ends. From experiments made by the author, the permeance is but little dependent on the shape—solenoid or disc—of the coils so long as a and U_s are the same (Fig. 4A, B and C). We shall write $\lambda_s=0{\cdot}46q_s(A+\log 2\times l_s/U_s)$, where q_s=number of neighbouring coils of the same phase which form one pole, and l_s=mean length of end connection. The term A is introduced to take account of the possible effect of the iron and mutual induction; the experiments enable its value to be determined for various cases.

We have then to consider the three parts of λ_s:—

(a) λ_{s_a} for a length $l_{s_a}=450$ and a periphery $U_{s_a}=260$.
(b) λ_{s_b} ,, ,, $l_{s_b}=450$,, ,, $U_{s_b}=210$.
(c) λ_{s_c} ,, ,, $l_{s_c}=470$,, ,, $U_{s_c}=500$.

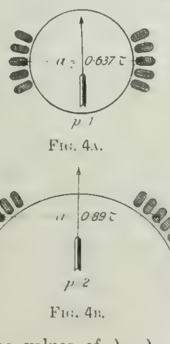


FIG. 4A.

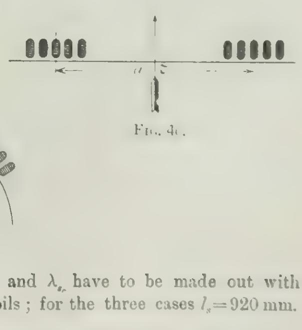


FIG. 4C.

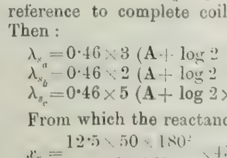


FIG. 4B.

The values of λ_{s_a}, λ_{s_b}, and λ_{s_c} have to be made out with reference to complete coils; for the three cases $l_s=920$ mm. Then:

$\lambda_{s_a}=0{\cdot}46\times3\ (A+\log 2\times920/260)=1{\cdot}17+1{\cdot}38A.$
$\lambda_{s_b}=0{\cdot}46\times2\ (A+\log 2\times920/210)=0{\cdot}87+0{\cdot}92A.$
$\lambda_{s_c}=0{\cdot}46\times5\ (A+\log 2\times920/500)=1{\cdot}29+2{\cdot}3\ A.$

From which the reactances:—

$$x_{s_a}=\frac{12{\cdot}5\times50\times180^2}{1\times3\times10^8}\times45\ (1{\cdot}17+1{\cdot}38A)=3{\cdot}56+4{\cdot}2A.$$

$$x_{s_b}=\frac{12{\cdot}5\times50\times120^2}{1\times2\times10^8}\times45\ (0{\cdot}87+0{\cdot}92A)=1{\cdot}74+1{\cdot}86A.$$

$$x_{s_c}=\frac{12{\cdot}5\times50\times300^2}{1\times5\times10^8}\times47\ (1{\cdot}29+2{\cdot}3A)=6{\cdot}8+12{\cdot}15A$$

$$x_{s_a}+x_{s_b}+x_{s_c}=12{\cdot}1+18{\cdot}21A.$$

Now, $x_{s_a} + x_{s_b} + x_{s_c} = 19{\cdot}45$. Then $12{\cdot}1 + 18{\cdot}21\text{A} = 19{\cdot}45$, and $\text{A} = 0{\cdot}4$.

Then
$$x_{s_a} = 3{\cdot}56 + 4{\cdot}2 \times 0{\cdot}4 = 5{\cdot}24\omega.$$
$$x_{s_b} = 1{\cdot}74 + 1{\cdot}86 \times 0{\cdot}4 = 2{\cdot}48\omega.$$
$$x_{s_c} = 6{\cdot}8 + 12{\cdot}15 \times 0{\cdot}4 = 11{\cdot}66\omega.$$

As a check on the above, we have the voltage $e_a = 5$, and $e_b = 3{\cdot}82$, readings taken separately on the auxiliary coils.
$$\frac{e_a \times 180}{e_b \times 120} = \frac{5 \times 180}{3{\cdot}82 \times 120} = 1{\cdot}96.$$

It follows then that $x_{s_a} + \sigma x_{s_c}$ should equal $1{\cdot}96\ \{x_{s_b} + (1-\sigma)\ x_{s_c}\}$. That is to say: $5{\cdot}24 + \sigma \times 11{\cdot}66 = 1{\cdot}96\ \{2{\cdot}48 + (1-\sigma)\ 11{\cdot}66\}$. Whence $\sigma = 0{\cdot}65$.

In reality, as can easily be seen from Fig. 3, σ should be a little larger than $\frac{3}{5}$.

The total voltage reading on phase I. was 406 volts, of which 136 are taken up by the end connections; 270 volts, therefore, are left for that portion of the winding which is embedded in the slots. From reasons of symmetry the same voltage of 270 must be induced in the embedded portion of the windings of each of the other two phases. The E.M.F. induced in the overhang or free portion of phase II. will then be $447{\cdot}2 - 270 = 177{\cdot}2$ volts, and of phase III. $480 - 270 = 210$ volts. The reactances corresponding to these voltages are $177{\cdot}2/7 = 25{\cdot}3\omega$ and $210/7 = 30\omega$.

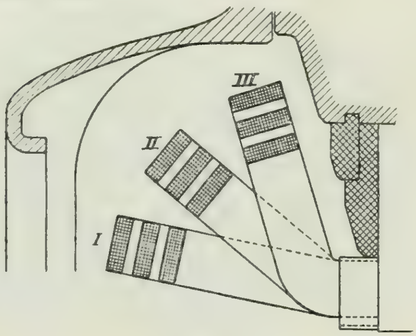


FIG. 5.

2. *Single-phase—Phase II.*—For this phase, $l_{s_a} = 710$, $\text{U}_{s_a}\ l = 260$ mm., $l_{s_b} = 710$, $\text{U}_{s_b} = 210$ mm., $l_{s_c} = 470$, $\text{U}_{s_c} = 500$ mm., $l_s = 1{,}180$.

Then
$$\lambda_{sa} = 0{\cdot}46 \times 3(\text{A} + \log 2 \times 1{,}180/260) = 1{\cdot}325 + 1{\cdot}38\text{A},$$
$$\lambda_{sb} = 0{\cdot}46 \times 2(\text{A} + \log 2 \times 1{,}180/210) = 0{\cdot}965 + 0{\cdot}92\text{A},$$
$$\lambda_{sc} = 0{\cdot}46 \times 5(\text{A} + \log 2 \times 1{,}180/500) = 1{\cdot}550 + 2{\cdot}3\text{A}.$$

And
$$x_{sa} = 0{\cdot}0675 \times 71(1{\cdot}325 + 1{\cdot}38\text{A}) = 6{\cdot}37 + 6{\cdot}63\text{A},$$
$$x_{sb} = 0{\cdot}045 \times 71(0{\cdot}965 + 0{\cdot}92\text{A}) = 3{\cdot}08 + 2{\cdot}94\text{A},$$
$$x_{sc} = 0{\cdot}1125 \times 47(1{\cdot}550 + 2{\cdot}3\text{A}) = 8{\cdot}17 + 12{\cdot}1\text{A}.$$
$$x_{s_a} + x_{s_b} + x_{s_c} = 17{\cdot}62 + 21{\cdot}67\text{A} = 25{\cdot}3\omega,$$

whence $\text{A} = 0{\cdot}355$.

3. *Single-phase—Phase III.*—We have $l_{s_a} = 790$, $\text{U}_{s_a} = 260$ mm., $l_{s_b} = 790$, $\text{U}_{s_b} = 210$ mm., $l_{s_c} = 470$, $\text{U}_{s_c} = 500$ mm., $l_s = 1{,}260$ mm. In a similar manner we find $\text{A} = 0{\cdot}47$, which is rather high. The overhang coils of this phase are nearer to the stator core than the others (Fig. 5); for this reason the rather high voltage of 210 is observed. For $\text{A} = 0{\cdot}4$ the voltage would be 200, and the total voltage $270 + 200 = 470$ instead of 480. (By removing the end shields the voltage is reduced from 480 to 470·4 volts.)

It still remains to determine the reactance of that portion of the winding which is in the slots. It has already been found that the E.M.F. induced in this part is 270 volts; the total reactance is then $270/7 = 38{\cdot}6\omega$. There are two permeances to be considered here, λ_n and λ_k. The permeance λ_n can be determined with sufficient accuracy by the formula:—

$\lambda_n = 1{\cdot}25\,(r_1/3r_4 + r_2/r_4 + 2 \times r_3/(r_1 + r_3) + r_4/r_1)$. Fig 2 (A and B).

We have then
$$\lambda_n = 1{\cdot}25\,(57/78 + 11/26 + 6/36 + 2{\cdot}5/10) = 1{\cdot}97$$
along a length $l_n = l_i = 410$ mm. Whence
$$x_{s_n} = \frac{12{\cdot}5 \times 50 \times 300^2}{1 \times 5 \times 10^8} \times 41 \times 1{\cdot}97 = 9{\cdot}1\omega.$$

There remains for x_{s_k}:—$x_{s_k} = 38{\cdot}6 - 9{\cdot}1 = 29{\cdot}5\omega$.

According to Arnold, λ_k for $q = 5$ can be calculated by:—
$$\lambda_k = 0{\cdot}92 \times \left\{\log\left(\frac{\pi t_1}{r_1}\right) + 2{\cdot}1 + 5\log\left(\frac{\tau}{4t_1} \times \frac{p+1}{p}\right)\right\}^*.$$

In the first term t_1 is used for simplicity, instead of z_1; for the machine under discussion, $t_1 = 34{\cdot}5$ and $z_1 = 24{\cdot}5$, and there is thus a fairly large difference, so that we will calculate with z_1.

The factor $(p+1)/p$ of the last term is a correction factor taking account of the polar angle, and is thus important for machines with a small number of poles. By assuming that the two first terms are correct we can check the value of $(p+1)/p$.
$$p = 1,\ q = 5;\ \lambda_k = 0{\cdot}92\{\log(\pi \times 24{\cdot}5/10) + 2{\cdot}1 + 5\log\left(\frac{520}{4 \times 34{\cdot}5}\,\text{B}\right)$$
$$= 0{\cdot}92\{2{\cdot}99 + 5\log(3{\cdot}77\text{B})\}$$
$$= 2{\cdot}75 + 4{\cdot}6\log 3{\cdot}77\,\text{B}$$
along a length $l_k = l_i = 410$ mm.
$$x_{s_k} = \frac{12{\cdot}5 \times 50 \times 300^2}{1 \times 5 \times 10^8} \times 41\{2{\cdot}75 + 4{\cdot}6\log(3{\cdot}77\text{B})\} = 29{\cdot}5.$$

Whence $\text{B} = 1{\cdot}65$.

We can again verify the voltages induced separately along the two parts of each phase; on phase I it was measured:—$406 = 252 + 154$, $e_a = 90$ and $e_b = 46$.

Then it is necessary that $252 = 270\sigma + 90$ and $154 = 270(1 - \sigma') + 46$. Whence $\sigma' = 0{\cdot}6$ and $(1 - \sigma') = 0{\cdot}4$.

The fact that $\sigma' \cong \frac{3}{5}$ proves that the lines of force (ψ_n and ψ_k) almost totally embrace all the conductors of the five slots per pole and phase.

From the table of experiment No. I:—

Phase II. induces 94·5 volts in phase I., and
Phase III. induces 86·6 volts in phase I.
Phase II. induces in the auxiliary coils $e_a = 1{\cdot}52$ and $e_b = 1{\cdot}09$, whence $18 \times 1{\cdot}52 + 12 \times 1{\cdot}09 = 40{\cdot}5$.
Phase III. induces in the auxiliary coils $e_a = 1{\cdot}23$ and $e_b = 0{\cdot}98$, whence $18 \times 1{\cdot}23 + 12 \times 0{\cdot}98 = 34$.

The flux $(\psi_n + \psi_k)$ then induces by mutual induction $\left\{\begin{matrix} 94{\cdot}5 - 40{\cdot}5 = 54 \\ 86{\cdot}6 - 34 = 52{\cdot}6 \end{matrix}\right\}$ or a mean of 53·3 volts in each of the other two phases.

The figures in the table of experiment No. I can be verified by those of experiment No. II.; the sum (e_{0-1} + the E.M.F. induced by phase II. in phase I.) of Table I. must be equal to the voltage e_{0-1} of the phases I.–II. of Table II.

Table I.		Table II.
406 + 94·5 = 500·5	....	498 volts.
406 + 86·6 = 492·6	....	492 "
447·2 + 94·2 = 541·4	....	542 "
447·2 + 101 = 548·2	....	547 "
480 + 86·7 = 566·7	....	567 "
480 + 101·8 = 581·8	....	573 "

4. *Single-phase—Two Phases in Series.*—In Table No. II. we have—

Phase I. $e_{0-1} = 498$; $e_a = 6{\cdot}7$ and $e_b = 5$ for a current of 7 amperes in phases I.–II.

$e_{0-1} = 492$; $e_a = 6{\cdot}4$ and $e_b = 4{\cdot}95$ for a current of 7 amperes in I.–III.

$18 \times 6{\cdot}7 + 12 \times 5 = 181$; and $18 \times 6{\cdot}4 + 12 \times 4{\cdot}95 = 174{\cdot}5$

The mean E.M.F. induced in the overhang of phase I, is $1/2(181 + 174{\cdot}5) = 178$ volts. Phase I. by itself induces 136 volts; there is then an increase of $178/136 = 1{\cdot}31$. This

* Arnold, "Die Wechelstromtechnik." Vol. IV., gives by mistake $p/(p+1)$ instead of $(p+1)/p$.

increase in the reactance of the overhang coils by the mutual induction of the phases is dependent on the shape and distance between the coils, but is always present with windings wound "per pole" (split phase windings). (We shall see later that this mutual induction is negligible for ordinary hemitropic or "consequent pole" windings.)

For the embedded portion of the winding there remains then $\left\{\begin{matrix} 498-181 \\ 492-174\cdot5 \end{matrix}\right\}$ the mean voltage of 317, which becomes $2\times 317=634$ volts for the two phases in series. As is shown by Fig. 6, the current has the same direction in the neighbouring slots of the two phases; it follows then that the connecting of the two phases in series represents a winding with twice the number of slots per pole. We can then calculate by taking $q=10$. The permeance λ_n, being independent of q, has the same value as for one phase, that is to say, $\lambda_n=1\cdot97$, whence $x_{s_n}=\dfrac{12\cdot5\times 50\times 600^2}{1\times 10\times 10^8}\times 41\times 1\cdot97=18\cdot2\omega$, and $7\times x_{s_n}=7\times 18\cdot2=127$ volts. There remains then $634-127=507$ volts, and the corresponding reactance will be $x_{s_k}=507/7=72\cdot5\omega$.

We have found that the reactance for one phase is $29\cdot5\omega$; $2\times 29\cdot5=59$; there is, therefore, an increase of $72\cdot5/59=1\cdot23$.

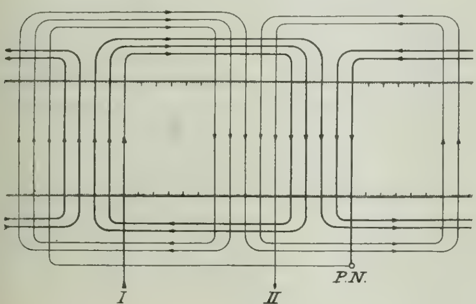


Fig. 6

The permeance λ_k of 10 slots covering $\frac{2}{3}$ of the pole-pitch is therefore 23 per cent. greater than that of five slots covering $\frac{1}{3}\tau$.

We have, similarly, $x_{s_k}=\dfrac{12\cdot5\times 50\times 600^2}{1\times 10\times 10^8}\times 41\lambda_k=72\cdot5$,

whence $\lambda_k=7\cdot95$.

In writing $\lambda_k=0\cdot92\left\{\log\left(\dfrac{\pi\times z_1}{r_1}\right)+5\cdot6+10\log\left(\dfrac{\tau}{q\times t_1}\times \mathrm{B}\right)\right\}$

$=7\cdot95$ with $q=10$ $p=1$, we find the value of 1·09 for B. It follows from this that the influence of the curvature of the pole-pitch is less for a winding covering $\frac{2}{3}\tau$, than for one which covers $\frac{1}{3}\tau$.

5. *Three-phase.*—By comparing the results in Table No. III. with those in Table No. II. it is immediately seen that for the same current the voltages of the corresponding phase have, to all practical purposes, the same value.

Table II.	Table III.
e_{0-1} mean=495	492·5
e_{0-2} mean=543	543
e_{0-3} mean=570	570

From this we draw the important conclusion, that *the reactance per phase with three phase, cannot be determined by considering one phase separately*, but that the reactance of two phases in series must be determined, and one half of this value be taken. In fact, at the moment when the current in one phase is zero, the currents in the two other phases have the same value and direction. This fact is well known, but up to the present one has in general been content to calculate the reactance for one phase, and to neglect the effect of the mutual induction.

Note.—Two-pole machines, with the rotor removed, have a large permeance λ_k, and thus a strong field in the bore; the introduction of the rotor on short-circuit prevents the formation of this field, and thus diminishes the reactance. Thus with its squirrel cage rotor, and a single air gap of 3 mm., the reactance of our stator decreases: on single phase, one phase only, by 43 per cent., on single phase, two phases in series, by 37 per cent., and on three phase by 50 per cent. In actual fact, as Arnold has already pointed out, the demagnetising action of the rotor winding on the flux ψ_s due to the stator, must also be taken into consideration; this, however, can be of little importance in our case, in which the squirrel cage rotor only overhangs the core by a short distance.

In order to complete the experiments on this stator, auxiliary coils were placed on the interior of the stator along the length of the slots of phase I. Four wires were placed in the opening of each of the five slots; their end connections were taken along the core end plates. By means of these auxiliary coils ψ_k could be measured. The reactances were measured without the end shields:—

1. Single phase on phase I.
2. Single phase on part (*a*) of phase I.
3. Single phase on part (*b*) of phase I.

Table of Tests.

—		e_{a+b}.	e_a.	e_b.	Volts induced in the auxiliary coils. 1 (b)	2 (b)	e_b.	3 (a)	4 (a)	5 (a)	e_a.	[illegible]
Readings with a current of 7 amp. in	(*a*+*b*)	393	242·1	150·4	2·4	2·7	.	2·3	2·72	2·4	.	13·2
	(*a*)	...	200·7	40·2	...		1·95	...			6·2	8·18
	(*b*)	...	41·0	110·0	...		3·25	...			1·93	5·25

In comparing these results with the preceding ones, a slight diminution in the reactance is noticed, due to the removal of the end shields, 393 instead of 406 volts for 7 amperes. There are $10\times 60=600$ main wires per phase and $10\times 4=40$ auxiliary wires. The E.M.F. induced in that part of the winding embedded in the slots due to the flux ψ_k will then be $600/40=15$ times the E.M.F. induced in the auxiliary coils.

Separation of the Voltages.—1. Phase I.—The voltage measured on the auxiliary coils was

$e_{\text{total}}=13\cdot2$; then $15\times 13\cdot2=198$ volts, and $x_{s_k}=198/7=28\cdot3\omega$.

The reactance x_{s_n} is $9\cdot1\omega$; there then remains for the end connections

$$x_{s_a}+x_{s_b}+x_{s_c}=393/7-28\cdot3-9\cdot1=18\cdot8\omega,$$

instead of $19\cdot45\omega$, found in the first experiment with end shields.

2. *Part (a) of Phase I. (3 slots.)*—The voltage measured on the auxiliary coils was

$e_a=6\cdot2$; then $15\times 6\cdot2=93$ volts and $x_{s_k}=93/7=13\cdot3\omega$;

the total reactance is $\dfrac{200\cdot7}{7}=28\cdot7\omega$. The permeance λ_n is still $1\cdot97$, whence $x_{s_n}=\dfrac{12\cdot5\times 50\times 180^2}{1\times 3\times 10^8}\times 41\times 1\cdot97=5\cdot45\omega$.

There thus remains for the end connections $x_{s_a}+x_{s_c}=28\cdot7-13\cdot3-5\cdot45=9\cdot95\omega$.

We have $l_{s_a}=450$; $\mathrm{U}_{s_a}=260$ mm.; $l_{s_c}=470$; $\mathrm{U}_{s_c}=330$ mm.; $l_s=920$ mm.

$$x_{s_a}=\frac{12\cdot5\times 50\times 180^2}{1\times 3\times 10^8}\times 45\times 0\cdot46\times 3\left(\log\frac{2\times 920}{260}+\mathrm{A}\right)$$
$$=3\cdot56+4\cdot20\mathrm{A};$$

$$x_{s_c}=\frac{12\cdot5\times 50\times 180^2}{1\times 3\times 10^8}\times 47\times 0\cdot46\times 3\left(\log\frac{2\times 920}{330}+\mathrm{A}\right)$$
$$=3\cdot30+4\cdot38\mathrm{A}.$$

thus $x_{s_a}+x_{s_c}=6\cdot86+8\cdot58\mathrm{A}=9\cdot95$, whence $\mathrm{A}=0\cdot36$.

3. *Part (b) of Phase I.*—(Two slots.) We find in like manner that $\mathrm{A}=0\cdot427$.

(To be concluded.)

CALCULATION OF IRON LOSSES IN DYNAMO ELECTRIC MACHINERY.*

BY I. E. HANSSEN.

Summary.—The author considers the different losses in the magnetic circuits of dynamo electric machines, and points out the causes of the additional losses compared with calculations from iron-loss curves.

It is well known that the iron losses in all kinds of electric motors and generators are invariably much greater than those calculated from iron-loss curves, such as are obtained from tests of samples of iron, unless an allowance is made for additional losses. The causes of this increase in the losses have been dealt with in detail by various writers, but so far as the writer knows, a simple method for predetermining the total iron loss has never appeared in print.

Smooth-core Armature.—Owing to the difference in length of the paths of the flux the distribution lacks uniformity, and this leads to an increase of the losses above what they would be were the distribution uniform. An allowance must further be made for imperfect insulation between the discs, caused by filing, burrs, and crushing of the insulating material when subjected to pressure, and also for the hardening effect caused by the punching process if the discs are not again annealed. To prevent the teeth from bulging out, a number of extra heavy discs are usually placed at the ends of the core and next to the ventilating ducts if such are provided. These heavy discs, being from two to three times thicker than the regular ones, will have from four to nine times greater eddy current losses. Sometimes these discs have a higher permeability than the thinner ones, and this will still further increase the losses due to the higher induction which will exist in the thicker discs. Iron-loss curves of iron samples, as usually made, give the losses taking place when the iron is subjected to an alternating magnetic field. The field in an armature, however, is not an alternating one but is of a rotary nature, probably elliptical. Such a field is generally conceded to cause considerably higher iron losses than the alternating field, provided the density at which the iron is worked does not exceed a certain limit—about 120,000 c.g.s. lines per square inch. If the density is increased above this value, the loss per unit of iron decreases rapidly. However, such high densities are hardly ever reached in armature cores, except in the teeth, so that there is generally a further allowance to be made, due to the field being a rotating one. The foregoing probably covers all the additional iron losses in the machines, provided the armature and field structure are perfectly concentric. If they are not concentric, the gap reluctances will vary with different positions of the armature, the result being that the flux in the field poles and yoke will not have a constant value, but will pulsate and thus produce eddy currents in the field structure. Dr. W. M. Thornton,† who first called attention to this fact, cites a case in which this loss amounted to 2,300 watts for a 10 kw. generator. Assuming that the armature and field structure are concentric, the actual iron loss, due to the above-mentioned causes, will be from 25 per cent. to 35 per cent. greater than calculated from the iron curves for smooth-core armatures.

Toothed Armatures.—What has just been said about smooth-core armatures applies equally well to the iron back of the slots of toothed armatures, the only difference being that in the latter the distribution is less uniform. It would be seen from the illustrations in Dr. W. M. Thornton's Paper (reproduced by the present author in his Paper) that for some distance behind the teeth the density is higher than behind the slots, and of the same order as the density in the teeth. If the iron is nearly saturated, these streamers of higher density appear to continue all the way from pole to pole, as pointed out by Dr. Thornton. It is probable that this phenomena nullifies somewhat the reduction of the iron loss which would otherwise occur when iron subjected to a rotating field is worked above 120,000 lines per square inch. The writer has found that adding 30 per cent., 35 per cent., and 40 per cent. for 25, 40 and 60 cycles, respectively, to the calculated loss in the iron behind the slots, gives very nearly correct results.

In the teeth the percentage increase in the losses due to filing and burrs may become much greater than is the case for the part of the iron already discussed, particularly in high-frequency machines (50 and 60 cycles), in which the eddy currents in the burrs become very marked. Here also we have to allow for the thicker discs next to the ventilating ducts and at the core ends. Furthermore, due to the leakage field, the resultant field is elliptical instead of alternating. An addition of 30 per cent., 60 per cent., and 80 per cent., for 25, 40, and 60 cycles, respectively, has been found to give satisfactory results.

In addition to the losses already mentioned there are other losses, particularly in machines having wide-open slots, caused by variations in the gap density. In direct-current and synchronous machines, these losses are produced by eddy currents in the pole-shoes, while in induction motors they are caused partly by eddy currents in the tooth-faces and partly by density variations extending throughout the depth of the teeth. The pole shoe is subjected to a field of frequency revs. per min. $\times$ S/120, S being the number of armature slots. In an induction motor in which both the primary and secondary members are slotted, both members will be subjected to these pulsations. However, as the secondary slot openings are generally very small, the losses from this source in the primary iron will as a rule be of no great moment. The frequency of the pulsations in the secondary member is revs. per min $\times S_p/120$ cycles per second, where S_p is the number of primary slots, while to obtain the frequency in the primary the number of secondary teeth is substituted for the number of primary teeth in this expression. The amount of variation in density can be calculated quite accurately, but this requires a considerable amount of time, and experience indicates that this refinement is not justified.

Within practical limits of slot and gap dimensions, the variation can be said to be roughly proportional to the expression k/δ, where δ = air-gap, and k = slot opening. As the losses are caused mainly by eddy currents, while the hysteresis loss is much smaller, the total losses from this source will vary nearly as the square of the frequency and probably approximately as $(k/\delta)^2$. Therefore it should be possible to plot curves of the expression BkS revs. per min./δ against watts lost per square inch of iron surface in the air-gap, B being the maximum density in kilolines per square inch of secondary tooth face, fringing being neglected.

In the case of alternating-current machines, in which only a few standard frequencies come into consideration, it is probably more accurate to plot the curves using the expression BkS_p/δ making a curve for each frequency to be used. The necessary data can be obtained by determining the losses in the teeth and in the portion of the core at the back of the teeth in the manner explained, deducting the value thus obtained from the iron loss observed on test. In direct-current machines and in alternating-current machines having projecting poles, the result will represent the loss in the pole shoes, provided the rotating and stationary parts are concentric. In machines with distributed field windings and in induction motors, part of the result represents losses in the primary and part in the secondary. It is possible in such a case to separate the two, but it is easier to obtain the necessary data from machines with projecting poles, and in the case of induction motors by choosing machines in which the secondary slot openings are small and the number of secondary slots less than that of the primary. Curves obtained in this manner have been used by the writer and others with satisfactory results. In induction motors in which the air-gap necessarily is very short, wide-open slots are often objectionable, particularly in high-speed machines, as the iron loss due to the slot openings will often equal the losses due to the variations of the main field. Moreover, in comparing the running iron loss of an induction motor with the iron loss at standstill, it will in many cases be found that the former exceeds the iron loss at standstill although in the latter case the secondary iron is subjected to the full frequency of the line.

* Paper read before the American Institute of Electrical Engineers; slightly abbreviated.

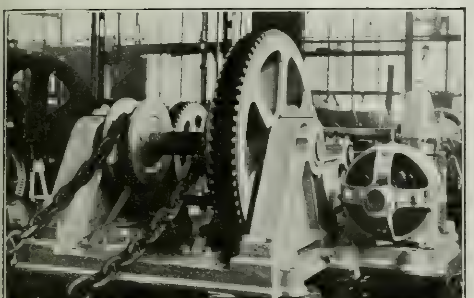
† THE ELECTRICIAN, Vol. LII., p. 419.

ELECTRICALLY DRIVEN SLIPWAY HAULAGE GEAR.

There can be no doubt that one of the directions in which the electric drive has made great progress during the last few years is in its application to ship work and in the allied branch, the operation of machinery in shipyards. An interesting example of such application is the winch shown in the accompanying illustration. This was recently built by Messrs. Clarke, Chapman & Co., of Gateshead, for an important firm of French contractors. It is designed to haul a load of 30 tons at a rate of 5 ft. per minute by means of chain cables, and can, therefore, deal with vessels up to a medium size. The over-all dimensions of this winch are only 10 ft. 3 in. by 11 ft. 6 in. by 6 ft. 3 in., this economy in space being effected by the use of chain cable lifters in place of the usual drum and steel ropes. The diameter of the lifter is only 2 ft. and the cable, after being drawn over it, is dropped into a tank, as are the anchor cables on board ship. If steel ropes were used a drum of about 8 ft. diameter would have to be used, while the speed of the machine would have to be reduced, and the extra gearing then required, to avoid the employment of a low-speed motor, would considerably increase the cost.

The chain wheels on this winch are of cast steel and are fitted with snugs which are carefully pitched to give easy running of the chains. The wheels are keyed to a massive steel shaft operated by a double helical spiral wheel of cast steel. The pinion is loose on this shaft, being engaged with it through a strong steel clutch when it is required to haul by means of the chain lifters. The shaft carrying this pinion is driven by worm gearing which is totally enclosed in a cast-iron box filled with oil. It is fitted with a roller bearing so that the thrust on the worm can be taken up. The worm wheel is specially designed, and consists of a gun-metal machine-cut rim, which is built on a cast-iron centre. The idea in this design is the avoidance of the development of any slackness between the wheel and the key which might occur in the course of operation, while the advantage obtained by the employment of gun-metal teeth is at the same time secured. The worm itself is of steel, cut from the solid of a shaft direct-coupled to the motor spindle.

This haulage gear is fitted with a warping arrangement which can be operated independently of the main haulage gear when it is required to start a vessel which has been docked for repair, to manipulate the cradle or to carry out other similar operations. The warping drum is attached to the clutch pinion shaft and is 26 in. in diameter, running at a speed of 45 ft. per minute. In order that the carriage may be held still while the warping drum is in use, the chain lifters



CLARKE CHAPMAN ELECTRICALLY DRIVEN HAULAGE GEAR FROM FRENCH SHIP YARD.

are disconnected from the motor by means of a clutch, and a powerful band brake is provided having a hard wood block. This operates on the intermediate shaft, and is controlled by a screw and hand wheel. A post brake, which is operated by a lever, is fitted on the motor spindle and is designed to hold the greatest load that the motor can pull by means of the warping drum.

The electrical equipment of this winch consists of a four-pole series motor of Messrs. Clarke, Chapman & Co.'s make, having a totally enclosed slot-wound armature. The motor runs at a speed of 750 revs. per min., and develops 27 H.P. when the circuit voltage is 550 volts. It is designed to have a temperature rise not exceeding 100°F. after a run of one hour on full load. It is operated through a controller by which the necessary speed regulation can be obtained, cast-iron grid resistances being fitted for this purpose. All the operating gear, including the controller and the various brake levers, are grouped at one end of the winch and are placed under the control of one operator. As will be seen from our illustration, the whole gear is very compact, and should be quite capable of doing the work for which it is designed.

AN IMPROVED FORM OF THE DUDDELL SINGING ARC.*

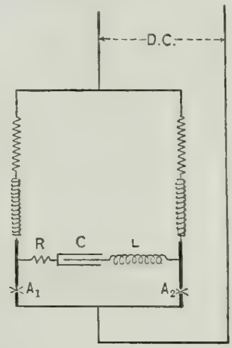
BY G. W. NASMYTH.

In the usual form of the Duddell singing arc, the direct-current arc, in series with a suitable resistance and choke coil, has the oscillation circuit containing capacity and inductance connected in shunt across the arc, from anode to cathode. In the improved form (*see* diagram herewith) two arcs are used in parallel, each with its own resistance and choke coil, and the oscillation circuit is connected between the two anodes, the two cathodes being connected together. (Or the two anodes may be connected together and the inductance and capacity placed between the two cathodes.)

The chief advantages of this form of the singing arc are in the increased power available in the oscillation circuit and a greatly increased stability in the oscillation conditions. The power available in the oscillation circuit is approximately twice that obtainable from the usual form of the singing arc. With two arcs connected in this way, the fluctuations in either arc have a tendency to be neutralised by the other arc, and the effect on the oscillations is greatly diminished. If the arcs are surrounded by a hydrogen atmosphere, supplied by alcohol lamps or illuminating gas, the oscillations will be maintained for a time even though one arc goes out, the other arc continuing to send the oscillations through the hydrogen atmosphere. If one arc is short-circuited the connections are changed to the usual form of the singing arc and the oscillations will continue.

With this new form of the singing arc the author has obtained oscillations over a range of frequencies from two per second to 1,000,000 per second. As in the usual form, small currents (from 0·5 to 3 amperes) give the most energy, and a water-cooled copper anode is of advantage. For low frequencies the arcs should be as long as possible, but for high frequencies it is necessary to shorten the arcs. As in the Duddell form of the singing arc, the phenomena may be explained as due to the negative slope of the voltage-current arc characteristic.

Preliminary experiments with varying arc length and arc currents indicate that the equation for the frequency of the usual form of



the singing arc holds also for the new form. If L is the inductance, C the capacity and R the resistance in the oscillation circuit, and A_1 and A_2, V_1 and V_2 the currents and P.D.s of the two arcs respectively, the equation for the frequency may be written

$$n=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{\left(R+\frac{dV_1}{dA_1}+\frac{dV_2}{dA_2}\right)^2}{4L^2}}.$$

Experiments also indicate that the power available in the oscillations increases with $-dV/dA$, the negative slope of the arc voltage-current characteristic curve, and data, which the author hopes to include in a more complete article in the near future, show that in order to have the oscillations set up the resistance of the oscillation circuit must be less than the sum of the negative slopes of the two arc characteristic curves.

* Abstract, from the "Physical Review," of a Paper read before the American Physical Society.

APPARATUS FOR THE RAPID ELECTRO-ANALYTICAL SEPARATION OF METALS.*

BY H. J. S. SAND, PH.D., D.SC.

Summary.—In this Paper the author describes an apparatus which marks an improvement over one previously designed by him for this purpose. It is now more portable and easier to set up. A potentiometer, containing all the apparatus required for the measurement of the potential of the electrode in a single box, is also described.

About two years ago I described a method for the rapid electro-analytical deposition and separation of metals (Chem. Soc. "Trans." 91,373 (1907), also "Trans." 93, 1,572 (1908) which for the first time combined in a practical form the use of an auxiliary electrode and a very rapid stirring of the electrolyte. During constant use in the atmosphere of a chemical laboratory for about three years the apparatus has not been subject to any derangement, and the criticism that has been occasionally made, that it is unnecessarily complicated, may therefore be said to be without foundation. Apart from the very

* Abstract of a Paper read before the Faraday Society. A brief account appeared in our issue of July 9, 1909.

high stirring efficiency of the electrodes, the apparatus is believed to be superior to others of similar type, firstly in the exceedingly great simplicity of the method of making and undoing the electrical connections on a single stand, which reduces to a minimum the time during which the electrodes are left in a wet state exposed to the atmosphere and renders short-circuits almost impossible; secondly, in the fact that the electrodes may be used with ordinary beakers, which renders them readily adaptable to very varying quantities of liquid, and makes it possible to heat the electrolyte rapidly to the desired temperature; and thirdly, in the very short time of less than a minute required for washing and drying the electrodes, and the small amount of wash-water necessary, amounting as a rule to about 10 to 20 cubic cm., in consequence of which evaporations become either altogether unnecessary or their number is greatly diminished.

Fig. 1 represents the complete apparatus set up for use. On the left is shown a wooden stand, to which is fitted the ammeter, and below the regulating resistance for the main current. On the stand is placed the potentiometer box described below with lid and sides removed. To the right of this the auxiliary electrode is visible. Special attention may be drawn to the position of the tip of the capillary in the beaker above the outer electrode. This position makes it possible to employ narrow beakers which allow the whole of the electrode to be covered with a small volume of liquid. The bore of the capillary is about 2 mm., but at the end where it is bent round several times it is drawn out to about 1 mm., so that the total breadth of the bends is slightly under 1 cm., and their height about 5 mm. The auxiliary electrode as now employed is so arranged that both arms of the capillary are filled from the funnel, the electrode being closed by a rubber cork. Special attention may be drawn to the method now adopted to fit the terminal to the electrode. A long thin platinum wire which passes through the glass of the electrode is soldered to the terminal, the wire is then coiled up above the terminal, and the latter cemented into a glass tube. The electrolytic stand is identical in principle with the improvised stand previously described (*loc. cit.*), but glass tubes have been discarded. Connection to the electrode is made by a steel tube rotating in ball bearings. To this is fitted the rubber tube that holds the clutch for the electrode (*loc. cit.*). The tubes contain mercury, reaching about half way up the steel tube and having a drop of oil on the top. A steel wire of about 3 mm. diameter connected to one of the sets of double terminals on the base of the stand dips into the mercury. A special screw cap is provided which may be screwed down when the apparatus is not in use, and makes it possible to transport it without taking out the mercury. It consists of a piece of rubber cork through a hole of which the steel wire passes. It is surrounded at the top by a brass ring to prevent the rubber from being squeezed away from the wire when it is screwed down. On the rubber cork a washer of vulcanised fibre is cemented, and the two may be screwed down by the brass screw. The insulation of the clamp holding the outer electrode from the stand is effected by a bush of vulcanised fibre.

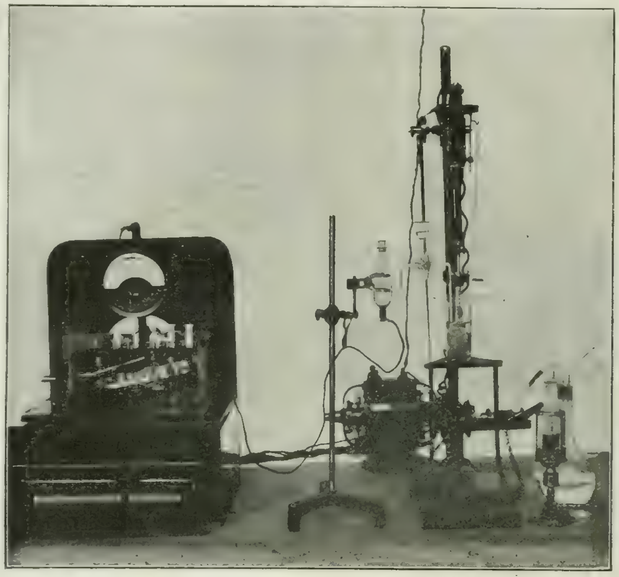


FIG. 1.—COMPLETE APPARATUS.

A clutch arrangement has been added, visible at the bottom of the stand on the right (Fig. 1), and shown in plan (Fig. 2), which has been designed to throw the stirrer in and out of gear with the motor at will. Such an arrangement will be found an advantage if it is desired to actuate several sets of apparatus from one shaft driven by a single motor, or if the current is obtained from a small motor-generator which is also employed for rotating the electrode, the clutch making it possible to stop or start the stirrer without stopping the current; or lastly, if a hot air or water motor is employed which cannot be stopped instantly during the washing of the electrodes. As will be seen from Fig. 2, when the clutch is in action the friction bevel wheel A of vulcanised fibre connected to the source of motion by a pulley engages the similar bevel wheel B which is in connection with the stirrer. A is fitted to a shaft running in a sliding bearing C. On the latter the flanged collar D is clamped by means of the screw S and is controlled by means of an eccentric, E. This eccentric is fitted to the same shaft as the handle H, so that the clutch can be put in and out of gear by throwing over H. The position of D on C can be readily adjusted so as to alter the tension on the bevel wheels.

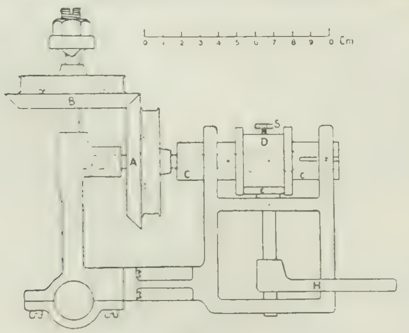


FIG. 2.

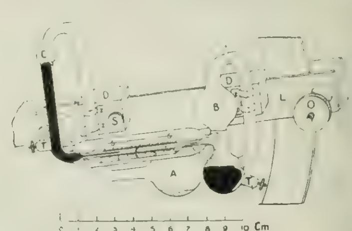


FIG. 3.

The Potentiometer Box.—A very considerable simplification has been obtained by fitting all the apparatus required for the measurement of the potential of the electrode in a single box.* The arrangement has been designed so that by depressing a key it will also allow

* In his book just published, "Elektroanalytische Schnellmethoden," p. 100, A. Fischer also describes a combination of apparatus serving for the same purpose as the above potentionmeter box. The types of the instruments employed, however, differ considerably from those described in the present Paper. The zero instrument is a galvanometer, and there is no arrangement for the measurement of the potential anode-cathode.

the potential difference between the anode and the cathode to be read directly. It was thought very desirable to retain the capillary electrometer as a zero instrument. The well-known fact that its indications are hardly affected by slight mechanical disturbances and by the electrical resistance of the circuit, and are quite unaffected by magnetic influences and by the air of a chemical laboratory render this form of instrument particularly suitable for chemical purposes. It became necessary, however, to design the new portable form which is described below.

The general arrangement of the box will be clear from Fig. 4, which also shows all the connections on the diagram in the lid. The two ends of a sliding rheostat shown on the left of the illustration are connected to a dry cell by means of the terminals marked *battery*. The P.D. to be measured is connected to the terminals marked *cathode* and *auxiliary*, and balanced by means of the capillary electrometer visible in front, with its tapping-key marked *electrometer*, against a P.D. between one end and the slider of the rheostat. The value of this P.D. is read directly on the delicate moving coil voltmeter, the scale of which is visible in the illustration, and which reads from 0 to 1·5 volts. When the key marked anode is depressed the connection of the voltmeter to the tapping-key of the electrometer and to the end

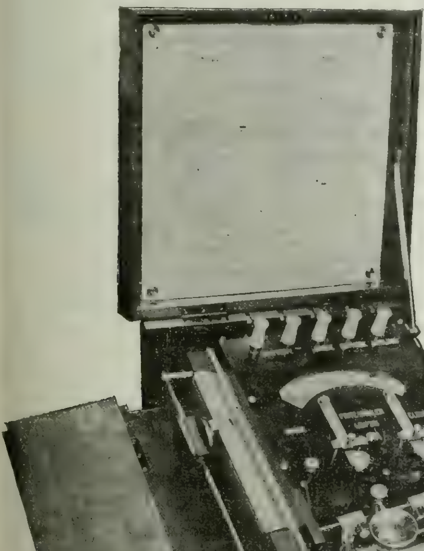


Fig. 4.—Potentiometer Box.

of the rheostat is broken, and a new connection made through a back resistance (not visible) to the terminal marked anode. The tapping keys and sliding rheostat of about 40 ohms are of known pattern. The platinum contacts on the former are substantially made and the latter is constructed to slide very evenly so as to facilitate adjustment. The box is provided with slots for the connecting wires, so that it can be closed without undoing the electrical connections. Hinges of such a pattern are fitted to the lid and to the three sides as to allow them to be removed at pleasure when the apparatus is in use.

The electrometer with its supporting lever is shown in Fig. 3. It may be described as a closed form,* developed from the Ostwald horizontal capillary electrometer. A distinctive feature of this instrument is to be found in the reservoir bulb A of about 3 cm. diameter for acid and mercury and the subsidiary reservoir bulbs B and C, which make it possible to set the mercury and acid in their proper position by suitable manipulation of the instrument. It is fitted with a very flat elliptical capillary and an enclosed scale S. The instrument is evacuated. Its sensitiveness is very considerable. 1 millivolt giving a deflection plainly visible through the lens. This is more than sufficient for all purposes of analysis. Terminals T T are fitted to the instrument, which are connected to platinum wires fused through the glass. (A different form of connection is shown in the instrument of Fig. 4.) The electrometer is held by two blocks D D, which are clamped to the lever L by the screws S. Sufficient adjustment for the mercury in the capillary is obtained by raising or lowering this lever. The latter can be clamped firmly by tightening the screw O, but an arrangement based on the application of a spring inside O is fitted, which makes the lever be held loosely in position, even when the screw O is not drawn tight, thus making it impossible to break the electrometer by accidentally leaving O loose. The potentiometer box will doubtless also prove of value for preparative electrochemical work.

The author desires to express his indebtedness for aid in the construction of the apparatus to grants obtained from the British Association and the Government Grant committee of the Royal Society.

* A closed form of capillary electrometer was first described by S. W. J. Smith, "Phil. Mag.," 1903, ser. 6, 5, 398. Another form is due to Luther, 79th meeting of the Deutsche Naturforscher und Aerzte.

THE ABSOLUTE VALUE OF THE MECHANICAL EQUIVALENT OF HEAT, IN TERMS OF THE INTERNATIONAL ELECTRICAL UNITS.*

BY H. T. BARNES, D.Sc.

In 1902† there were published the results of an extended series of measurements of the capacity for heat of water at different temperatures between 0°C. and 100°C., the continuous method of calorimetry being employed by Prof. H. L. Callendar and myself. A steady electric current was used to heat a steady flow of water through a fine bore tube, bringing about steady temperature conditions in the calorimeter. The energy given in joules per calorie was expressed in terms of the international electric units, and was consequently dependent on the values of the standards used in the measurements. We adopted the legal value of the Clark cell, viz., 1·4342 volts at 15°C. Recent investigations have shown that this value is too high. The most probable absolute figure, so far as it is possible to fix it, is now given as 1·4330 volts at 15°C. for the cells set up according to the new specifications. There is, however, an important difference between the cells set up according to the old specifications, such as were used in our determinations of the mechanical equivalent of heat, and the cells set up according to the approved methods now adopted at the various standardising laboratories. The fundamental difference lies in the treatment of the mercurous sulphate. F. A. Wolff and Waters‡ have shown that the cells set up according to the old specification are 0·30 millivolt higher than the new cells.

With the assistance of Dr. H. L. Bronson we have recently equipped the laboratory with a set of modern standards, and we have constructed several cells in an exactly similar way to those previously used and compared them with our new cells. The result of this test has shown that the mean of our cells, set up according to the old specifications, is 0·28 millivolt higher than the modern Clark cells. As a matter of fact, our new cells are exactly 0·018 millivolt higher than the reference standards at Washington, which brings the mean of our cells set up according to the the old specifications to 0·30 millivolt. The absolute value which we must therefore take for our cells in order to reduce the values of the mechanical equivalent is 0·30 millivolt higher than the value assumed for the modern Clark cells, or 1·4330 + 0·0003 = 1·4333 volts at 15°C.

It is possible now to express the original determinations on the basis of the new value for the Clark cell. It is exceedingly unlikely that either the mean of the resistance standards or of the Clark cells were in error by as much as 1 part in 10,000 from the international units, whatever values may ultimately be assigned to these in C.G.S. units. In the calorimetry also great pains were taken to eliminate errors of thermometry and heat loss, and the agreement of the observations, taken at different times and under widely different conditions, was not far from 1 part in 10,000. A table in the Paper gives the values of the thermal capacity of water at different temperatures between 5°C. and 95°C. in joules per calorie. The mean value over the range is now 4·1835, compared with 4·1888 originally.

* Abstract of a Paper read before the Royal Society.
† "Phil. Trans.," A, Vol. CXCIX., p. [illegible] (1902).
‡ "Bull. Bureau of Standards," Vol. IV., p. 94 (1907).

It is of interest to compare these values with the direct mechanical measurements of Rowland, and of Reynolds and Moorby. On account of the limited range of Rowland's experiments comparison can only be made between 5°C. and 35°C. The mean value over this range from Rowland's curve is found to be 4·185 joules, whilst over the same range our value comes to 4·1826 joules. A divergence of 1 part in 2,000 is shown between the two values, but Rowland only assigned to his value an accuracy of about 1 part in 1,000. Hence we find an agreement of 1 part in 2,000, which is better than Rowland gives as the probable accuracy of his measurements. When we come to the absolute measurements of Reynolds and Moorby, we find probably greater accuracy on account of the method they adopted. The value they obtained was the mean over the entire range, and was found to be 4·1832 joules. Prof. A. W. Smith* has recently pointed out that their results are really for an interval of temperature between 1°C. and 100°C. To express this mean value accurately between 0°C. and 100°C., it becomes necessary to increase their value slightly, since the value of "J" increases rapidly between 1°C. and 0°C. Assuming the variation of the specific heat of water from our determinations, this value is increased to 4·1836 joules. Over the same interval our mean value must be increased slightly, making allowance for the increase at both ends of the temperature range. This brings our value to 4·1849 between 0°C. and 100°C., which is in accord with their value to 1 part in 4,000. The value is therefore seen to be between that of Rowland and that of Reynolds and Moorby.

The excellent agreement shown here indicates that we must, at the present time, have a knowledge of the electrical units not far from the truth, both as regards the Clark cell and resistance. The agreement with Rowland to within the limits of accuracy of his measurements serves to link his absolute mechanical measurements with those of Reynolds and Moorby in a very satisfactory way, and to show that they obtained almost identical values.

A Paper has recently appeared† in which the 15°C. calorie has been discussed. Our value of this quantity is given as 4·187 joules. This value is given as expressed in terms of a Clark cell equal to 1·4334 volts at 15°C.

[*Note by Prof. H. L. Callendar.*—I designed the apparatus used by Mr. R. O. King to read to an order of accuracy of 1 in 100,000, and personally assisted him in all the fundamental measurements. I had no doubt at the time that the result which I worked out from Mr. King's observations, though not so perfect as might have been obtained in a more extended investigation, correctly represented to 1 in 10,000 the absolute value of the Clark cells at that time employed in our investigations in terms of the international ohm. It is very satisfactory to find that Dr. Barnes' recent comparisons agree so well with the old absolute measurement, but I think the absolute value of the mechanical equivalent deduced from the electrical standards may possibly be in error by at least 1 part in 4,000.

ELECTRIC-DRIVEN ROLLING MILLS.‡

BY E. FRIEDLANDER.

Summary.—The author discusses the general advantages of the electric drive for rolling mills. A preference is expressed for continuous-current motors for such work.

The first electric-driven steel rolling mill in the United States was installed about four years ago by the Carnegie Steel Co. at their Edgar Thomson works. Since then a number of other electric mill drives have been installed and run with entire success, a noteworthy example being found at the steel plant at Gary, Indiana.§ The introduction of the electric drive has made it possible to clear up many points in regard to the power required for rolling different shapes of steel, and, moreover, the operator is able to see at a glance the work done by each pass. The electric roll drive has also taught us how to get the best relation between rotating masses, speed, time and horse-power. It has helped the roll designer to calibrate rolls in such a manner that the power characteristic for all the passes is uniform, thereby avoiding high-power peaks, decreasing the size of the prime mover and reducing first cost and fuel consumption.

The watt-hour meter warns the roller of bearings or rolls becoming tight and hot, or that steel is causing excessive friction in the passes, often due to overfilling, cold steel or faulty calibration, thereby guarding against damage to the rolls and bearings. The meter indicates that lower heat, greater elongation and especially change of profile in different directions increase the power required at the rolls much more rapidly than do chemical hardness, high tensile strength or larger draughts. The meter also shows that it is not the higher percentage of carbon in steel which requires more power in rolling but the lower temperatures at which this steel has to be rolled, and also that an increase in width of the steel shape requires more power than a decrease in height. By means of the meter, too, it can readily be seen that rolling "squares" and "rounds" takes per square inch displacement much less power than shapes with large peripheries and many flanges, as the latter cool off quickly and cause much friction in the rolls.

Tests on rail mills have shown that the foot-pounds per square inch of displacement gradually increase the nearer the rail is to the finishing pass. A 75 lb. rail required 1,100 ft.-lb. at the first pass on the first "rougher." On the same stand in the seventh pass it required 3,000 ft.-lb., in the first pass on the second roughing rolls 4,800 ft.-lb., in the fifth pass 8,150 ft.-lb.; 9,500 ft.-lb. were required for the last or finishing pass. The large increase in foot-pounds is partly due to the greater density and rapid cooling of the steel, especially at the thinner flanges near the finishing pass. For this reason the flanges are rolled out as late as possible. Whenever required, exact power consumption can be given for each phase of rolling.

The ideal motive power for rolls should drive them slowly when the steel enters and should drive the roll faster as the piece lengthens. The reciprocating engine will do just the reverse—namely, run very fast without load and slow down as the load increases, finally stopping if the load becomes too great.

The maximum torque of reciprocating engines is fixed by the size of the cylinders and the pressure; it cannot be increased no matter how much steam or gas is available. For this reason most mill engines are made very large and often run with only half load, causing high steam consumption per horse-power, their most economical cut-off being at full load. For this work the characteristics of the electric motor are much better. Even with double its full torque, the efficiency is good and the motor will not stop, but will take more and more current, finally becoming overheated and burning unless properly protected. If desirable, its speed changes from no-load to full load can be made small. The current can also be limited to a certain maximum, without stopping the motor, in this manner preventing excessive strains and probably serious breakdowns. Where high speeds are necessary, motors can be direct connected to rolls, increasing the energy of the rotating parts and at the same time decreasing the size of motor, the power required and the fuel consumption. Heavy reciprocating engines cannot run at such high speeds, and must be connected to the rolls by means of gears, ropes or belts.

To obtain accurate information as to the exact power requirements for rolling steel, indicator diagrams were taken on reciprocating engines doing similar work, but these in many instances were misleading. The work of rolling steel is very changeable and intermittent. Engines often run with light loads, but at short intervals have their valves wide open. This, together with the work done due to the energy of the rotating parts, should be carefully observed. Although it probably is not difficult to get the maximum torque required to decide on the normal capacity of the motor, the abovementioned points must be considered, together with the length and number of pieces in the rolls and also the time-intervals between the passes. To be on the safe side it is advisable to follow standard mill practice and make motors of ample size and strength in order to stand the severe service and overloads without injury.

In mentioning flywheels, the writer had only three high non-reversible mills in mind. As the weight of rotating parts is much greater in large motors than in reciprocating engines, and the energy of the rotating parts increases as the square of the speed, it is obvious that even a small change in speed is of great importance. As tests have shown that rotating masses are sometimes not only of no use but that they often prove a drag on the motor, careful study of this feature has to be made in each case.

While the steel is being rolled, both the motor and the flywheel should furnish the power, but as soon as the steel leaves the rolls the motor should accelerate the rotating masses to the same speed before rolling. The time available and the number of revolutions will determine the size of the motor more than anything else. It has been observed that on blooming and roughing mills, where the pieces are very short and the intervals long, rotating masses supply the largest part of energy during the rolling period and should therefore be large. The reverse takes place at the finishing passes, where pieces are long and follow each other rapidly. Heavy rotating masses would in this case be useless, and would even require larger motors for their quick acceleration.

* 'Monthly Weather Review,' Vol. XXXV., p. 458 (1907).

† 'Verh. der Deut. Phy. Ges.,' Vol. VI., p. 589 (1908).

‡ Paper read before the American Institute of Electrical Engineers.

§ A description of the installation was given in THE ELECTRICIAN, Vol. LXIII., p. 49.

Where one motor drives roughing and finishing rolls, curves should be plotted showing the number of pieces in the rolls at the same time, the length of passes and intervals, the power required for each pass, &c. With the help of such curves, the best relation between the sizes and speed of the motor and flywheel, radius of gyration and slip of motor can be easily determined.

The total motive power required in a steel plant is changeable and fluctuates continuously, the average in many plants being often below one-fourth of the total horse-power installed in motors. The electric-driven rolling mills will, however, demand considerably larger power stations to supply the large currents, especially when all the motors happen to be overloaded at one time, as, for instance, when rolling cold steel. It is very important to find out beforehand how much of this fluctuating load the power house may have to supply, assuming the worst conditions, as the shut-down of the electric power station for even a very short time will stop the operation of a large number of machines and cause enormous losses. This is the one very objectionable feature of making such a great number of prime movers entirely dependent on one power station, and, therefore, some means should be taken to prevent this disturbance.

With steam engines and boilers the liability of a complete shut-down is not so great, but the delays and annoyances caused by low steam pressure are of daily occurrence in many plants. In such cases not only will all the steam-driven prime movers be unable to develop the required power, but also in trying to develop this power, they will use more and more steam, thus making it difficult to raise the steam pressure without increasing the number of boilers, or decreasing for a while the load and consequently the production.

The short high-peaked current demands should be kept off the power station as much as possible and only the average current be supplied. The least number of units can then be kept running under nearly full load with the most economical fuel consumption and the least wear and tear of moving parts. As before mentioned, the average current consumption in a steel plant is always small in comparison with motor capacity, on account of the intermittent work and large amount of inertia of the rotating parts. By means of storage batteries or flywheel sub-stations the occasional large demands for current can be taken off the station and supplied from these two sources, where it is stored up when the current demand is below the average. The exchange of current from one motor to another, in connection with electric roll drives, is often considerable and should not be overlooked.

With regard to the electric reversing mill, it is a fact that soon after its first appearance the use of reversing rolls became more general, especially in England and Germany. In those countries small quantities of one kind and shape of material are rolled, and the cost of the large number of rolls required and the saving of time in changing rolls are probably the chief reasons for using the reversing mill, where many different sections can be worked with the same rolls. The absence of the heavy and troublesome lifting tables is also a welcome feature, especially when pieces rolled are very long.

The first installation in this country of an electric reversing mill, at the Illinois Steel Co.'s works at South Chicago, has given entire satisfaction from the start, and has demonstrated that the electric motor is much better adapted for this kind of work than the reciprocating engine. Although the first cost was high, its lower depreciation, better operation and lower cost of maintenance should justify its installation.

In a reversing mill the operator is able to draw steel slowly into the rolls and "speed up" while the piece lengthens, a great advantage in rolling steel. In order to obtain perfect speed regulation, no use can be made of steam expansion, but admission continues during nearly full stroke. Even then much depends on the skill of the operator, who can subject the engine and the mill to very severe shocks and cause serious breakdowns if he is not careful. Reversing mills are therefore made heavy and strong.

If too much steam is admitted it is difficult to prevent such large engines from racing without load. It is also wasteful, as both the time of actual rolling and the speed of the rolls are limited, most of the power being consumed in the rapid starting and stopping of the heavy rotating parts, without making any use of their flywheel energy. With the use of electric motors in place of reciprocating engines the problem of reversing rolls becomes much simpler and better, in regard to manipulation, fuel consumption and cost of maintenance. Operation of electric-driven reversing mills is nearly automatic; no skilled operator is required and all danger to the motor and the mill is eliminated. The speed of acceleration is prearranged, and, no matter how fast the operator moves his levers, the maximum current and the speed are limited.

Reversing is done with the least shocks in rolls and couplings and the danger of overstraining machinery is done away with. It is important to be able to reverse the motor just as rapidly as the engine. Special care should therefore be taken to have a motor-generator that will give large currents with very low excitation, and one that will be quickly magnetised and demagnetised.

It has been observed that only one-fourth of the power required at the reversing-roll motor is the average supplied from the power station. The large current demands are furnished by the motor-generator through the energy of the high-speed fly-wheel, and a considerable amount of current is sometimes sent back into the line.

As for all other mill work where power and speed variation are considerable, the direct-current motor, on account of its load and speed characteristics, is better adapted for driving rolls than the alternating-current motor. For reversible roll drives it is used exclusively. There is no reason why the direct-current motor should give any more trouble than the direct-current generator at the power station. Four years' experience has shown that the wear of the commutator and the cost of maintenance amount to practically nothing. The transmission of large low-tension currents is much more serious, especially when tens of thousands of horse-power have to be supplied and the distance of the motors from the station is considerable.

The use of higher direct-current voltages in connection with large rolling-mill motors should be satisfactory; but no doubt high-tension alternating-current transmission and induction motors direct on the line will be generally employed, especially in new installations. Where conditions demand it, the induction motor characteristics can now be made nearly similar to the compound-wound direct-current motor. However, much of its simplicity and efficiency will be sacrificed in doing this.

Among some of the earlier disadvantages of the induction motor were: Very large current required for starting under heavy load; one speed fixed by the number of poles and the tendency always to run at synchronous speed; low power factor with light loads; small air-gaps; impracticability of reversing large units; and inability to change speed to flywheel requirements. In the design of the modern rolling-mill motor, most of these objectionable points have been remedied by different means such as wound rotors, the introduction of variable resistance, changing the number of poles, shifting the phases, slip-rings, &c.

Whether direct-current power stations and direct-current motors are used, or alternating-current stations are installed for high-tension transmission with alternating-current motors directly on the line or fed through transformers, or direct-current motors are supplied from an alternating-current station through converters, or motor-generators, batteries or flywheel sub-stations, is a matter of detail. No doubt any one of these systems will give satisfaction if properly designed and installed.

High-tension Insulators.—The employment of electricity for the transmission of power at higher and higher voltages has of necessity led to the modification of many of the earlier ideas on the subject. This statement can be nowhere applied with more truth than to the question of insulator design. Two types are now generally employed: one used with the catenary suspension adopted in America and the other, almost exclusively used in Europe, which is made up of a number of superimposed discs, of which the last forms a kind of umbrella. The factors which are of interest in insulator design are the surface conductivity and the disruptive resistance, this latter value depending on the shape and dimensions of the insulator. Mr. Semenza, who has gone into this question, is of the opinion that smooth insulators are better than those with a ribbed surface. He explains this superiority by pointing out that more even distribution of the potential occurs with the latter type. But experimental demonstration is still insufficient, nor does it prove with sufficient force the small utility of the old shapes, which are difficult to manufacture, are more fragile and less easily cleaned. The fundamental principle which should be applied in determining the profile of an insulator is that of the line of maximum loss. To do this is excellent, when it is well defined and when not more use is made of it than it is able to bear. M. R. Valabrègue, in an article recently published in "La Lumière Electrique," examines the way in which insulators behave under different conditions. And he is led to the conclusion that purely electrical data are not sufficient for determining the external shape of the insulator. The thickness of material and ease in storing the parts are both data which must be taken into account without making them of first importance.

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THE ENGINEER *VERSUS* THE ACCOUNTANT.

It is with some concern that we notice a very marked tendency at the present time to undermine the authority of the Engineer in public undertakings, and to transfer the control to the non-technical or commercial side. That such a movement is on foot and may have serious effects upon the engineering profession is not appreciated as fully as it should be. Our readers will remember that in June last we published a communication from Mr. H. FARADAY PROCTOR showing briefly how the Institute of Municipal Treasurers and Accountants were attempting to obtain control over the various municipal undertakings, such as tramways, electricity supply, gas supply, waterworks, &c. Although the proposals of the Institute have aroused considerable opposition, and have been subjected to a large amount of criticism by the Incorporated Municipal Electrical Association, the Municipal Tramways Association, and other representative bodies, such proposals are by no means dead, for their consideration has merely been postponed by the "Accountants" until the meeting in October next.

We need scarcely remark that dual control is generally impossible. Either the commercial man or the engineer must be at the head; there is not room for both, and as to which should be supreme must depend upon the character of the undertaking, whether it is more in the nature of commerce or of engineering. There is no doubt, however,

that the commercial side must never be neglected, and that the engineer should play a more prominent part in this direction than has often been the case hitherto, or he may be supplanted by a commercial manager with, perhaps, a smattering of engineering knowledge. In the past, engineers have been prone too often to pride themselves only on the engineering results obtained—which certainly have usually reflected the greatest credit on those concerned—and to overlook very largely the essential feature, namely, commercial success. It is by the latter result that most undertakings must finally be judged. From time to time we have drawn attention to the fact that engineers generally interest themselves only in technical questions, and that as a result they are losing their influence in all matters of policy. This is regretable, because it may lead, if unchecked, to engineers playing quite a secondary part to that of the financial or commercial controller, whereas the guiding hand of the engineer is essential if the most economical expenditure is to be secured; it is only the knowledge of the engineer that can determine the direction in which savings can be properly effected both as regards design and subsequent maintenance. The importance of this point of view was evidently felt by Sir George Armytage, at the recent meeting of the Institution of Mechanical Engineers, when he expressed the view that it was an advantage to a railway company to have an engineer as its general manager.

Municipal service is not the only one in which this tendency is noticeable. Last year the Postmaster-General appointed a committee of accountants, with Mr. C. A. King, Comptroller and Accountant-General of the Post Office, as chairman, "to consider the various accounts and returns presented to Parliament in connection with the telegraph and telephone services, and to report in what manner those accounts and returns can be modified or supplemented so as to show more clearly the financial results of those services." This request in itself seems quite innocuous, but a little reading between the lines of the report leads to the conclusion that the accountant, as a branch of the public service, wishes to dominate the handling of the purse and to place the engineer in quite a secondary position. In concluding their report, this Committee state that they have been impressed by the large amount of account work which devolves in the Post Office upon the engineering officers. They express the view that such officers should be responsible only for the allocation of labour and material, and that the cost statements should be compiled in the Accountant-General's department, as by so doing the engineering officers would be relieved of that part of their work for which an engineering training is not required. It is also suggested that there would be more effective control over works expenditure if the Accountant-General could so map out the expense returns as to bring about detailed comparison between different sections of the country, "thus securing an independent review of engineering expenditure by the accounting office of the department."

Now these conclusions show a complete failure to grasp the essential conditions of success in an engineering department. The more closely the engineer can keep in touch with the costs of his work the better must be the result from the commercial point of view. This statement is confirmed by the fact that the expenditure in the Post Office engineering department has decreased since the engineer officers have become responsible for their own accounting. There is no more salutary check to commercial inefficiency than accounting. It is one thing, however, for the engineer to be responsible for such accounting as is necessary to guide him to the best result, but quite another for the accountant to be responible for the main part of the engineering. It is impossible for an accountant to acquire such a knowledge of engineering as to appreciate the pros and cons that every engineer must weigh up along with financial considerations when any development is contemplated. The engineer, on the other hand, is necessarily in contact with figures of cost, and must be guided by them in his decisions. It is curious that, with the ever-increasing importance of engineering, and its ever-increasing complexity, any such movement as that to which we have referred should be possible at the present day. There can be no doubt that it will be very bad for both State and municipal engineering in this country when the engineer becomes subservient to the accountant.

OBITUARY.

HUGH ERAT HARRISON.

It is with great regret that we record the death, which occurred on Thursday, the 12th inst., of Mr. H. E. Harrison, B.Sc. (Lond.), Principal of the Electrical Standardising, Testing and Training Institution, perhaps better known familiarly as Faraday House.

Hugh Erat Harrison was born at Westminster on April 23, 1859, and was educated at University College School. He matriculated in 1876 and entered University College, where he gained a Cloth Workers' Exhibition in Chemistry and Physics in 1877. He studied for a short time in Paris, and subsequently took his degree in 1880 with honours in experimental physics. In the following year he entered the service of the Anglo-American Brush Co., and subsequently became Managing Engineer of the Sheffield branch of the Hammond Electric Light & Power Co. The most memorable, though by no means the most important, piece of lighting work carried out by him was that at Barnsley, where protection from the advocates of gas became necessary, they having effectually stopped the light on the opening night by plugging up the chimney with straw and damaging a feed pump at the station.

In 1882 Mr. Harrison organised and became Principal of the Hammond Company's Electrical Engineering College in Red Lion-square, London, and when it was closed in 1885 he became a partner in the firm of Phillips, Harrison & Hart. On retiring from this firm he was appointed clerk to the Research Committee of the Institution of Mechanical Engineers, but it was in 1889 that he carried out the work with which his memory will be associated—viz., the organisation and foundation of the Electrical Standardising, Testing & Training Institution, Faraday House, London, of which he was Principal at the time of his death. He drew up the scheme of studies himself, and to the close of last term he lectured to the students on electrical engineering. In addition to this he organised the testing department, and superintended its work, and in connection with this he was appointed Board of Trade electric inspector for Croydon, Tunbridge Wells, Ealing, Wimbledon, Chatham, Godalming and Clacton. From 1887–1901 he was assistant examiner in magnetism and electricity to the Board of Education, and he was one of the delegates sent by the Institution of Electrical Engineers to attend the International Electrical Congress at St. Louis in 1904. He was a member of the Institution of Electrical Engineers, an asso-

ciate member of the Institution of Civil Engineers, a fellow of the Chemical Society and of the Physical Society.

Mr. Harrison at one time contributed largely to the technical press, and we may mention "The Principles of Alternate-current Measurement" to THE ELECTRICIAN, "Notes on Electrostatics treated Opsigraphically" to the "Electrical Times," and "Electricity, Magnetism and Electricity Supply" to the "Builder." He also wrote two small text books for the pupils of Faraday House, one upon "Graphics" and another on "Armatures" (first part), and was engaged in the preparation of the second part of this latter at the time of his decease. Mr. Harrison specialised very considerably in alternate-current work, and in 1893 the editor of "Industries" credited him with "perhaps the most important discovery in alternating-current work during the last few years."

Mr. Harrison was a man of wide reading with a well-balanced mind and singularly clear judgment. He was, however, reserved almost to shyness, and shrank instinctively from anything approaching publicity. Nervous to a degree and highly sensitive, he was, nevertheless, possessed of great tenacity of purpose and strength of will, and those with whom he happened to come into active opposition were often astonished at the force he disclosed. His favourite recreations were golf and yachting; he was an excellent walker, and for years made it a

HUGH E[illegible] HARRISON

rule to walk at least 50 miles a week. Latterly, however, due to weak health, he was less active. Indeed, it was to indifferent health that the fatal occurrence which terminated his career was due. Extremely fond of music, he at one time sang very well, and a few years ago he installed an organ at Sussex-place and played on it almost daily. One of his chief delights was curio hunting, especially in glass, and a competent judge expressed the opinion that his was the finest private collection of glass in the country. He remained unmarried.

For reasons which we have mentioned above, he was, perhaps, not as well known personally as his position and abilities might have led one to expect, but to those who were intimate with him his premature death has come as a terrible blow. Of no one could it be more truly said that "those who knew him best loved him most." The Faraday House Institution, which he organised, developed and guided for nearly 20 years, will feel his loss acutely; his name had become synonymous with it, and the Institution of Electrical Engineers, who twice elected him a member of their Council, will feel the loss of his thorough learning and shrewd judgment.

The funeral of the late Mr. H. E. Harrison took place on Tuesday last at Golder's Green crematorium. Among those present were Lord Crawford (Chairman of the Board of Governors of Faraday House), Mr. W. M. Mordey (President of the Institution of Electrical Engineers), Mr. Robert Hammond, Mr. H. M. Hobart, Mr. J. E. Kingsbury, Dr. Alexander Russell, Mr. C. P. Sparks, and several others associated with the electrical profession.

WILLIAM FORD STANLEY.

We regret to record the death of Mr. William Ford Stanley, which occurred at South Norwood on Saturday last. The deceased was 81 years old. Mr. Stanley was the son of a well-known mechanical engineer, and in his early days started in business as a metal and ivory worker. In 1856 he invented the first simple open stereoscope, and was for many years after engaged in designing and manufacturing scientific instruments for Government use, a direction in which he achieved great success. He was also the author of a number of books on surveying, mathematics and astronomy. On retiring from business he erected and equipped the Stanley Technical Trade Schools at South Norwood, where boys receive general education and technical training combined. As these schools are largely experimental, their progress is being closely watched by educationalists, and the Board of Education has adopted a wholly friendly attitude towards them. They have been endowed with property valued at £25,000. Under a trust deed executed with the Charity Commissioners the future administration of the schools and the halls is fully provided for. Mr. Stanley took a keen interest in physical science, and some years ago he transferred certain stock to the Physical Society of London on condition that the Council issued a bulletin to Fellows after each meeting, giving a brief account of the proceedings.

M. WILSON.

Those who have had dealings with the Electrical Standards Laboratory of the Board of Trade, will learn with regret of the death, after only one day's illness, of Mr. M. Wilson, sen. He had served in the R.E. as sapper for over 21 years, and held for seven or eight years the office of storekeeper whilst acting as laboratory assistant at the School of Military Engineering under Major P. Cardew. He has held the office of assistant electrician and mechanic to the Board of Trade Electrical Standards Laboratory since its inception in 1890, and the wide range of practical knowledge which he brought to bear on his duties made his services highly appreciated by all with whom he came into contact.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Elektrolytische Zahler. By KONRAD NORDEN. Vol. XXXI. of "Monographien uber angewandte Elektrochemie." (Halle a,S.: Wilhelm Knapp.) Pp. ix.—165. M.9.

In the present work, which forms the 31st volume of the German technical series, "Monographs on Applied Chemistry," edited by Victor Engelhardt, the subject of electrolytic meters is handled in an able, comprehensive and critical manner. The book constitutes a scientific investigation by the author into the possibilities of the application of the electrolytic principle to the production of a practical electricity meter. It does not form a mere record of the various constructions of electrolytic meters which have either been proposed or tried with varying success in actual practice, but is an earnest and successful attempt to solve the limits imposed on the electrolytic meter by its principle of action. It also shows to what extent the electrolytic meter fulfils present-day requirements in meter practice.

The conditions which have to be complied with by modern electricity meters are formulated and explained in the first 16 pages, comprising Part I. of the volume, and the remaining

pages of this section contain an examination of the electro-chemical conditions of the subject.

In the second part the different types the water, mercury, copper and other voltameters—are very fully considered from the point of view of their compliance with the conditions laid down in Part I. And Part III. discusses the constructive means of converting the laboratory voltameter into the practical instrument.

The various influences at work which upset the proportionality between the rate of decomposition with the current are carefully and ably elucidated, such as temperature error, concentration, back E.M.F., &c., and the methods of neutralising them. The electrolytic process, the E.M.F.s due to primary and secondary causes, and the conductivity of the copper, zinc, silver, mercury and water voltameters are carefully and exhaustively explained together with tables and curves. Exceeedingly valuable information will be found in the section (Part II.) dealing with these various points, and deductions are given as to the accuracy of the corresponding meter type, its suitability as a shunted or unshunted meter, &c.

In dealing with the construction of the meter from its voltameter prototype three different classes are separately dealt with—meters having a solid deposit, briefly termed "deposit meters" (*e.g.*, the old Edison meter); those having a liquid deposit (the mercury meter); and meters with a gaseous deposit (explosive gas or hydrogen meters). Their evolution is traced, and their characteristics are detailed. Reference is also made to the latest type of the Wright electrolytic meter with the double iodide of mercury solution, due to the researches carried out by Hatfield under Prof. Abegg at Breslau. And electrolytic meters with periodic registration are also explained in the concluding pages of the book, which is an excellent treatise on the subject and can be thoroughly recommended to all interested in the use of electrolytic meters, and especially to those engaged in their manufacture. The book is highly readable and lucid; is well printed and well illustrated. Its perusal leaves one with the impression that the electrolytic meter presents a problem, the satisfactory solution of which will bring great possibilities in its train. H. G. S.

Some Electro-Chemical Centres. By J. N. Pring, M.Sc. (Manchester: University Press.) Pp. xiii.—136. 1s. 6d.

In 1902 Mr. J. H. Gartside established the Gartside Scholarships at the University of Manchester. About three of these scholarships are awarded each year, and every scholar, after passing through a session at the University, must take up the examination of subjects bearing upon commerce or industry in Germany or Switzerland, or in the United States of America. It is intended that each scholar shall select some industry for examination with a view to a comparative investigation in the United Kingdom and abroad. The first year's work at the University is designed to prepare the student for this investigation. The value of a scholarship is about £80 a year for the time spent in England, £150 a year for the time spent on the Continent, and about £250 a year for the time spent in America. Consequently there should be some competition for their tenure.

The volume before us is a Gartside Report written under these conditions by Mr. J. N. Pring, and is a general description of what is being done electro-chemically on the Continent, in America and in this country. After an introduction on the cost of power production, the author proceeds to describe the industries around Niagara Falls, including the manufacture of carborundum, graphite, siloxicon, electrolytic alkali by the Townsend cell, aluminium and carbide. Then follows a brief description of the copper refineries of New Jersey, being chiefly of the methods followed at the Maurer Works. A general account of Canadian water power is followed by particulars of the treatment of copper and bullion at Trail, and by some interesting details of the Betts process for lead refining. Iron and steel production bring us back to European countries, as also the problems of water purification. After referring to electrolytic bullion refining and the manufacture of carbon bisulphide, both of which have been taken up energetically in the United States, a chapter is devoted to the electro-chemical industries in the Alps, France and Belgium. This naturally includes the manufacture of steel, ferro-alloys, the manufacture of carbons and the electrolysis of water. A short chapter on the fixation of nitrogen, chiefly descriptive of the Birkeland-Eyde and cyanamide processes, is followed by a chapter of 22 pages on power centres and electro-chemical works in Great Britain. A considerable part of this is devoted to a brief description of the power companies, more particularly the Newcastle-upon-Tyne undertaking. Brief particulars, however, are given of the Thermal Syndicate, of copper refining, electrolytic alkali and bleach, of the Castner sodium process and of the aluminium industry.

It is difficult to judge to what extent the information here given is first hand, or is collected from the scattered literature on the subject. It is well known that particulars of this kind are difficult to obtain and are generally very far from being trustworthy. In a general way, however, the volume before us is certainly interesting; it serves to give a general idea of how the industry stands, and therefore should be welcomed. It is, perhaps, disappointing to find that Great Britain occupies so small a portion of the volume. In this country a good deal of work is being done in the electro-chemical world under certain disadvantages, but we are tempted to ask whether this work might not be considerably more extended than it is. We are not in a position to do much in the way of copper refining, but is there any reason why we should lag behind in such matters as the electro-thermal production of steel and ferro-alloys, the electrolytic treatment of water and sewage or electrolytic bullion refining?

Notes on and Drawings of a Four-Cylinder Petrol Engine. By Henry J. Spooner. (London: Longmans, Green & Co.) Pp. 16. 2s. net.

This book, which is in the main a collection of drawings of a petrol engine, should prove of use to the student-draughtsman. It must not, however, be taken as more than a collection of exercises in draughtsmanship, for it contains some inaccuracies, and is somewhat inconsistent and incomplete. In the Diagrammatic Sketch of the complete motor system the details are so distorted that it requires an expert to recognise such parts as the sparking plug, or the carburettor. It is also somewhat misleading to the student mind to see that, in the sectional elevation of the engine, the sparking plugs are to be fitted in the valve-covers, but that when the detailed drawings are turned to, provision is made for the plugs in the cylinder *water-jacket* covers, the valve covers being left unthreaded. We should also like to see greater exactness in the dimensioning of the various parts; a 4 in. piston will not enter a 4 in. cylinder, while there is an absence of holes for cotter-pins which would bring tears to the eyes of the testing department of a factory turning out these engines.

MODERN INCANDESCENT ELECTRIC LAMPS.

BY A. C. JOLLEY.

(*Concluded from page 702.*)

In order to apply these methods to the lamp filaments under investigation the latter were dismounted from their bulbs and their dimensions, given in the table below, were carefully ascertained.

Type of filament.	Diam., cm.	Length, cm.	Area, sq. cm.
Carbon	0·015	20·3	0·956
Gem (metallised carbon)	0·0086	24·0	0·648
Tantalum	0·0052	59·0	0·963
Osram (tungsten)	0·0053	68·0	1·13

Using these areas and Kurlbaum's constant given above, temperature curves have been plotted in Figs. 5 to 8, assuming Stefan's law, for each of the lamps. Also, by measuring the candle-power in a given direction, and estimating the projected area of the filament in that direction, the formulæ of Petaval and Rasch have also been applied, together with the higher values given by Nernst's figures; these have also been plotted in Figs. 5 to 8.

It is at once noticeable that the results given by an application of Stefan's law are in all cases lower than those given by the other methods.

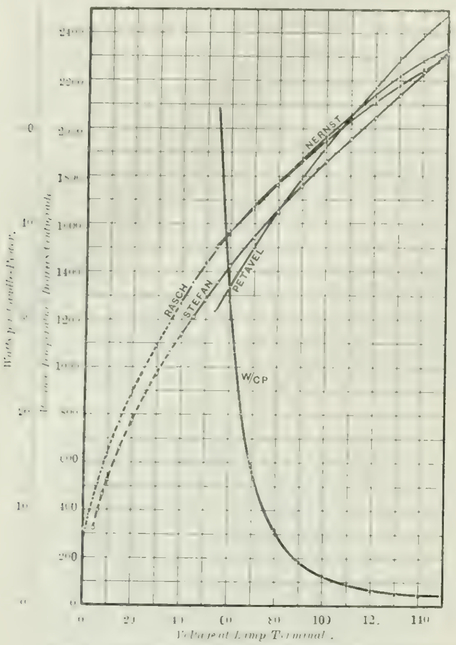


Fig. 5.—Temperature-voltage Curves for Carbon Lamp.

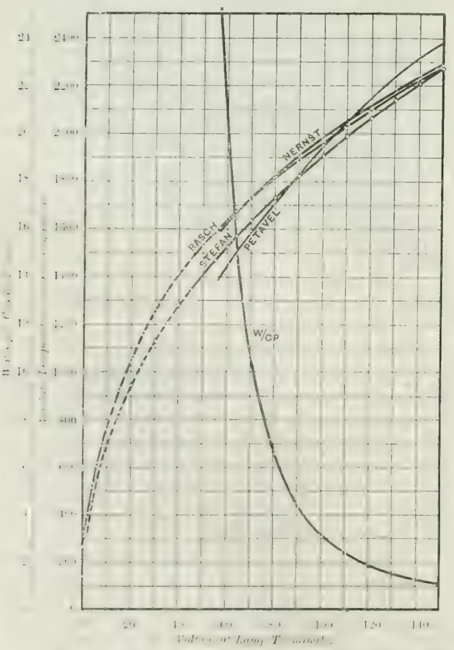


Fig. 6.—Temperature-voltage Curves for Gem Lamp.

For the metal filaments, the curves obtained from Rasch and Nernst's figures are displaced from the Stefan curve by an almost constant ordinate, and this would seem to bear out Prof. Féry's contention as to the virtual temperature of the reflecting enclosure, but for the fact than in the case of the Gem and carbon filaments no such constant displacement occurs and the curves lie much more closely together. It should be noted that the curves based on Rasch's formula were not carried below the point of minimum intensity at

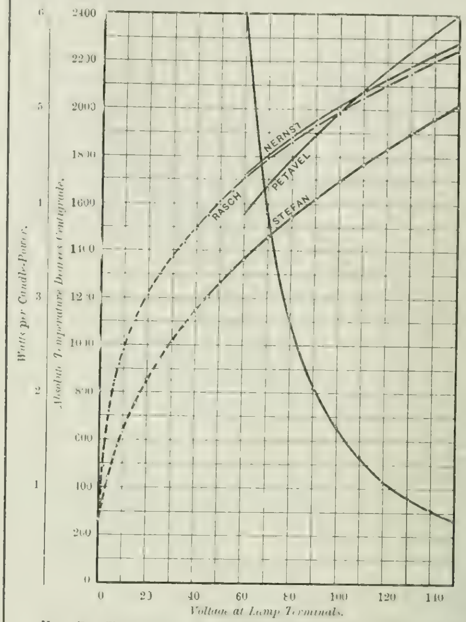


Fig. 7.—Temperature-voltage Curve for Tantalum Lamp.

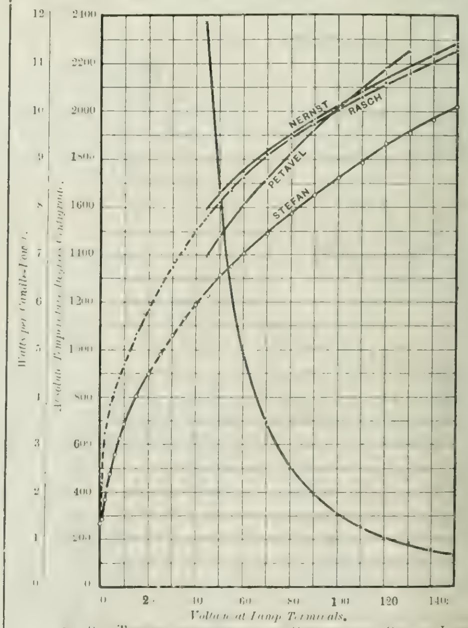


Fig. 8.—Temperature-voltage Curves for Osram Lamp.

which good photometric observations could be made, but we may approximately determine the shape of the lower part of the curve by measuring the voltage at which the filament

just becomes visible in an absolutely darkened room. This point will, according to Draper's law, correspond to a temperature of about 525°C., and although it is known that bodies emit light at lower temperatures that this, the above temperature represents the point at which the body is clearly visible and red in colour; a further point at zero voltage is given by the laboratory temperature. From the curves given in Figs. 5 to 8 we, therefore, find the following values for the filament temperatures of the lamps:—

Type of filament.	W./c.p.	Temperatures, deg C.			
		Stefan.	Petavel.	Rasch.	Nernst.
Carbon	3·5	1,557	1,607	1,647	1,657
Gem (metallised carbon)	3·13	1,632	1,667	1,687	1,717
Tantalum....................	1·645	1,427	1,707	1,717	1,737
Osram (tungsten)	1·25	1,517	1,827	1,777	1,807

A brief consideration of these figures at once reveals how small the range of temperature is between the carbon filament and its more modern rivals; and it will be further seen that the figures given in columns 5 and 6 are in practical agreement with the empirical law of Lummer and Kurlbaum—*i.e.*, that the light emitted by a glowing body increases as the 12th power of the absolute temperature in the neighbourhood of 1,900°C. absolute.

In order to illustrate further this point I have plotted in Fig. 10 the watts per candle for an ideal black body against the temperature absolute. With this curve are the corresponding ones for the Osram and carbon filaments, the scale of temperature for the full line curve being given by the formula of Rasch, and that of the dotted curves being given by Stefan's law.

It is at once noticed that the Osram lamp curve lies always below the black-body curve, which, of course, means that at a given temperature more light is derived from the metal filament than from the black-body for the same expenditure of total energy.

On the other hand, the carbon filament curve lies in one case above the black-body curve. This is probably due to two causes. Firstly, a small absorption in the glass of the bulb, which will tend to lower all the lamp curves; secondly, to a change in the form of the energy curve for this type of filament. Using the temperatures given by Rasch's equation, I have plotted in Fig. 9 a set of temperature resistance curves for the lamps, and these present many points of interest.

The straightness of the lines for the metal filaments is well shown, and this, together with the fact that the tantalum curve passes through the absolute zero, would seem to indicate that the basis of temperature estimation is a correct one, for when we remember that, owing to the processes involved in the manufacture of the tungsten filament, its metallic purity can never be guaranteed, we should not expect it to rigidly follow the pure metal law so well as tantalum.

The curve for the Gem filament partakes, as we should expect, both of the characteristics of carbon and the pure metal. If we calculate the specific resistances of each of the filaments at any given temperature we find the following relation holds over practically all the range—viz.,

$$0{\cdot}07\rho_c + 5{\cdot}03\rho_t = \rho_g,$$

where ρ_c, ρ_t and ρ_g are the specific resistances of the carbon, tantalum and Gem filaments respectively.

For purposes of comparison the table on p, 758 has been drawn up, and contains some of the results of previous observers upon lamps of a type similar to those employed by the author.

It is probable that the disagreement among the several observers would be considerably reduced were it possible to bring all the observations to the same definition of temperature.

It, however, serves to show that such disagreements do exist, and that the method advocated by the author gives results which are in substantial agreement with the best direct measurement when corrected to the same energy consumption in the lamp.

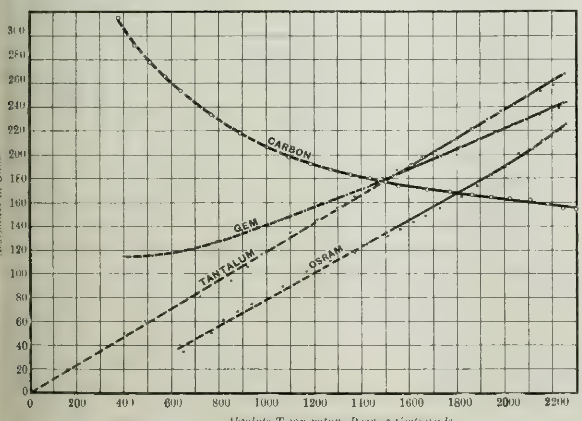


FIG. 9.—TEMPERATURE RESISTANCE CURVES.

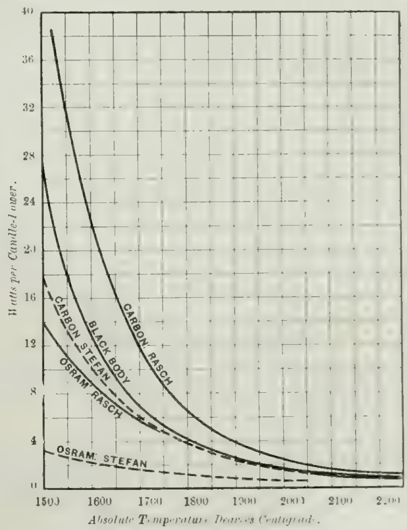


FIG. 10.

Grau, in his valuable paper, has found by extrapolation that the curves for the carbon and tungsten filaments cross at a temperature of 1,850°C. The point of crossing for these materials is 1,867°C. when the temperatures are estimated by Rasch's formula. We may, therefore, conclude that the form of the curve in each case is very closely the same.

Waidner and Burgess's results are much higher than those of any other observer, and it is interesting to note in this connection that they used an incandescent carbon ribbon in an evacuated glass enclosure as their comparison body, measuring its temperature with a pyrometer.

Now, if there is selective radiation for incandescent carbon of the nature indicated by the curves in Fig. 10, then their temperature deductions will require modification; and in further support of this we have the experiments of Grau, which were conducted in much the same manner, except that as his standard of comparison he used an *incandescent metal strip in a spherical metal enclosure*, and thus approached much more nearly to an ideal black body.

Still more recently the work of Coblentz has shown that the "radiation constant" in Wien's equation, which for a black body is 5, may for metals like tungsten and osmium rise as

Author.	Year.	Type of filament.	Temp.	W./c.p.	Method employed.	Reference.
H. F. Weber	1892	Carbon	1,565°C. 1,580°C.	...	......	......
Lummer and Pringsheim	1899	Carbon	1,602°C. 1,827°C.	3 per Hef.	Bolometer	"Verhandlungen der Deutsch. Phys. Ges.," Vol. I., 1899.
Waidner and Burgess	1906	Carbon .... Tantalum .... Tungsten	1,950°C. Abs. 2,000°C. Abs. 2,300°C. Abs.	3 ... 1	Photometric balance against carbon ribbon whose temperature is measured with Kurlbaum pyrometer	"Electrical World," Vol. XLVIII., p. 915, 1906.
Grau	1907	Carbon .... Tungsten	1,660 } Black 1,850 } temp.	3 per Hef. 1 per Hef.	Photometric balance against calibrated black body	"Elektrotechnik und Maschinenbau," April, 1907.
Morris, Stroud and Ellis	1907	Tungsten .... Tantalum	2,000°C. Abs. 1,850°C. Abs.	...	Application of Stefan law and matching to carbon at 3·5 w./c.p.	THE ELECTRICIAN, Vol. LIX., August, 1907.
Clerici	1907	Carbon .... Tantalum .... Tungsten	1,950°C. 2,000°C. 2,300°C.	3·1	Not stated	THE ELECTRICIAN, Vol. LIX., May, 1907.
P. Janet	1898	Carbon	1,610 to 1,720°C.	...	Electrical measurement.........	"Comptes Rendus," 126, p. 734, 1898.
Le Chatelier and Boudouard	...	Carbon	1,800°C.	...	Absorption pyrometer	"Mesure des Temperatures élevées," p. 171.
W. W. Coblentz	1909	Metallised carbon... Tantalum .... Tungsten	1,570°C. 1,670°C. 1,810°C.	...	Experimental determination of energy curve and assuming platinum constant	"Electrical World," Vol. LIII., April, 1909.

high as 7, and is to some extent itself dependent upon temperature.

It is, therefore, obvious that a careful study of the form of the energy curves of incandescent bodies is the direction in which we must look for further advances in economical light production: for, apart from the difficulty in finding suitable refractory materials which are permanent at very high temperatures, we are always confronted by the facts that, firstly, at the highest temperatures, by pure temperature radiation, more than 50 per cent. efficiency can never be attained, and as temperatures are pushed up the increase in economy must be always offset against the serious surface disintegration, and consequent short life which always accompanies it.

Finally, the author wishes to acknowledge his indebtedness to Mr. A. F. Burgess, B.Sc., for much valuable help with the calculations and for drawing the curves which illustrate this article.

CORRESPONDENCE.

THE PHOTOMETRY OF DIFFERENTLY COLOURED LIGHTS.

TO THE EDITOR OF THE ELECTRICIAN.

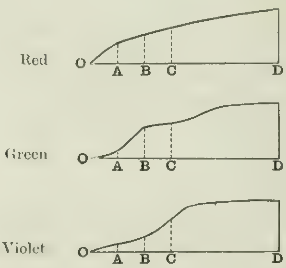
SIR: In the interesting correspondence in your columns on the photometry of differently coloured lights, a suggestion has been made that the reason why the Flicker Photometer gives varying results when the sources to be compared are of different tint may lie in the fact that the percipient structure of the eye includes two types of sensitive elements—the rods and cones. Mr. Wild suggests that as the speed of the flicker head is increased the cones are unable to follow the changes, so that we have rod vision only, and since for colour sensation we depend on the cones, the comparison of the differently coloured lights will lead to inaccuracies.

It has, however, been shown that the cones respond much more quickly to stimulation than the rods. This would necessitate some modification of Mr. Wild's theory without altogether destroying the main idea, which could be tested roughly as follows.

In the *fovea centralis*, the area where the image of any object directly looked at falls, the cones alone are present, the rods first appearing intermingled with cones in the surrounding zone. If the photometer is adjusted for direct vison, then looking a little to one side of the disc so as to throw the image on to a region where the rods are more numerous should alter the conditions and cause the flicker to reappear.

I believe, however, that the real explanation is to found in the excitation curves of the retina for different coloured lights. The known facts concerning colour vision are consistent with the assumption of three separate groups of nerve fibres which are most sensitive to the colours red, green and violet respectively. The rate of excitation of these fibres when a white stimulus is applied is different, and the resultant behaviour of the three groups towards red, green and violet light is shown in the following curves:—

The time during which the stimulus acts is represented along the horizontal axis and the intensity of the excitation, is measured in a vertical direction. If the stimulus (white) lasts for a comparatively long time (OD), the excitation of the three groups of fibres will be equal, as seen by the equal length of the ordinates at D, and the resulting sensation is that of white light. But if the stimulus is of shorter duration (OC) the violet sensitive fibres will be more excited than the green and still more than the red. The resulting sensation will therefore be one of bluish violet light. If the duration of the stimulus is very short (OA) the red fibres are more excited than the others, and the result is the sensation of red light.



If we compare two lights by means of the Flicker Photometer, then at one speed we are practically comparing the red components, while at another speed it may be the violet components which are preponderating in the stimulus of the retina. Clearly this can only lead to correct results, for the comparative total intensities if the two lights have their component colours mixed in exactly the same proportions—*i.e*, when the two lights are identical in tint. In the case where the lights to be compared have such different tints as a carbon filament lamp and a metallic filament or Nernst lamp it is obvious that we must use great caution in interpreting the values obtained by any photometric method depending on intermittent illumination. I am, &c.,

Physical Laboratory, Armstrong College, Aug. 11. H. MORRIS-AIREY.

COMMUTATION IN DYNAMO-ELECTRIC MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the article on "Commutation in Dynamo-electric Machines," by Mr. R. Rüdenberg, in your current issue, the fact that there are circuits in parallel with the short-circuited coil has already been pointed out by Mr. C. C. Hawkins in his pamphlet on "The Theory of

Commutation"* published some years ago. Mr. Rüdenberg's final criterion that $\frac{L_{s}}{TR_{u}} < 1 + \frac{L_{s}}{L_{u}}$ does not seem to admit of immediate application as R_{u} is a limiting value for the contact resistance at the last instant. This is a value which depends on the current density at the last instant and cannot be readily calculated. In a machine which is balanced electrically and mechanically, it is a matter of experience that a brush lead can be given at which it will commutate sparklessly for a particular load. This shows that the external field is of the utmost importance in assisting commutation. It is quite true that there are a few machines in which the current density in the leaving edge of the brush rises to very high values, and it is possible that the criterion given may be of value in such cases, providing that a value for R_{u} can be obtained, and also providing that the external field is of the correct density. Since, however, the sparking in the majority of machines is governed by the density of the external field, cut by the short-circuited coil, it would seem that the calculation of this density ought to be the first consideration.—We are, &c.,

Preston, Aug. 17. W. E. Highfield and R. Livingstone.

THE C.M.B. AUTO-CONVERTER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It is obvious from Messrs. Macfarlane and Burge's letter, published in your last issue, that they have not fully grasped the meaning of my remarks published on July 30th. They certainly do appear to be aware of the desirability of making the losses equal in the primary and secondary sections of a transformer, but if this be so they will doubtless also agree that the principle, as shown in my last letter, should be applied to the individual losses as well as to the total loss per section.

The figures they give in your last issue prove admirably how careful they have been to get the efficiency of these machines as high as possible without abandoning the C.M.B. principle, but it certainly would be extremely interesting to know whether these figures will bear the scrutiny of analysis.

If, for example, the armature copper loss should prove, as I predicted, to be much greater on the low-tension than on the high-tension side there is no doubt that the armature copper is used wastefully on the high-tension and overloaded on the low-tension side. There will be no difficulty, however, in balancing up the total losses to equality, since the inequalities in the sectional losses both in the armature iron and field copper are in the opposite direction.

The repetition of a statement does not constitute proof, and having read most carefully all that Messrs. Macfarlane and Burge have written on the subject, I still fail to see any interaction between the generator conductors and the motor field.

There are several other points in my previous letters that require answering, and although I should be only too happy to believe that my statements are incorrect, they will stand until some reasonable proof is brought to show that they are wrong.—I am, &c.,

East London College, Aug. 16. Leonard Murphy.

A STRING ELECTROMETER.†

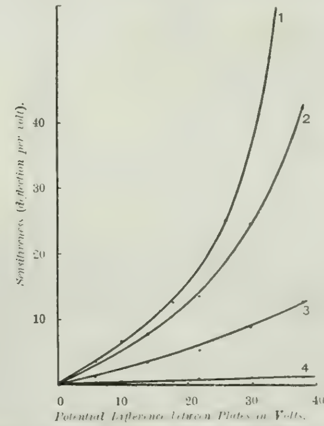
BY T. H. LABY, B.A.

The minute force, 10^{-8} dynes, that is sufficient to deflect perceptibly a stretched silvered quartz fibre, is of the same order of smallness as that acting on the gold leaf of the most sensitive of the usual electroscopes. This suggested that the fragile and irregularly shaped gold leaf might be replaced with advantage by a silvered quartz fibre. I constructed a very simple form of string electrometer, and then learnt that Dr. C. V. Burton had designed a model of a similar instrument. The Cambridge Scientific Instrument Co. kindly lent me it to test. The results given below were obtained with this instrument after it had been somewhat altered.

The string electrometer used in these experiments consisted of two vertical insulated plates 15 cm. long by 0·8 cm. thick, with their edges parallel and at an adjustable distance apart. These plates were connected to the ends of a battery, the middle of which was earthed. The silvered quartz fibre is stretched parallel to and equidistant from the two plates by the lateral movement of its points of support, while its tension, which has to be kept very constant, is controlled by a screw. The terminals of the middle cell of the battery were connected to a potentiometer, the middle of which was earthed, so that the potential of the fibre could be varied from −1 volt to 1 volt by steps of 1/50 of a volt. As the fibre was not highly insulated tests could not be made with it isolated, so that the results given later were got with the potential of the fibre maintained. The motion of the middle of the fibre was observed by means of a microscope. A slight illumination gave a sharp image of the black silvered fibre on a bright ground.

The purpose of the tests was to find: (1) The sensitiveness, (2) the oscillograph powers of the electrometer depended on (*a*) distance of the plates apart, (*b*) their P.D., (*c*) the tension on the fibre.

The plates were first set far apart (1·1 cm.) and then the sensitiveness (deflection per volt) was observed for a range of plate P.D.s. With a new tension the same observations were repeated. In this way the equal tension P.D. sensitiveness curves (*see* Fig. 1) were obtained. The sensitiveness is expressed in eye-piece divisions per volt on the fibre: one eye-piece division = 0·0012 cm. movement of the fibre itself. We see from these curves that a high sensitiveness was obtained with the fibre not very tight (curves 1, 2, Fig. 1), which increased with the P.D. With the plates 1·1 cm. apart the position



Plates 1·1 cm. apart. Tension on fibre increases from curve 1 to 4.

Fig. 1.

of the fibre was plotted against its voltage. One of the graphs was a straight line, so that the deflection was proportional to the voltage even for high sensitiveness and for a wide range (for an electroscope) of voltages.

When the distance between the plates was reduced to 6·6 mm., and finally to 3·3 mm., several properties of the instrument came into greater evidence. The chief change in the P.D. sensitiveness curves is that smaller P.D.s appear to give a larger sensitiveness for a given tension, or, as is to be expected theoretically, the sensitiveness for a given fibre tension depends on V/d^2, where V is the P.D. and *d* the distance between the plates. This could not be fully proved, as the tension of the fibre did not remain sufficiently constant. With the plates at 3·3 mm. apart the deflection of the fibre as its potential changed became markedly different. With the fibre tight its deflection was still proportional to its potential (the straight line of Fig. 2), but when slackened the position which the fibre took up for different potentials is represented by the curve AB (Fig. 2); on lowering the tension still further the fibre had two stable positions, and apparently an unstable one not experimentally realisable. In other words, if the fibre is slackened the sensitiveness increases, but for a decreasing range of voltages: theoretically, we pass through infinite sensitiveness to instability. This property of the instrument, which sets a superior limit to its useful sensitiveness, is best grasped by examining Fig. 2.

In Mr. C. T. R. Wilson's tilted electroscope, as is well known, this property is used to obtain a high sensitiveness, the adjustments (plate potential, tilt and length of gold leaf) are altered till the portion AB (Fig. 2) of the deflection potential curve is realised

* "The Electrician" Printing & Publishing Co.

† Abstracted from the "Proceedings" of the Cambridge Philosophical Society.

Characteristics of the String Electroscope.—The fibre will stand vibration and sudden large changes of voltage without breaking. The instrument has been carried on a bicycle without damage to the fibre. No common standard of comparison has yet been proposed for electroscopes. The unit of deflection used in this Paper is one division of the micrometer eye-piece: one-fifth of this could be read with certainty. With the plates 6·6 mm. apart a sensitiveness of 50 divisions per volt is shown: at the same time the deflection is approximately proportional to the voltage, and the P.D. between the plates was less than 40 volts. With the plates at 3·3 mm. apart and a P.D. of 36 volts a sensitiveness of 100 divisions per volt over a range of 0·4 volt was readily obtained.

I do not think, however, that the value of the string electrometer will lie especially in its sensitiveness. But there is a distinct need now for an electrometer capable of automatically recording rapid changes of voltage in the study of discontinuous phenomena in the direction indicated by von Schweidler. For example, in the beautiful experiment of Rutherford and Geiger of counting the number of a particles which arrive in an ionisation vessel by the excursions of an electrometer the smaller the free period of the electrometer the better. To test the oscillograph powers of the instrument, the plates were placed 3 mm. apart at a P.D. of 120 volts, and the tension

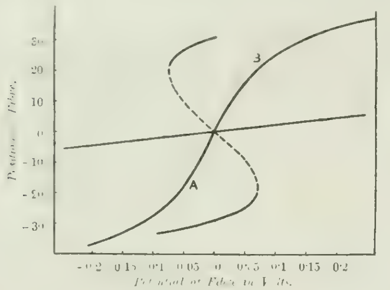


Fig. 2.

on the fibre increased; the sensitiveness was then 50 divisions per volt. Yet the motion of the fibre was dead beat, and it took up a new position in less than one-tenth of a second. Since the movement of a fibre can be readily recorded photographically, the instrument seems to promise well as an oscillograph. Further experiments are being made on this use of it.

ROLLING MILL MOTORS.*

BY E. W. YEARSLEY.

Protection is extremely important in the steel mill where conditions are necessarily uncleanly, and electrical apparatus must work in the midst of dust, moisture and gases. Large motors should be enclosed in solidly built tight compartments, ventilated by clean air if necessary, or should be of the totally enclosed type.

Considered economically, the writer believes main motor drives to be superior to engine drives, even when power must be derived from a steam engine driven generator plant fed by coal-fired boilers. Steam losses due to condensation and leaky valves and rings are surprisingly large, but usually escape definite measurement. Then in the usual rolling-mill engine, very little expansion is utilised, and it is not likely that attempts to refine such machines are satisfactory. Where water power or waste gas is available there is no question of the greater economy of electric drive.

The controlling apparatus for mill service is usually the weak part of the system; it is much less satisfactory than the motors. Mechanical strength and simplicity are the main points to be observed in designing this apparatus. Heavier and more mechanical switches and circuit-breakers, better protected and more durable rheostats, and more dependable automatic controlling devices, requiring less attention, are badly needed. This is a problem more difficult of solution than improvement of the motor, but no less necessary.

For large main-drive motors the advantage of continuous running at constant speed is so great that it would appear advisable to make the design of the mill suit the characteristics of the motor, and avoid the extra expense and complication of devices like the reversing drive. The tendency has been to build a machine and then to couple on a motor somewhere to drive it. This mistake, while not so frequent as formerly, is still made.

* Paper read before the American Institute of Electrical Engineers.

There seems to be no great difficulty in designing mills for continuous-running motors. By combining such motors with a suitable flywheel, it should be possible to keep the line load sufficiently uniform. This combination has not, in the writer's opinion, received sufficient attention, possibly because of lack of knowledge of power and speed regulations of the rolling operation.

Tests of these characteristics will be comparatively easy on electric mills, so that data will rapidly become available for supplying the system with the proper inertia. In some installations the writer has seen the flywheel so badly proportioned as to be detrimental to the operation of the motor. Initial speeds should be carefully selected, especially when the drive is direct, and if possible a considerable speed regulation should be provided, so that the speed may be increased with increase in proficiency of the operators.

The importance of low armature inertia for reversing motors is now well recognised, but designs could be improved by still further reduction in speed. The writer is decidedly against the use of high-speed motors for any kind of mill service and believes the extra cost of slow-speed machines well warranted.

Electric motors subject to excessive vibration communicated from the gearing and other parts of the machine should be protected by a flexible coupling. For mill apparatus which must be handled directly, especially for direct-current apparatus, the writer favours a maximum of 250 volts. Safety of employés requires that with higher voltages special guards be provided to isolate the apparatus.

Alternating-current and direct-current motors and apparatus both have their advantages for steel mill installations. Local conditions must determine which is superior. Unless transmissions are too long, the writer favours a direct-current installation, especially if the plant has many machine tools. With an alternating-current system as few direct-current motors as possible should be used.

THE IMPERIAL INTERNATIONAL EXHIBITION.

When we last referred to this Exhibition, just after the opening ceremony, the technical exhibits, such as they are, were by no means complete, and even now those in search of interesting information similar to that obtainable last year will probably be disappointed. A tour round the old Machinery Hall reveals very few technical exhibits, and those that might be termed new are in the minority. Of those of electrical interest probably the best is the exhibit of the Central London Railway Co. A complete motor coach is shown standing on a section of standard permanent way, and also a section of the tunnel, giving an excellent idea of the construction of the line. The rails, signals, &c., are wired up exactly as on the line itself, while the driving compartment has switches and gear complete and in running order. A standard four-wheel motor bogie truck, shown separately, gives an idea of the actuating mechanism, and is wired up for exhibition runs. The Western Electric Co., have several cases in which are shown samples of their many types of telephones, together with sample peices of electric cable and electric fans. Messrs. Tredegar & Co. show a complete country house lighting installation. This comprises a petrol-electric generator with storage battery, switchboard and the various electric fittings and apparatus suitable for use in a country house. The Cowper Coles Engineering Co. have a series of electrochemical exhibits, comprising samples and processes in operation. Of these, a process for welding aluminium, a regenerative process of electro-galvanising and a system of vapour galvanising are of special interest. Parabolic reflectors, constructed so as to throw yellow and white beams of light, are also interesting, as it is claimed that these have great advantages for naval and military purposes. Messrs. Babcock & Wilcox are exhibiting various models and specimens of their work. A miniature water-tube boiler fitted with chain-grate stoker and superheater, and a model feed water heating and softening apparatus show very clearly the construction of these sets. A portion of a header and sections of wrought-steel piping with riveted flanges and branches are also shown.

Apart from these exhibits, there is in the "Daily Mail" pavilion an interesting and instructive collection of electrical and electrochemical apparatus and models in working order, the details of which are described in a series of lectures given at stated periods. Amongst these Prof. Korn's system of sending photographs by telegraphy, the Thorne-Baker system of transmitting photographs by wireless telegraphy, the Pollak-Virag system of high-speed telegraphy and the Telewriter are to be seen working.

An interesting exhibit to be seen near the Elite Gardens is the electrically equipped model house erected by Simplex Conduits (Ltd.) Here the wide application of electricity for heating, cooking, lighting, &c., is demonstrated in a most artistic and able manner. The entrance leads into a very handsome showroom, in which the many

and various types of electric apparatus made by this firm are laid out for inspection. Passing through this the dining room is reached, in which is shown a dining table laid for four people with various electrical apparatus suitable for use in connection with the dinner table, such as plate-warmers, water-heaters, &c. In the drawing room, which is carried out in Adams style and lighted by means of a central ceiling fitting having a large cut-glass bowl for distributing the light from four metallic filament lamps, an electric kettle, raidator and ornamental portable lamps are exhibited. In the bedroom electric toilet requisites, foot-warmers, &c., are shown, while a new design in shaving mirrors is to be seen. This consists of a special lens, behind which is fixed an electric lamp and by the use of which the light may be concentrated upon any part of the face, doing away entirely with shadows. In the kitchen practical applications of many types of electrical cooking apparatus are to be seen, and those who are lucky have the opportunity of tasting cakes, &c., newly made from the electric oven. Electric laundry fittings are also shown in the kitchen and the use of the electric iron is demonstrated at frequent intervals. The ventilation of these rooms, carried out by means of electric fans, is most effective, and even when the rooms are crowded with people no increase in temperature is found, while there is an absence of that stuffy atmosphere usually found when people are congregated in a small room.

In conclusion, it may be mentioned that in the majority of the side shows electricity plays no small part, motors being used for providing the necessary power, while those in which lighting effects play a prominent part use electric lamps very extensively.

NEW PROCESS FOR GALVANISING STEEL AND IRON TUBES.

The effective protection of steel and iron tubes both externally and internally from the action of the weather, and from corrosive acids and other deleterious substances is of great such importance that any new process in this connection is of real interest. Messrs. John Russell & Co., of Walsall, London, an old established firm of makers of wrought iron and steel tubes and fittings hold the patent for Great Britain (as regards tubes) of a new cold process of galvanising by electro-deposition, which it is claimed possesses very material advantages over the old process of dipping in molten spelter.

By this electric process pure zinc is deposited in minute particles on a clean metallic surface in such a way that the zinc practically becomes amalgamated with the iron or steel. The advantages of this system may be summarised as follows: Every part of the internal and external surface including the thread is absolutely protected. The durability of the tube is increased by the evenness of the coating, as by the electro-deposition a coating of zinc is secured which is of exactly the same density throughout, whereas in the hot process a heavy average coat may be obtained and at the same time the surface may in parts be barely covered. This variation is said to be impossible in the process under review. The full capacity of the bore of the tube is maintained, whilst in the hot process there is an appreciable reduction in the bore at the best and frequently this reduction assumes very serious dimensions, owing to the chilling of the spelter or the intrusion of dross. The zinc deposit is united to the metal of the tube in such a thorough manner that after being galvanised the tube may, it is stated, be bent without any resultant scaling or chipping off of the deposit. This is a most important point, because tubes treated by the hot process can neither be intentionally bent nor accidentally distorted without cracking and probably scaling off of the coating, a disadvantage so obvious that it need not be enlarged upon. The protective efficiency of the coating is much greater in proportion to its weight owing to the fact that the zinc used in the cold process has greater purity and consistency than the spelter employed in the hot process.

One frequently hears as an argument against the use of galvanised tube that the treatment tends to conceal defects. This is quite true as regards hot galvanising, but does not, it is claimed, apply in any sense to the electro-galvanising process, as after treatment by the latter, tubes show flaws, fractures, pitting, &c., just as plainly as when in the "black" state. The effect of galvanising upon the metal of the tube is a very important consideration, affecting, as it must do, its life and reliability. In this connection the cold electro-deposition process possesses the very salient advantage that it tends to improve the malleability of the metal, whereas by the hot process the latter is rendered extremely brittle.

Notwithstanding the above-mentioned advantages, the electro-deposition process does not increase the price of the tubes treated as compared with the hot spelter process, and this fact would appear to remove the only possible bar to the very general use of electro-galvanised tubes.

B.T.-H. FITTINGS FOR TUNGSTEN LAMPS.

The season will soon, unfortunately, be on us when we shall have to have greater resource to artificial light than is the case at present. To have to use artificial light at all is doubtless a great nuisance, but it is also a necessity, and, bearing this in mind, we can so arrange matters that our lighting arrangements and fittings harmonise with the other room decorations and do not unnecessarily intrude themselves on our comfort.

The introduction of metallic filament lamps has necessitated the re-designing of a number of fittings which, though quite suitable for the old carbon lamps, scarcely fulfil all the requirements of the newer "tungstens." A number of new fittings have also been designed and good examples of the new types are those manufactured by the British Thomson-Houston Co., of Rugby. These fittings are illustrated and described in a catalogue of tungsten lamp fittings recently sent us, which fittings have been developed for the purpose of allowing B.T.-H. tungsten lamps to be burnt in groups, so that a powerful light equal to that of a small arc lamp can be obtained at any particular point without the attendant troubles of carboning and trimming. The devices are artistic, and should be most effective for shop, ship, hall or club-room lighting. The fittings are made of copper or zinc, with a standardised finish of oxidised copper, and the globes, which are supplied either plain or pocketed, are of flint glass ground on the inner surface. The whole fitting forms a most excellent way of obtaining concentrated light in a small space. Two of these new fittings are shown in the accompanying illustrations.

FIG. 1.—HOOK SUSPENSION WITH ORNAMENTAL BRACKET AND CHAIN.

FIG. 2.—FIXED SUSPENSION WITH CEILING PLATE.

NEWFOUNDLAND CABLE MATTERS.

In our last issue (p. 723) we published a communication from the vice-president and general manager of the Commercial Cable Co. (Mr. Geo. G. Ward) to the Premier of Newfoundland (the Hon. Sir Edward P. Morris) complaining of the attitude of the Newfoundland Government in regard to the contract entered into between the company and the Government on Feb. 18, 1909, in regard to the cable recently laid by the company. In reply to the serious statements contained in Mr. Ward's communication, Sir Edward Morris, who is now in London, denies that there has been a breach of faith, that the Government of Newfoundland do not recognise these contracts made with its predecessors, or that it is offering obstacles to the successful operation of the laying of the Commercial Co.'s cable.

Sir Edward Morris says the Newfoundland Government does not refuse to ratify agreements, but it did refuse, without ample consideration, to bring before the Legislature for ratification the contract of 1909, principally for the reason that it was unfair and prejudicial in many respects to the Anglo-American Telegraph Co., which is a cable company, and would create in favour of the Commercial Co. a monopoly for 25 years of the transmission of all cable messages passing over the Newfoundland Government land lines. The Commercial Co., under its agreement of 1905 with the Newfoundland Government, are now bringing in their cables. There is no objection to this, as the Government only a few weeks ago gave them the land they require; but the Government have not felt justified (not, however, without fully considering the matter) in granting by Act of Parliament the further concession attempted to be given in the agreement of 1909- namely, a monopoly for 25 years and freedom from taxation, whilst taxing the Anglo Co.

In connection with the above dispute a memorial has been sent by the chairman of the Anglo-American Telegraph Co. (Mr. F. A. Bevan) to the Secretary of State for the Colonies, the Earl of Crewe.

The memorial, which we reproduce practically in full, states that :—

This agreement is, for the reasons hereafter stated, unfair, and prejudicial in many respects to the Anglo-American Telegraph Co. (Ltd.), which is an English company, and of which I am chairman, and would create in favour of the Commercial Cable Co., which is an American company, a monopoly for 25 years of the transmission of all cable messages passing over the Newfoundland Government land lines. In order that you may have the situation and the views of my company before you, in case you have at any time to consider the matter, I desire, on behalf of my company, to place before you, first, the general relations of my company with the Colony; secondly, the main features of the agreement in question; and, thirdly, the prejudicial effect of such agreement as regards my company. In 1854 a company, called "The New York, Newfoundland, & London Telegraph Company," was incorporated in the Colony of Newfoundland by an Act which empowered the Newfoundland Company to establish submarine telegraphs between America and Europe by way of Newfoundland. The Atlantic Telegraph Company (Limited) was another company which at about the same time attempted to establish cable communication between America and Europe, but both were unsuccessful, notwithstanding the expenditure of large sums of money and most strenuous labours, and it was not until 1866 that telegraphic communication was effectually established between Ireland and America by the Anglo-American Telegraph Company (Ltd.), which was incorporated in that year for the purpose, and which subsequently took over, and now holds, all the rights and privileges of the Newfoundland Co. and of the Atlantic Telegraph Co.

Mr. Bevan next refers to the various agreements between the Newfoundland Government and the Commercial Co. and the Marconi Co., and especially to the one dated Aug. 26, 1905, between the island Government and the Commercial Co. This document was signed for a minimum period of 10 years from its date. It provides that the Newfoundland Government shall hand over to the Commercial Cable Co. at Canso, in Nova Scotia, all traffic destined to points outside Newfoundland and coming within the Government control or to the Government land lines for the time being, unless directed by the sender via some other route, the Commercial Co., on its side, handing over to the Government at Canso all traffic destined to points in Newfoundland coming within the Commercial Co.'s control, or to its lines, for the time being existing, unless directed by the sender via some other route. The agreement further provides (clause 4) that the Government will grant the Commercial Cable Co. the right to land any of its through cables at Newfoundland on terms and conditions as favourable to the Commercial Co. as those under which any other cables, present or future, are granted landing rights and privileges by the Government (except any special privileges then enjoyed by the Anglo-American Co., inclusive of the right of the Anglo-American Co. to compete with the Government telegraph system), and by clause 5 if the Commercial Co., with the permission of the Government, lands cables as before provided, it shall be optional for the Commercial Co. to transfer at its Newfoundland station, instead of at Canso, a part of the whole of the traffic exchanged with the Newfoundland Government system, provided the terms of transfer are the same as at Canso. Mr. Bevan considers the agreement of Feb. 18, 1909, "as unfair and prejudicial to his company, because clause 2 extends the period of the Commercial Cable Co.'s 1905 agreement to 25 years from Feb. 18, 1909, and, together with clause 3, confirms in specific terms the monopoly during that period to the Commercial Cable Co. (which is an American company) of all traffic from the Government land lines, to the exclusion of my company (which is a British company), and whose land lines are also excluded from all business passing over the Commercial Co.'s cable. When read in conjunction with the Marconi Co.'s agreement, this monopoly also covers messages received or transmitted partly by Marconi wireless stations on the island and partly by cable. My company is thus precluded from all opportunity of competing for the above traffic, although the satisfactory service rendered by it, its superior equipment, and its faithful performance of all its undertakings should have fairly entitled it to more equitable and businesslike treatment at the hands of the late Government." In regard to clause 4, under which the island Government is to pay the Commercial Co. $4,000 a year, Mr. Bevan states that such payment is in the agreement stated to be in consideration of the advantages and facilities secured by the cable which the Commercial Co. agree to extend from the Flemish Cap to Newfoundland, and to continue thence to New York. But the system of the Anglo-American Telegraph Co., with its four cables to Europe and five lines to the United States, has been and is available for all Government cable purposes without risk of interruption. The Government's own cable to Canso has been in operation for a period of four years, and has only once been interrupted, and the cost to the Government of the transmission of its traffic over the Anglo-American Co.'s cables during such interruption did not amount to $300, whilst the subsidy to the Commercial Cable Co. during a corresponding period of four years would have amounted to $16,000 under the agreement of Feb. 18, 1909. Moreover, it will be seen that the practical effect of the subsidy is to remit to the Commercial Cable Co. the landing tax imposed by the Taxing Act. Such a provision of a money subsidy would seem to be beyond the powers of the Newfoundland Government without special authority from its Legislature. In carrying out its enterprise the Anglo-American Co. has made a large expenditure of capital, and makes a large annual expenditure within the Colony, the latter being greatly in excess of any revenue earned in the Colony, and this capital and annual expenditure as an economical resource and contribution to the prosperity of the island are of great value to the Colony. My company has, however, in the past been, and still is, subjected to heavy taxation, amounting in all to as much as £4,600 per annum, from which its competitors, including the Government land lines, are practically exempt. It is perfectly ready to compete on fair and equal terms, and considers it should be dealt with in the same spirit. It has, therefore, welcomed the action of the present Government in refusing to ratify the agreement of Feb. 18, 1909, as indicating that the Government appreciate that the arrangements contemplated by that agreement are not consistent with fair and equal competition, and it trusts that under no circumstances will the Government confirm an arrangement which bears so hardly and unfairly on its enterprise.

PARLIAMENTARY INTELLIGENCE.

GLASGOW CORPORATION BILL.

This bill was passed by a Select Committee of the House of Commons on 12th inst. The clause removing doubts as to the tramway undertaking being part of the Common Good was sanctioned by the Committee, and the powers of the Corporation over the residue of the tramway revenue were extended.

Mr. Balfour Browne, K.C., for the promoters, said that only one provision in the bill was to be brought before the Committee—the question of the Common Good. The Common Good was the private property of the Corporation, but of course it was to be expended for the public good. When years ago the tramway company was selling its undertaking it was taken over by the Corporation, and the Common Good was a security for the money borrowed to pay the company. The Corporation had no other alternative, because that was before the Tramways Act of 1870. Every other corporation in Great Britain had the city rates as a security for money borrowed. If there was a deficit from the tramways in Glasgow the rates had not to bear it. What they desired to do was to make it perfectly certain that the tramways were part of the Common Good of the city. The Corporation had transferred tramway profits to the Common Good to the amount of £326,000, and no one had ever suggested that it was illegal.

After hearing evidence, the Chairman (the Hon. A. Stanley) said the Committee were of opinion that clause 20 must stand as it was. In regard to the limit of £50,000 in clause 30, the Committee saw no reason for the imposition of that limit, and were prepared to agree that the whole residue of the tramway revenue should go to the Common Good. They did not see their way to alter the clause in order to meet the possible loss on the tramways. From what they knew of the management of the Glasgow Corporation tramways that was not likely to arise.

The preamble of the bill was then passed.

Holsworthy Provisional Electric Lighting Order.—The bill to confirm this order, which has been granted to Messrs. Christy Bros. & Co., was passed on Thursday last by the Select Committee of the House of Commons on Unopposed Bills. The district council may, by 12 months' notice in writing, after the expiration of 25 years from commencement of order, require the undertakers to sell, the price to be a sum equal to the fair market value of the undertaking purchased as a going concern. In default of agreement the sum is to be determined by arbitration.

Metropolitan Ambulances Bill.—This bill came before the Grand Committee of the House of Commons on Aug. 17, when it was decided by 28 votes to 1 that the L.C.C., and not the Metropolitan Asylums Board, should be the body to carry out the service. Clause 1 (7) runs as follows: "To provide and maintain ambulances and other vehicles and means of conveyance, to be drawn by electrical or other mechanical power, by horse or by hand; provided that any electrical power used for moving such vehicle shall be entirely contained in and carried along with such vehicle."

New Acts of Parliament.—In the House of Lords on Monday Royal Assent was given by Commission to a number of new Acts, including York Town and Blackwater Gas (Electric Lighting, &c.); Preston, Chorley and Horwich Tramways; Durham (County) Electric Power Supply; Southport and Lytham Tramroad (abandonment); Wallasey Tramways and Improvements; North-east London Railway; Folkestone,

Sandgate and Hythe Tramways; Oxford and District Tramways; Thames Tunnel (North and South Woolwich); South-Western and Isle of Wight Junction Railway; Gateshead and District Tramways; Central London Railway; Holywood Tramways; London County Council (Tramways and Improvements); and West Kent Electric Power.

National Telephone Co.'s Staff.—In the House of Commons on Tuesday Mr. P. Curran asked the Postmaster-General if he was aware that reductions in the staff of the National Telephone Co. still continued; that the users of the company's system were suffering inconvenience owing to the negligence of the company in carrying out alterations and repairs and the placing of new plant.

In reply, Mr. BUXTON said that the National Telephone Co. had discharged a certain number of construction hands during the present year owing to a slight diminution of the amount of new work and orders. He had no evidence that the company were causing inconvenience to subscribers by failure to carry out alterations and repairs to plant. The condition of the plant would be taken into account in the settlement in December, 1911, and the company had therefore a direct interest in keeping it up to date. He had just concluded an arrangement with the company for the continuance of certain new work, and he was in communication with them as to arrangements for establishing new exchanges in the districts served by their system.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT.

The Governing Body of Northampton Polytechnic Institute, London, invite applications for the appointment of practical instructor in electric light wiring and cable jointing. Two evenings per week. Particulars and forms of application (to be returned by Sept. 1) from the Principal, Dr. R. Mullineux Walmsley. See an advertisement.

An assistant mains engineer is wanted by a large power company to take charge of laying, maintenance and testing of e.h.t. three-phase cables, overhead line construction, &c. Salary about £200. See advertisement.

A foreman of electric light service is required for Dominica, West Indies. Engagement for three years, with possible extension, salary £150 per annum, with free second-class passage to Colony and home again. Applications to the Crown Agents for the Colonies, White Hall-gardens, London, S.W., up to Aug. 31. See an advertisement.

A draughtsman is required conversant with the design of cable junction boxes. See advertisement.

A draughtsman is required for the design of switch pillars, main switches, &c. See advertisement.

Llandilo Council require an engineer to take charge of electrical installation. Applications to the Clerk by Aug. 31.

Applications are invited for the position of head of the electrical engineering department at the Technical College, Sunderland. Salary £250, rising to £300 per annum by two equal annual increments. Applications to the secretary, Mr. T. W. Bryers, Education Offices, 15, John-street, Sunderland, by Aug. 23.

The lectureship in electrical engineering at University College, Galway, is vacant. Salary £120. Applications to the Secretary, Mr. Robt. Donovan, Royal University-buildings, Dublin, by Aug. 31.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

There is a vacancy for a lecturer and demonstrator of physics at the Sir John Cass Technical Institute, London. Commencing salary £150. Applications to the Principal by Aug. 28.

The Council of the University College of Wales, Aberystwyth, require a demonstrator or assistant lecturer in the department of physics. Salary £150 per annum. Applications to the Registrar by Sept. 16.

EDUCATIONAL NOTICES.

University of London (University College).—The courses in mechanical, civil, municipal and electrical engineering begins on Monday Oct. 4. The College contains spacious electrical and mechanical engineering laboratories, workshops, drawing office, &c. Special and post-graduate courses on "Steam Turbines," "Recent Methods and Instruments in Surveying," and "On the Theory and Design of the Ideal Arch, Metal and Masonry" have been arranged. Further particulars may be obtained of the Secretary, Mr. Walter W. Seaton, University College, Gower-street, London, W.C.

University of Glasgow.—The next session commences on Oct. 11 next and ends on March 17, 1910. Students in the department of engineering and mining and naval architecture usually spend the summer months in practical work, thus receiving their training on the sandwich system. Prospectuses for the course of B.Sc. and D.Sc. in Engineering and syllabus of classes will be forwarded on application to the Assistant Clerk, Matriculation Offices, The University, Glasgow.

University of Manchester.—Prospectuses, containing full particulars of the lecture, laboratory and drawing courses in engineering, and the courses in physics (including electrical engineering, mathematics and chemistry, &c.), can be obtained from the Registrar. There are new and enlarged engineering laboratories which will be open to students in the new session commencing Oct. 5.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

City and Guilds of London Institute.—The course of instruction at the Institute's Central Technical College, Exhibition-road, are for students not under 16 years of age, and those at the Institute's Technical College, Leonard-street, Finsbury, are for students not under 14 years of age. The entrance examinations to both colleges are held in September, and the entrances commence in October. Particulars of the entrance examinations, scholarships, fees, &c., may be obtained from the respective colleges or the head offices of the Institute, Gresham College, Basinghall-street, London, E.C.

Glasgow and West of Scotland Technical College.—The session 1909-10 commences on Sept. 23 for the evening classes and Sept. 28 for the day classes. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, and the courses of study for the diploma usually extend over three sessions. Holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. There are new and well equipped laboratories in the departments of physics, chemistry, electrical engineering, mechanics, metallurgy, &c., and facilities for research are afforded. Calendar (price 1s. 4d.) and prospectus (free) can be obtained on application to the Secretary.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

Hackney Technical Institute, London.—The next session commence on Sept. 20. There are evening lecture and laboratory courses in electrical engineering, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses may be obtained from the Principal of the Institute, Dalston-lane, London, N.E.

Engineering Scholarships.—The late Mrs. E. Boyd, of Rothesay, left £2,000 to the University of Liverpool to found engineering scholarships.

Amble.—The Council discussed the question of the erection of electricity supply works last week when it was decided to issue circulars to householders setting forth the probable cost of electric current for public and private lighting, also the approximate cost of wiring an ordinary dwelling, &c., and inviting householders to state whether they would become consumers of electric current if a scheme is carried out for the town. The proposal is to put down suction gas plant at an estimated cost of about £5,000.

Amoy (China).—Mr. Consul Sundius, in his report for 1908, states that during the year a telephone service was established in the city, and it is proposed to link up the system with that of Kulangsu by a sub-aqueous cable across the harbour. There is some talk also of establishing electricity works.

Australasia.—The ratepayers of Fremantle (W.A.) have voted in favour of raising a loan of £25,714 for the construction of an electric tramway and for extensions of the electricity works.

The Electrical Association of Queensland are endeavouring to get the existing restrictions as to the use of overhead electric light wires removed.

The borough of Eaglehawk (Victoria) has been authorised to establish electricity supply works.

The New South Wales Railway Commissioners announce that they propose to convert the remaining steam tramway lines in Sydney (about 43¼ miles) to electric traction. During the past nine years, since the inception of electrification, the length of line has increased about 80 per cent., at an outlay of double the original capital, and three times the original number of passengers are carried. The interest return on the capital invested has risen from 4 to nearly 6 per cent. The total length of single track operated by electricity is 146 miles. The substitution of electric power for steam has been very successful from every point of view.

Barnstaple.—The new municipal secondary schools are to be wired.

Bray (Ireland).—The Council have received a further communication from the L.G. Board in regard to their recent application for sanction to a loan of £2,600 for extensions of the electricity works.

The Board state that with regard to the excess expenditure, making up the sum of £1,162, accounts had not been kept, while payments in respect of the works were made, and the engineer was not able at the time of the inquiry to say what were the exact works necessitating the extra cost. Sec. 238 (3) of the Public Health (Ireland) Act, 1878, required that a local inquiry should be held in cases where the sum proposed to be borrowed with the balances of the outstanding sanitary loans would exceed the assessable valuation of the district, and it was evident that such a requirement became nugatory if expenditure were incurred (as in the present case) several years prior to sanction of the loan to defray it—unless in cases of emergency. Moreover, items comprised in the sum in question had long since been presented in the ordinary accounts of the Council, and had passed audit, and it was not the practice of the Board to sanction loans for such items. Regarding £460 for a new switchboard, the Board had again to point out that capital sums amounting to £407. 6s. had already been sanctioned for that work, of which £200 did not appear to have been applied for the purpose for which the borrowing was sanctioned. The switchboard obtained for £203. 5s. was afterwards sold by the Council for £30, and a new switchboard provided. Such replacement must be regarded as a work of maintenance, for which a loan could not be sanctioned. In the circumstances, therefore, the Board were unable to alter the decision conveyed in their previous letter, which sanctioned a loan of £1,000 for procuring a gas-producing plant, disconnecting boxes, &c.

Brazil.—Acting-Consul Sandall (Santos district) says the principal hydro-electric installations constructed in the State of Sao Paulo are that of the Sao Paulo Tramway Light & Power Co. at Parnahyba, and those of other companies at Jundiahy, Sorocaba, Rio Claro, Mococa and Piracicaba, the first mentioned having a capacity of 8,000 kw. and the others varying from 450 kw. to 1,000 kw.

An important hydro-electric station is in course of construction by the Santos Dock Co. at the Itatinga Falls, near Santos, which station will be of 3,000 kw. capacity, and will supply light and power in the city of Santos and also current for working cranes on the quays. Mr. Sandall gives a list of the principal waterfalls in the district that have been surveyed with a view to their utilisation for the generation of electrical energy. These are eight in number, and the total horse-power to be obtained is estimated at 1,125,700. The city of Sao Paulo has electric tramways 75 miles in extent, and is partly lighted by electricity, but chiefly by gas, over 8¼ million cubic metres of gas having been consumed in 1907. One part of the tramways in the city of Santos (hitherto worked entirely by mule traction) has been converted to electric traction, and it is hoped that the remainder will soon be converted. This city is also chiefly lighted by gas, two avenues leading to the suburbs on the beach being lighted electrically. Imports at the Port of Santos in 1908 included electrical appliances valued at £77,087 (compared with £97,138 in 1907).

In Curityba (Vice-Consul H. H. Gomm says) the Empresa de Electricidade de Curityba (a Germany company, using nearly all German material) has a 30 years' concession to supply electric light, and made 20 per cent. net profit last year. The same company has also a 50 years' concession to explore the waterfall of Cayacanga on the river Yguassu, 40 miles from Curityba, with a view to using power obtained from the fall for the generation of electrical energy. There are small electric plants in other towns of the State and others in course of construction. These are generally built by Germans and with German material.

British Railways.—The returns relating to the working of the railways of the United Kingdom for 1908 have been issued.

The total amount of authorised capital was £1,398,000,000, an increase over the previous year of about £4,000,000, the smallest increase recorded with the exception of that in 1906 (£2,500,000). The total amount of capital paid up at the close of last year was £1,310,000,000. The average rate of dividend on the ordinary capital last year was 2·99 per cent., compared with 3·31 per cent. on preferential capital 3·42, against 3·46 per cent. in 1907, the rates on the other classes of capital remaining practically unchanged.

Excluding from consideration the lines worked by electric power, the variation in the number of ordinary passengers in 1908, compared with 1907, exceeded half a million in the case of 16 companies, of which three only showed increases, whilst with 13 there were decreases. The reduced numbers observable in the case of certain of the companies are no doubt largely due to tramway and motor omnibus competition in the neighbourhood of large urban areas.

The number of passengers conveyed by the tube railways of the metropolis increased from 130 millions in 1907 to 161 millions in 1908, the increase being more than that shown in the total number of third-class ordinary passengers, in which these are included. Of the increase in receipts from third-class passengers £239,380 was due to the development of the traffic of those deep-level underground railways. The average receipts per passenger (excluding season-ticket holders) worked out at 7·3d. in 1899 to 1903 inclusive, 7·2d. in the two following years, 7·1d. in 1906, and 7 2d. again in 1907 and 1908. Last year the average was 25·4d. first-class, 19·1d. second-class, and 6·4d. third-class, an increase of less than 1d. for first and second-class on the year, whilst third remains the same. Third-class passengers went up from 1,003,996,000 in 1899 to 1,213,138,000 in 1908, and tramway passengers from 924,820,000 to 2,635,333,000 in 1907, the latest year for which figures are available. The total length of the running track of the railways of the United Kingdom at the end of 1908 was 39,319 miles, and the total length of sidings 14,353 miles, whilst the length of line worked solely by electricity was 204½ miles, and 200½ miles were worked partly by electricity.

Boston.—Messrs. Crompton & Co. have decided to apply for a provisional electric lighting order.

Camborne-Redruth Tramway.—An official inquiry was held on Tuesday by Lieut.-Col. Druitt, R.E., relative to the proposed reconstruction of the tramway between Camborne and Redruth.

Costa Rica.—Mr. Consul Cox reports that the Abangarez Goldfields and the Aguacate Mining Co. are installing hydro-electric power plants which will, it is stated, be completed early in 1910, and will render milling possible on a very large scale and at much reduced cost.

The Costa Rica Electric Light & Traction Co. is extending its tramway system, and has acquired rights for a 5,000 H.P. hydro-electric power station at El Brazil.

Damascus.—Consul Devey says the local Belgian electricity supply company at Damascus is making fair progress, considering the great difficulties and foolish prejudices with which it has had to contend.

The company contemplate extensions in two directions, towards Salihiyeh and Bab-Sherki, which will make their district a total length of 6¼ miles. 750 houses and shops are lighted, yielding about £400 a month, and the municipality pay £2,700 per annum for 1,000 street lamps. The total receipts are about £22,000 a year, which would give about £10,000 net profit to pay dividend on the capital of £240,000 (about 4 per cent.). The company's lighting business is doing better than its tramways.

Doncaster.—The Council have authorised the extension of the Bentley tramway route for a distance of about 1,200 yds.

East London (South Africa).—The borough electrical engineer (Mr. J. Mordy Lambe) has intimated to the Council that he does not wish to continue his engagement after the expiration of his agreement in November.

Ecuador.—Mr. J. H. Cardon has been granted a concession for the construction of a 3 ft. 6 in. gauge electric railway from Babahoyo (capital of Los Rios Province) to Balzapamba (Bolivar Province) and subsequently to Guaranda (Bolivar Province). The cost of the line is estimated at £287,000, to be guaranteed by 6 per cent. Ecuador Government bonds. The material for construction and working will be admitted duty free.

Electric Traction in Chili.—It is reported that the Government have decided to adopt electric traction on about 1,150 km. (about 713 miles) of railway, but at the outset only 184 km. (about 114 miles) will be converted.

Electric Traction in Hungary.—The Hungarian Minister of the Interior has placed an order with Messrs. Ganz & Co. for the construction of an electric railway between the city of Pressburg (Hungary) and the Austrian frontier, to be ready for traffic about the end of 1910.

Electricity in Mining.—The report of the Dolcoath Mine (Ltd.) for the half-year ended June 30 states that a satisfactory contract has been entered into with the Cornwall Electric Power Co. and the Urban Electric Supply Co. for the power required for pumping at this shaft, and also for driving the new 12 heads of pneumatic stamps, orders for which have been placed.

Gravesend.—Sanction has been received to loans of £3,250 for excess expenditure on the electricity undertaking, £1,800 for new mains and £700 for house services.

In regard to the proposal to extend the present system of public electric lighting, the L.G. Board recommend the Council to carefully consider the comparative cost of lighting by electricity and gas.

At the meeting of the Council last week, Councillor Huartson moved that a chartered accountant be appointed to investigate the electricity

accounts and report as to the financial and commercial position of the electricity works, and that the L.G. Board be asked to nominate such accountant. After discussion the resolution was lost by nine votes to six.

Hospital Lighting.—Aberdeen Public Health committee have decided to adopt electric lighting at the new and old buildings of the City Hospital at a cost of about £500. This decision has been arrived at after a careful comparison of the cost of electricity and gas.

Huddersfield.—On Wednesday the Council sanctioned application being made for a provisional order for the construction of additional tramways.

Ipswich.—The Council have arranged to give a seven years' supply of current to the Admiralty telegraph station at 1¾d. per unit, on an annual consumption of 40,000 units. The Admiralty will bear the cost of surface cables and pay £5. 10s. a year for upkeep.

Kearsley (Lancs.)—The Board of Trade have approved the transfer of the Council's electric lighting order to the Lancashire Electric Power Co.

Light Railway.—The Board of Trade have confirmed the Dover, St. Margaret's and Martin Mill Light Railway Order, 1909, authorising the construction of light railways in the borough and rural district of Dover.

Maldens and Coombe.—Last week the Council were recommended to receive the report of the Parliamentary and Electric Lighting committee, with a view to the opinion of an expert engineer being obtained on the question of electricity supply.

Mr. DAVIS, in moving the adoption of the report, asked the Council to reconsider the decision arrived at at the last meeting. A large number of ratepayers desired electric light, and it seemed to him that the Council was bound to see if it was expedient to introduce it.

After discussion, the recommendation was rejected, and the members of the committee subsequently resigned.

Marriage.—At Burnley, on Aug. 12, Mr. Thos. Medcalfe, general manager of the Swindon tramways, was married to Miss Alice I. Grey.

Mining Fatalities.—A serious accident occurred on Thursday last at the Cribbwr Fawr Colliery, near Porthcawl, Cornwall, resulting in the death of two men, David Thomas and Owen Davies.

It appears that the two men were descending to work when they accidentally touched an electric cable and received a severe shock. A similar accident, fortunately without serious results, occurred in the same mine a few days previously. The cables carrying electricity to light the colliery are suspended from the roof of the drift. The two men mere in the act of leaving the tram, and, slipping, put out their hands, which came in contact with the live cable.

An inquest was opened on Saturday, but after evidence of identification had been given, the coroner (Mr. H. Cuthbertson) adjourned the inquiry for the attendance of H.M. electrical inspector of mines.

At Auchingiech Colliery, Chryston, N.B., a miner named M'Mahon was killed on Sunday. Deceased was engaged splicing a rope, with the aid of a portable electric lamp. On taking the lamp off the hook he received a slight shock, which caused him to drop the lamp, when it burst. Evidently thinking that the current was cut off he stooped to lift it when he received the full voltage, death being instantaneous.

Newport (Mon.)—Mains extensions (estimated to cost £130) have been authorised to supply energy for power to Messrs. Guest, Keen & Nettlefolds and to Messrs. King & Co.

Northampton.—Electric power is to be used for driving the laundry machinery at the general hospital.

Personal.—Sir Matthew Nathan, G.C.M.G., has been appointed secretary to the Post Office in succession to Sir H. Babington Smith, K.C.B., C.S.I., who has been appointed president of the National Bank of Turkey. Sir Matthew Nathan will take up his duties in January next, on his return from Natal.

Mr. Frank Stuart Milne, who some time ago left the Newcastle-upon-Tyne Electric Supply Company to take up an important appointment in the Argentine in connection with the electrical department of the State railways, has, in view of the rapid commercial expansion of the Republic, commenced business in Buenos Aires as commercial engineer and agent for British railway, mechanical and electrical engineering firms. Associated with him as British engineer and secretary is Mr. J. A. Seager, A.M.Inst.C.E., A.I.E.E., and any firms desiring representation in Argentina should communicate with the latter gentleman at Emerson Chambers, Newcastle-upon-Tyne.

Presentations.—In celebration of the recent marriage of Mr. Harold Dickinson, manager of Leeds Corporation electric lighting department, a social gathering of the officers and workpeople, together with their wives and lady friends, was held at the Grand Central Hotel, Leeds, on Friday evening, 13th inst., when Mr. Dickinson was presented with a grandfather clock and silver tea and coffee service and other articles subscribed for by the entire staff, numbering 237 persons.

The directors of Suffolk Electricity Supply Company have presented a cheque for £10. 10s. and the staffs at Stowmarket, Diss and Felixstowe a marble clock to Mr. Frank Allen on his marriage.

Railways and Tramway Competition.—The "Financial Times" of 16th inst. contains an article on this subject.

It is stated there is what might be called a vulgar impression abroad as to the efficacy of electrification to meet tramway competition. Electrifying suburban lines will not in itself draw traffic to the tramways, but it provides the means of so doing by enabling a fighting policy to be adopted. Thus, as the North-Eastern Railway, where the conversion of the Tyneside lines from steam traction has actually brought back traffic that had gone over to the tramways, electrification enabled the company to put on a fast and frequent service that would otherwise have been either impossible or unremunerative. So far as the London district is concerned, it is impossible to deny that the railways are themselves largely to blame for the present situation. The development of the tramway network has been so gradual that some form of campaign might have been devised before competition had become really serious; yet it is no exaggeration to say that no step of any importance was taken until at least a large proportion of the traffic diverted had been permanently lost. But the chief indictment relates to fares and facilities. In many parts of the metropolitan area, especially in the south and west, the train services are in frequency and speed exactly the same as a generation ago, whilst the fares, which have also been unchanged, are twice as high as those charged by tramcar. Can it be wondered at if the public prefer the more convenient, more frequent and cheaper service given by the tramways, although for journeys of more than a very few miles the railway has an undoubted superiority if the suburban traffic facilities were only remodelled on modern lines.

Seoul (Corea).—The local electric tramway and electricity supply works have been purchased by the Japanese Gas Co.

Southport.—Metallic filament lamps have recently been substituted for carbon filament lamps in several thoroughfares.

Theft.—At West Ham Police Court on Tuesday Geo. Freakley was sentenced to six months' hard labour for stealing platinum valued £173, the property of the Indiarubber, Gutta-percha & Telegraph Works Co. at Silvertown. Freakley was chief clerk in the instrument department.

Turin International Exhibition of Industry and Labour.—This exhibition, which will be held between April and October, 1911, will have important electrical and mechanical engineering groups. The electrical group will be divided into seven classes—viz., mechanical generation and supply of electric power, mechanical utilisation of electric power, electric lighting, telegraphy and telephony, electrochemistry, electric power measuring instruments, and apparatus for scientific and experimental researches. Particulars as to charges for space, &c., from the Executive committee, Turin.

Uruguay.—Mr. J. R. Kennedy, H.M. Minister in Uruguay, in his report on the trade and commerce of the Republic for 1908, states that last year a special committee was appointed to report upon the question of establishing a Government or municipal telephone service.

The committee recommended the institution of a national telephone service with underground lines, in accordance with plans drawn up by a British engineer, in place of the present overhead system, and a project of law dealing with the question (which is, however, beset with certain legal and equitable difficulties in connection with the existing telephone companies) has been submitted to the Chambers by the Government. The cost of the proposed work, calculated at $1,000,000 (£212,766) will probably be met by a 5 per cent. loan of $1,500,000 (£319,149).

The electrification of the tramways of Monte Video has been completed after nearly four years' work. The contract included the construction of 82 miles of track, the supply of 215 cars, the building of power houses, &c., the plant, rolling stock, &c., are British.

Widnes.—The Council have decided to obtain a report from an electrical engineer on the electricity supply scheme submitted by Mr. J. Carr.

Wireless Telegraph Notes.—The "Review of the River Plate" states that the Argentine Government have resolved to establish wireless telegraph stations between Buenos Aires and Ushuaia at a cost of $75,000 gold, the work to be finished by May, 1910.

In the estimates of the Australian Commonwealth provision is to be made for the erection of three wireless telegraph stations.

It is announced that the Governor of Natal (Sir Matthew Nathan) and the Prime Minister of the Colony (Mr. Moore) are negotiating with the Imperial Government on the subject of the establishment of wireless telegraph stations on the South African Coast, as it is regarded as very desirable that a station should be established on the Bluff at Durban. The scheme in view is the establishment of a line of wireless stations between Delagoa Bay and Cape Colony, and it is also urged that a similar system should be established on the West Coast.

The French Inter-Ministerial Commission on Wireless Telegraphy, of which M. Henri Poincaré is president, has drawn up a bill pro-

hibiting employment of any radio telegraphic apparatus on French territory or on board any French vessel without State authorisation. A penalty of from one month to one year's imprisonment (or a fine of from £40 to £720) is proposed. Heavy fines are also to be imposed on persons receiving and divulging radio-telegraphic or radio-telephonic messages.

It is reported by a "Times" correspondent that the Military Department at St. Petersburg has made successful trials with wireless telegraphy between St. Petersburg and Sebastopol, a distance of about 1,900 miles.

It has been stated that wireless messages from New York are received or intercepted almost daily by the military station on the Eiffel Tower, outside Paris. Occasionally raido-telegrams have also been received from Canada, which, it is believed, form a record in wireless working.

A wireless telegraph station has placed Mazatlan (Mexico) in communication with Lower California.

The experimental work which has been conducted with wireless telegraphy by the Direct West India Cable Co. at Kingston, Jamaica, has, so far, been limited to about 70-mile radius. The Lepel system is being installed, and the station will have a range of 300 miles. A 190 ft. mast will be used. Mr. W. H. Marchant, representative of the Lepel Co., has returned to England, and the company are considering whether the existing station shall be transferred to Bowden or to some other more suitable place if certain disadvantages now experienced cannot be overcome.

Wireless Telegraphy in the Navy.—The Lords Commissioners of the Admiralty have had under consideration the question of the emoluments of officers of the Royal Marines appointed to the charge of wireless telegraph stations, and have decided that the extra responsibility imposed upon these officers merits additional remuneration. His Majesty, by Order in Council, has sanctioned the grant of an allowance of 2s. 6d. per day to officers of the Royal Marines when appointed to the charge of wireless telegraph stations. In addition, there is to be a further allowance of 1s. per day in lieu of a servant to these officers while they are employed on telegraphic duty. The new allowances take effect as from Nov. 14, 1908, and are to be in addition to the full pay of the officers employed.

Workhouse Lighting.—The Works committee of Sculcoates Board of Guardians are endeavouring to obtain better terms from the Hull Electric Lighting committee for a stand-by supply of electricity for lighting.

The city electrical engineer (Mr. H. Bell) recently offered a supply at £4 per kw. per annum for the maximum kilowatts demanded, plus a charge of ½d. per unit for every unit used; but the Works committee consider these terms unreasonable.

Haslingden Guardians have instructed Messrs. Peers, Copland & Cardin to draw a specification for wiring the workhouse and infirmary.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—On Monday the Corporation approved the tramway estimates for the ensuing year.

The income is calculated at £69,580, including £68,120 from passenger fares. The expenditure is estimated at £57,921, which would leave a balance of £11,659. The traffic expenses are estimated at £17,443; electric current at £9,400, and maintenance of permanent way, £5,470.

Bermondsey (London).—The accounts of the electricity undertaking for the year ended March 31 show that 2,781,583 units were sold and the income was £20,172.

The cost of coal was £3,918 and the total expenditure was £18,443, or 1·59d. per unit sold. After paying interest and instalments of loans the net profit was £123, which has been carried to reserve.

During the quarter ended June 30, the number of units sold exceeded those in the corresponding period of 1908 by 16½ per cent.

Bradford.—The accounts of the tramways department for the year ended March 31 show total revenue £244,235, an increase of £1,086 over 1907-8.

Traffic receipts were £234,223 against £235,258, parcels revenue £7,350 against £6,023 and motor garage department £1,484 against £943. The total expenditure (including interest and sinking fund) was £170,196, compared with £167,994.

In the lengthy report of the general manager (Mr. C. J. Spencer) it is stated that the amount paid to workmen under the Workmen's Compensation Act is considerable, and continues to grow, and the Corporation are thinking of dealing with the question, as it affects all departments. The amount paid under the head of accident insurance and compensation was £1,964, a decrease of £2,039. The number of parcels handled during the year was 605,513, against 576,041, and the small capital of £2,360 invested in this branch of the business is earning from £1,000 to £1,500 a year in profit. 800 tons of tobacco were carried by the cars in Bradford and district during the year, and £238 was received for the carriage of milk from the suburban districts to the centre of the city. The increase of £1,327 in the earnings of the department is due largely to the new work undertaken for the Education committee in conveying food from the feeding centres to the schools. Two lorries of 1 ton and 3 tons capacity were purchased during the year to meet the extra traffic. The through traffic between Bradford and Halifax and the Heavy Woollen District still shows an increase. 47,660,011 passengers were carried, compared with 47,839,569 in 1907-8, a decrease of 179,558, and the car-mileage was 5,376,228 against 5,331,007. The average receipts per car-mile were 10·66d. against 10·70; the total expenditure averaged 7·598d. against 7·563d. per car-mile.

Broken Hill (Australia).—The profit on the working of the municipal electricity works for 1908 was £2,654.

Glasgow.—The gross revenue of the electricity department for the year ended May 31 was £245,673, including £234,164 from the sale of current by meter, £9,944 from public lighting and £1,565 from private street and stair lighting.

The expenses were £104,902 (including £59,332 cost of generation) and depreciation on works, machinery, mains, &c., came to £53,260, leaving £87,511 to meet interest (£54,748) and sinking fund charges (£36,308) so that there was a deficit of £3,545, which has been met out of reserve. The reduction in the charges for current last year, the extensive use of metallic filament lamps, and general trade depression have caused a decrease in income of £7,729, which was more than counterbalanced by a decrease in expenses of £10,415. The deficit is due to the increased contribution to sinking fund of £4,000 and to the increase in depreciation of £3,108 compared with 1907-8. The units generated were 41,493,033, and the units sold 34,464,911, including 32,736,058 to private consumers, 1,555,150 for public lighting and 173,703 by contract. There are 18,158 consumers (against 16,926), 837 public lamps, and the total maximum supply demanded was 49,115 kw. (against 47,007 kw.). The total motors connected were 4,292 (of 29,505 H.P.), against 3,853 (of 23,748 H.P.); and the units consumed for power amounted to 17,612,483. The equivalent of 1,566,907 8 c.p. lamps is connected, an increase of 70,280 8 c.p. The capital expenditure is £1,800,203, an increase of £168,378 during the past year.

Greenock.—There was a net profit on the past year's working of the electricity department of £1,045, which is to be placed to reserve.

Hull.—The accounts of the Corporation electricity department for the year ended March 31 show total net income of £49,501, including £29,330 from the sale of electric current by meter for lighting, £17,827 from power and £624 from public lighting.

The expenses came to £26,958, including £15,759 for generation (£8,496 being for coal), distribution £4,275, and management and general expenses £2,980. The gross profit was £22,543. Interest absorbed £11,401, capital charges £9,886 and income tax £90, leaving a net profit of £1,165, out of which certain items for show-room equipment and for capital outlay in excess of loan sanctions were paid, and £747 was carried to reserve. The total capital exepnded is £389,476, an increase of £17,622 during the year. 8,431,114 units were generated; 73,800 units were supplied to the public lamps, 5,649,274 were sold to private consumers and 2,179,443 units were used on works. There are 3,039 consumers, and the total maximum supply demanded was 4,513 kw. The works costs were 0·83d. per unit sold (against 0·88d.) and the total costs were 1·92d. (against 2·02d.)

In the report of the city electrical engineer (Mr. H. Bell) it is stated that the units sold for lighting have actually fallen to a lesser figure than the previous year and that the total income has only been maintained by reason of the largely increased sale for power. The income from private lighting was £29,330 (against £30,232) and from power £17,826 (against £16,291). In regard to costs there is a reduction practically under all heads and it is claimed that before long Hull will have reached a figure quite comparable with the larger towns of England which have no traction or public lighting supply. During the year a large amount of new plant was installed in order to replace unreliable or obsolete machinery. The three 500 kw. dynamos are working satisfactorily and have more than fulfilled expectations. There are still certain dynamos at the works which it would be desirable to replace when opportunity offers, and Mr. Bell suggests that a fund for the purchase of these machines should be spread over three years. A considerable amount of obsolete and unreliable mains, principally in the old town, have been replaced by mains of modern description. The mains renewals represent an outlay on the year's trading account of approximately £1,336, less sales of scrap metal £232, or £1,104 net. An information bureau and show rooms have been opened.

Ipswich.—The accounts of the electricity department for the year ended March 31 show total income of £15,390. 15s., including £12,307 from the sale of current for lighting, power and traction.

The expenses were £9,496, leaving £5,895 to meet interest (£3,040), and after providing for repayment of loan, preliminary expenses, &c., the surplus was £166. 8s. 11d., compared with a deficit of £926. 11s. 4d. in

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1908. 1,399,990 units of electric current were sold, including 365,725 units for private lighting, 296,725 for power and 733,369 for traction. The total maximum supply demanded was 837 kw. The total capital expenditure is £87,015, an increase of £2,353 during the year. There are 603 consumers, an increase of 137 compared with 1908, and the equivalent of 64,839 8 c.p. lamps is connected, against 56,420.

In the report of the engineer and manager (Mr. Frank Ayton) it is stated that negotiations have been concluded with the Admiralty for supplying electrical energy for operating the new wireless telegraph station. A special feeder is to be supplied for this purpose at the expense of the Admiralty. The free wiring system for consumers' installations, which was introduced in March last year, has been very successful, 69 consumers having been connected on this system since its inception. The capital expended on this branch at March was only £488. Under the scheme for hiring out arc lamps for shop lighting, 26 lamps have been installed, representing a capital outlay of £128. There has been a considerable increase in the turnover of the installation department, on which there was a profit of £150 on the year's working.

The total revenue of the tramways department for the year ended March 31 was £20,169, including £19,592 from traffic revenue. The total working expenses came to £16,383, including traffic expenses £7,366, general expenses £1,638, power (current at 1½d. per unit) £4,585, and repairs and maintenance £2,795. The gross profit was £3,786, interest absorbed £4,028, repayment of loan £1,852, and the proportion of preliminary expenses was £200. The total capital outlay is £114,431, an increase of £85 during the year.

Leeds.—For the year ended March 31 the total receipts of the tramways department were £342,000. 19s. 7d., including £338,031. 13s. 5d. traffic revenue.

The working expenses were £178,323. 16s. 5d., leaving a gross profit of £163,677. 3s. 2d., against £163,063. 16s. 3d. in 1907-8. After paying interest, redemption charges, income tax and providing for permanent way renewals, &c., and placing £4,000 to reserve, there was a net surplus of £47,566. 12s. 5d., against £64,279. 13s. 7d. The reduction in net profit is due to increased interest and sinking fund charges, provision for reserve, permanent way renewals, &c. 76,215,618 passengers were carried (against 75,734,083 in 1908) and the car-mileage was 7,828,794 (against 7,694,989), the receipts per mile being 10·47d. (against 10·62d.).

In regard to the electricity department it is reported that, while the use of electrical energy and power continues to extend, special conditions caused a diminution in the sales and a large reduction in revenue during the past year. There was a reduction of £7,842 in the receipts from the sale of current for private lighting due to the extended use of metallic filament lamps. The substitution of these lamps reported to the department represented a reduction equal to 11,490 35 watt lamps. There was an increase in the aggregate number of units sold for power, but there was a decrease in revenue of £1,935 due to reduced charges. The total receipts for the year were £104,148 (including £73,087 from private lighting and £25,911 from power); the working expenses were £34,271, and the cost of extraordinary renewals £2,139. The gross profit was £67,738. Income tax and interest absorbed £29,193 and redemption fund charges came to £30,297, leaving a surplus of £8,248. 12,395,118 units of electric current were sold (against 12,412,861 in 1908), including 5,241,523 for private lighting (against 5,771,597), 988,785 for street lighting (against 895,009), and 6,164,810 for power and heating (against 5,746,255). The units sold per 35 watt lamp installed were 19·69 (against 21·25 in 1908), and the average net price per unit was 3·01d. (against 3·08d.). The revenue per horse-power installed for power and heating was £2. 17s. 8d. (against £3. 13s. 2d.). There are 5,632 consumers for lighting (an increase of 128), and 958 consumers for power and heat (an increase of 127), and the total connections represent 562,170 35 watt lamps (against 527,370), an increase of 34,800. There are 1,710 motors, representing an aggregate horse-power of 9,942. Out of the surplus profit for the year £3,000 has been carried to the newly-formed reserve fund, and the balance has been applied in relief of rates. Up to date £45,867 has been contributed out of the profits of the electricity works to relief of rates. The maximum load upon the plant was 8,220 kw., compared with 8,300 kw. in the preceding year. The capital expenditure during the year was £37,130. 10s. 6d., and the gross outstanding debt is now £755,844. 10s. 7d. The total working expenses were 0·67d. per unit sold (the same as last year), and the total costs were 1·86d. (against 2·06d.).

Portsmouth.—The traffic receipts of the Corporation tramways for the year ended March 31 were £99,449. 11s. 2d. and other revenue amounted to £1,704. 18s. 9d., total £101,154. 9s. 11d., increase £1,813. 16s. 7d. over 1907-8.

Working expenses were £48,879. 3s. 7d. and gross profit £52,275. 6s. 4d., which, with £147. 8s. 4d. for bank interest, made a disposable balance of £52,422. 14s. 8d., against £51,689. 18s. After paying interest, sinking fund, income tax, &c., the net profit was £13,615. 3s. 5d., an increase of £482. 14s. 9d. £8,971. 13s. 7d. was placed to renewals fund, £2,320. 2s. to reserve, £2,000 to relief of rates, and, after various charges for extensions, &c., had been met, the balance was carried forward. 21,735,613 passengers were carried and 2,361,347 car miles run. The output of the generating station was 2,589,460 units (an increase of 69,970). Cost of generation was 0·543d. per unit, or 0·058d. less than in 1907-8.

Sydney (N.S.W.).—The revenue of the electricity supply department for the year ended Dec. 31, 1908 was £87,006, compared with £59,742 in 1907.

The total expenses were £56,785, compared with £31,899, leaving a gross profit of £30,221, against £27,844. After deducting debenture interest, sinking fund, &c., the net profit was £13,113, against £15,557 in 1907. 2,540,437 units were supplied for private lighting, 3,097,936 units for power and 1,395,788 units for public lighting.

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer We would add that the portrait is mounted so as to be conformable is to size with "The Electrician" series of steel plate portraits, and a well suited for framing with the series.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

LEYTON Urban District Council invite tenders for wiring and electric light fittings for the extension of the public offices now in course of erection. Specification, conditions and form of tender may be obtained from the architect (Mr. Wm. Jacques, A.R.I.B.A.), 2, Fen-court, Fenchurch-street, London, E.C. Tenders must be delivered at the meeting of the Council, to be held at the Town Hall, Leyton, on Tuesday, Sept. 7, at 7 p.m. See also an advertisement.

LEYTON Urban Council also invite tenders for public lighting lanterns with clock switches for incandescent electric lamps. Tenders to the Clerk, Town Hall, Leyton, by 7 p.m. Sept. 7.

Tenders are invited for supply of 2,550 common battery telephones and protectors to the Postmaster-General's Department, NEW SOUTH WALES. Tender forms, &c., may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited by LEEDS Corporation for supply of paper-insulated cables required during one, two or three years (at the option of the Corporation, to be declared on the acceptance of the tender), commencing Jan. 1, 1910. Copies of specification, conditions of contract and form of tender from the manager of the electric lighting department, Mr. H. Dickinson, 1, Whitehall-road, Leeds. Tenders to the town clerk, Mr. Robt. E. Fox, by 10 a.m. Tuesday, Sept. 7.

LONDON County Council also invite tenders for the manufacture, delivery and laying of about 6½ miles of 0·075 sq. in. three core lead-covered h.t. cables, &c., and about 46 miles of single core lead-covered l.t. cables, telephone cables, &c.; manufacture (but not erection) of 50 tramway feeder pillars; laying about 16 miles of stoneware cable ducts, including necessary manholes, repaving, &c., and manufacture and delivery of 440,000 ducts of glazed stoneware for electric cables. Drawings, &c., at the County Hall, Spring Gardens, S.W. Tenders to the Clerk by 11 a.m. Sept. 14.

LONDON COUNTY COUNCIL invite tenders for the roadwork and platelaying required for the reconstruction of the tramway in Highgate Hill. Tenders to the Clerk, Spring-gardens, S.W., by 11 a.m., Sept. 7.

LONDON COUNTY COUNCIL also invite tenders for the partial reconstruction of the bridge carrying Lower-road, Deptford, over the East London Railway, and reconstruction and widening of the bridge carrying the same road over the Grand Surrey Canal. Tenders to the Clerk by 11 a.m., Sept. 14.

EDINBURGH Corporation invite tenders for the supply at the McDonald-road electricity supply station of a motor-alternator. Specification, form of tender, &c., can be obtained at the engineer's office, Dewar-place. Specification, general conditions and drawings can be seen at (but not obtained from) the office of the consulting engineer, Sir A. B. W. Kennedy, 17, Victoria-street, London, S.W. Tenders to the Town Clerk, City-chambers, Edinburgh, by Sept. 4.

EDINBURGH Corporation also want tenders by Sept. 4 for the electric lighting installation at the new slaughter houses. Specification from the Engineer, Dewar-place, Edinburgh.

The Cleansing committee of DUBLIN Corporation invite tenders for supply of one electric water sprinkling car, fitted with electrically-driven air compressor or "Roturbo" pump. Specification, form of tender, &c., from the secretary, Mr. Fred. J. Allan, 3, Cork-hill, Dublin, where tenders must be delivered by noon Tuesday, Aug. 31.

Tenders are required by Sept. 10 for supply and erection of overhead cables in connection with the electric lighting of BALLINASLOE District Lunatic Asylum. Specifications from Mr. G. B. Meenan, 5, Charleville-road, Rathmines, Dublin.

PLYMOUTH Corporation invite tenders for the supply and erection of a steam turbo-dynamo, &c. Tenders to the Borough Electrical Engineer by Sept. 2.

WISHAW Burgh electricity department require a three-wire d.c. switchboard. Specifications from the Burgh Electrical Engineer and tenders to Town Clerk by 30th inst.

TENDERS RECEIVED AND ACCEPTED.

John Booth & Sons, Bolton, recently secured the contract for the steelwork and the erection of a generating station for the Northern Light, Power & Coal Co., of Dawson City, Klondyke, who are putting down plant for the supply of electric energy for lighting and power to the surrounding mining district.

Worksop Council have accepted the following tenders :—

W. T. Glover & Co. 660 yds. vulcanised cable, £7. 16s. 5d., and joint box compound £1. 1s. per cwt.; T. J. Green, black corrugated sheets, £3. 17s., and steel joists and angles, £6. 10s.; S. Broadway & Co., bolts, nuts, &c., £2. 18s. 4d.

Newport (Mon.) Council have accepted the tender ofthe Liverpool Electric Cable Co. for 2,500 yds. of small cable (at £65. 6s. 9d., less $2\frac{1}{2}$ per cent.), and that of the General Electric Co. for lamp fittings at £1. 2s. 6d. per set.

Messrs. Maxwell, Son & Co. have secured the contract to instal electric light throughout the premises taken over by the Admiralty at Rosyth for the naval base. The contract comprises the illumination of the officers' quarters, out-buildings, lavatories, and extra lights surrounding the dry dock.

Eastbourne Education committee have accepted the tender of the Corporation electricity department for wiring the Willowfield Higher Grade Schools.

Dewsbury Infirmary Board have accepted the tender of E. J. Hood for wiring the nurses' home.

Hyde Council have accepted the tender of Mr. Fern for wiring the fire station.

Gravesend Council have accepted the tender of W. R. Wills for an automatic stoker at £215.

Glasgow Libraries committee have accepted the tender of Allan, Arthur & Ure for the wiring of the new Mitchell Library at £2,799.

BUSINESS NOTICES.

Messrs. A. P. Lundberg & Sons notify that Mr. H. Jackson is no longer representing them.

Mr. James Veit has been appointed secretary and Mr. F. B. Pell sales manager of Ship Carbons (Ltd.), 67, Aldersgate-street, London, E.C.

Messrs. Stewart & McDonald have commenced as electrical engineers and contractors at 245, Buchanan-street, Glasgow.

The Omega Electric Lamp Co. have moved into their new factory at Palace Works, Crab Tree-lane, Hammersmith, W.

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell will sell by auction in lots at the Edisonia Works, 62, Glengall-road, Old Kent-road, London, S.E., on Wednesday, Sept. 8, and following days, a number of modern machine tools, including 30 screw-cutting and other lathes, 10 capstan lathes, milling and shaping machines, &c.; also 13 c.c. motors, three dynamos, shafting, pulleys, belting, &c., 800 Edison electric 200-thread phonographs for Amberol records, 200 electric multiplex phonographs, &c. On view two days preceding sale. Catalogues may be had on the premises or of the Auctioneers, 11, Billiter-square, E.C. An advertisement contains further particulars.

Telegraph Patents Development.—The owners of certain patents relating to "Improvements in printing telegraphs, typewriters &c.," and "Apparatus for punching strips of paper and like materials, suitable for use in telegraph transmitters, &c.," desire to enter into negotiations with the view of granting licences under same. Information may be obtained from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C. See also an advertisement.

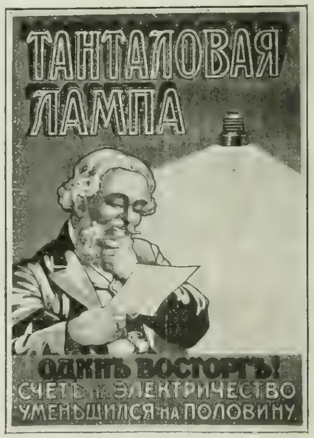
Telegraphone Patents.—Messrs. W. E. Heys & Son, 51, Deansgate-arcade, Manchester, are desirous of entering into arrangements on behalf of the owners of Poulsen's, Pedersen & Schou's telegraphone patents for developing same in this country.

Patents Development.—The owners of patents No. 11,933/1900, for "Improvements relating to the regulation of electric motors," Nos. 19,899/1905 and 26,808/1905, for "Improvements relating to a.c. electric motors," desire to enter into arrangements, by way of licence and otherwise, for exploiting same. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

The owners of patents No. 23,501/1899, relating to "Improvements in vacuum tube lighting," and No. 12,582/1902, relating to "An improved system of electric lighting," wish to negotiate for the granting of licences. Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's-inn-fields, London, W.C.

The Proprietors of patent No. 226 of 1904 relating to "Improvements in electrical conductors for illuminating purposes such as lamp pencils or filaments," desire to sell the patent or to grant licences. Inquiries to Messrs. Hyde & Heide, 3, Bread-street, buildings, Liverpool-street, E.C.

"**Tantalum Lamp Posters and Show Cards.**"—The "Satisfied Consumer" design of posters and show cards for advertising tantalum lamps are now widely known. The design has not only appealed to the electrical trade in this country, but has found a ready acceptance

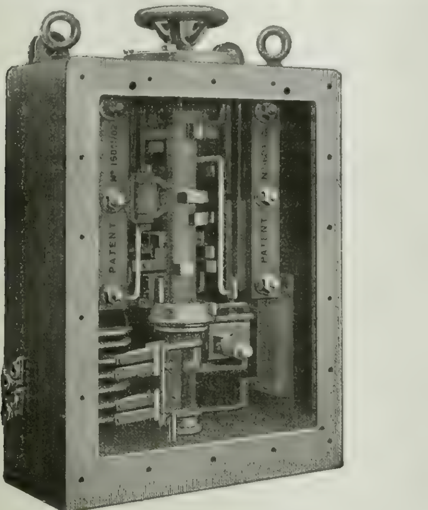


on the Continent. It has been translated into Russian, German, Spanish and Portuguese. It will be understood, however, that for different countries an alteration in the design is necessary to bring it into line with the prevailing types of the country represented. We reproduce the Russian version of the "Satisfied Consumer."

"**A.E.G. Zeitung.**"—The August number of this journal contains the first part of an article by Dr. Bloch on "Electricity in the Home." In this instalment lifts for persons and things are also dealt with, together with ventilation, vacuum cleaners and portable fans. Other articles deal with "The Efficiency of Sub-stations, with Rotary Converters" and the "Test Bed of the A.E.G. Turbine Factory." An article on Edison concludes the number.

Flame-proof Drum Type Starters.—The accompanying illustration shows a new type of flame-proof drum type starter manufactured by Messrs. A. Reyrolle & Co., of Hebburn-on Tyne, who have been very carefully studying the question of switchgear in mines for some considerable time. Internally the starter is of the firm's standard drum

type construction, and it is, of course, fitted with the "Reyrolle" patent "current growing" resistances. The outer casing, however, consists of a specially strong casting provided with a broad metal flange, to which the steel cover is bolted. This flange is very carefully machined, as is also the bearing surface of the cover, and the result is a joint through which flame cannot pass owing to the cooling effect of the adjacent large masses of metal. The main spindle works through a long close-fitting bearing, and special provision is also made for working the push button. This design has been used with success for a considerable period, and the makers express every confidence in this type.



FLAME-PROOF DRUM TYPE STARTER.

CATALOGUES, &c.

OERLIKON MOTORS AND GENERATORS.—We have received from Mr. G. Wüthrich, who represents the Maschinenfabrik Oerlikon in this country, a couple of illustrated leaflets dealing with this firm's latest direct and alternating-current machines. The first pamphlet describes and illustrates direct-current motors and generators for small outputs, together with the necessary starters and regulators for these machines. Single, two-phase and three-phase asynchronous motors are dealt with in the second pamphlet.

D.P. STORAGE BATTERIES FOR POWER.—A pamphlet with this title, which we have received from the D.P. Battery Co., contains some interesting information regarding the application of accumulators to crane work. The current for driving some cranes recently installed at Southampton is provided by a producer gas engine. As the load is naturally of a very fluctuating nature, and, therefore, bad for this type of engine, a D.P. battery having a capacity of 400 amperes for one hour, or 1,000 amperes for short periods, has been installed. By means of this battery we are informed that, although the load fluctuates from zero to 800 amperes, the variation in the current taken from the generator is only about 15 amperes above or below the mean. The operation of this plant is well shown in the pamphlet by means of charts taken under working conditions.

WHIPALL ELECTRIC TYRE PUMP.—Mr. E. E. Coy, of Liverpool, sends us a pamphlet dealing with an electrically-driven tyre pump. This equipment should be of great use in garages and other places where much tyre pumping has to be done.

BANKRUPTCIES, LIQUIDATIONS, &c.

Herbert Shuttleworth, electrical engineer, Cross-court, Briggate, Leeds, has been adjudicated bankrupt. First meeting of creditors Aug. 25 at O.R.'s, 24, Bond-street, Leeds, and public examination Sept. 14 at the County Court House, Albion-place, Leeds.

A first and final dividend of 2s. 4½d. is payable on Aug. 27 at 147, Leadenhall-street, London, E.C., to the creditors of J. H. Mockridge and Arthur Pearce, lately trading as Jukes, Coulson, Stokes & Co. and as Moreton & Foster, engineers and contractors.

In the winding up of Auto-Controllers (Ltd.), of Bournemouth, Mr. Charles R. Blissett, 35A, Christchurch-road, Bournemouth, is liquidator

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—The undermentioned Applications [illegible] inspection until after acceptance of Complete Specification. [illegible] inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.

July 9, 1909.

16,029 WALLWORK, WALLWORK & [illegible] [illegible] machine.
6,076 [illegible] ELECTRIC LAMP CO. (Dr. Carl [illegible], Germany.) [illegible] metallic connection between incandescent filaments and their leading-in wires.

July 10, 1909.

16,095 HILL. Electromagnetic clutches.
16,114 ELECTROMOTOR EQUIPMENT CO. & BARLOW. Controlling mechanism of automatic electric lifts.
16,170 HUNT & SANDYCROFT FOUNDRY CO. Alternating-current [illegible] machines.
16,174 MAVOR & MAVOR & COULSON. [illegible]

July 12, 1909.

16,203 BURTWELL & HODDER. Operating tramway and like points from the vehicle.
16,205 TAYLOR. Direct-current and alternating-current balancers, boosters and auto-transformers.
16,222 KENT. Lights with permanent metallic electrodes.
16,224 BUNET & BADIN. Production of compounds of oxygen and nitrogen by electrical means. (Date applied for, 17/8/08.)*†

July 13, 1909.

16,273 FERGUSON. Automatic electric switches.
16,292 MESSENIE & SLAUGHTER. Arc lamps.*
16,328 WEBER. Incandescence lamp filaments.*
16,331 MORRISON. Electric transmission for motor vehicles.*
16,332 JOHNSON & BILLINGTON. Electricity meters.

July 14, 1909.

16,415 WILSON & WILSON. Valves or rectifiers for high alternating P.D.s
16,447 MIDGLEY & VANDERVELL. Dynamoelectric machinery.
16,457 HAEFELY. Apparatus for winding frames, coils and similar parts of electric machinery with insulating material, and for manufacturing structures from the same material.*

July 15, 1909.

16,475 CARTER. Multiplex accumulator.
16,476 ALLDAYS & ONIONS PNEUMATIC ENGINEERING CO. & JOSELIN. Electrically-driven centrifugal fans.
16,520 TATTERSALL. Telephone and other similar mouthpieces.
16,522 TAYLOR. Methods of charging and discharging electric accumulators or secondary batteries.
16,537 SIEMENS BROS. DYNAMO WORKS & SCHUPP. Electric motor-starting switches.*
16,538 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Bearings of electricity meters.*
16,547 ROSS. Electric heaters.
16,552 J. STONE & CO. & VIDAL. Electrical generating plant.
16,558 LAKE. ("Polyfrequenz" Elektricitäts-Ges.m.b.H., Germany.) Devices for producing electrical oscillations.*
16,559 MILCH. Control of induction motors.

July 16, 1909.

16,575 GLEW. Instrument for collecting atmospheric electricity.
16,584 MICKLETHWAIT. Electric terminals or binding screws.
16,607 CHETWYND, KELVIN & JAMES WHITE & CLARK. Portable magnetic compasses. (Addition to No. 21,634/08.)
16,621 RENNIE. Electrical device chiefly designed for use in indicating the speed of vehicles.
16,630 AKT.-GES. BROWN, BOVERI ET CIE. Regulation of electric installations. (Date applied for, 16/9/08.)*†
16,631 AKT.-GES. BROWN, BOVERI ET CIE. Control of dynamoelectric machinery in electric lighting installations worked with accumulators. (Date applied for, 14/9/08.)*†
16,642 AITKEN & BRITISH INSULATED & HELSBY CABLES. Telephone switchboards.
16,643 AITKEN & BRITISH INSULATED & HELSBY CABLES. Telephonic sub-station switching systems.*
16,645 DALZIEL'S CONSTANT VOLTAGE PATENTS & DALZIEL. Electric distribution systems
16,649 WEST. Quick make and break electric switches.
16,662 DEARLOVE & BROWN. Manufacture of electrical condensers and similar apparatus

July 17, 1909.

16,678 BROOK & HIRST. Multiple electric switches and automatic circuit-breakers.
16,679 RICHMOND. Electric batteries.
16,682 JACKSON. Trolley heads employed for electric traction.
16,690 WRAITH. Portable electric hand lamps.
16,702 SIMMONS. Electric batteries.
16,709 NOBEL'S EXPLOSIVES CO. & EVANS. Electric igniting apparatus.
16,728 VANDAM. Means for making electrical connections.
16,732 DELAGE & WOOG. Amplifying device for use in high-tension electric spark-ignition apparatus. (Date applied for, 12/10/08.)*†

July 19, 1909.

16,811 SIEMENS BROS. DYNAMO WORKS & KIEFFER. Alternating-current electric induction motors.
16,812 SIEMENS BROS. DYNAMO WORKS & KIEFFER. Fans for cooling dynamoelectric machines and for other purposes.
16,823 MOSS. Conduits and adaptors for electrical conductors.
16,847 HADDAN. (Optische Anstalt C. P. Goerz A.-G., Germany.) Telemeters.*
16,855 GES FUR ELEKTROTECHNISCHE INDUSTRIE M.B.H. & GYURIS. Production of electric light between the electrodes of arc lamps.*

SPECIFICATIONS PUBLISHED.

1908 SPECIFICATIONS.

19,589 B.T.-H. CO. (G.E. Co., U.S.) Electric circuit-breakers.
19,886 BIGGE & BUTT. Induction coils and transformers. (Post-dated, 10/2/09.)
20,268 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke Ges.). Overload circuit-breakers.
20,758 THOMAS & THOMAS. Elect[illegible] fuse.
21,004 HADDAN. (Nya Ackumulator Aktiebolaget Jungner.) Electrodes for accumulators.
21,405 AITKEN. Telephone instruments.
24,403 MULHOLLAND. Magneto-ignition devices for use in connection with internal combustion engines.
25,122 WINTERBOTTOM. Means for mounting or supporting telephonic instruments.
25,478 VAN RADEN & CO. & METZ. Secondary batteries.
26,967 TIMAR & ZIEGLER. Time relay for electric currents.

1909 SPECIFICATIONS.

425 GIRARD. Mounting electric lamps. (Request under sec. 19 not granted.)
687 FERY. Pendulum electricity meters
3,252 WHYTE. Electric flash lamps.
3,511 BOSCH. Armatures for magneto-induction machines. (Date applied for, 20/11/08.)
3,517 LAKE. (Cutler-Hammer Mfg. Co.) Multiple switch starting devices for electric motors.
3,897 BOHM. Incandescent electric lamps.

4,122 K[illegible]. Alternating-current arc lamps.
4,228 MURRAY. Electric cutouts.
4,394 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
4,652 MASCHINENFABRIK OERLIKON. Single-phase alternating-current electric commutator motors. (Date applied for, 26/2/08.)
4,690 FAIRWEATHER. (Landers, Frary & Clark.) Vapour lamps. (Date applied for, [illegible].)
4,762 PEUKERT. Producing electrical oscillations of high frequency. (Date applied for, 17/3/08.)

COMPANIES' MEETINGS AND REPORTS.

BAKER STREET & WATERLOO RAILWAY CO.—Sir Geo. S. Gibb, who presided at the meeting last week, stated that receipts had gone up and expenses had gone down, and they were thereby able to double the small dividend declared in the first half of 1908. They had carried 14,300,000 passengers, an increase of nearly 11 per cent., which had mainly occurred in through passengers, which were now 40¼ per cent. of the whole. Through traffic did not yield quite so much money to them as the local traffic, but the increase of through traffic was due to the co-operation of all the companies and their efforts in establishing the habit of underground travelling. The average payment by through passengers for these through journeys came to 2·8d. The company's share of that came to 1·3d., and their average of local traffic, including workmen, was 1·54d., while the average of their total traffic—local and through together including workmen—was 1·46d. The gross revenue was £91,510, increase £7,981, or 9·56 per cent. Working expenses, notwithstanding an increase of car-mileage, showed a decrease of £3,228, of which £2,100 was under the head of train working, and was largely due to a decrease in the price of electric energy. Total working expenses worked out at an average of 0·71d. per passenger. The directors had considered the subject very carefully of the extension to Paddington, and had no hesitation in recommending the abandonment of the existing powers for that extension. The North-West London Railway had an authorised line through Victoria to Cricklewood, and they had come, he believed, to the conclusion that the piece of line from Edgware-road to Victoria would not pay, and they had abandoned it. It was also agreed that the Edgware-road and Baker-street company should work that piece of line as a continuous line. The Baker Street & Waterloo Co. were to have nothing to do with the construction of the line, but were to give an annual contribution out of their share of through receipts of the line, which was to be worked as an extension of the Bakerloo Railway.

CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY CO.—At the meeting last week Sir Geo. S. Gibb said the gross revenue amounted to £105,182, an increase of £16,299, or 18·3 per cent., the largest percentage of increase shown in any London traffic carrying company. The prospects for the future on the Hampstead line seemed to be very good, building was going on at a very rapid rate out at Golder's Green, and they anticipated a large increase in houses and population in that district. Working expenses amounted to £57,795, increase £1,302, while train mileage was 28 per cent. more than in the corresponding half-year, and the car-mileage 17 per cent. more. The directors recommend a dividend of ¾ per cent. on the ordinary shares, carrying forward £2,950. 14,862,882 passengers were carried; the through traffic represented 26·87 per cent. and the local traffic 73·13 per cent.

COLNE & TRAWDEN LIGHT RAILWAY CO.—At the annual meeting on Wednesday, it was reported that there had been a decrease in the number of passengers carried compared with the previous year. The profit amounted to £2,294, and after paying debenture interest the balance was £479. A dividend of 6 per cent. was declared on the preference shares and £300 was carried to reserve.

ELECTRIC SUPPLY CO. OF VICTORIA (LTD.)—The accounts for the year ended March 31 show, after payment of interest, a credit balance of £7,760, added to £8,582 brought forward, making £16,342. From this has been deducted £7,800 for the preference dividend to March 31, 1908, and £3,962 for debenture stock redemption account, leaving £4,581. Dividend on the preference shares due March 31, 1909, would amount to £8,250.

GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.—At the meeting last week Sir Geo. S. Gibb said the number of passengers carried was 19,155,883, an increase of 1,709,000, or 9·8 per cent. During the last two years the increase had amounted to 60·5 per cent. Local traffic accounted for 68¾ of the total, increase about 2½ per cent., while through traffic accounted for 31¾ per cent., increase 30½ per cent. Their gross receipts had increased and expenses had decreased. The net revenue balance was £84,588, out of which £6,000 was set aside for contingencies and renewals, leaving £40,732. It was proposed to pay 4 per cent. on the preference and 1 per cent. on the ordinary shares, and to carry forward £8,532.

LANARKSHIRE TRAMWAYS CO.—At the meeting on Wednesday Mr. A. R. Monks, who presided, stated that they were paying a dividend at the rate of 5½ per cent. per annum. Owing to the continued trade depression there was a decrease in the traffic receipts of £1,764 compared with the corresponding half of 1908, but the expenses showed a reduction of £1,306, mainly owing to less mileage being run, to the price of coal being lower, and the fact that there were no Parliamentary expenses.

LIVERPOOL OVERHEAD RAILWAY CO.—Sir W. B. Forwood stated at the meeting on Tuesday that there was a further shrinkage in revenue, amounting to £2,486. 14s. 7d., mainly due to depression in trade. On the other hand, they had saved £3,138 in working expenses by introducing a more frequent, but less rapid, and, therefore, less expensive, train service. They now run in the middle of the day a five minutes' service in place of a seven minutes' service, and, although the trains were a few minutes longer on the road, there was practically no waiting for a train, and the time and annoyance thus saved fully compensated for the slightly lengthened journey. The new service had given satisfaction. He was not very confident that they should ever be able to restore their fares to their former level. They were governed by the fares charged upon the Corporation tramways and the Lancashire & Yorkshire Railway. The latter would, as a trading concern, adjust their fares to a more remunerative level, but they also had to compete with the tramways, and it was one of the evils of a municipal trading concern such as the Corporation tramways that they must be worked upon popular lines rather than upon business principles. The Liverpool Tramways committee would, he was sure, be the first to admit that if the tramways were run on purely business principles their revenue would be much larger than at present, and they could make annually a very large profit. As to the probabilities of their recovering this lost traffic they had no greater competition to meet than they had four years ago, except that the electrical service of the Lancashire & Yorkshire Railway was more popular and attractive, but the conditions of traffic were not normal. A recovery in trade was already in process. In America the rising tide in trade had set in vigorously, and it could not be long before it reached this country.

MERSEY RAILWAY CO.—The train-mileage run during the half-year ended June 30 was 384,962, compared with 408,134 in the corresponding six months of 1908. The number of passengers conveyed was 5,818,759, against 5,719,572, exclusive of season ticket holders. Total receipts were £53,227. 18s. 10d., compared with £51,783. 14s. 4d.; working expenses (exclusive of the charges for pumping, ventilation and lifts) were £30,810. 9s. 10d. (equal to 57·88 per cent.), against £33,075. 0s. 1d. (equal 63·87 per cent.) The charges for pumping, ventilation and hydraulic lifts amounted to £3,659. 11s. 11d. (6·83 per cent.), compared with £4,070. 0s. 10d. (7·86 per cent.).

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

GEARY, ADAMS & CO. (LTD.) (104,463.)—Reg. Aug. 9, capital £3,000 in £1 shares, to adopt an agreement with F. C. Geary, and to carry on the business of electrical installation and general engineers and agents, &c. Private company. First directors, F. C. Geary and G. W. M. Adams (both permanent).

GENERAL ACCESSORIES CO. (LTD.) (104,464.)—Reg. Aug. 9, capital £3,000 in £1 shares (1,580 6 per cent. preference, 920 5 per cent. preference and 500 ordinary), to carry on the business of manufacturers of and dealers in electrical goods of all kinds, general merchants, factors and agents, &c., and to adopt an agreement with E. C. Friend. Private company. G. X. Markt is permanent director and manager with £391. 10s. per annum. Reg. office, 148-150, Curtain-road, London, E.C.

LAING WHARTON (LTD.) (104,536.)—Reg. Aug. 12, capital £3,000 in 2,900 preference shares of £1 each and 2,000 ordinary shares of 1s. each, to carry on the business of electricians, mechanical engineers, &c. Private company. First directors, H. P. Allison and H. J. de Courcey Moore.

MIDLAND ELECTRIC WIRE CO. (LTD.) (104,571.)—Reg. Aug. 14, capital £5,000 in £1 shares, to acquire the business carried on as the Midland Electric Wire Co. and to carry on the business of electric cable and insulated wire manufacturers and dealers, electricians, &c. Private company. W. J. Levi is manager.

MORTGAGES AND CHARGES.

CRYSELCO (LTD.)—Particulars of £5,000 first and £5,000 second debentures created by resolutions of June 26 and secured by trust deeds dated July 11, 1905, filed pursuant to sec. 93 (3) of Companies (Consolidation) Act, 1908, the amount of present issues being £500 of each series. Property charged, company's undertaking and property, present and future, including uncalled capital. Trustees, A. Baker and H. S. Deacon.

CITY NOTES.

MEMORANDA (Aug. 12).—**Bank rate 2½ per cent.** (since April 1, 1909). **Price of silver, 23⅛d. per oz. Consols** 84 1/16—84 3/16 for money, 84⅛ – 84¼ for account. Consols Pay Day, Sept. 1; **Stock and Shares Continuation Days, Aug. 24 and Sept. 8; Ticket Days, Aug. 25** and Sept. 9; Pay Days, Aug. 26 and Sept. 10; Mining Shares Carry Over Days, Aug. 23 and Sept. 7.

PRICES OF METALS (London).—*Copper*, cash, 59⅓; three months 60 7/16. *Lead*, English, 12½—13; foreign, cash, 12½; three months, 12⅝. *Spelter*, cash, 21¾—22. *Tin*, English, 133—135; foreign, cash, 136⅜; three months, 136½. *Iron*, Cleveland, cash, 49/7, and three months, 50/4. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

DIRECT SPANISH TELEGRAPH CO. (LTD.)—The Board have decided to pay, in addition to the dividend at the rate of 10 per cent. per annum on the preference shares, an interim dividend at the rate of 4 per cent. per annum (tax free) on the ordinary shares, both for the half-year ended June 30 and payable on Oct. 1.

NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)—The directors have declared an interim dividend at the rate of 4½ per cent. (less tax) on the "B" ordinary shares for the past half-year.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 11	1,867	+ 162	10	16,009	− 665
Airdrie	,, 6	213	+ 1	31	6,701	− 137
Anglo-Argentine	,, 12	36,950	+ 1,053	32	1,243,835	+ 70,136
Ayr Corporation	,, 14	501	− 12	13	5,306	− 241
Baker St. & Waterloo Ry.	,, 11	2,450	− 130	6	17,880	+ 820
Barnsley	,, 6	174	− 22	31	5,160	− 259
Barrow	,, 6	328	− 32	31	7,014	− 600
Bath Electric Trams, Ltd.	...	...	...	...	...	...
Birmingham Corporation	,, 14	5,967	+ 240	20	129,207	+ 3,437
Birmingham & Mid.	,, 6	841	− 42	30	25,013	+ 331
Blackburn Corporation	,, 11	1,407	+ 191	20	22,853	− 711
Blackpool and Fleetwood	...	...	...	...	...	...
Bolton Corporation	,, 15	2,587	+ 122	20	47,232	− 748
Bombay	July 15	R33,411	+ R862	27	R1,056,076	+ R62,173
Bournemouth Corporation	Aug. 11	2,612	+ 189	19	33,153	− 35
Bradford Corporation	,, 7	5,603	+ 33	18	92,045	+ 1,092
Brighton Corporation	,, 15	1,443	+ 78	20	20,631	+ 696
Bristol Trams & Carriage	,, 13	5,915	+ 912	12	71,901	+ 1,231
Burnley Corporation	,, 14	1,417	+ 38	20	25,788	− 207
Burton Corporation	,, 15	299	+ 15	20	5,382	− 149
Bury Corporation	,, 15	1,337	+ 66	†20	23,768	+ 590
Calcutta Tramways Co.	,, 14	R43,400	+ R248	6	R239,694	+ R20,723
Camborne-Redruth	,, 14	131	+ 3	33	4,029	− 115
Cardiff Corporation	,, 7	3,531	+ 683	13	42,421	− 16
Cavehill	,, 6	142	− 6	31	2,668	− 188
Central London Railway	,, 14	4,302	− 2,229	6	30,482	− 12,001
Charing C., Euston & H'stead	,, 14	3,305	+ 325	6	22,499	+ 2,975
Chatham & Dist. Lt. Rys.	,, 12	1,111	+ 188	32	25,737	− 1,360
City & South London Rly.	,, 15	2,983	+ 107	6	18,401	+ 1,033
City of Birmingham	,, 6	3,106	+ 126	31	87,209	+ 809
Colchester Corporation	,, 11	246	+ 12	6	1,378	− 864
Cork Electric Trams Co.	,, 12	590	+ 69	35	13,923	− 807
Croydon Corporation	...	...	...	...	...	...
Devonport & Dist. Trams.	,, 6	452	− 194	31	11,391	− 2,718
Dover Corporation	,, 14	326	+ 18	20	4,318	− 477
Dublin & Lucan Railway	,, 13	181	+ 19	3	1,047	+ 12
Dublin United	,, 13	6,334	+ 694	6	37,758	+ 433
Dudley-Stourbridge	,, 6	1,141	− 124	31	21,994	− 785
Dundee Corporation	...	...	...	...	...	...
East Ham Council	,, 14	1,049	+ 125	§19	20,120	+ 2,817
Exeter Corporation	,, 13	413	+ 49	20	7,081	+ 657
Gateshead & Dist. Trams.	,, 6	1,075	− 41	31	30,803	− 356
Glasgow Corporation	,, 14	17,431	+ 370	‖11	179,418	− 3,899
Glossop Trams	,, 14	142	+ 1	33	4,403	− 118
Gravesend—Northfleet	,, 6	313	− 29	31	6,377	− 189
Great Northern & City Rly.	,, 14	1,151	− 5	6	7,502	− 32
Gt. Northern, Piccadilly, &c.	,, 14	4,110	− 180	6	30,155	+ 615
Greenock & Port Glasgow	,, 6	636	+ 40	31	16,377	+ 263
Hartlepool Tramways	,, 6	245	− 51	31	7,035	− 273
Hastings Elec. Trams Co.	,, 14	1,791	+ 23	6	8,207	− 391
Hong Kong	...	...	...	...	...	...
Huddersfield Corpn.	,, 14	2,002	+ 265	19	32,863	+ 675
Hull Corporation	,, 14	2,664	+ 283	19	49,160	+ 968
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 17	156	+ 12	19	2,606	− 207
Ipswich Corporation	,, 14	555	+ 65	20	8,268	+ 37
Isle of Thanet Co.	...	...	...	...	...	...
Jarrow	,, 6	171	+ 12	31	3,618	+ 302
Keighley Corporation	,, 12	218	+ 40	19	3,368	+ 80
Kidderminster & District	,, 6	287	− 23	31	3,306	− 261
Kilmarnock Corporation	,, 14	142	+ 8	13	2,051	− 81
Lanarkshire Trams Co.	,, 12	1,596	+ 318	32	40,395	− 1,149
Lancashire United	,, 11	1,676	+ 219	32	42,380	− 105
Leamington	,, 6	308	− 27	31	5,310	+ 125
Leeds Corporation	,, 7	7,994	+ 413	19	128,319	+ 497
Leicester Corporation	,, 14	2,203	+ 190	6	13,857	− 388
Leith Corporation	,, 14	814	+ 219	13	8,694	+ 933
Lincoln Corporation	...	...	...	...	...	...
Liverpool Corporation	,, 7	11,978	+ 85	‖31	334,385	− 3,246
Liverpool Overhead Rly.	,, 15	1,547	+ 51	‡7	10,484	− 2
Llandudno & Colwyn Bay Ry.	,, 13	840	+ 92	37	9,230	+ 1,717
London County Council	July 31	35,625	− 1,251	§17	634,234	+ 21,272
London United	Aug. 14	8,040	− 131	‖34	195,531	− 20,207
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 14	225	+ 4	19	3,729	− 305
Manchester Corporation	,, 14	15,789	+ 1,024	21	298,582	− 3,114
Mersey Railway	,, 14	1,827	+ 27	6	11,599	+ 496
Merthyr	,, 6	317	+ 30	31	6,647	+ 74
Metropolitan Dist. Railway	,, 14	8,217	+ 159	6	58,080	+ 4,916
Metropolitan Elec. Trams	,, 6	8,241	− 125	31	188,957	+ 13,894
Middleton	,, 6	364	− 134	31	10,342	− 957
Nelson Corporation	,, 14	163	+ 11	§19	2,785	− 107
Newcastle-on-Tyne Corp.	,, 14	3,814	+ 146	...	76,996	− 1,273
Newport (Mon.)	,, 14	706	+ 63	20	13,423	− 359
Northampton Corporation	,, 13	531	+ 67	§20	9,763	+ 189
Oldham, Ashton & Hyde	,, 6	575	− 80	31	17,238	− 1,165
Oldham Corporation	,, 15	1,939	− 90	20	39,059	− 2,740
Perth (N.B.) Corporation	,, 11	195	+ 23	§13	2,115	− 23
Perth (W.A.) Elec. Trams	,, 13	1,266	− 21	32	45,222	− 65
Peterborough	,, 6	175	− 41	31	3,602	− 316
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 6	2,099	+ 4	31	55,075	− 1,410
Preston Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 12	588	− 29	19	11,491	− 510
Rothesay	,, 6	537	− 52	31	6,165	− 282
Salford Corporation	,, 15	4,771	− 90	‡20	92,315	− 3,305
Sheerness	,, 6	75	− 21	31	1,628	− 225
Sheffield Corporation	,, 15	5,419	+ 112	§20	115,092	− 1,503
Singapore Trams	...	...	...	...	...	...
South Metropolitan	,, 6	1,163	− 132	31	24,123	− 612
South Staffs	,, 6	1,129	− 42	31	25,918	− 1,462
Southend Corporation	,, 11	943	+ 118	19	11,023	+ 1,830
Southport Tramways	,, 6	498	− 30	31	8,837	− 319
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 14	891	+ 93	§20	15,386	− 616
Sunderland Corporation	,, 15	1,118	+ 130	20	23,598	− 871
Sunderland District	,, 11	551	+ 34	41	18,850	− 762
Swansea Trams	,, 6	1,549	− 83	31	29,444	+ 369
Swindon Corporation	,, 11	183	+ 2	...	...	...
Taunton	,, 6	55	− 5	31	1,171	− 88
Tynemouth and District	,, 6	637	+ 53	31	7,208	+ 215
Tyneside Trams Co.	,, 11	532	+ 85	6	2,916	+ 185
Wallasey District Council	,, 14	1,033	+ 66	§19	19,081	+ 523
Walsall Corpn.	,, 14	519	+ 19	32	16,364	− 1,151
Warrington Corpn.	,, 5	399	− 4	18	7,008	+ 19
West Ham Corporation	,, 5	2,705	− 48	18	43,615	+ 2,362
Weston-super-Mare	,, 6	767	+ 112	31	4,101	+ 177
Wolverhampton Co.	,, 6	602	− 65	31	12,958	− 1,308
Wolverhampton Corpn.	,, 11	797	...	6	...	...
Worcester	,, 6	493	+ 5	31	8,517	− 136
Wrexham	,, 6	130	− 10	31	2,990	− 157
Yorkshire W.R. Trams	,, 15	1,320	+ 23	33	39,033	...
Yorkshire Woollen District	,, 6	979	− 36	31	27,790	− 601

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share.	Last Dividend	Name.	Price Wed., Aug. 18.	Rate % Yield-ed.	Dividend Due.	Business Week to Aug. 18: Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s d.			
10	7/0	Bournemouth & Poole Elec. Sup. Ord. xd	9¼–9¾	6 3	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref. xd	9½–10	4 10 0	Feb, Aug	9½	9½
10	6/0	Do. 6 per Cent. Cum. Second Pref. xd	10–10½	5 14	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99–103	4 7 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½–4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93–96	4 16 0	May, Nov	..	—
5	5/6	Brompton & Kensington Elec. Sup. Ord. xd	7½–8	6 12 0	March	..	..
5	3/6	Do. 7 per Cent. Pref. xd	7½–8	4 8	Mar, Sept	7	7½
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97–100	4 0 0	June, Dec	7	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4–4¼	5 16 0	Feb, Aug	..	—
5	2/3	Do. 4½ per Cent. Pref. xd	4¼–4½	4 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96–99	4 1 0	Jan, July	9 7½	7½
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	99–101	4 9 0	..	100¾	..
5	2/8	Do. City Undertaking 4½% Cm. Pref.	3¾–4⅛	5 2 6	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3½–4⅛	4 9 3	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100–103	4 7 0	June, Dec	..	..
10	5/0	†City of London Electric Lighting Ord.	10½–11¼	5 10 0	Feb, Aug	..	—
10	6/0	†Do. 6 per Cent. Cum. Pref.	12–12½	4 11	Jan, July		12⅛
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121–124	4 0 0	June, Dec	—	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99–102	4 5	Jan, July	..	..
5	..	County of Durham Elec. P.D. Ord.	2¾–3¼	—	April, Oct	..	—
5	2½%	Do. 5 per Cent. non Cum. Pref.	3–3½	3 11 0	April, Oct	—	..
10	4/0	†County of London Elec. Supply Ord.	7⅞–8½	8 3 0	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Cum. Pref.	10⅞–11	5 9 0	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (red.)	103–106	4 5	Jan, July	105½	..
St.	4½%	Do. Second Deb. Stock	100–103	4 7 6	May, Nov	101	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅞–5½	5 9 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5¼	4 11 0	Mar, Sept	..	..
St.	4½%	†Do. 4½ 1st Deb. Stock (red)	97–100	4 10 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7½–7⅞	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord. xd	6½–6¾	5 18 0	Feb, Aug	—	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅝–6⅞	4 14 6	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	95–98	4 2 0	..	..	..
St.	4%	Kensingtn. & Kngthg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98–101	3 19 0	April, Oct	—	—
St.	4½%	Kent Elec. Power Co.	84–88	5 3 0	Jan, July	..	..
8	1/9⅜	London Electric Supply Ord.	1⅞–2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛–5⅜	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93–97	4 2 6	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord. xd	4⅝–4¾	5 15 6	April, Oct	5	—
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝–5	4 10 0	Jan, July	5	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105–108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½–86½	4 1 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	94–97	4 12 6	June, Dec	..	..
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4¾–5	4 2 1	Feb, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	84–88	5 5 11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4–4½	2 10 6	Feb, Aug	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	4⅞–5⅛	4 19 0	Feb, Aug	—	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97–99	4 1 8	Jan, July	—	—
100	50/	North Metro. Elec. Power Sup. 5 Morts	99–101	4 19 0	..	—	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	—
100	4½%	Do. 4½ per Cent. Deb.	89–91	5 0 0	Jan, July	—	..
10	6/0	Notting Hill Electric Ord.	11–12	5 16 9	March	—	—
5	4/6	Oxford Electric Ord.	6–6½	5 8 0	March	6⅜	—
St.	4%	Do. 4 per Cent. Deb. Stock	95–98	4 2 0	Jan, July	..	—
5	5/0	†St. James' & Pall Mall Elec. Ord.	8½–9	5 11 0	Feb, Aug	9	..
5	3/6	†Do. 7 per Cent. Pref.	7–7½	4 13 4	Feb, Aug	—	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84–88	3 19 6	Jan, July	—	—
5	..	Smithfield Markets Electric Sup. Ord.	1⅝–1⅞	—	Feb	—	..
5	4/0	South London Electric Supply Ord.	2⅝–3	6 16 0	April	..	..
St.	5%	Do. 5% 1st Mort. Stk. Red.	101–103	4 17 0	—	102½	—
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝–⅞	4 14 0	..		..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.	1⅛–1⅜	5 7 0	Feb, Aug	..	—
St.	4½%	Do. 4½ 1st Db. Stk. Red.	102–105	4 6 0	April, Oct	—	..
5	2/6	Urban Electric Supply Ord.	½–1	—	April, Oct	..	—
5	2/6	Do. 5 per Cent. Cum. Pref.	1½–2	..	April, Oct	3	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	77–81	5 11 6	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord. xd	8⅝–9⅛	5 8 0	Mar, Sept	8	8⅜
5	2/3	Do. 4½ per Cent. Cum. Pref.	4½–5¼	4 8 0	Jan, July	5	5
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	99–101	3 19 0	Jan, July	100	97½
1	..	Bath Elec. Trams Pref. Ord.	¼–⅜	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝–⅞	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87–91	4 19 0	April, Oct	..	—
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88–91	4 19 0	Jan, July	..	..
10	6%	†Bristol Tramways & Carriage Ord.	8–8½	7 2 6	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	8–8½	4 11 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100–101	3 19 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	1⅛–1⅜	..	June, Dec	..	—
10	8/0	Do. 6 per Cent. Cum. Pref.	2–2½	12 0 0	Feb, Aug	..	—
St.	5%	Do. 5 per Cent. Perpetual Debs.	85–89	5 13 0	April, Oct	8	85
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63–67	6 14 0	May, Nov	..	..
St.	3½%	Central London Ordinary Stock	61–63	5 3 0	Feb, Aug	61½	61
St.	4%	Do. 4 per Cent. Pref. Stock	82–84	4 15 0	Feb, Aug	..	..
St.	2½%	Do. Deferred Stock	43–45	5 11 0	Feb	44	..
100	4%	Do. 4 per Cent. Debs.	101–103	3 18 0	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	92–94	4 5 0	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½–5¼	4 15 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97–101	3 19 0	April, Oct	..	..
St.	1⅜%	†City & South London Rly. Con. Ord.	31½–33½	4 12 0	Feb, Aug	3	31⅜
St.	5%	†Do. 5 per Cent. Perp. Pref. (1891)	108–110	4 11	Feb, Aug	..	..
St.	5%	†Do. (1896)	104–107	4 13 6	Feb, Aug	.	..
St.	5%	†Do. (1901)	100–103	5 2	Feb, Aug	.	..
St.	5%	†Do. (1903)	92–95	5 5 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	100–102	3 18 0	May, Nov	..	—
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾–13¼	4 7 6	Feb, Aug	—	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾–1	..	Feb, Aug	..	..
10	..	G. Northern, Picc. & Brompton 4% G.Pf	8–8½	—	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94–96	4 3 6	Jan, July	.	—
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¾–2¼	..	Mar, Sept	.	—
St.	4½%	Do. 4½ Db. St.	76–81	5 11 6	April, Oct	..	—
10	6%	Imperial Tramways Ord.	1–1½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6–6	6 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80–84	5 10 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58–63	6 7 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9⅞–10⅛	5 18 6	Feb, Aug		—
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½–90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	4–4½	..	Feb, Aug	.	.
10	5%	Do. 5 per Cent. Pref.	6–6	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82–84	4 15 3	Jan, July	..	—
10	2/6	London United Trams. 5% Cum. Pref.	1¾–2¼	..	Jan, July	1⅞	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68–71	5 12 6	Jan, July	..	..
St.	—	Mersey Con. Ord. Stock	1–2	—	Feb, Aug.	..	..
1	10⅝	Metropolitan Elec. Tramways Ord.	1¼–1⅜	—	..	1⅜	..
1	—	Do. Deferred	¼–⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref. xd	⅞–1⅛	5 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95–97	4 12 3	Jan, July	..	..
St.	1%	†Metropolitan Railway Consolidated	39½–40½	1 17 0	Feb, Aug	41	41⅛
St.	2½%	†Do. Surplus Lands Stocks	66–67	4 5 0	Feb, Aug	66½	64⅛
St.	3½%	†Do. 3½ per Cent. Preference	88–91	3 17 3	Feb, Aug	88¾	..
St.	3½%	†Do. 3½ per Cent. "A" Preference	84–85	4 1 0	Feb, Aug	85½	85
St.	3½%	†Do. 3½ per Cent. Convertible Pref.	84–85	4 1 0	Feb, Aug	85⅛	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92–94	3 14 6	Jan, July	93¼	92¾

In calculating the yield allowance has been made for accrued interest but *not* for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., Aug. 18.	Rate % Yielded £ s. d.	Dividend Due	Business Week to Aug. 18. Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—Continued.					
St.	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 3	Jan, July		
St.	..	Metropolitan District Railway Ord.	17 —17½	—	Feb, Aug	17⅝	17¼
St.	..	Do. Extension Pref. (5 per Cent.)	49 —51	—	Feb, Aug	50½	49⅝
St.	3½	†Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	64 —66	5 6 0	Feb, Aug	65½	65
St.	3½	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	1½	Do. Guar. Stock 4 per Cent. ...	94 —97	4 2 6	Mar, Sept	96½	95½
St.	6	Do. 6 per Cent. Perp. Deb. Stock	142 —144	4 3 0	Jan, July	141½	141
St.	4%	Do. 4 per Cent. Ditto	94 —96	4 4 0	Jan, July	95½	95
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref. ....xd	⅝—⅞	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	81 —85	5 18 0	Jan, July	..	..
..	..	UndergdE.Rys.Lon.6 In.bds.with coup.3	35 —37	..	June, Dec	36½	..
..	†	Do. 5% Prior Lien Bonds..	102½—103½	4 16 6	..	..	..
..	4½	Do. 4½% Bonds with coup. 8	88 —90	5 0 0	..	89	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—1	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	..	..
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	¼—½	..	..	..	..
1	1/4½	Do. 6% Cum. Pf.	¾—⅞	6 17 0	April, Oct	—	—
1	2 4½	Babcock & Wilcox Ord. '...............	4¼—4½	4 14 0	April, Oct	—	..
1	0/7½	Do. Pref.	1⅜—1½	4 0 0		28/0	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅜—7⅝	6 9 0	July, Feb	7⅝	..
5	3/0	†Do. 6 per Cent. Pref.	6⅛—6⅜	4 12 0	Jan, July	6⅛	6⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	104⅛	104
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	⅝—⅞	—	Feb, Aug	..	—
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0		..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	..	..
St.	4½%	Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	45½	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	—
1	1/0	Callender's Cable Con. Ord.	10 —11	6 18 0	Jan, July	10⅞	10½
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	104½—105½	4 5 6	Nov, May	104½	..
1	1/0	Castner-Kellner Alkali Co.	1⅝—2⅛	6 4 0	May, Nov	40/6	40/0
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.).	106 —108	4 3 6	Feb, Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅜—1⅝	6 11 9	March ..	..	—
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/5½	Consolidated Electrical Co.	⅝—¾	7 0 0	August	..	..
1	1/0	Consolidated Signal Co.	1⅛—1⅜	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1	6 0 0	April, Oct	..	..
1	3/0	*Crompton & Co. (Nos. 1 to 85,000)	⅞—1⅛	13 7 0	Jan, July	17/6	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	90 —93	5 7 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1¼	8 0 0	Sept	23/6	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1½	4 16 9	Sept	24/3	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅜—⅝	..	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	—
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	⅛—¼	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅞—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 5 0	Jan, July	..	..
2	..	Electric Construction Co.	⅛—⅛	..	Jan, July	..	..
2	2/9⅜	†Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	9 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	64 —66	6 0 0	Jan, July	..	..
St.	5%	Ferranti Ltd. 5 per Cent. 1st Mt.Db.St.	71 —77	6 10 0	...	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.........	85 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	12½—13½	5 15 6	Feb, Aug	12	12⅜
5	2/3	Do. 4½ per Cent. Pref.	4¼—4¾	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 4 6	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14½—15½	6 9 0	Feb, Aug	15⅛	14⅜
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—10⅝	..	..	10⅜	10⅛
100	4%	Do. 4 per Cent. Debs. (red.)............	100 —102	3 19 0	April, Oct	..	..
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	81 —84	5 7 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1⅜	—		..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..		..	..
12	12/0	†Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	34½	34¼
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100 —101½	3 18 6	Jan, July	..	..
1	1/9	Vickers, Sons & Maxim, Ltd., Ord ...xd	2⅛—2⅜	4 11 0	—	43/9	43/3
1	1/6	Do. 5 per Cent. non-Cum. Preference	1⅞—1⅝	3 11 6	—	25/0	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3		..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	101½—103½	3 17 6	June, Dec	102½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	104½	..
10	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	106¼	105¾
10	6%	J. G. White & Co. 6% Cm. Pref.	9½—10⅛	8 6 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—¾	3 15 0	Apr, Oct	..	..
1	3/0	Do. 6 per Cent. Cum. Pref.	1⅛—⅜	9 12 0	Apr, Oct	..	—
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2¼—3¼	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	93 —96	5 4 0	June, Dec	..	..
St.	15/0	†Anglo-American	60 —62	5 4 0	F,My,Ag,N	..	..
St.	30/0	†Do. Preferred	103 —104	5 16 0	F,My,Ag,N	103½	102⅝
St.	0/0	†Do. Deferred	20 —21	2 0 0	F,My,Ag,N	21	19⅞
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	91	..
10	6/0	Cuba Submarine Ord.	8⅞—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	2⅞—3⅛	5 18 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅛—8⅜	6 12 9	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99½—101½	4 9 3	Jan, July	..	..
20	5/0	*Direct United States Cable	12½—13⅛	6 7 3	Ja,Ap,Jy,O	13¼	12⅞
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 —101	4 9 0	June, Dec	..	..
St.	7/0	Eastern Ordinary	129 —132	6 6 0	Ja,My,Jy,O	131½	129½
St.	17/6	Do. 3½ per Cent. Pref. Stock	84½—86½	..	Ja,My,Jy,O	85½	..
St.	4	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	..	..
St.	2/6	Eastern Extension	11⅜—11⅝	5 19 3	Ja,Ap,Jy,O	11½	11⅜
100	4	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	..	..
100	4	Eastern & S.Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	..	..
10	..	G. N. of Copenhagen, with Coupon 76	26½—27½	6 0 0	Jan, July	..	..
..	4½	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 —101	4 9 0	June, Dec	..	..
..	..	Indo-European Tel.	61½—62½	5 16 9	May, Nov	..	..
..	4	Mackay Companies Common	80 —84	4 16 0	Ja,Ap,Jy,O	..	..
..	4	Do. Preference	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
..	..	Marconi's Wireless Teleg. Co.	1 —1⅛	..	April	..	..
..	..	Pacific & European Tel. 4% Guar. Dbs. (red.)	99½—101½	3 19 0	June, Dec	..	..
1	1/3	West Coast of America	1⅛—1⅜	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	99½—101½	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅝—¾	..	May, Nov	..	..
10	1/0	Do. 6 per Cent. 1st Pref	8 —8½	7 1 0	May, Nov	..	..
10	1/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	6%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
10	5/0	Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	13¾	13⅝
100	4%	Do. 4 per Cent. Deb Stock (red.)	102½—104½	3 18 6	June, Dec	103	..
..	4	Western Union Telegh. $1 000 4% Bonds	95 —97	4 2 0	..	..	..

Share	Last Dividend	Name	Price Wed., Aug. 18	Rate % Yielded £ s. d.	Dividend Due	Business Week to Aug. 18 Highest	Lowest
		TELEPHONES.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	145 —146	5 10 0	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	—	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103½—105½	4 16 0	Mar, Sept	..	—
5	5/0	Chili Telephone	8 —8⅝	4 15 6	August ..	..	..
1	0/7½	Monte Video Telephone Ord.	1⅜—1⅝	6 8 0	Nov	16/3	—
1	0/6	Do. 5 per Cent. Pref.	¾—⅞	5 14 3	May, Nov	..	..
St.	6%	†National Co. Pref. Stock	106 —107½	5 11 6	Feb, Aug	107¼	106
St.	6%	†Do. Def. Stock...........................	123 —125	4 16 6	Feb, Aug	124	123
10	6/0	†Do. 6 per Cent. Cum. 1st Pref.	10 —10¾	5 11 6	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. 2nd Pref.	10 —10¾	5 11 6	Feb, Aug	..	..
5	2/6	†Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛—5⅜	4 8 0	Feb, Aug	6⅞	6
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.) ...	98 —100	3 10 0	June, Dec	99	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99½—101½	3 19 0	Jan, July	101	100
1	1/0	Oriental	1⅛—1⅜	5 7 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	5 1 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85 —87	4 13 0	Jan, July	—	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	99 —101	4 9 0	Jan, July	..	..
5	5/0	†United River Plate........................	6⅞—7⅛	5 12 0	July	7⅛	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5½	5 10 6	June, Dec	..	..
St	4½%	Do. 4½ Deb. St. Red.	103 —105	4 6 0	Jan, July	104½	..
		FINANCIAL INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..	..
10	5 6	Globe Telegraph & Trust..................	10½—10¾	6 7 0	SpDcMrJu	10⅜	10
10	3/0	Do. 6 per Cent. Pref.	13½—14	4 5 9	SpDcMrJu	13¾	13
10	6%	Submarine Cables Trust (Cert.)...........	130 —133	4 10 3	April, Oct	131	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	—	Anglo-Argentine 5% Cum. 1st Pref.	4⅝—4⅞	5 2 6	April, Oct	—	..
5	—	Do. 5% Cum. 2nd Pref.	4⅛—4⅜	5 7 0	Jan, July	..	..
St.	4%	Do. 4% Deb. Stock.........................	91½—92½	4 6 6	June, Dec	..	..
St	..	Do. 4½% Deb. Stock	95 —96	..	—	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)...	102 —105	4 15 6	Jan, July	—	..
5	3 6	Brisbane Electric Trams. Invest. Ord....	6½—7	4 6 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	—	..
St.	8%	British Columbia El.Ry.Df. Ord.	145 —149	5 7 6	Mar, Sept	..	..
St.	6%	†Do. Pref. Ord. Stock	121 —125	4 16 0	May, Nov	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock..........	107 —110	4 11 0	Jan, July	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	101 —104	4 7 0	Jan, July	—	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	101½—103½	4 7 0	—	—	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	98½	..
St.	6%	†Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock...	92 —96	6 5 0	Feb, Aug	—	..
5	2/0	Calcutta Tramways (1 to 137,610)	4⅞—4⅞	4 2 0	Mar, Sept	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	99½	..
St.	..	Cape Electric Tram Shares	¼—½	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904)Sh.	5⅛—5⅜	4 4 0	F,My,A,N	—	..
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	—	..
1	..	Kalgoorlie Elec. Trams Sh.	3⅛—3⅜	..	..	—	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	90 —93	5 7 6	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 12 0	Jan, July	..	..
5	1/0	Lisbon Elec. Trams. Ord....................	1⅛—1⅛	4 14 0	July	—	..
100	0/7½	Do. 6 per Cent. Cum. Pref..................	1⅛—1⅛	5 1 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	97 —101	5 1 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds...xd	95 —97	5 3 0	Feb, Aug	—	..
100	$1½	†Mexico Trams Co Com. St.	127 —130	4 13 0	..	129	..
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds....	96 —98	5 2 0	..	97½	..
St.	4½%	†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,000)............	102 —104	4 6 6	..	..	..
1	0/6	Perth Elec. Trams Ord..........................	⅝—⅞	8 0 0	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅝	5 4 8	..	—	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	92¼— 94	..	..	93¼	9
..	5%	Do. 30 yr. Gold Bnds.	93½—95½%	5 4 0	..	94¼	9
100	5%	Do. 50 yr. Mt. Bnds.	84½—85½	5 18 0	..	85¼	8
—	$1½	Sao Paulo Tramway, Light & Power Co. $100 Stock....................................	150 —153	6 11 0	..	150½	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102	1
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 12 6	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	8/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅝	5 11 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 0	..	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93½—95½	4 13 6	Jan, July	—	..
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	95½—96½	..	..	—	..
5	4/9	Calcutta Elec. Supply Ord.	5⅝—6⅛	6 5 6	April, Oct	..	..
100	$1½	Canadian Gen. Elec. Co. Com. St.	121 —125	5 15 6	..	124½	..
100	$3½	Do. 7% Cm. Pf. Stock........................	118½—120½	5 17 0	..	119	..
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
500	5%	Elect. Development Co of Ontario	81½—86½	5 16 0	..	—	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	91⅞	..
5	..	Indian Elec. Sup. & Trac. Co................	1½—2	—	..	—	..
108	4	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—⅜	..	—	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—⅝	6 18 3	April, Oct	—	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83½—84½	5 19 6	..	81½	..
St.	$1	Mexican Lt & Power Co. Com. St.	72 —76	5 18 0	—	74¼	..
500	5%	Do. 5% 1st Mort. Gold Bnds.	85 —87	5 15 0	..	87⅛	..
100	$1½	†Montreal Lt. Ht. & Power Co. Cap. St....	126 —130	4 16 3	F,My,A,N	129	..
1	1/7½	River Plate Electricity Co. Ord.	1⅛—1⅛	5 11 0	April	..	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref	1⅛—1⅜	5 1 6	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock................	102 —105	4 15 0	Jan, July	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)......	5⅜—5⅝	5 6 6	April, Oct	..	..
5	5/0	Do. 2nd Pref.	5⅝— 6	5 0 0	—	..	..
100	$4	Shawinigan Water & Power Co. Ca	93 —95	4 4 0	—	—	..
..	5%	Do. 5 per Cent. Bds..........................	104 —106	4 14 3	Jan, July	..	..
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	97 —98	4 12 0	—	97⅛	..
St	4½%	Toronto Power Co. 4½ Db St.	99 —100	4 10 0	..	..	..
..	6d.	Victoria Falls Power Co. Pref..................	1⅛—1⅛	5 14 0	Jan, July	..	..
1	..	Do. 15/- paid	1⅛—1⅛	..	..	..	..

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Electrician No. 1631.
Indust. Suppt. No. 39.

AUGUST 20, 1909.

Gratis to Subscribers.

Electricity on the Land.

In another part of this issue will be found two articles dealing with different aspects of a question which, if not doing so at the present time, should shortly be engrossing the attention of electrical engineers. In this legislation-trammelled country there are, apart from such business matters as whether the erection of a supply station will be justified by the load obtainable, other questions which prevent promoters from taking up an electricity scheme in rural districts quite so confidently as they might otherwise do. The result of this timidity is not pleasant, as witness the almost entire absence of electrical facilities in villages, rural districts and even small towns, and when we read what is being done in other countries as regards the provision of electricity supply in similar areas, the remarks liable to be passed on our present methods are the reverse of complimentary. Whether popular requirements will undergo a change facilitating cheaper distribution is a point with which we leave to the prophets to deal, turning now to indicate examples of work being done in Germany and America towards providing rural districts with a supply of electricity.

One of the articles to be found on another page of this issue describes how the Germans have solved the problem. Several large stations are erected in convenient positions adjacent to a source of water power and near an agricultural district. Power is then delivered by a cheaply-erected overhead network to convenient points near a village or farm where the pressure can be stepped down and utilised for agricultural or domestic uses. Further, isolated consumers are able, by means of portable sub-stations, to tap the high-tension mains and obtain the necessary energy exactly where they want it.

It may be contended that such good results are not possible in this country, as water power is not available to any great extent. There are, however, other methods of obtaining cheap power, and in a country where the population is so concentrated as in England, the number of inhabitants per acre is greater, and therefore the length of pole line per consumer less than is apparently the case in East Germany, where these stations are now working.

On the other hand it is an open question whether we are really so destitute of water power as is sometimes believed to be the case. It is true we have no Niagara, but there are in parts of the country, at any rate, a number of quite respectably-sized falls near enough to agricultural or rural districts to make their utilization for generating an electricity supply, quite a commercial proposition.

While the first of the articles already cited shows the producing end of the story, the second illustrates how the electrical energy thus supplied may be efficiently utilised. On his farm in California, Mr. Franklin has made good use of his electricity, and, in fact, seems to employ it for practically every purpose. Such an example should not be lost on farmers in this country.

The introduction of science into agricultural work has greatly increased the bearing power of the land, and this bearing power cannot but be further increased by the application of engineering, in the form of the electric motor, to many of the operations now performed by hand. Much is, in fact, even now being done in this way on large estates, and we must therefore confidently hope, and agitate, for the removal of those restrictions which now press so hardly on electricity undertakings, so that the blessings of the electric drive may be also made possible to the small farmer.

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A.C. Motor-Starters and Circuit-Breakers.

IN view of the fact that the method of driving machinery by electricity has come so much to the fore in recent years, and that a considerable portion of this driving is effected by alternating-current slip-ring or squirrel-cage induction motors, the following points in

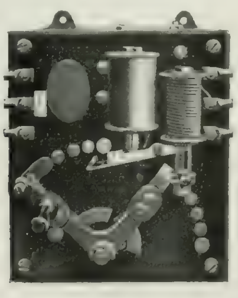

Fig. 1. No-Volt and Overload Starter, for Squirrel Cage Two-phase Motor.

connection with their starting gear will doubtless prove worthy of note. The aim of the manufacturer of electrical switchgear has been to produce apparatus which can be relied upon to perform satisfactorily all the duties for which it has been designed and installed, and in this respect Mr. George Ellison, of Birmingham, is well known, his firm making quite a speciality of this class of work. Within a very short time several new types of alternating current motor-starters and circuit-breakers have been put on the market by Mr. George Ellison, and the more interesting ones are shown in the accompanying illustrations.

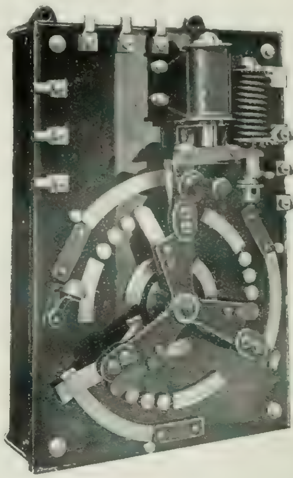

Fig. 2.—No-Volt and Overload Starter, for Slip-Ring Motor.

Fig. 2 illustrates a patent overload and no-voltage release starter which is now very largely used with equal success in connection with single, two and three-phase slip-ring type induction motors. We referred to the details of this starter at the time of its introduction, and we understand it has become very popular since. Figs. 1 and 3 illustrate squirrel-cage motor-starters of the rheostatic type, which can be used with either two or three-phase squirrel-cage type induction motors. It will be noticed that these starters are fitted with overload and no-voltage release coils, and it is claimed by the maker that after

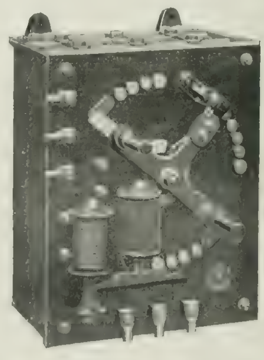

Fig. 3.—No-Volt and Overload Starter, for Squirrel Cage Three-phase Motor.

numerous comparative tests it was found that this type of starter was not only superior to, but simpler and much cheaper than, the ordinary compensator or auto-transformer in cases where the motors only start against light loads.

Fig. 4 shows the general appearance of the above two-phase squirrel-cage type motor-starter fitted with a semi-enclosed cast-iron cover, which is said to render contact with any live parts of the apparatus absolutely impossible. Squirrel-cage motors, as is well known, have

Fig. 4.—Protected Type Starter.

a comparatively high starting current, and for this reason the above starters are arranged in such a manner that the overload release coil is not in circuit until the motor is up to speed. We are informed that the same starters can also be made completely immersed in oil for mining purposes.

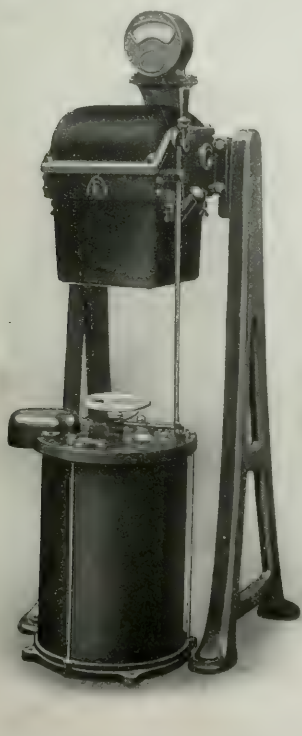

Fig. 5.—Gas-tight Mining Panel with Oil Break. Circuit-Breaker interlocked with Oil-immersed Starter.

Fig. 6 illustrates a dust-proof starting and speed regulating panel, of which the maker has supplied a considerable quantity during the last few years, specially designed for the requirements of textile mills. These panels consist merely of three-pole quick-break switch and fuse in a dust-proof cast-iron box mounted on the lower portion of the panel, and an ordinary three-phase motor-starter and regulator operated by means of a polished brass handwheel and fitted with a glass inspection window. The arrangement of these panels is extremely neat, simple and robust, and in spite of the heavy resistances required for

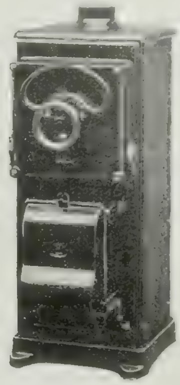

Fig 6.—Dust-tight Textile Panel for Starting and Speed-regulating A.C. Motors.

continuous-speed regulation, occupy only a comparatively small floor space. In place of the three-pole switch and fuse a completely enclosed and dust-tight circuit-breaker with overload and no-voltage release is sometimes supplied. In order to meet the require-

ments for properly designed alternating-current plain slip-ring type motor-starters and circuit-breakers for mining purposes Mr. George Ellison has developed some oil-immersed, gas-tight and fool-proof switchgear on lines which appear to differ entirely from any previous designs.

Fig. 7 illustrates a line of oil-immersed plain rotor-starters, which can be used in connection with single, two- and three-phase induction slip-ring type motors. These starters have the contact dial and resistances fixed to a strong cast-iron cover, so that the whole can be lifted out of the oil-containing tank for inspection.

Simplicity and safety are essential features in the design. The gear, as will be seen from Fig. 7, is completely enclosed, and parts that require occasional inspection are readily accessible and can easily be examined by one man.

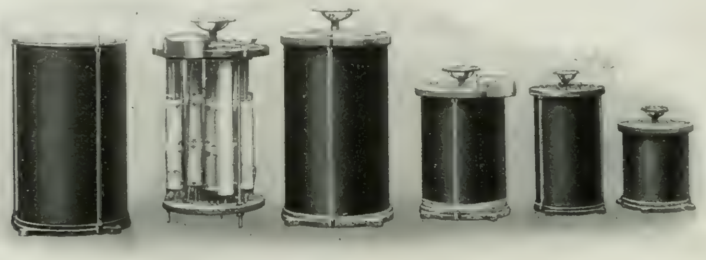

Fig. 7.—Oil Immersed A.C. Starters.

In order to provide for protection against overload and no-voltage in connection with these oil-immersed starters, the maker has also developed a line of mining panels, as illustrated in Fig. 5, which consist of an oil-immersed completely gas-tight three-pole circuit-breaker with overload and no-voltage release coils and an oil-immersed rotor starter, as already described, mounted on a very substantial cast-iron frame. These panels, it will be noticed, can also be fitted with an ammeter or a horse-power indicator as required. A special feature and radical departure from the ordinary oil-immersed circuit-breakers is that not only the brushes are under oil but also all the coils are completely enclosed. Starter and circuit-breaker are interlocked in such a manner that it is impossible to short-circuit the rotor resistances before the stator circuit of the motor has been closed. Every time the circuit-breaker is opened through no-voltage, overload, or by hand, the starter also comes back to the off position and the apparatus is quite ready to start the motor again.

These panels are absolutely fool-proof, and the simplicity of their design enables the motors to be started up by an operator with no electrical experience at all.

It will be readily admitted that proper design of apparatus for motor starting or control, especially when the motors happen to be of the alternating-current type, is a matter to which great attention and much time must be given before satisfactory results can be obtained. Besides making a piece of apparatus which shall fulfil all possible conditions from both an electrical and mechanical point of view, it is often necessary further to arrange matters that the equipment shall be gas and water-tight, in order that it may be used in mines or other similar places. From the foregoing description of Mr. George Ellison's switchgear it appears, and we think our readers will agree, that these critera are adequately fulfilled, and no trouble should be experienced in its employment.

Eclipse Fittings.

THE tendency as regards lighting at the present day is towards what may be called the indirect method. It is no longer considered the proper thing to simply suspend a lamp from a ceiling fitting or fix it to a wall bracket, leaving the filament fully exposed to the eye. Many designs have been got out whereby direct glare is avoided, the lamp proper being contained in some sort of "bowl" fitted with a suitable reflector, so that while good illumination is obtained the lamp itself is invisible.

One of the latest methods of doing this is due to Mr. G. Braulik, and is illustrated in the accompanying figure. The fitting, which is known as the "Eclipse," consists, as will be seen, of a bowl suspended from the supporting hook by two chains. The lamp is carried in an ordinary bayonet fitting, and is partially enclosed in this bowl. In the fitting illustrated no reflector is provided, but this addition can easily be made when desired. In this particular case metal filament lamps of high candle-power, say up to

Standard Eclipse Fitting.

400 c.p., are utilised; but a number of smaller units can also be fitted as arranged, so that they can be switched on or off in groups. With this fitting it is claimed that every ray of light is usefully employed, and there are no shadows. The illumination, it is further claimed, compares favourably with arc lamps, while the current consumption is, of course, much less.

Electricity on the Land.

As the "back to the land" movement is at the present time a sort of war cry with a certain set of politicians, it may be of interest to our readers to indicate the progress which is being made by the electric drive in this way. Unfortunately, in this country, progress in this direction has been rather slow, but, owing to the greater facilities as regards cheap power, more has been done in other countries and especially on the Continent of Europe. We are indebted to the "A.E.G. Zeitung" for the details given in this article.

The year 1893 saw the beginning of the adoption of electricity in agricultural operations, the power being supplied from a central power station specially erected for the purpose. In order to be able to distribute the energy at the lowest price, the undertakers sought to employ water power for generating purposes, and three stations driven by this means, and intended to supply current for agricultural purposes, were erected one after another in the east of Germany, at Vangerow-Lothu, Bartin-Besswitz and Birnbaum respectively. The first of these was equipped with hydraulically driven sets of an aggregate capacity of 300 H.P., while a 180 H.P. locomobile was installed as a reserve. This station fed 61 agricultural plants and five villages, comprising a total area of many thousand acres. The distributing network was 85 miles long and covered an area of 105 sq. miles. There were last year 102 consumers and an aggregate of 150 motors, with a total horse-power of 1,115, and about 5,000 lamps. The total output of this station during the same period was 440,000 units, the average price charged being 1·2d. for power and 2·2d. for light per unit.

The second of these stations was started to work last year, and supplies a network 112 miles long, which will be extended to 137 miles during the course of the summer. One hundred and eighty motors and about 5,000 glow lamps are connected, the price for lighting being 2·5d. per unit.

Fig. 1.—Stationary Transformer House for "Land" Supply.

An adjustable tariff for power is in force, the price varying between 1·1d. and 1·5d. per unit. Each consumer has to guarantee a minimum consumption of 5 kw.-hours per acre. The third station has only just been put to work, 10 consumers and 14 villages having been connected. When in full operation this station will serve 162,000 acres and five towns, the total length of the network being nearly 200 miles. Considering the speed with which the present agricultural power stations have been erected it would appear

Fig. 2.—Portable Transformer and Converter Station supplying Farm Machinery.

to be only a few years before whole provinces are covered with feeders capable of supplying electrical energy. Such development has been made possible by the use of high-tension three-phase current, and it only wants suitable apparatus to supply any demands that may be made.

Three small wires fixed to insulators, which in their turn are placed on wooden or iron masts, can carry electrical energy for miles across field and woodland and over water to the

Fig. 3.—Electrically-driven Railway in Agricultural Districts.

consumers. Protective apparatus has, of course, to be provided at places where roads are crossed to prevent man or beast being damaged, and protection to the line from lightning must also be ensured. At places where current is to

Fig. 4.—Portable Sub-station for "Land" Purposes.

be used, or at the entrance to villages, step-down transformers are erected in order that the energy may be employed at a lower voltage.

Such transformers are usually erected in small houses, such as that shown in Fig. 1, but in agricultural work, where the power is required first in one place and then in another, a portable sub-station such as that shown in Fig. 4 is used. This can be placed at any suitable spot and connected by means of "flexibles" to the high-tension cables. The low-tension current obtained from the transformer can then be supplied to the machinery, as shown in Fig. 2. The farmer is, therefore, able to obtain power at any required place, and can work the various agricultural ma-

chinery by electrical means. Such an arrangement should do much towards developing the use of electricity on the land.

Another very useful apparatus, for which electricity may be used in agriculture or even in industrial work, is the locomotive. The question of transferring goods to the nearest railway is of the highest importance. On account of the ease with which cheap electric current in large quantities can be obtained from these agricultural stations, the electric locomotive is specially useful on railways which are used for conveying industrial produce from the place of production to the main line system. An example of such a railway is shown in Fig. 3. The work is carried on by two four-axle electric locomotives, each having a capacity of 58 H.P., and capable of running at a speed of 16 miles an hour. The weight of the motors is 6 tons. On account of the fact that this weight is distributed over eight wheels the pressure on each does not exceed that on the waggons used. These locomotives can draw 50-ton trains up a gradient of 140 with the greatest ease, and have replaced 60 horses which used formerly to be employed during busy times. By the introduction of electric traction the weight of produce handled during the year is now $2\frac{3}{4}$ times as great as it was three years ago. It would, therefore, appear desirable that electric railways of this description should be much extended, as their use would seem to be for the benefit of all concerned.

Bennis Gritless Coking Stoker.

THE question of mechanical stokers is an interesting one to electrical engineers at the present time, for we have been told by many eminent authorities that the boiler house is the only part of the generating station in which further economies can be expected. Several firms have given their special attention to this subject, and among these, and certainly not the least successful, may be placed Messrs. Ed. Bennis & Co., Ltd., of Little Hulton, Bolton. A problem which has been exercising the ingenuity of this firm for some years is the evolution of a stoker which shall be suitable for use in paper mills. The problem to be faced was the proper consumption of the carbon before it reached the smoke stack, and thus to prevent the smuts and grit from finding its way into the "half-stuff" with dire results to the paper.

Fig. 1. General View of Bennis Gritless Coking Stoker.

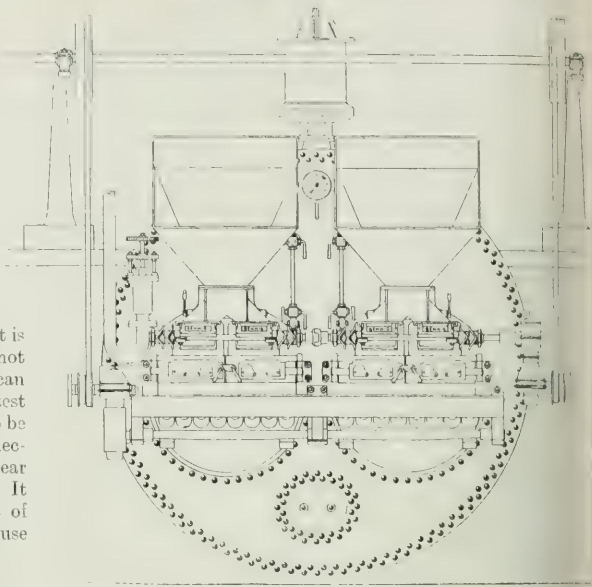

Fig. 2.—End Elevation of Gritless Stoker.

Without going at any great length into the vicissitudes which were met with in solving this problem we may simply say that it has now been successfully solved, and we give a description of the apparatus known as the Gritless Coking Stoker, by means of which successful results in this class of work have been achieved.

The new Bennis patent high-temperature coking stoker consists of a machine fitted with a hopper, into which the fuel is fed in any ordinary way. The bottom of this hopper is provided with cut-offs which are isolated entirely from the fire at such times as it is desired to stop the operation. Underneath the cut-offs are placed duplicate feed boxes, which are fed with reciprocating feeder rams, and by which coal is fed into the furnace at intervals and alternately. Between these boxes a sight-hole door is provided, through which the state of the fire at any time can be seen, and this sight-hole is of a good size so that an excellent view of the furnace is obtained. The rams mentioned above are worked by a pair of double adjustable scroll cams which are controlled by hand nuts. This control allows the feed to be adjusted very gradually over wide limits.

A very wide fire door is fitted below the feeder boxes. This cuts off the air and prevents its entry into the front of the furnace. Below the fire door a series of special dead plate bars are provided. These bars are somewhat paradoxically known as live, owing to the fact that they are designed to admit air under pressure

so as to obtain a rapid lighting up of the fuel. This practice is, it is claimed, confined to the Bennis coking stoker. Below these bars is placed the main furnace,

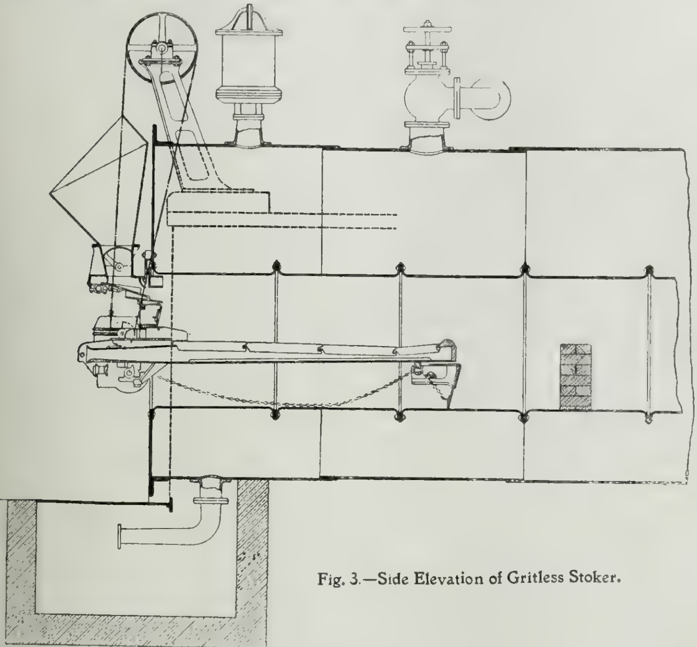

Fig. 3.—Side Elevation of Gritless Stoker.

which consists of powerful Bennis self-cleaning compressed air furnace bars, the bars in which move to and fro. Owing to a special arrangement of the two outside bars, however, the fuel does not travel as rapidly away from the front as from the rest of the furnace, so that there is always a white hot fire near the front at the two sides, and the blast here, through the fine air space in the bars and of the live dead plate bars, is such that the whole of the fuel fed across the fire is lighted up within a few inches of the live dead plate bars, at such a speed that the machine will burn at about as high a temperature as a sprinkling stoker.

Unlike the operation in an ordinary coking stoker, in the Bennis coker the fuel, as it leaves the dead plate, tumbles over several inches, and as it tumbles is split up into small pieces, so that the air is allowed full play over the whole mass. The result is that the fire pit becomes quite porous. The fuel is then travelled backwards along the compressed-air furnace bars, where it meets air at various pressures, which are proportioned to the thickness of the fire on a grate at each point. The rated amount of air is thus automatically fed in to burn the fuel that is on the bars. At the bar end of the furnace a dumping plate is provided so that the clinker may not drop off the end of the bar and leave a bare space.

This last advantage is not the only one claimed for the new stoker. It also, it is said, possesses the power of rapidly lighting back, so that a much larger amount of fuel can be put off the furnace then, while the scrubbing of the coke by the air blown into the fire gives a high and even temperature, which is so much desired by boiler house economists. Great flexibility is obtained by the way in which the air supplied to the furnace can be regulated, while only two adjustments have to be made by the fireman, one for altering the rate of feed, and the other for altering the air valve.

Brush Fans.

We are pleased to call attention to the excellent series of fans obtainable from the Brush Electrical Engineering Co. The box-blade is, as an inspection will show, a well-finished and thoroughly reliable article. It is fitted with an enclosed ventilator motor of good workmanship and design, wound for circuits up to 250 volts and for either direct or alternating current. The blades are of special construction and run with an absence of noise. They are manufactured in several sizes from 12 in. to 60 in. diameter, while a regulator can be provided with the direct-current fans, if desired, to give five different speeds.

In addition to the box-blade type the Brush Co. also makes porthole, ceiling and desk fans of various designs. A fan price list is available, and will be forwarded on request.

An interesting example of another type of fan is the table or desk fan, designed for use with a 6 or 12 volt battery of dry cells or accumulators which are contained in a very neat box. The blades are 9 in. in diameter, and the whole fitting is mounted on a wood base complete with starting switch and terminals. The net weight of this fan is only $9\frac{1}{4}$ lb.

THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.
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Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Optimism or Pessimism?

In our last issue we were led to express the opinion that during the present state of depression it was hard to feel optimistic about the future. But at the same time we did not mean to imply that the future would not be brighter than the present, and indeed took upon ourselves the task of enlightening the present gloom by indicating some ways in which matters might be improved. That this method of procedure is not to the liking of all our readers is evident from a short paragraph on the subject which has recently appeared in one of our contemporaries, known as the "Journal of Gas Lighting," though one cannot help thinking that the "Journal of Electric Lighting" would be a better cognomen, seeing the large amount of space that is often given in its columns to criticism of the latter method of illumination. While complaining that our article begins pessimistically and ends optimistically, they are pleased to find us not perpetually ill at ease, as such a state of things would doubtless detract from the gaieties of competition. Such solicitude is indeed touching, and one may be allowed to express the polite doubt whether all is as well with the gas industry as some would have us believe. A form of illumination which apparently requires so much boasting of its own merits, and so much detraction of its opponent's advantages to keep it going, is not necessarily in the pink of condition. There is a well-known proverb relating to the volume of sound emanating from empty vessels. Perhaps the same statement applies also to gasometers. However that may be, we are confident that the time is shortly coming when electricity will be a much more serious competitor in domestic heating and cooking and that, though there may be now 600,000 gas cookers in use in the London area, the time when they will be much less numerous and even near to vanishing point is not so far off as some people seem to think.

Electrical Energy from Peat.

The time has now arrived when greater care must be taken of our coal supplies in order that a dangerous depletion of the amount yet available may be avoided. To provide the necessary power for industrial work under such conditions electricity generated by water power, oil or gas obtained from some low quality coal, not possessing a high enough calorific value to be used direct, is pre-eminently suitable. Even with these fuels available, others are likely to be needed, and attention has, therefore, been turned to peat, large natural sources of which exist in certain parts of the world, notably in Ireland and in districts of Germany. As a fuel, peat has long been used for domestic purposes, but from the industrial point of view it possesses the great disadvantages that in its original state it contains a very high percentage, from 85 to 95 per cent., of water which must be reduced as far as possible before it is used. A peat containing 25 per cent. of water is considered as a good fuel for general purposes, but such a state of dryness requires six or seven weeks to obtain, even under favourable conditions. From the industrial point of view a great advance has, therefore, been made by the introduction by a well-known firm of engine makers of a producer which will work satisfactorily with peat containing 60 per cent. of moisture. By using this producer raw peat can be employed very soon after its removal from the bog, and the long interval which was formerly necessary to allow the peat to be dried is now reduced to a very short time. Further, by exposing the raw peat to a high temperature and moderate pressure a great part of the moisture can be artificially extracted very much more quickly than by natural methods. Turning to the economic side, which is naturally all important, it was recently stated by Capt. Sankey, after he had gone into the question, that dry peat would cost 3s. per ton at the producers, supposing these to be near the bog. On a calorific basis this would be equal to coal at 4s. 6d. per ton, so that peat appears to possess certain potential advantages. It has further been stated that the gas from such peat producers is quite suitable for use in the ordinary gas engine, so that no difficulties need be anticipated on this score. It is interesting to note in this connection that works are now being erected near Aurich, Germany, for the purpose of utilising peat in generating electricity. The energy thus produced, which is estimated at 2,000,000 kw. hours, will be used by the German Government on the new harbour works at Emden. It will therefore be seen that very definite steps are being taken towards the utilisation of this new fuel. In districts where it is easily available its employment should be economically advantageous, but whether the same would apply in other districts seems decidedly open to question at the present time.

Motor Load and Population.

The subject of motor loads generally being one of great interest to electrical engineers at the present time, it is not unimportant to consider the question from a statistical point of view, and to find out how this load depends on the population of or on the industries carried on in a particular town. Such an investigation has, in fact, been made by our contemporary, the "Electrical Review and Western

Electrician," with some interesting results. It would naturally be thought, for instance, that towns possessing large stations would be in a better position to supply energy at cheaper rates and would therefore have a larger load per thousand of population, the unit adopted by our contemporary, than the smaller towns. But this is not the case. In fact, to quote our contemporary :—

Generating stations of large capacity are supposed to show high efficiency and to attract motor loads by low rates, but it appears that some of the lowest annual incomes per horse power of motors served are found in the small cities and the towns. While large cities with diverse lines of manufactures may appear to offer the best fields for motor loads on electrical supply systems, the fact is that rather small places with only two or three important industries often lead, not only in the horse power of motors per thousand of population, but in total horse power as well.

As the result, all the electrical undertakings with a motor load exceeding 900 H.P. were considered, the smallest having a load of 935 H.P. and the largest 40,000 H.P. It was then found that the largest motor load per thousand of inhabitants was 108 H.P. in a town of 13,000 inhabitants, and the smallest 11·2 H.P. in a town of more than 100,000 inhabitants. In making such a comparison there are many things to be considered before the figures can be taken just as they stand. The type of supply is one of these. This seems to be as various in the United States as in this country, and is a factor which cannot be without influence on the motor load. The supply voltage is another similar factor. On the other hand, it must not be forgotten that in a large town there is probably a greater percentage of merely residential, or at least, not manufacturing, population, who will never, even under the most enlightened conditions, require more than a relatively small amount of energy for power purposes. Again, the activities of the supply department have not improbably a very wide influence on the motor load. There may be small towns with very active canvassers and large towns with canvassers of quite another description. These statistics, though interesting, should not, therefore, be used for "political" purposes, as so much depends on local conditions and on other factors which cannot be indicated by mere figures.

The Electric Drive in Laundries. A section of industrial work in which the electric drive is experiencing an ever greater development is in laundries. That such is the case can only be looked upon as a very valuable testimonial for this form of power production, as a steamy, moisture-laden atmosphere is far from being ideal for such a class of machinery. As regards the motors, those of the continuous-current type are found to be the most advantageous, owing to the great ease with which they can be regulated, but the employment of induction motors, with short-circuited rotors, should for obvious reasons be worth considering. Besides the actual driving of machinery, electricity can also find a useful application in laundry work for such purposes as irons, goffering machines and the other apparatus which is necessary to make the appearance of modern man and woman what it is.

Electrical Organ Blowing.

ORGAN blowing is a subject of which very little is heard by the "man in the street," although it plays a very important part in practically every church and chapel in the world. The necessary power required for "blowing the bellows" was until comparatively recently supplied by the organ blower, whose art lay in so manipulating the apparatus that the pressure remained as steady as possible under all conditions of the organist's playing. With the advance of mechanical power this method has in some cases been superseded by the installation of water turbines, where conditions are favourable, but of late years, where electric current is available, the "electric drive" has been used to very great advantage in many instances.

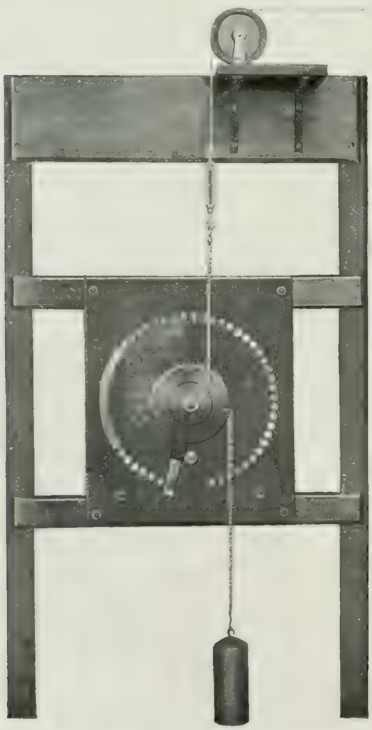


Fig. 1.—Electrically driven Organ Regulator.

With a view to catering in this particular direction the Adnil Electric Co., of Artillery-lane, London, have made a study of electrical organ-blowing outfits for some time past, details of which will doubtless interest our readers. The general arrangement for continuous-current supply consists of a motor driving, by means of a belt or silent chain drive, on to a crankshaft, which, in turn, drives the wind feeders. The motor used is of the slow speed type designed for silent working, while at the same time the speed is capable of regulation from full working load down to zero. Perhaps the most important feature is the controller for automatically regulating the speed of the motor to suit the quickly varying condition of the bellows. The controller used with these special sets is Marple's patent regulator, illustrated in Fig. 1, which has been designed to give the speed regulation, while at the same time the necessary starting gear is provided in the one piece of apparatus. The simplicity of this arrangement is shown by the fact that to start the blowing gear the organist has only to close a switch, and the motor immediately rotates automatically. The regulation of the controller is effected by means of a flexible wire cable connected to the bellows over pulleys, the pull of the moving portion of the bellows being balanced by a weight attached to the controller handle and capable of moving the controller back when the wind pressure raises the bellows. As the wind is used the motor increases its speed automatically, and vice versa, always keeping the bellows full of wind whatever the demand made by the organist.

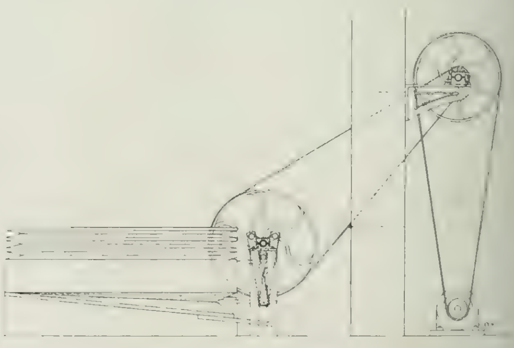


Fig. 2.—Blowing Arrangement used with A.C. Motors.

For use where the current supply is "alternating," and where consequently slow-speed motors cannot be supplied, a countershaft is placed between the motor and the bellows, a typical arrangement of which is shown in Fig. 2. The motor, which is one of the "Adnil" self-starting type, can be started or stopped by the operation of a single switch at the organ console, the whole making a very neat arrangement. In this case, as the speed of alternating motors cannot be controlled, a mechanical device has to be supplied, either by varying the speed of the crankshaft or arranging for an overflow valve to come into operation when the bellows are full.

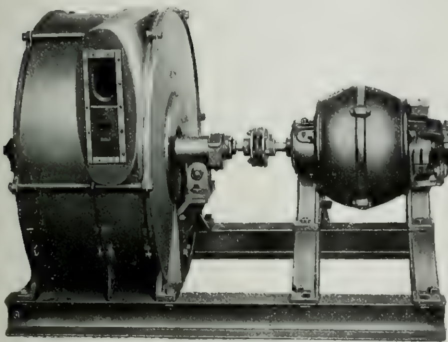


Fig. 3.—Direct-Coupled Motor and Blower

These two arrangements are for use when the bellows are already installed and it is required to adapt them to the electric drive. The Adnil Electric Co. also supply a combined set for installing with new organs. One of these for direct current is shown in Fig. 3, consisting of a motor direct coupled to a fan blower. The wind is forced by the blower through suitable trunks into the reservoirs, and the speed is controlled by a Marple's patent regulator in the same manner as previously described. It is claimed that this fan-blower is the only type which will develop the desired wind pressure without greatly increasing the temperature of the air.

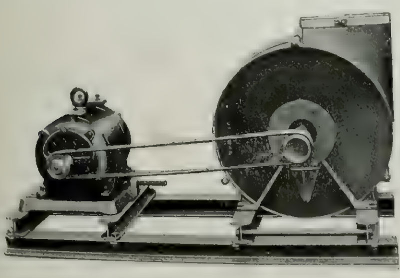


Fig. 4.—Belt-driven Blower.

The electric motor has several distinct advantages for this kind of work, not the least of which may be mentioned convenience and reliability. An electrically-driven organ blower is always ready for use, and the organist is entirely independent of outside help. It is also claimed that the cost of running is reduced very considerably by the use of electric power, while the initial outlay is comparatively small, taking into consideration the resulting reduction in maintenance expenses.

Hope's Patent Spring-on Switch Fuse.

THE design of switch fuses is a subject which is receiving a good deal of attention at the present time. All makers who have the matter in hand are endeavouring to reach the same end, but many different ways are being employed for so doing. Not the least in-

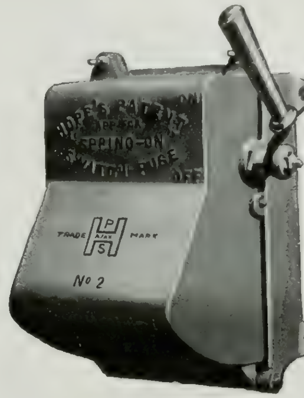


Fig. 1.—Hope Switch Fuse (closed).

teresting of these is that adopted by Messrs. Parmiter, Hope & Sugden in their Hope patent spring-on switch-fuse, which

is illustrated herewith. It is made in both the two and three pole types, and its production has been a matter which has had much careful attention, the finished article being the result of considerable experimental work.

The following special points in connection with this spring-on switch-fuse are claimed: The operation of the switch is independent of the handle and both "make" and "break" are as positive and quick as possible. The breaking of the switch is not dependent on the spring, but has a mechanical "kick-off." The switch is locked in both "on" and "off" positions, and can be left intermediately between "full on" and "full off." The whole of the operating mechanism is contained in the lid, and consequently when the fuses require renewing the connections are all clear of any live parts. Only the four contacts are actually alive at any time, consequently there is small chance of leakage. The switch fuse proper is interlocked with the cover, so that the case cannot be opened until the switch fuse is in the "off" position, and the case cannot be closed unless it is in this position. In general construction the switch fuse is very similar to Messrs. Parmiter, Hope & Sugden s well-known Ajax switch, and is equally gas and water tight. It is specially recommended for use with motors driving textile machinery.

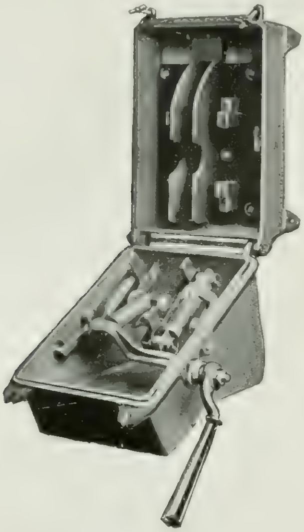


Fig. 2.—Hope Switch Fuse (open).

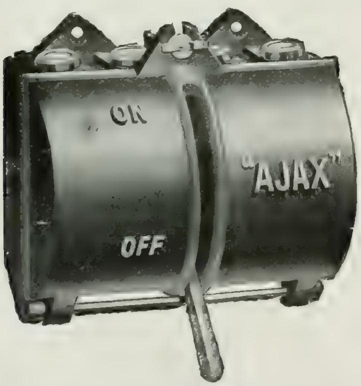


Fig. 3.—"Ajax" Switch (closed).

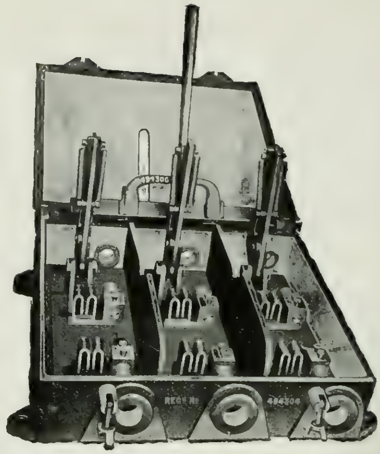


Fig. 4.—"Ajax" Switch (open).

Of Day Loads.

IN the early days of the electricity supply industry the lighting load was inevitably the part on which the greatest attention was concentrated. Lighting was, in fact, in many cases the only purpose for which electricity was supplied, any power load being of quite an auxiliary nature. At the present time, on the other hand, while perhaps the number of units supplied for lighting from the majority of stations exceeds that supplied for power, the power load is becoming of increasing importance, and on this importance the future prosperity of the station will doubtless to a great extent depend.

In the case of a station supplying a purely lighting load it is necessary, as is well known, to have plant available to meet a large, but almost momentary, demand at a certain time of the day. For the remainder of the twenty-four hours quite a large proportion of the plant may be idle, its earning capacity being therefore nil, though certain standing charges have always to be met. Such a state of things is inevitable where lighting is supplied, the only remedy for these uneconomical working conditions being to "top up" the "valleys" on each side of the "peak" by obtaining a day load sufficient to keep the station as fully loaded as possible throughout the 24 hours, due consideration being given to the question of stand-by plant.

It, therefore, behoves all supply engineers, for the good of their station, to do their utmost towards obtaining a satisfactory day load, by persuading manufacturers in their area to adopt the electric drive, by inducing the ordinary inhabitants to employ radiators and other similar apparatus, thus making clear the advantages of electricity to manufacturers, shopkeepers and others and the ease with which the motor may be employed to perform certain operations which are now laboriously effected by human or other unsuitable means.

It is regretable, however, that nothing like enough missionary work has been done, or is being done, towards these

ends. In the columns of THE ELECTRICIAN some months ago we took upon ourselves the unpleasant task of pointing out how much the canvassing departments of such electricity supply undertakings as possessed public showrooms fell short of a not-too-hard-to-be-obtained ideal. But there are numerous other undertakings, not possessing showrooms and apparently not caring what happens, where the would-be consumer has to go on bended knee to the "high priest" at the station, and be treated as if he had come to borrow a five pound note or to sell a fountain pen.

Lest it be thought we exaggerate, a flagrant example of the lackadaisical methods now in vogue, and which was quite unofficially recently brought to our notice, may be cited. It appears that in one of the outermost London suburbs the supply company (a company, be it remarked), whose object is presumably dividends, has laid a distributor from a main road, where consumers do exist, along a side road whose length is perhaps a mile. The houses in this road are of good class, wholly detached, occupied by well-to-do and educated people, so that the advantages of electric lighting would presumably appeal to them, and if these advantages had been put forward in a proper way no doubt many of them would have had their houses wired, especially as the supply is alternating and tranformers and metal filament lamps could easily have been used. And it would naturally be thought that the company, having been enterprising enough to lay a main down this road before a single application for current had been made in it, would also have been enterprising enough to canvass its inhabitants and thus attempt to earn some interest on the capital thus expended. Such, however, is not the way this company go to work. Only one consumer is at present connected. He only obtained his desires after much persuasion of the company's officials, and when his warlike frame (he comes of a fighting race) was nearly worn out. The other householders still use archaic methods of illumination, being probably in ignorance that electricity is at their doors; and we may be permitted to wonder, doubtless in company with the underground inhabitants of that neighbourhood, why in the name of all that's electrical that distributor is there at all.

We digress, however, our original purpose having been to point out some directions in which a profitable day load can be obtained. In industrial districts in this country much has already been done towards this end; in fact, in some manufacturing towns the power is even more important than the lighting load. But, on the other hand, in many of the smaller towns the supply station practically only exists for lighting purposes, a state of things which we should like to see changed as speedily as possible.

The way in which a day load may be built up in small central stations was a subject which recently received a good deal of attention at a recent meeting of the Minnesota Electrical Association. One of the speakers, Mr. G. T. Cadwell, dealt especially with the use of small motors for developing a day load, and as his remarks on the subject are likely to be of interest to our readers we give a brief abstract of them on another page of this issue. Apart from motors, for the use of which it will be seen Mr. Cadwell makes out an exceedingly good case, other speakers gave it as their opinion that the employment of electrical heating and cooking apparatus was a great help towards improving the day load.

From a consideration of the whole question of day loads in as broad a way as possible, it appears there are two general principles to be observed. Catch your consumer, by honeyed words or other means, and having got him, keep him. The second of these may be the harder, for electricity is a mysterious agent to most people, so that besides selling the apparatus the supply engineer has often to teach the consumer how to use it. As an example we find that much more appears to be done in the United States with electric heating and cooking apparatus than in this country, and the effect on the day load is found to be most beneficial, such apparatus being a very good educational medium, for even a flat-iron will go far towards showing what can be done domestically by using electricity. Judicious advertising of the benefits of electricity for domestic purposes will allow the first principle set out above to be accomplished, while the second should follow from the satisfied consumer, provided care is taken to see that the apparatus used is suitable for the work it has to do. In this way annoying breakdowns can be avoided. Further, if the customer finds that the supply engineer sympathises with him in his trouble, which, we fear, is far too seldom the case at present, he will be more inclined to take this trouble philosophically and less to rave about the unreliability of electricity, forgetting how often it has faithfully served him.

It is, therefore, now the bounden duty of all supply engineers, especially those in small towns where the power load can only be relatively unimportant, to convince the inhabitants of their district of the many advantages to be gained by using electricity for domestic purposes. By so doing they will inevitably improve their load factor and develop their undertaking generally. Considering how bad things are in the industry at present, it is astonishing that more energy is not being displayed towards improving them. Sitting down will not do; an energetic campaign is necessary to hold even our proper place in the world's economy and to allow us to advance along the road of progress. It is, in fact, a question of "Wake up electrical engineers."

B.T.-H. Controllers.

A RELIABLE form of controlling device is essential for the successful and economical operation of an electric motor. Such a device must be able to open the motor circuit under all conditions of load, and make the required changes in the circuit connections as frequently as desired, without injury to the contacts or danger of short-circuits. The parts that are subject to wear must be readily and economically replaceable, every portion of the controlling apparatus must be accessible for inspection and repair, and the construction should be strong and substantial, so that the apparatus may be used by inexperienced operators without danger of injury either to the operator or the machinery. These requirements are, it is claimed, complied with in the B.T.-H. controllers, which are now well known in the electrical world as being one of the

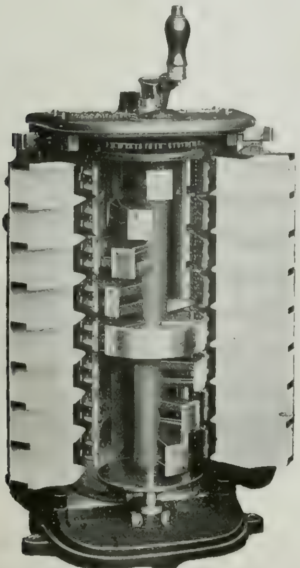


Fig. 1.—B.T.-H. Continuous-Current Controller.

many specialities made by the British Thomson-Houston Co. Further, the parts in these controllers which are subject to wear are readily replaceable, while the whole can be easily exposed for inspection.

B.T.-H. controllers are fitted with a large number of controlling points, so that the motor can be started under load uniformly and without shock. The continuous-current controllers, a standard type of which we show in Fig. 1, are fitted when necessary with magnetic blow-out devices, and can be provided with either the usual crank handle or a horizontal or vertical lever as desired. A single lever can also be arranged for working one or more controllers through suitable gearing when these are used on cranes and similar apparatus. A controller for mining work is shown in Fig. 2. This type of controller has been specially designed for use in those parts of mines where an explosive mixture is likely to exist. All arcing occurs under the surface of the oil, so that practically every chance of firing the gas is avoided. The resistances can also, if desired, be placed under the oil surface, and in this case special cable, whose insulation is unaffected by the oil, is used for the various connections.

The dial controller, shown in Fig. 3, which has been specially designed for use in printing press work, is so arranged that the necessary speed control of the motor is obtained by altering both armature and field connections.

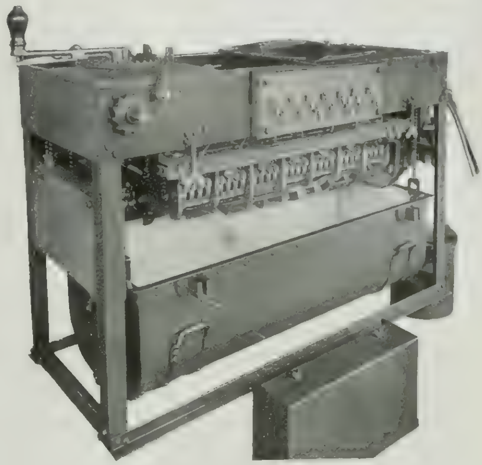


Fig. 2.—Controller for Mining Work.

These controllers are enclosed in iron cases through which a single handle projects for working the apparatus. All circuits on which arcing can occur are made on a contactor type of solenoid switch, a feature which, it is claimed, makes this type of controller specially rugged and durable—a point of great advantage in printing work. The movement of the operating gear in either direction energises the

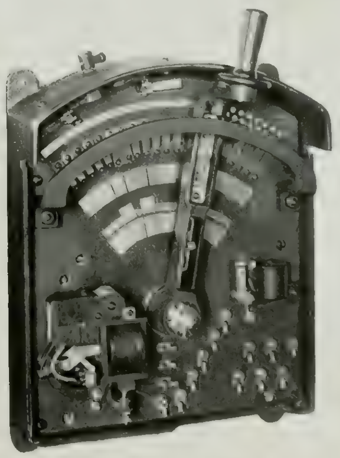


Fig. 3.—Dial Controller.

contactor which, in its turn, closes the motor circuit. Should the contactor be opened, either by the overload devices opening the contactor coil, or by failure of the voltage, the lever must be returned to the off position by the operator before the contactor can be again energised. A notched rack is provided to centre the lever at each point, while push buttons may be used to "inch" the motor

slowly or to allow a quick stop to be obtained in case of accident. The armature regulating resistance is mounted in a separate box, the other resistances being placed in the controller case. These controllers can also be supplied in the drum type and are, in this case, also provided with all the devices which are necessary for printing press work.

Siemens A.C. and D.C. Crane Controllers.

FOR many years Messrs. Siemens have been placing on the market controllers designed for use in a variety of electrical work. It will therefore doubtless be of interest to our readers to indicate what they are doing at the present time as regards drum-type controllers for cranes, hoists, winches, turn-tables and other similar apparatus where the motions are frequently reversed and where the loads are very intermittent and varying.

Controllers for these purposes are made suitable for both continuous and alternating-current circuits. Those for use on the former may be divided into six types, the first three of which are designed for series, shunt and compound wound motors respectively, plain reversal without any braking positions being provided with or without, in the case of the series motors, a series or shunt wound solenoid brake magnet and in the case of the shunt and compound controllers a special non-inductive field discharge resistance is provided.

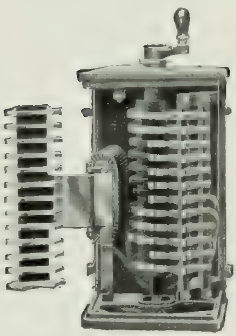


Fig. 1.—Standard Siemens Controller

The fourth type of controller is designed for use with series motors. It is adapted for full reversal and has rheostatic braking positions in both directions. This type of controller is specially adapted for use with longitudinal travelling and traversing motors on high-speed cranes, when it is desired to stop the motors quickly by electric braking. Where this control is used it is found that it is not necessary to provide a solenoid braking magnet. The fifth type of controller is designed for lifting work and for lowering with electric braking and reverse current positions. It is suitable where the crane gearing is of such design that it allows the load to drive the motor, which then acts as a generator. A special feature of this type of control is that the field of the motor is excited direct from the mains on the first lowering position, thus preventing the load from dropping quickly on commencing to lower. A shunt-wound brake magnet is necessary with this form of control. The sixth type of controller is similar to the above but is arranged to give a very low lifting speed on the first two positions. This criterion is obtained by inserting a resistance in shunt with the armature. A number of other types of d.c. control are also made, besides those described here.

As regards the alternating-current controllers, several types are made. These are fitted with plain reversal without braking positions, and can be designed for either two or three-phase slip-ring motors, which may be fitted either with or without a braking magnet.

The frame is of cast iron with a cast-iron top, provided with a dial-plate to mark the various positions. Bolt holes are provided to enable the frame to be fixed vertically; horizontal controllers are fitted with special brackets for fixing. A sheet metal cover is fitted which completely encloses all the working parts, and is held in position by suitable catches. The fingers are hinged to a brass finger carrier, and are made of hard-drawn copper; they are specially thickened at the end, in order to increase their wearing depth. The fingers are pressed against the drum contacts by a stout flat steel spring (except in the smallest size), a copper braid being provided to carry the current; their tension can be regulated by a set screw. The finger carriers are securely clamped to two metal bars which are insulated by micanite tubes. All continuous-current controllers are provided with an efficient magnetic blow-out (acting on all the fingers) the winding of which is in series with the motor. The arc shield carrier which forms part of the magnetic blow-out can be swung back, to give easy access to the working parts. The arc shields are of very durable material and so arranged as to prevent any arcing across. Alternating-current controllers are not provided with a blow-out; they are, however, fitted with arc shields for the stator contacts.

The drum, except in two cases, consists of a number of castings to which the contact segments are fixed, the castings being insulated from the spindle and from one another by micanite. In these two cases the drum is of the built-up

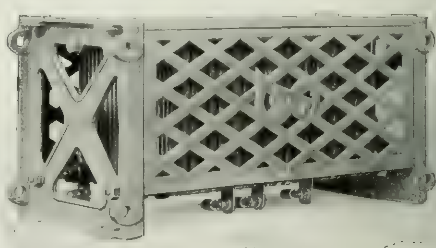


Fig. 2.—Siemens' Standard Resistance for Controller Work.

type and consists of rings of insulating material possessing high insulating qualities on which the contact segments are fixed. A pawl wheel and spring-controlled pawl are fitted to define the various running positions. The controllers are usually operated by means of a tramway type of handle (Fig. 1), or a handwheel, and can be fitted with an automatic return to the "off" position.

The resistances supplied with Siemens' standard controllers consist of either wire or cast-iron grids (Fig. 2) mounted in frames, and are all of the protected Siemens' type. The former type is provided with suitable terminals, while with the latter cable lugs are provided. They are all rated for one-third load factor—*i.e.* four minutes on load followed by eight minutes rest.

To meet all requirements three different sizes of resistances are supplied designed to limit the current on the first step of the controller to $33\frac{1}{3}$, 50 and 75 per cent. respectively of normal full-load current. Resistances designed to allow $33\frac{1}{3}$ per cent. full-load current on the first step are recommended for lifting motions where a large range of speed is required with varying loads. Resistances designed to limit the current on the first step to 50 per cent. are suitable for ordinary lifting, cross traversing and derricking. Resistances designed to allow 75 per cent. full-load current on the first contact are suitable for travelling and slewing motions, and for similar purposes where the work on the motor remains practically constant irrespective of the load.

"Silundum" Cooking Apparatus.

A NEW form of high temperature cooking apparatus, which forms a prominent feature of the Simplex Company's exhibit at the White City, has just been introduced. The new element is known by the name of "Silundum," and is a compound, manufactured in an electric furnace, consisting principally of carbides silicon and boron subjected to a temperature of 200°C. The specific resistance of "Silundum" is approximately three times that of carbon, and possesses a slightly positive temperature coefficient of resistance. It can be adapted for almost any voltage, but the standard pressures are at present limited to those between 100 and 250 volts. The nature of the compound lends itself admirably to the use to which it is put in connection with electric cooking, it being entirely unaffected by the actions of acids or alkalies, and water and grease being spilt over the elements themselves even when on circuit have no effect whatever. A temperature of 3,000°F. can be reached in open air without oxidation or any chemical or visible change. The material is, however, when made in rods, in which form it is adapted to electric cooking, brittle, so, to guard against accidental damage, in every case the elements are efficiently protected by a cast-iron grid. It has the further advantage of being unaffected by being left on circuit for any period of time. The advantage of this "Silundum" apparatus as against wire resistance coils will be at once apparent as the latter cannot be run at temperatures sufficiently high to admit of toasting or grilling and other operations requiring incandescent heat.

The Simplex Company are at present introducing a number of useful forms in cooking appliances, principally confined to cookers, grills, toasters and ovens. The breakfast cooker is perhaps that which is most suitable for ordinary use as several operations may be carried out at one time—viz., grilling, toasting, and boiling water. These operations which are entailed in the cooking of a complete meal, can be accomplished in under 20 minutes, and as the full load of the apparatus is only 1,000 watts, it will be seen that the cost of current consumption is kept exceedingly low. In the small class of apparatus facilities for heat regulation are not provided, but in the case of ovens one-third, two-thirds and full heat are allowed for in the course of ordinary cooking operations. The working temperature is about 2,000°F., in which case the silundum rods assume a cherry red appearance.

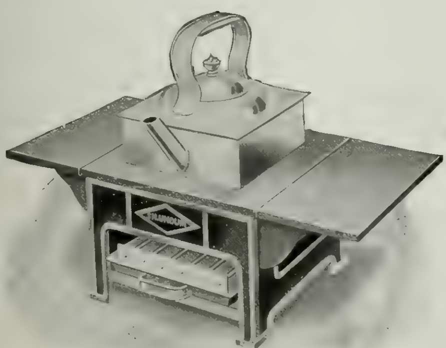


Fig. 1.—"Silundum" Oven.

Fig. 2.—Another Type of "Silundum" Apparatus.

Extensive plant is being laid down for the manufacture of this class of apparatus for which an exceedingly large demand is anticipated in the near future. It is hoped that the introduction of this system will give the requisite impetus to the adoption of cooking by means of electricity, and demonstrations are held daily at Simplex Company's exhibit at the White City of this system.

Illustrations of the cooking apparatus manufactured according to this new principle are given herewith, and show that nothing is lost either from the artistic or useful points of view—matters for which the Simplex Company have long been noted.

Liquid Motor Starters.

SOME people are of the opinion that liquid starters are a constant source of trouble and require a great deal of attention, besides being of bulky appearance and dirty to handle. This is indeed almost a wholesale condemnation, but perhaps, as is so often the case with electrical apparatus, carelessness and neglect have a great deal to answer for, whereas common-sense and forethought would prescribe many a "stitch in time."

As specialists in this form of motor control Messrs. Tetley & Co., of Falcon Electrical Works, Salford, contend that their liquid starters both in efficient design and practical results compare most favourably with the various other types of starters at present on the market. In Fig. 3 we show a standard polyphase starter with cover removed. It will be noticed that the blades are of a special shape, and that the tanks for holding the electrolyte, into which the blades dip, taper towards the bottom. The shape of these blades have been found experimentally, the idea being to obtain a graduated and more even flow of current during the starting process, and consequently a nearly constant torque on the motor while starting. The shape of the tanks further balances the resistance and helps to ensure an evenly increasing flow of current. The blades are insulated from the spindle, to which they are attached by split bosses, by either porcelain or vulcanite, the latter being rendered acid-proof by means of acid resisting varnish. They can be easily detached, and a new blade can be put into position in a very few minutes. The starting motion in which the blades are lowered into the electrolyte is effected by means of a worm gear actuated by a handwheel, and when the starter is full on, that is, the motor is up to speed, a short circuiting brush fixed on the blades makes contact, preventing the tendency to undue heating that would arise if the current were passing continously through the liquid. The most suitable electrolyte for use with these starters consists of a saturated solution of common washing soda to which $\frac{1}{2}$ oz. caustic potash per gallon is added, this mixture being diluted with pure water to the correct strength which is best found by trial. The solution is of correct strength if slight sparking occurs when the blades come in contact with the liquid, with no appreciable sparking at the short-circuiting switch.

In Fig. 1 a combined panel with triple-pole ironclad switches, fuses and liquid starter is shown. This makes a very neat combination, the whole thing being ironclad and fool-proof when the covers are in position. Fig. 2 illustrates a panel having a triple-pole oil switch combined with a liquid starter.

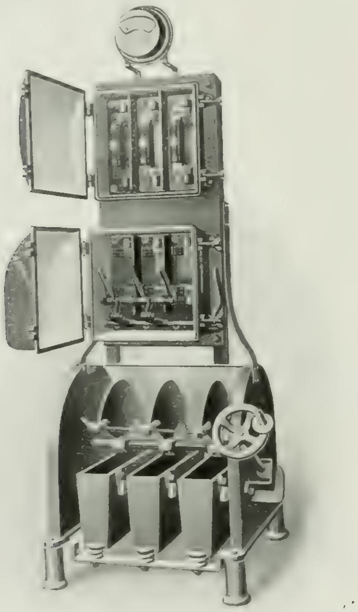


Fig. 1.—Starter and Panel complete, with covers removed.

Fig. 2.—Starter and Panel complete with Triple-pole Oil Switch

The question of the up-keep of liquid starters, always a much debated point, seems to be quite insignificant with this particular make. All current carrying parts are designed so that the current density is very low, in fact 10 amperes per square inch sectional area is the standard taken, and consequently the necessity for constant renewal of blades, &c., is practically done away with. The addition of clean water from time to time making up for evaporation, and keeping the electrolyte at correct strength, is really the only attention required by these starters when handled sensibly and kept free from abuse.

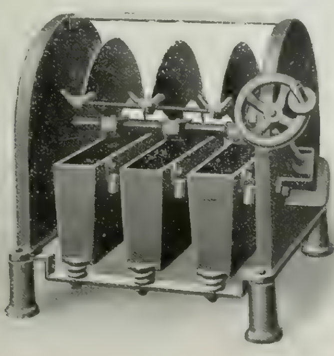


Fig. 3.—Polyphase Liquid Starter, with cover removed.

Motors and a Day Load.

At a recent meeting of Minneosta Electrical Association, Mr. G. J. Cadwell read a Paper on small electric motors and their possibilities in developing a day load. He called attention to the specific applications for electric motors found in small towns. Beginning at the hotel, there were dumb waiters, potato peelers, meat choppers, dish washers, knife grinders, silver buffers, ice cream freezers and dough mixers. In the hotel laundry there were washing machines, and every hotel should have a vacuum cleaner. In hotels, restaurants and saloons motor-driven refrigerators reduced the cost of refrigerating considerably. The ventilating of such places could not be handled better than by motor-driven fans. The restaurants could also use all of the kitchen machinery mentioned in connection with the hotel. The saloon should have a motor-driven beer-pumping and carbonating machine. In the dry goods business the electric motor could be applied to dumb waiters, moving window displays, cash carriers and elevators. The drug store could use motors for ice cream freezing and carbonating machinery. The grocery had its coffee grinder and the meat market its meat grinder and meat chopper, also refrigerating machinery. Offices used motors for turning adding machines, addressing machines and phonographs, while electric exhaust fans were employed for the ventilation and the vacuum apparatus kept the office clean. At the bakery, dough mixing and the making and pulling of candy could be done by electric motors. In the shoe shop shoes were repaired

while you wait, thanks to the small motor. In the barber shop vibrator motors massaged the face and polishing motors cleaned shoes. Newspapers and job printing establishments were equipped with motors. The livery stable used a motor for clipping and grooming and another for the feed. The blacksmith's shop had a motor-driven forge blower, drill press and grindstone. In laundry work there were especial advantages for motors for direct driving, doing away with the dirty belts and saving loss in transmission. The grain elevator had conveyors, cleaners and corn shellers for motor possibilities; the dairy had a motor for churning, cream separators, pumps and refrigerating machines. Doctors used motors for static machines and dentists used them for running drills and lathes. Moving picture shows used motors for the picture machines, for ventilating fans and for the automatic pianos. Theatres used them for ventilating, for raising and lowering curtains, as well as for vacuum cleaning. Churches needed motors for vacuum cleaning, heating and ventilating fans, also for the organ blower. In the residence there was much work that could be done by motors. It was comparatively easy to apply one motor to a number of different tasks, such as running the washing machine, sewing machine and dish washer. The motor being small could be mounted on a portable stand and connected to a plug in a lamp socket. Another application of general interest was that of the small motor-driven house pump, both for general supply water and for seepage and sewerage. Where there were apartment houses or flats, vacuum cleaning was an attractive field. Where a town consisted of small detached residences a profitable business might be worked up by some enterprising man with a portable electric cleaning outfit which could be easily connected up wherever the residences were wired. Mr. Cadwell also called attention to the possibility of extending lines to farms in the surrounding country.

Propeller Fans.

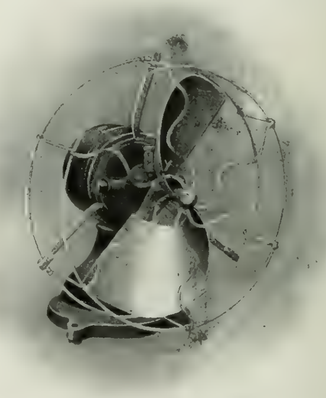
USUALLY at this time of the year electric fans become a very necessary adjunct to comfort practically everywhere, with the result that the general public for once in a way, is not slow to take advantage of the benefit received from the use of the artificial "cooling breeze" maker. Apart from the question of price, one fan is very like another and in a number of different makes of about the same size, a slight difference in the curve of the blades, or the setting of the same, may or may not affect the amount of the "stirring-up" process.

During a visit to the recent Ironmongery and Hardware Trades Exhibition at the Agricultural Hall, Islington, we had the opportunity of inspecting the Blizzard Patent Propeller Fans made by the Albany Engineering Co., Old Kent-road, London, particulars of which will doubtless interest our readers.

As will be seen in the accompanying illustration, the blading used in this fan is of a novel type, and the makers claim that a greater efficiency is obtained by this design than with any other fan on the market.

The blade is cut and shaped from one sheet of brass fixed on a spindle at the centre, this spindle being made solid with a stout strip of metal forming a stay for the edges of the blades. It will thus be seen that strength is not the least of the features in the Blizzard propeller. By virtue of the shape of the blade the air is drawn in at the periphery, and converted into a steady parallel stream, while the slipping at the centre of the blades, often met with in other makes, is stated to be entirely avoided.

Comparative tests made with the Blizzard propeller and an ordinary fan of the same size show that for various speeds



Albany Blizzard Propeller Fan.

the power required to drive the Blizzard is less, whereas both the pressure and volume of air obtained are appreciably greater. It is also interesting to note that Gold Medals were awarded for this fan, both at the Paris Exhibition this year and the Milan Exhibition held in June last, showing that out of the very great number of fans on the market this type is receiving well-merited recognition.

Electricity on the Farm.

WE have from time to time called attention to the many openings for the electric drive which are available on an ordinary farm. In some cases, even in this country, where cheap power is available, much is done in this direction, so that it will be of interest in this article to call attention to an example of a farm installation electrically-driven now working in California.

Fifty miles east of Sacramento, Mr. Ellis Franklin owns a small farm. A little trout stream is harnessed to supply the necessary power, and by its means sufficient electrical energy is generated to do most of the mechanical work about the premises, including heating and lighting the building, doing the cooking, washing and ironing, and numerous other small "chores."

This diminutive trout stream in times of high water is a small torrent, but during the dry season it shrinks to a few cubic inches a minute, so it was necessary to utilise an old miner's ditch for a reservoir to store up a supply of water sufficient for use in the dry months. A part of this old ditch, dug by early placer miners, was repaired to hold 100,000 cubic ft. of water. A 6 in. riveted steel pipe, 445 ft. in length, carries the water to the foot of the fall, where the "power house" is located. The little 2 ft. waterwheel in the power house works under a 75 ft. head, and is belted to a 240-volt 6 H.P. generator. The water enters the waterwheel through a $1\frac{1}{2}$ in. nozzle and develops more than 6 H.P. The heavy pulley-wheel takes the place of a balance wheel, and a small governor is provided as a prevention against accidents.

Current from the power house is carried to the house, a quarter of a mile away, over a small copper wire strung on 20 ft. poles. The residence and a small log cabin are lighted with a total of about 50 16 c.p. lamps. Another lighting circuit runs to the barns and other outbuildings. In the basement at the house a 3 H.P. motor operates a centrifugal pump and with line shafting drives a washing machine, wringer, churn, cream separator, grindstone and a circular saw.

It is not necessary to go down to the power house to start or stop the machinery. Near the switchboard in the house is a small crank attached to a shaft running through the wall to the outside. By a system of pulleys this crank operates two long galvanised iron wires, running just beneath the transmission wire, which open or close the water-wheel gates as desired. An electric buzzer on the switchboard tells when the gate valve is tightly closed.

The residence is very well lighted, lamps aggregating fully 900 c.p. making the rooms as cheerful and pretty as any city home. Artistic fittings, harmonising with the interior, make, it is said, one almost forget that he is living on a farm. Outside the broad verandahs, with their pendant electric bulbs and lanterns, add to the charm of this country home. The farm labourers also share in the luxury of electric lighting. In their little cottage, which is apart from the residence, electric lamps are provided for the bedrooms and for the library, where the men pass their evenings.

The 3 H.P. motor in the basement drives a horizontal centrifugal pump, which lifts water from an almost inexhaustible well to a reservoir dug in the hill side and connected to the pump by a 2 in. pipe 250 ft. long. The reservoir has a capacity of about 6,000 gallons, and is placed 40 ft. above the level of the pump, furnishing kitchen, bathroom and laundry with water at a good pressure. In the front yard there is hose connection with a hydrant, which furnishes water for the lawn and also adds security to the home in case of fire.

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Relative Advantages of Belt, Group, and Single Drive.

A RECENT issue of the "Zeitschrift des Vereins Deutscher Ingenieur" deals with this subject, and belt driving is shown to have advantages where machines are very close to the source of power and can be worked without any intermediate transmission being necessary. This is especially the case where the power demand is large and the machines are seldom resting. In all other cases it is contended that the electric drive possesses advantages, and group driving by this means should be used for steady working and evenly loaded shops, as the belting losses are practically the same for all loads, resulting in good overall efficiency. Electrical individual drive should be used for all quick running work where the stops are many, and in cases where the conditions in the shop are not favourable to belting being used. The same conditions may be observed in all cases where power is not generated on the premises.

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NOTES.

The Entz Petrol-Electric System.

THE advantages of petrol-electric systems are well known, and, doubtless, they would have come into serious use had it not been for the fact that they involve greater weight than the ordinary petrol apparatus, and very often more complication. On the other hand, from the point of view of manipulation, there is no question that such systems are very much to be preferred, as they give greater smoothness of running and more elasticity of drive. In our present issue we give an account of an ingenious system due to Mr. J. B. ENTZ. This consists essentially of a generator used as a slipping clutch, the field being mounted on the engine crank shaft and the armature on the shaft transmitting the motion to the driving gear. Under ordinary conditions the generator is short-circuited, and, therefore, as the field revolves, the armature revolves also with a certain slip, this slip being sufficient to generate current to give the required torque when running at ordinary full speed. The slip is thus about 5 per cent., and the energy undergoing conversion is comparatively small. For lower speeds a motor is included in the generator circuit, the armature of this motor being on the same shaft as the armature of the generator. Thus, as greater slip is introduced between the generator field and armature, more energy is transformed electrically and passes to the motor, thus providing additional torque. In this way much higher efficiency is obtained than by the use of a generator for transforming the whole of the energy into electrical energy and then using it with the motor, and at the same time the weight introduced by the electrical equipment is much less. Mr. ENTZ does not say on what type of car his system has been used. With all purely petrol systems the clutch and change-speed gear are an evil, but this evil becomes reduced in proportion as the engine is made too large for its normal work. In a car which has a large power compared with the work that has to be done the change-speed gear introduces very little difficulty, for the simple reason that it need not be used except just for getting the car into motion, but if the power of the engine is cut down a change-speed gear is, undoubtedly, an evil. This is the case, for instance, on the petrol motor omnibus and it is quite possible that a system such as that due to, Mr. ENTZ might afford something of a solution to the petrol motor omnibus problem.

The Value of Research.

FROM one so pre-eminent in research as Sir J. J. THOMSON it is interesting to have opinions upon some of the educational questions so frequently under discussion. It may, perhaps, be thought that these opinions should be restricted to education in pure science, but there is not much doubt that the same type of mind is required for progress, no matter whether it be in the world of pure science or in that of its applications. The problems are different, no doubt, but initiative is required in both cases, and the same tenacity of purpose. It is interesting to notice that Sir J. J. THOMSON, in his presidential address to the British Association, considers that the chief evil under which Cambridge labours at the present time is that of excessive competition for scholarships; indeed, the yearly aggregate sum thus given to undergraduates amounts to more than £35,000. The result of this is that specialisation begins at quite an early age—that is, before the University is reached—and continues increasingly as the college course is pursued. Finally, a minute acquaintance with a particular subject is acquired, but the effect of studying one subject for so long a time is generally to dull the enthusiasm of the student, and when research at length begins it is taken up with much less interest and keenness than would have been the case originally had the field of study been less restricted.

Considering that research is laborious and disheartening, it is no doubt true that no greater evil can be done to a young man than to dull his enthusiasm. Sir J. J. Thomson mentions that he has met many more failures from lack of enthusiasm and determination than from any lack of knowledge, or what is usually known as cleverness. There may be some who feel that research is of little value except to those who can continue in it; but we do not think such a view can be supported, for there is no doubt that this class of work has a very great educational value. As is mentioned in Sir J. J. Thomson's address, it is possible to read books and pass examinations without the higher qualities of the mind being brought into play. The mind can be very quiescent in reading without interest, and, indeed, many of us know the soporific effect of a book in which the interest cannot be maintained. In research, on the other hand, there is a different object to be attained independent of all reading, and therefore it is not surprising that Sir J. J. Thomson should have been frequently struck by the quite remarkable improvement in judgment, independence of thought and maturity produced by a year's research. The opinion is expressed, and we think quite rightly, that research develops qualities which are apt to atrophy when the student is preparing for examinations, and, quite apart from the addition of new knowledge to our store, it is of the greatest importance as a means of education.

In referring to the study of mathematics, Sir J. J. Thomson mentions the fact that there is a tendency in some quarters to discourage the use of mathematics in physics, and that some writers indeed seem to consider ignorance of mathematics to be almost a virtue. We sincerely hope that this view is not often held. On the other hand, we think it will be admitted that the mathematician has often done harm to his cause by altogether failing to grasp the practical considerations entering into his problem, or by making assumptions which are altogether impossible in practice. There is a no more valuable servant than mathematics if used with discretion. On the other hand, there is a no more misleading master if its limitations are not clearly seen. For this reason we think, on the whole, that it is more important for a mathematician to study physics than for the physicist or engineer to study mathematics. There can be no question, however, that the proper use of mathematics in both physics and engineering is of the greatest importance, and we only regret that a good knowledge of mathematics is not more general.

Electric Lighting Acts (Amendment) Bill.

The treatment finally accorded to the Electric Lighting Acts (Amendment) Bill in Parliament is quite characteristic of our methods of legislation. The chief bone of contention throughout has been the clause enabling local authorities to let apparatus out on hire and to carry out wiring. There has been a great deal of opposition to the clause, and in the House of Lords, at the instance of Lord Avebury, the clause was altered so that wiring could only be carried out by local authorities through the medium of a contractor. In the present state of feeling this alteration was not likely to be acceptable to the House of Commons. When, therefore, the Bill was considered in Committee by that House, Lord Avebury's amendment was excised; but on Saturday, when the measure came up for third reading, with a mere handful of members present, Sir Frederick Banbury moved that the entire clause be deleted. This amendment was accepted, and the Bill rushed through, the only other serious alteration being that a clause was included prohibiting unauthorised supply in districts already supplied by authorised undertakings. It will thus be seen that the electrical contractors have gained the day, but we doubt if their victory will be for the good of the industry. Certainly, it is extremely unfortunate that municipalities should not have obtained powers to let apparatus out on hire. We think that Lord Avebury's amendment was the best solution of the difficulty, but, failing that, it would probably have been better for the municipalities to have had the wiring powers, for most of those who already possess wiring powers find it best to work through the medium of contractors. So long, however, as our legislation is carried out by those who know very little about the issues involved, we can only expect this sort of result.

Age of the Electrical Industry.

To those who speak habitually of the electrical industry being in its infancy the announcement may come as a shock that Mr. R. Stewart Bain and Mr. G. W. Partridge have each been presented with a handsome piece of plate by the directors of the London Electric Supply Corporation in recognition of 21 year's service. Although the dawn of the electrical age may seem but yesterday, the fact remains that the industry has nevertheless reached the stage of full manhood, and it is quite possible to have spent 21 years of one's life in the service of a single undertaking. Of course, if the telegraphic world alone is considered, it is possible to go much further; in fact, to have been born in it, and to have retired from it with the proverbial grey hairs; but the electrical industry in the wider sense is more youthful, and, we fear, correspondingly less robust. We offer our congratulations to Mr. Bain and Mr. Partridge.

Obituary.—We regret to record the death of Alderman Dowson, chairman of the Doncaster Electricity Committee, which occurred at Norwich on Saturday, August 14th. Mr. Dowson had long experience of municipal work generally and especially of the branch connected with electrical engineering. He was for some years a member of the council of the Municipal Electric Tramways Association.

Electric Induction Furnace for Brass Smelting.—According to the "Electrical Review and Western Electrician," the electric induction furnace has been suggested for brass smelting, and possesses the advantage that, by covering in the furnace before the melting temperature is reached, the oxidation of the zinc can be materially reduced. Brass and similar alloys at present are usually melted in crucibles in coke furnaces, a method which is wasteful of fuel and difficult to regulate, besides incurring a loss of zinc.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tangier—Cadiz	May 19, 1909	—
Tourane—Amoy	June 17, 1909	—
Assab—Perim	July 8, 1909	—
Gibraltar—Tangier	Aug. 7, 1909	—
Cueta—Tangier	Aug. 7, 1909	—
Melilla—Chafrinas	Aug. 7, 1909	—
Corfu—Trieste	Aug. 16, 1909	Aug. 23, 1909
Dakar—Conakry	Aug. 19, 1909	—

Telephones from Paris to Madrid.—We understand that negotiations for through telephone communication between Madrid and Paris are well advanced, and it has been decided definitely to provide telephone lines between Madrid and Bordeaux. When the Franco-Spanish communication has been established the problem of through speaking from London to Madrid will require speedy solution.

Financial Assistance from an Electric Light Company.—A pleasing instance of the good relations existing between a supply company and a municipality, a state of things which is too often non-existent in this country, is given in a recent issue of the "Illuminating Engineer." It appears that when the city of Chicago was "strapped" last January and could not meet its payments, the Commonwealth Edison Co. advanced £20,000 on account of its tax. It has recently handed over the balance, amounting to about £80,000. "A friend in need is a friend indeed."

"Engineering Day" at Shepherd's Bush Exhibition.—It is announced that an "engineering day" will be held at the Shepherd's Bush Exhibition on Saturday, September 4th. A large number of invitations have already been issued, and the guests will be received by the Lord Mayor. Lectures on engineering subjects will be included in the programme. Among these we may mention lectures on "The Extended Uses of Electricity on board Ship," by Mr. J. McLaren, and on "Large Gas Engines," by Mr. P. R. Allen. A number of special demonstrations will be given in the Machinery Hall, and there will be ample opportunities for inspecting the other engineering features of the Exhibition.

Institution of Mining Electrical Engineers.—A council meeting of this Institution was held at the Royal Victoria Hotel, Sheffield, on Saturday last, when a report was presented by the hon. secretary showing that the membership had now reached 300, with a prospective immediate increase to 400 by the addition of candidates who had not yet been formally elected. The draft memorandum and articles of association were submitted and provisionally approved. It was resolved to create a diploma class of membership, to which candidates could only obtain admission by examination after having had an approved term of practical experience in charge of electrical plant in mines.

Traffic Problems in Berlin.—In a recent issue of the "Elektrotechnische Zeitschrift" Herr Petersen criticises the present "fast-train" policy of the Berlin suburban authorities; this consists in building lines on which fast trains can be run only underground. He demands such a tariff for these railways that it shall be possible for them to withstand the competition of other traffic undertakings such as tramways and omnibus, and states that underground construction should be confined to the crowded parts of the town where surface lines are impossible. He supports this argument by referring to the unsatisfactory results obtained on the London underground railways. The extensions of the Berlin railways underground will load the undertakers with debts which the receipts will not justify.

Errors in Electrical Instruments.—As is well known electrical measuring instruments are very liable to many sources of error. A simple source of error which, however, is sometimes overlooked is mentioned by J. F. van Lonkhuyzen in a recent issue of the "Elektrotechnische Zeitschrift." It is the static charge of the cover-glass of the instrument. The longer the pointer, the nearer it is to the glass, the drier the atmosphere, and the feebler the directive force of the instrument, the greater will be this error. By drawing a piece of soft leather across the glass of a galvanometer Lonkhuyzen produced a deflection up to 5 per cent. In a dry warm room instruments went wrong by as much as 20 per cent. when touched with the dry hand. These deflections are not lasting of course, but it may be an hour before the pointer indicates correctly again. When making comparisons with mirror instruments the error may become pronounced, because the glass is cleaned to wipe off the dust. Particular care has to be exercised in this respect in the workshop, especially with suspended instruments. There is, fortunately, an easy preventive—breathing upon the glass. Faulty indications may also result when the instrument is joined to the secondary of an insulated transformer. The secondary may have a static charge sufficient to upset the instrument. Our readers will remember in this connection that the late Prof. Ayrton described before the Institution of Electrical Engineers a transparent conducting varnish, by the use of which these errors were avoided.

Headlights for Motor Cars.—The Royal Automobile Club has just issued an interesting report as the result of careful tests made upon a number of headlights for motor cars and motor cycles. The object particularly aimed at was to investigate how the glare, which is very disconcerting to other users of the road, could be reduced to a minimum. For this purpose certain definitions were necessary. For example, the range of a lamp was defined as the distance at which an illumination of $\frac{1}{10}$ candle-ft. was reached along a line in the centre of the beam. The width of the beam (to obtain its dispersion) was determined by measuring the distance over which the illumination was not less than $\frac{1}{10}$ candle-ft. This standard of illumination was adopted because it is sufficient to enable details to be distinguished. The "dazzling effect" was judged by measuring the distance in front of the lamp at which the observer could distinguish an object placed 6 ft. to the side of and 6 ft. beyond the lamp under observation. The object chosen was such that it could be discerned on a starlit, moonless, clear night at a distance of 100 ft. in the absence of any headlight. One point brought out by the tests is that the candle-power used in these lamps is much lower than is generally supposed. For example, the naked lamp of a headlight, such as is usually employed, is from 15 c.p. to 25 c.p. Consequently, the electric lamp is by no means out of the question, because 20 candle-power can be obtained by the consumption of about 21 watts. It is interesting to note that a number of electric headlights were submitted for test, and gave a very good account of themselves, the distance at which "dazzle" ceased often comparing very favourably with their non-electrical competitors. Although much interesting data was obtained, no awards were made.

Electric Smelting of Iron Ore.—"Engineering News" states that the Electric Iron Co., of Trollhättan, Sweden, has recently been organised in Stockholm for electric smelting of iron ore for producing pig iron on a commercial scale. The new plant is to be erected at Trollhättan, where the Government owns a large hydro-electric power station, from which electric energy is sold at cheap rates to surrounding cities and industrial consumers. The falls yield about 75,000 H.P., but will, in the future, after regulation of Lake Venern, give 150,000 H.P. Electric power will be bought from the Goverment at the rate of 30s. per horse-power for the first 10 years and at £2 per horse-power for the following 10 years. A preliminary contract for renting up to 10,000 H.P. has been drawn up. The first installation is to consist of three ore-reduction furnaces of 2,500 H.P. each. Of these, one furnace is to be in reserve. The yearly production is calculated at 15,000 metric tons of pig iron, or 7,500 tons for each furnace. The pig iron produced is intended to be used for foundry purposes only and to contain 0·4 to 1·0 per cent. of phosphorus. Phosphorus-carrying ore from the Grängesberg mining district will be used. For the reduction of the ore, German coke from the Westphalia district will be used, costing at Trollhättan 22s. per ton, which is considerably cheaper than the Swedish charcoal ordinarily employed in Swedish blast furnaces. The pig iron is calculated to be produced at £2. 14s. per ton. The cost of the new plant is estimated as follows:—

Three smelting furnaces	£8,000
Ladles, ladle-cars and various appliances	800
Crushing plant (35,000 tons of ore and 7,000 tons of coke annually)	480
Transformer and motors for crushing plant, for transportation, lighting, &c.	320
Conveying machinery for conveying between harbour and crushing plant and to top of furnace	800
Machinery for conveying pig iron and slag, and tracking	640
Buildings for furnaces and coke storage	3,200
Building for crushers	220
Excavation, grading, fencing and harbour work	800
Office and laboratory	1,100
Superintendence and incidentals	1,820
Royalty	1,340
Total	£19,520

SIR J. J. THOMSON'S ADDRESS TO THE BRITISH ASSOCIATION.*

The eminence of my predecessors in the chair at the meetings of the British Association in Canada makes my task this evening a difficult one. The meeting at Montreal was presided over by Lord Rayleigh, who, like Lord Kelvin, his colleague in the chair of Section A at that meeting, has left the lion's mark on every department of physics, and who has shown that, vast as is the empire of physics, there are still men who can extend its frontiers in all of the many regions under its sway. It has been my lot to succeed Lord Rayleigh in other offices as well as this, and I know how difficult a man he is to follow.

The president of the second meeting in Canada—that held in 1897 at Toronto—was Sir John Evans, one of those men who, like Boyle, Cavendish, Darwin, Joule and Huggins, have, from their own resources and without the aid derived from official positions or from the universities, made memorable contributions to science; such men form one of the characteristic features of British science. May we not hope that, as the knowledge of science and the interest taken in it increase, more of the large number of men of independent means in our country may be found working for the advancement of science, and thereby rendering services to the community no less valuable than the political, philanthropic and social work at which many of them labour with so much zeal and success?

I can claim to have some experience of, at any rate, one branch of Canadian science, for it has been my privilege to receive at the Cavendish Laboratory many students from your universities, as well as from those of New Zealand, Australia and the United States, and have thus had opportunities of comparing the effect on the best men of the educational system in force at your universities with that which prevails in the older English universities. Well, as the result, I have come to the conclusion that there is a good deal in the latter system which you have been wise not to imitate. The chief evil from which we at Cambridge suffer and which you have avoided is, I am convinced, the excessive competition for scholarships which confronts our students at almost every stage of their education. You may form some estimate of the prevalence of these scholarships if I tell you that the colleges in the University of Cambridge alone give more than £35,000 a year in scholarships to undergraduates, and I suppose the case is much the same at Oxford. The result of this is that preparation for these scholarships dominates the education of the great majority of the cleverer boys who come to these universities. From the age of 16 he does little else than the subject, be it mathematics, classics or natural science, for which he wishes to get a scholarship; then, on entering the university, he spends three or four years studying the same subject before he takes his degree, when his real life work ought to begin. How has this training fitted him for this work? I will take the case in which the system might perhaps be expected to show to greatest advantage, when his work is to be original research in the subject he has been studying. He has certainly acquired a very minute acquaintance with his subject—indeed, the knowledge possessed by some of the students trained under this system is quite remarkable, much greater than that of any other students I have ever met. But though he has acquired knowledge, the effect of studying one subject, and one subject only, for so long a time is too often to dull his enthusiasm for it, and he begins research with much of his early interest and keenness evaporated. Now there is hardly any quality more essential to success in research than enthusiasm. Research is difficult, laborious, often disheartening. The carefully-designed apparatus refuses to work, it develops defects which may take months of patient work to rectify, the results obtained may appear inconsistent with each other and with every known law of Nature, sleepless nights and laborious days may seem only to make the confusion more confounded, and there is nothing for the student to do but to take for his motto "It's dogged as does it," and plod on, comforting himself with the assurance that when success does come the difficulties he has overcome will increase the pleasure—one of the most exquisite men can enjoy—of getting some conception which will make all that was tangled, confused and contradictory clear and consistent. Unless he has enthusiasm to carry him on when the prospect seems almost hopeless and the labour and strain incessant, the student may give up his task and take to easier though less important pursuits.

I am convinced that no greater evil can be done to a young man than to dull his enthusiasm. In a very considerable experience of students of physics beginning research I have met with more—many more—failures from lack of enthusiasm and determination than from any lack of knowledge or of what is usually known as cleverness.

The premature specialisation fostered by the preparation for these scholarships injures the student by depriving him of adequate literary culture, while when it extends, as it often does, to specialisation in one or two branches of science, it retards the progress of science by tending to isolate one science from another. The boundaries between the sciences are arbitrary, and tend to disappear as science progresses. The principles of one science often find most striking and suggestive illustrations in the phenomena of another.

Again, the specialisation prevalent in schools often prevents students of science from acquiring sufficient knowledge of mathematics: it is true that most of those who study physics do some mathematics, but I hold that, in general, they do not do enough, and that they are not as efficient physicists as they would be if they had a wider knowledge of that subject. There seems at present a tendency in some quarters to discourage the use of mathematics in physics: indeed, one might infer, from the statements of some writers in quasi-scientific journals, that ignorance of mathematics is almost a virtue. If this is so, then surely of all the virtues this is the easiest and most prevalent.

Two points of view are better than one, and the physicist who is also a mathematician possesses a most powerful instrument for scientific research with which many of the greatest discoveries have been made; for example, electric waves were discovered by mathematics long before they were detected in the laboratory. He has also at his command a language clear, concise and universal, and there is no better way of detecting ambiguities and discrepancies in his ideas than by trying to express them in this language. Again, it often happens that we are not able to appreciate the full significance of some physical discovery until we have subjected it to mathematical treatment, when we find that the effect we have discovered involves other effects which have not been detected, and we are able by this means to duplicate the discovery. Thus James Thomson, starting from the fact that ice floats on water, showed that it follows by mathematics that ice can be melted and water prevented from freezing by pressure. This effect, which was at that time unknown, was afterwards verified by his brother, Lord Kelvin. Multitudes of similar duplication of physical discoveries by mathematics could be quoted.

I have been pleading in the interests of physics for a greater study of mathematics by physicists. I would also plead for a greater study of physics by mathematicians in the interest of pure mathematics.

The history of pure mathematics shows that many of the most important branches of the subject have arisen from the attempts made to get a mathematical solution of a problem suggested by physics. Thus the differential calculus arose from attempts to deal with the problem of moving bodies. Fourier's theorem resulted from attempts to deal with the vibrations of strings and the conduction of heat; indeed, it would seem that the most fruitful crop of scientific ideas is produced by cross-fertilisation between the mind and some definite fact, and that the mind by itself is comparatively unproductive.

I think, if we could trace the origin of some of our most comprehensive and important scientific ideas, it would be found that they arose in the attempt to find an explanation of some apparently trivial and very special phenomenon; when once started the ideas grew to such generality and importance that their modest origin could hardly be suspected. Water vapour we know will refuse to condense into rain unless there are particles of dust to form nuclei; so an idea before taking shape seems to require a nucleus of solid fact round which it can condense.

I have ventured to urge the closer union between mathematics and physics because I think of late years there has been some tendency for these sciences to drift apart, and that the workers in applied mathematics are relatively fewer than they were some years ago. This is no doubt due to some extent to the remarkable developments made in the last few years in experimental physics on the one hand and in the most abstract and metaphysical parts of pure mathematics on the other. The fascination of these has drawn workers to the frontiers of these regions who would otherwise have worked nearer the junction of the two. In part, too, it may be due to the fact that the problems with which the applied mathematician has to deal are exceedingly difficult, and many may have felt that the problems presented by the older physics have been worked over so often by men of the highest genius that there was but little chance of any problem which they could have any hope of solving being left.

But the newer developments of physics have opened virgin ground which has not yet been worked over, and which offers problems to the mathematician of great interest and novelty—problems which will suggest and require new methods of attack, the development of which will advance pure mathematics as well as physics.

I have alluded to the fact that pure mathematicians have been indebted to the study of concrete problems for the origination of some of their most valuable conceptions; but though no doubt pure mathematicians are in many ways very exceptional folk, yet in this respect they are very human. Most of us need to tackle some definite difficulty before our minds develop whatever powers they may pos-

* Abstract of the Presidental Address delivered by Prof. Sir J. J. Thomson, M.A., LL.D., D.Sc., F.R.S., at Winnipeg on August 25th.

sess. This is true for even the youngest of us, for our school boys and school girls, and I think the moral to be drawn from it is that we should aim at making the education in our schools as little bookish and as practical and concrete as possible.

I once had an illustration of the power of the concrete in stimulating the mind which made a very lasting impression upon me. One of my first pupils came to me with the assurance from his previous teacher that he knew little and cared less about mathematics, and that he had no chance of obtaining a degree in that subject. For some time I thought this estimate was correct, but he happened to be enthusiastic about billiards, and when we were reading that part of mechanics which deals with the collision of elastic bodies I pointed out that many of the effects he was constantly observing were illustrations of the subject we were studying. From that time he was a changed man. He had never before regarded mathematics as anything but a means of annoying innocent undergraduates; now, when he saw what important results it could obtain, he became enthusiastic about it, developed very considerable mathematical ability, and, though he had already wasted two out of his three years at college, took a good place in the Mathematical Tripos.

It is possible to read books, to pass examinations without the higher qualities of the mind being called into play. Indeed, I doubt if there is any process in which the mind is more quiescent than in reading without interest. I might appeal to the widespread habit of reading in bed as a prevention of insomnia as a proof of this. But it is not possible for a boy to make a boat or for a girl to cook a dinner without using their brains. With practical things the difficulties have to be surmounted, the boat must be made watertight, the dinner must be cooked, while in reading there is always the hope that the difficulties which have been slurred over will not be set in the examination.

I think it was Helmholtz who said that often in the course of a research more thought and energy were spent in reducing a refractory piece of brass to order than in devising the method or planning the scheme of campaign. This constant need for thought and action gives to original research in any branch of experimental science great educational value even for those who will not become professional men of science. I have had considerable experience with students beginning research in experimental physics, and I have always been struck by the quite remarkable improvement in judgment, independence of thought and maturity produced by a year's research. Research develops qualities which are apt to atrophy when the student is preparing for examinations, and, quite apart from the addition of new knowledge to our store, is of the greatest importance as a means of education.

It is the practice in many universities to make special provision for the reception of students from other universities who wish to do original research or to study the more advanced parts of their subject, and considerable numbers of such students migrate from one university to another. I think it would be a good thing if this practice were to extend to student sat an earlier stage in their career; especially should I like to see a considerable interchange of students between the universities in the Mother Country and those in the colonies. I am quite sure that many of our English students, especially those destined for public life, could have no more valuable experience than to spend a year in one or other of your universities, and I hope some of your students might profit by a visit to ours. I can think of nothing more likely to lead to a better understanding of the feelings, the sympathies and, what is not less important, the prejudices of one country by another than by the youths of those countries spending a part of their student life together.

It has usually been the practice of the president of this Association to give some account of the progress made in the last few years in the branch of science which he has the honour to represent. I propose this evening to follow that precedent.

The period which has elapsed since the Association last met in Canada has been one of almost unparalleled activity in many branches of physics, and many new and unsuspected properties of matter and electricity have been discovered. The history of this period affords a remarkable illustration of the effect which may be produced by a single discovery; for it is, I think, to the discovery of the Röntgen rays that we owe the rapidity of the progress which has recently been made in physics. Their influence on physics is chiefly due to the fact that these rays make gases, and, indeed, solids and liquids, through which they pass conductors of electricity. It is true that before the discovery of these rays other methods of making gases conductors were known, but none of these were so convenient for the purposes of accurate measurement. The study of gases exposed to Röntgen rays has revealed in such gases the presence of particles charged with electricity; some of these particles are charged with positive, others with negative electricity.

The properties of these particles have been investigated; we know the charge they carry, the speed with which they move under an electric force, the rate at which the oppositely charged ones re-combine, and these investigations have thrown a new light, not only on electricity, but also on the structure of matter. We know from these investigations that electricity, like matter, is molecular in structure, that just as a quantity of hydrogen is a collection of an immense number of small particles called molecules, so a charge of electricity is made up of a great number of small charges, each of a perfectly definite and known amount.

The great advantage of the electrical methods for the study of the properties of matter is due to the fact that whenever a particle is electrified it is very easily identified, whereas an uncharged molecule is most elusive; and it is only when these are present in immense numbers that we are able to detect them. For example, the neon in $\frac{1}{2}$ cubic cm. of air can be detected, but there are present about 10 million million molecules, whereas Rutherford has shown that we can detect the presence of a single α particle.

We have already made considerable progress in the task of discovering what the structure of electricity is. We have known for some time of one kind of electricity—the negative—and a very interesting one it is. We know that negative electricity is made up of units all of which are of the same kind; that these units are exceedingly small compared with even the smallest atom, for the mass of the unit is only $\frac{1}{1700}$ part of the mass of an atom of hydrogen; that its radius is only 10^{-13} cm., and that these units—"corpuscles," as they have been called—can be obtained from all substances. The size of these corpuscles is on an altogether different scale from that of atoms; the volume of a corpuscle bears to that of the atom about the same relation as that of a speck of dust to the volume of this room. Under suitable conditions they move at enormous speeds which approach in some instances the velocity of light.

We know a great deal about negative electricity. Are similar effects true for positive electricity? Can we get, for example, a positive unit from oxygen of the same kind as that we get from hydrogen? For my own part, I think the evidence is in favour of the view that we can, although the nature of the unit of positive electricity makes the proof much more difficult than for the negative unit. In the first place we find that the positive particles—"Kanalstrahlen" is their technical name—discovered by our distinguished guest, Dr. Goldstein, which are found when an electric discharge passes through a highly rarefied gas, are, when the pressure is very low, the same, whatever may have been the gas in the vessel to begin with. Some experiments made lately by Wellisch, in the Cavendish Laboratory, strongly support the view that there is a definite unit of positive electricity independent of the gas from which it is derived.

The investigations made on the unit of positive electricity show that it is of quite a different kind from the unit of negative, the mass of the negative unit is exceedingly small compared with any atom, the only positive units that up to the present have been detected are quite comparable in mass with the mass of an atom of hydrogen; in fact, they seem equal to it.

A knowledge of the mass and size of the two units of electricity, the positive and the negative, would give us the material for constructing what may be called a molecular theory of electricity, and would be a starting point for a theory of the structure of matter.

As it would seem that the units of positive and negative electricity are of very different sizes, we must regard matter as a mixture containing systems of very different types, one type corresponding to the small corpuscle, the other to the large positive unit.

Since the energy associated with a given charge is greater the smaller the body on which the charge is concentrated, the energy stored up in the negative corpuscles will be far greater than that stored up by the positive. The amount of energy which is stored up in ordinary matter in the form of the electrostatic potential energy of its corpuscles is, I think, not generally realised. All substances give out corpuscles, so that we may assume that each atom of a substance contains at least one corpuscle. From the size and the charge on the corpuscle, both of which are known, we find that each corpuscle has 8×10^{-7} ergs of energy; this is on the supposition that the usual expressions for the energy of a charged body hold when, as in the case of a corpuscle, the charge is reduced to one unit. Now in 1 gramme of hydrogen there are about 6×10^{23} atoms, so if there is only one corpuscle in each atom the energy due to the corpuscles in a gramme of hydrogen would be 48×10^{16} ergs, or 11×10^{9} calories. This is more than seven times the heat developed by 1 gramme of radium, or than that developed by the burning of 5 tons of coal. Thus we see that even ordinary matter contains enormous stores of energy; this energy is fortunately kept fast bound by the corpuscles; if at any time an appreciable fraction were to get free the earth would explode and become a gaseous nebula.

The matter of which I have been speaking so far is the material which builds up the matter studied by the chemist; this matter

occupies, however, but an insignificant fraction of the universe. it forms but minute islands in the great ocean of the ether. The ether is not a fantastic creation of the speculative philosopher: it is as essential to us as the air we breathe. How great is the supply of energy the sun lavishes upon us becomes clear when we consider that the heat received by the earth under a high sun and a clear sky is equivalent, according to the measurements of Langley, to about 7.000 H.P. per acre.

The study of this all-pervading substance is perhaps the most fascinating and important duty of the physicist. On the electromagnetic theory of light, now universally accepted, the energy streaming to the earth travels through the ether in electric waves; thus practically the whole of the energy at our disposal has at one time or another been electrical energy. The ether must, then, be the seat of electrical and magnetic forces. We know, thanks to the genius of Clerk Maxwell, the founder and inspirer of modern electrical theory, the equations which express the relation between these forces, and although for some purposes these are all we require, yet they do not tell us very much about the nature of the ether. The interest inspired by equations, too, in some minds is apt to be somewhat platonic; and something more grossly mechanical—a model, for example—is felt by many to be more suggestive and manageable, and for them a more powerful instrument of research than a purely analytical theory.

Is the ether dense or rare? Has it a structure? Is it at rest or in motion? are some of the questions which force themselves upon us. Let us consider some of the facts known about the ether. When light falls on a body and is absorbed by it, the body is pushed forward in the direction in which the light is travelling, and if the body is free to move it is set in motion by the light. The ether carried along by a wave of light must be an exceedingly small part of the volume through which the wave is spread. The place where the density of the ether carried along by an electric field rises to its highest value is close to a corpuscle, for round the corpuscles are by far the strongest electric fields of which we have any knowledge. We know the mass of the corpuscle, we know from Kaufmann's experiments that this arises entirely from the electric charge, and is, therefore, due to the ether carried along with the corpuscle by the lines of force attached to it. A simple calculation shows that one-half of this mass is contained in a volume seven times that of a corpuscle. Since we know the volume of the corpuscle as well as the mass, we can calculate the density of the ether attached to the corpuscle; doing so, we find it amounts to the prodigious value of about 5×10^{10}, or about 2.000 million times that of lead. Sir Oliver Lodge, by somewhat different considerations, has arrived at a value of the same order of magnitude.

I do not know at present of any effect which would enable us to determine whether ether is compressible or not. And although at first sight the idea that we are immersed in a medium almost infinitely denser than lead might seem inconceivable, it is not so if we remember that in all probability matter is composed mainly of holes. We may, in fact, regard matter as possessing a bird-cage kind of structure, in which the volume of the ether disturbed by the wires when the structure is moved is infinitesimal in comparison with the volume enclosed by them. If we do this, no difficulty arises from the great density of the ether; all we have to do is to increase the distance between the wires in proportion as we increase the density of the ether.

Let us now consider how much ether is carried along by ordinary matter, and what effects this might be expected to produce. The simplest electrical system we know, an electrified sphere, has attached to it a mass of ether proportional to its potential energy, and such that if the mass were to move with the velocity of light its kinetic energy would equal the electrostatic potential energy of the particle.

The question now arises, Does this part of the mass add anything to the weight of the body? Now, experiments with pendulums, as Newton pointed out, enable us to determine with great accuracy the weights of equal masses of different substances. Newton and Bessel made such experiments with negative results, but the substances tried by them did not include any of those substances which possess the marvellous power of radio-activity. Prof. Rutherford's measurements show that the energy emitted by 1 gramme of radium in the course of its degradation to non-radio-active forms is equal to the kinetic energy of a mass of one-thirteenth of a milligramme moving with the velocity of light. This energy, according to the rule I have stated, corresponds to a mass of one-thirteenth of a milligramme of the ether, and thus a gramme of radium in its radio-active state must have at least one-thirteenth of a milligramme more of ether attached to it than when it has been degraded into the non-radio-active forms. Thus, if this ether does not increase the weight of the radium, the ratio of mass to weight for radium would be greater by about one part in 13.000 than for its non-radio-active products.

I attempted several years ago to find the ratio of mass to weight for radium by swinging a little pendulum, the bob of which was made of radium. I had only a small quantity of radium, and was not, therefore, able to attain any great accuracy. I found that the difference, if any, in the ratio of the mass to weight between radium and other substances was not more than one part in 2.000.

The mass of ether bound by any system is such that if it were to move with the velocity of light its kinetic energy would be equal to the potential energy of the system. This result suggests a new view of the nature of potential energy. Potential energy is usually regarded as essentially different from kinetic energy. According to the principle of the conservation of energy, the one form can be converted into the other at a fixed rate of exchange, so that when one unit of one kind disappears a unit of the other simultaneously appears. Now in many cases this rule is all that we require to calculate the behaviour of the system, and the conception of potential energy is of the utmost value in making the knowledge derived from experiment and observation available for mathematical calculation. It must, however, I think, be admitted that from the purely philosophical point of view it is open to serious objection. It violates, for example, the principle of continuity.

We may regard the ether as a bank in which we may deposit energy and withdraw it at our convenience. The mass of the ether attached to the system will change as the potential energy changes, and thus the mass of a system whose potential energy is changing cannot be constant; the fluctuations in mass under ordinary conditions are, however, so small that they cannot be detected by any means at present at our disposal.

Radiation of light and heat from an incandescent body like the sun involves a constant loss of mass by the body. Each unit of energy radiated carries off its quota of mass, but as the mass ejected from the sun per year is only one part in 20 billionths (1 in 2×10^{13}) of the mass of the sun, and as this diminution in mass is not necessarily accompanied by any decrease in its gravitational attraction, we cannot expect to be able to get any evidence of this effect.

I now pass to a very brief consideration of one of the most important and interesting advances ever made in physics, and in which Canada, as the place of the labours of Profs. Rutherford and Soddy, has taken a conspicuous part. I mean the discovery and investigation of radio-activity. Radio-activity was brought to light by the Röntgen rays. One of the many remarkable properties of these rays is to excite phosphorescence in certain substances, including the salts of uranium, when they fall upon them. Since Röntgen rays produce phosphorescence, it occurred to Becquerel to try whether phosphorescence would produce Röntgen rays. He took some uranium salts which had been made to phosphoresce by exposure, not to Röntgen rays, but to sunlight, tested them, and found that they gave out rays possessing properties similar to Röntgen rays. Further investigation showed, however, that to get these rays it was not necessary to make the uranium phosphoresce, that the salts were just as active if they had been kept in the dark. It thus appeared that the property was due to the metal, and not to the phosphorescence, and that uranium and its compounds possessed the power of giving out rays which, like Röntgen rays, affect a photographic plate, make certain minerals phorphoresce, and make gases through which they pass conductors of electricity.

Shortly after Becquerel's discovery of uranium Schmidt found that thorium possessed similar properties. Then Monsieur and Madame Curie, after a most difficult and laborious investigation, discovered two new substances, radium and polonium possessing this property to an enormously greater extent than either thorium or uranium, and this was followed by the discovery of actinium by Debierne. Now the researches of Rutherford and others have led to the discovery of so many new radio-active substances that any attempts at christening seems to have been abandoned, and they are denoted, like policemen, by the letters of the alphabet.

The radiation emitted by these substances is of three types, known as α, β and γ rays. The α rays have been shown by Rutherford to be positively electrified atoms of helium, moving with speeds which reach up to about one-tenth of the velocity of light. The β rays are negatively electrified corpuscles, moving in some cases with very nearly the velocity of light itself, while the γ rays are unelectrified, and are analogous to the Röntgen rays. The radio-active effects and many others receive a complete explanation by the theory of radio-active change which we owe to Rutherford and Soddy. According to this theory, the radio-active elements are not permanent, but are gradually breaking up into elements of lower atomic weight. When the atoms pass from one state to another they give out large stores of energy.

Many points of interest arise when we consider the rate at which the atoms of radio-active substance disappear. Rutherford has shown that whatever be the age of these atoms the percentage of atoms which disappear in one second is always the same. Now this would be the case if the death of the atom were due to something

from outside which struck old and young indiscriminately. But here we are met with the difficulty that no changes in the external conditions that we have as yet been able to produce have had any effect on the life of the atom. The evidence we have at present is against a disturbance coming from outside breaking up of the radio-active atoms, and we must, therefore, look to some process of decay in the atom itself; for example, by supposing that the atoms when they are first produced have not all the same strength of constitution.

The energy developed by radio-active substances is exceedingly large, 1 gramme of radium developing nearly as much energy as would be produced by burning a ton of coal. The source of this energy is a problem of the deepest interest; if it arises from the repulsion of similarly electrified systems exerting forces varying inversely as the square of the distance, then to get the requisite amount of energy the systems, if their charges were comparable with the charge on the a particle, could not when they start be further apart than the radius of a corpuscle, 10^{-13} cm. If we suppose that the particles do not acquire this energy at the explosion, but that before they are shot out of the radium atom they move in circles inside this atom with the speed with which they emerge, the forces required to prevent particles moving with this velocity from flying off at a tangent are so great that finite charges of electricity could only produce them at distances comparable with the radius of a corpuscle.

The properties of radium have consequences of enormous importance to the geologist as well as to the physicist or chemist. In fact, the discovery of these properties has entirely altered the aspect of one of the most interesting geological problems, that of the age of the earth. Before the discovery of radium it was supposed that the supplies of heat furnished by chemical changes going on in the earth were quite insignificant, and that there was nothing to replace the heat which flows from the hot interior of the earth to the colder crust. Though the quantity of radium in the earth is an exceedingly small fraction of the mass of the earth, only amounting, according to the determinations of Profs. Strutt and Joly, to about 5 grammes in a cube whose side is 100 miles, yet the amount of heat given out by this small quantity of radium is so great that it is more than enough to replace the heat which flows from the inside to the outside of the earth. This, as Rutherford has pointed out, entirely vitiates the previous method of determining the age of the earth. The fact is that the radium gives out so much heat that we do not quite know what to do with it, for if there was as much radium throughout the interior of the earth as there is in its crust the temperature of the earth would increase much more rapidly than it does as we descend below the earth's surface.

It is remarkable that Prof. Milne, from the study of earthquake phenomena, had previously come to the conclusion that rocks similar to those at the earth's surface only descend a short distance below the surface; he estimates this distance at about 30 miles, and concludes that at a depth greater than this the earth is fairly homogeneous.

Though the discovery of radio-activity has taken away one method of calculating the age of the earth it has supplied another—namely, by helium.

The physiological and medical properties of the rays emitted by radium is a field of research in which enough has already been done to justify the hope that it may lead to considerable alleviation of human suffering. The new discoveries made in physics in the last few years, and the ideas and potentialities suggested by them, have had an effect upon the workers in that subject akin to that produced in literature by the Renaissance. Enthusiasm has been quickened, and there is a hopeful, youthful, perhaps exuberant, spirit abroad which leads men to make with confidence experiments which would have been thought fantastic 20 years ago.

PETROL-ELECTRIC AUTOMOBILES.

BY JUSTUS B. ENTZ.

Summary.—After briefly referring to the main systems of petrol-electric drive so far attempted, the author describes his own system, which has been in commercial use for the last three years. This consists essentially of a generator used as a clutch, which at full speeds is short-circuited, whereas at low speeds it supplies current to a motor on the same shaft.

Electric gasoline automobiles may be taken to cover all automobiles in which the prime mover or source of power is a gasoline engine, and with which electricity is used as a supplementary power or as a means of control. There are several of such systems. First, there is the combination of a gasoline engine driving an electric generator, which in turn supplies the electric energy to an electric motor or motors connected to the driving wheels. This system calls for the total conversion of the power of the engine into electricity and its reconversion into mechanical power, and is, therefore, heavy and inefficient. This system has also had a storage battery added to it to help out the engine at times of overload, the battery being charged from the engine and generator at times of light load. This adds further to the weight and lack of efficiency of the system.

A third system seeks to avoid transforming the total engine power into electricity, and so has the engine mechanically connected to the driving wheels with a fixed gear ratio, dispensing with the ordinary mechanical transmission system for changing the gear ratio between engine and driving wheels. There is also connected with the same driving shaft as the engine an electric generator, which is also capable of acting as an electric motor. A storage battery is carried, which, at times of heavy load, discharges into this machine, which is then a motor, and assists the engine in turning the driving shaft and propelling the automobile. At times of light load, when the engine is capable of a greater turning effort than required to propel the automobile, the electric machine becomes an electric generator and recharges the battery. As with a constant field strength the voltage of this electric machine is proportional to its speed, it becomes automatically a generator when the engine speeds up, due to light load, as then its voltage becomes higher than that of the battery, and current flows from it into the battery and charges it, while when the engine slows down, due to overload, the voltage of this machine drops below that of the battery, and it becomes a motor receiving current from the battery. The operator is also given control of the field strength of this electric machine, so that he can determine, through a slight range, at what speed the machine changes from a generator to a motor. The objection to this system is that, in order to avoid carrying a great weight of battery, the electric part of the equipment is capable of adding much turning effort to the driving shaft only at very low speeds, and for a very short length of time, and as the engine and electric motor are both connected to the same driving shaft, the engine has got to come down to a very low speed before it gets any assistance from the battery and motor. The loss in horse-power of the engine from its reduction of speed being much more than the added horse-power from the motor and battery, the only thing that is gained is that the engine is not stalled on loads beyond its capacity with the fixed gear ratio provided. If the overload continues for more than a short length of time, the battery is exhausted. The rates of charge and discharge of the battery are very high, and it is therefore short-lived. It is also very difficult to keep the battery from becoming exhausted unless it is almost continually overcharged, which means loss of efficiency and a high rate of depreciation.

A system differing from all of these has been in use for the last three years on Columbia automobiles, built in Hartford, Conn., and is known as the "Direct Electric Transmission System" or "Entz Electric Transmission System."

Source of Power.—The system of transmission and control as installed on this car is purely an electric system, the gasoline engine being the sole source of power. The field of an electric generator is bolted directly to the 45 H.P. engine, taking the place of the ordinary flywheel. The other end of the field is carried in a large ball bearing.

The armature of this revolving field generator is enclosed within the field, and its shaft is extended through to the driving bevel in the rear axle housing, which contains the bevel gear drive and the differential, these being the only gears in the machine.

No Loss of Driving Effort.—In line with the revolving field generator and behind it is an electric motor whose armature is mounted upon the same driving shaft, which extends from the armature of the revolving field generator to the driving pinion. The revolving field generator serves the purpose of a clutch, and, by maintenance of current in its field and armature circuits, transmits the full driving effort exerted by the engine directly to the driving pinion, there being no loss of driving effort, as any friction between the armature and field would to that extent transmit a part of the driving effort in the same manner that a friction clutch does. It is necessary, however, to have a small speed difference between the armature and field in order to establish the necessary current through the low resistance of the generator armature and field, which is short-circuited upon itself. This causes a continuous slip, of an amount depending upon the driving effort developed by the engine. This slip, however, amounts to only 5 per cent. of the engine speed when the engine is running at 1,000 revs. per min. and developing its maximum torque. To this extent this revolving field generator acts as a friction clutch capable of transmitting continuously and uniformly, without wear, the full driving effort of the engine. Such a clutch, however, although infinitely superior in its method of

* Paper read before the Franklin Institute, Philadelphia, somewhat abbreviated.

ntrol to an ordinary friction clutch, would not provide means for more than reducing the speed of the vehicle in relation to the engine speed, and would not in itself provide means for multiplying the driving effort delivered to the wheels to more than that established by the fixed ratio between engine and wheels. A multiplication of this driving effort, however, is secured by including in the circuit of the revolving field generator, the motor, which is mounted upon the same driving shaft. The current which it is necessary to establish in the field and armature of the generator to transmit the engine torque, can still be established with the motor in circuit, and it will still deliver the driving effort of the engine to the driving shaft without loss; but an increased slip takes place which, instead of appearing as heat, as in the case of a slipping friction clutch, appears as electrical energy, and this electrical energy is utilised in the motor to give the desired added driving effort over and above that of the engine as transmitted by the revolving field generator.

Control.—All changes of speed are made by a small controller handle similar to that of an electric car, which has five speeds ahead and two reverse speeds, and provides means for putting the two armature windings, which the motor has, in different series parallel relation, and also provides means for shunting both the field of the motor and the generator for desired speed combinations. The result is that the driving effort of the engine can be multiplied very greatly, and the maximum effort capable of being developed by this combination can be made available continuously, even with the car at a standstill, as the revolving field generator forms a clutch which may be slipped continuously and uniformly, and which will deliver the result of its slippage as useful power instead of heat.

The control involves absolutely no change in the mechanical relation between the engine and the rear axle, and in going from point to point does not disconnect the driving effort of the engine from the driving pinion. Only the power represented by the difference of speed or slip between the field and armature is transformed.

Capacity of Generator and Motor.—The capacity of the electrical clutch generator and motor in this system is about four times greater than it would be with a generator and motor considered simply as such—that is, they will transmit and control the power of the engine with one-qarter of the weight and far greater efficiency than would be the case if all the power of the engine were used to drive a generator, which in turn delivered it to the motor to be transformed into mechanical energy.

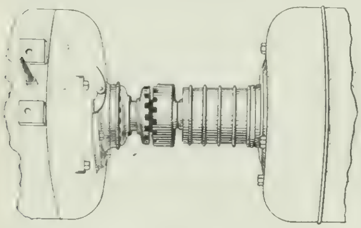


Fig. 1.

The result is that actually less than 10 per cent. more weight is added to the vehicle than would be called for if it were equipped with sliding gear transmission, clutch and flywheel. The efficiency of transmission is very high, being 95 per cent. on the high speed, and from 85 per cent. to 92 per cent. on the lower speeds.

Reversing.—Reversing is accomplished without the use of gears by clutching fast the armature in the revolving field generator, and at the same time disconnecting it from the driving shaft leading to the rear axle. In this way the revolving field generator loses its clutch action and becomes simply a generator, stationary armature and revolving field. The motor, whose armature is still connected with the driving shaft, receives current from this generator and drives the car either forward or backward, according to the relation of its field and armature connection. Under these conditions the system is simply a motor dynamo combination, but as reversing is only necessary for short distances at low speeds, this is amply sufficient, and is much simpler mechanically than the use of a reversing gear, although the latter may be used when it is desired, as in railway service, to have equal capacity and efficiency for running in either direction.

Fig. 1 shows the generator with its collector rings and the clutch sliding on the squared end of the generator armature shaft, which is used for reversing, as explained. In order to show the gain in efficiency and the less weight of the electrical apparatus, as used in this system, as compared with one in which all the power of the engine is transformed into electricity by means of the engine driving an electrical generator and retransformed into mechanical power by means of an electric motor, the conditions are shown diagrammatically in Figs. 2 and 3. I have assumed in the latter case that the engine is revolving the generator field around its armature at 500 revs. per min., and that it is developing a turning effort of 100 lb. I have also assumed that the generator and motor each have an efficiency of 80 per cent., which is about the efficiency of such units of a size to be used in automobile work. The combined efficiency of the two, therefore, is 64 per cent. I have assumed that the generator and motor are so wound that the motor will run at 500 revs. per min., the same as the engine. In this case the entire loss in the efficiency must be in the torque or turning effort of the motor, which would be 64 per cent. of the engine torque or 64 lb.

Fig. 2 illustrates the new system. In this case the generator armature, instead of being anchored stationary, has its armature shaft connected with the armature shaft of the motor. If the motor is still assumed to run at 500 revs. per min., and to develop the same turning effort as before, it must receive the same amount of electricity from the generator. This is accomplished by revolving the generator field at 500 revs. per min. faster than its armature, and as the latter is turning at 500 revs. per min. it will be necessary to turn the generator field and engine at 1,000 revs. per min. This calls for double the output from the engine, but the full turning effort of the engine of 100 lb. torque has been transmitted directly to the driving shaft and added to that of the motor, so that we have on the driving shaft a torque of 164 lb. at 500 revs. per min., or an output two and a half times as great as in the previous case, with the same capacity of electrical apparatus, and an efficiency of 82 per cent. instead of 64 per cent. This, however, is not the full gain, as this figure represents one of the lower speed positions, which is used only a short part of the total running time. The highest speed position, and the one that is mostly used, is shown in Fig. 3, in which the generator armature is circuited upon itself. In this case the generator field is turning only slightly faster than the armature, which it drags around after it. This difference of speed or slip, in the case of a generator having the efficiency assumed in the other cases, would be 50 revs. per min. when transmitting the full torque of the engine, and, as there is no loss of torque, we would have, with the engine running at 1,000 revolutions, the speed of 950 revolutions and 100 lb. torque.

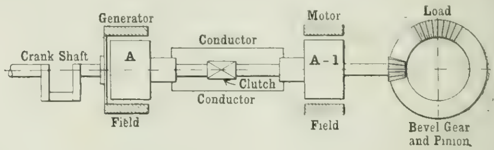


Fig. 2.

This output is three times as great as in the first case, and with the motor doing no work at all, and the efficiency is 95 per cent. instead of 64 per cent.

Brakes.—In connection with the control, an electric brake is provided, and there is also a connection between one of the foot brakes and a small short-circuiting switch, by means of which the field of the generator is short-circuited when the brake is applied. This immediately stops generation and answers exactly the same purpose as throwing out the friction clutch on an ordinary car upon the application of the brake, so that, to bring the car to a standstill, it is only necessary to put on the brake.

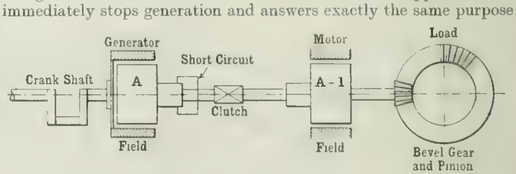


Fig. 3.

Coasting.—In order to establish any current in the circuit of the generator it is necessary that there should be a slight slip between the field and the armature; in other words, the engine should run slightly faster than the driving shaft to which the armature is connected. With the engine slowed down by a partial closing of the throttle, there is no clutching action and the car may coast ahead of the engine without any retarding effort. This adds very greatly to the ease of control and allows driving and coasting in perfect silence, entirely free of any connection with the intermittent driving or braking effort of the engine. It also permits regaining speed and headway much more rapidly than would be possible with the ordinary gasoline car, because as the engine is speeded up again by opening the throttle, it attains a speed some little higher than the speed of the car before it starts generating and picks up its load. Although this interval of time is but a fraction of a second, the speed gained in that time and the elastic method of clutching to the load, coupled

with the great inertia of the flywheel (which is of about three times the ordinary weight), permit a very high rate of acceleration under load.

Even Propulsion.—There is no direct mechanical connection between the engine and the driving shaft, and as the clutching medium is perfectly elastic, there is absolutely none of the intermittent driving effort of the engine transmitted to the driving shaft and wheels; also it is impossible for the engine to have a retarding effort upon the driving shaft. There can be absolutely no "bucking" from the loss of a cylinder. The most expert factory testers find it difficult to detect the cutting out of a cylinder except through the diminution of available power. The propelling effort is apparently just as even and constant with three out of four cylinders running as with all four.

Running Backward.—On all points of the controller, both zero, forward and reverse, the circuit of the electric motor is closed upon itself. The result of this is that, being a series motor, it has no tendency to generate when armature and field are coupled in a relation for the desired direction of motion of the car, but if for any reason the driving effort from the engine should be lost, as by stalling on a grade, the instant the car commences to run backward the motor will generate and act as a brake, not permitting of a speed of more than 1 mile an hour even upon a very steep incline. This, in effect, is an automatic sprag, or ratchet, which must come into play the minute the car gains any backward speed on any position of the controller.

Ignition is by jump spark, with current from a storage battery, in combination with a small amount of current diverted from the generator by means of which not only is the storage battery always maintained charged, but the heat of the spark is also increased automatically with the load on the engine.

The speed of the car is from ½ mile to 55 miles an hour, and its ease of control and ability to adapt itself to varying conditions of road and traffic make it a considerably faster road car than even its maximum speed would indicate. Its hill-climbing powers are remarkable owing to the elimination of practically all friction.

SIR WM. WHITE'S ADDRESS TO SECTION G OF THE BRITISH ASSOCIATION.

On the present occasion, when the meetings of the British Association are held in the heart of Canada it is natural that the proceedings of Section G should be largely concerned with the consideration of great engineering enterprises, by means of which the resources of Canada have and are being developed. British colonies started from the sea front, and have gradually pushed inland, so that the maintenance of British supremacy in both the mercantile marine and the war fleet is essential to the continued existence and prosperity of the Empire. The "seas but join the nations they divide," and every triumph of engineering draws closer the links which bind together the several parts of the Empire.

While claiming for the ship builder and marine engineer an important place in the creation and maintenance of the Empire, it is recognised that the work of other branches of civil engineering is equally important, and one of the chief fields of engineering operations at the present time is to be found in the Dominion of Canada, whose governing authorities have appreciated the fact that bold enterprise and generous financial provision are essential to the progress and prosperity of the country.

In no direction is this so well shown as in the case of railways, in which department successive administrations have given substantial assistance to private enterprise in the execution of great engineering works. Progress in railway engineering work has been remarkable since the Federation was accomplished 20 years ago. During the preceding 30 years the total mileage increased to 2.278 miles, in 1887 it was 12.184 miles, in 1897 16.550 miles, in 1907 22.452. The number of miles of railway actually under construction in 1907 was officially estimated at 3,000, exclusive of lines projected but not under contract. In 1906, when the lines in operation were 21,353, it was estimated by competent authorities that the railways under construction, and projects for extensions likely to be carried into effect in the immediate future, reached a total of at least 10,000 miles, while probable further extensions of about 3,500 miles were under consideration. Further, it was estimated that the capital expenditure required to complete these schemes would be about 60 millions sterling. These figures may need amendment, but there are others representing ascertained facts which equally well illustrate the magnitude of the railway interests of the Dominion. The total capital invested in Canadian railways in 1907 was officially reported to be about £234,390,000; the aid given to railways up to that date by Dominion and Provincial Governments, and by municipalities, considerably exceeded £36,000,000 sterling in money; the land grants from the Dominion Government approached 32 million acres, while the Provincial Governments of Quebec, British Columbia, New Brunswick and Nova Scotia had granted about 20½ million acres. The Governments have also guaranteed the bonds of railway companies to the extent of many millions of dollars. The capitalisation per mile of railway lines owned by the Governments (amounting to 1,890 miles) is reported as being £11,400; this is practically the same amount as that for Indian railways, that for the United States being £13,600 and for New South Wales and Victoria about £12,600. For British railways the figure given is £54,700 per mile. The freight carried by Canadian railways in 1907 amounted to nearly 63.900.000 tons (of 2,000 lb.), which included about 14,000,000 tons of coal and coke, nearly 4,500,000 tons of ores and minerals, 10,250,000 tons of lumber and other forest products, nearly 7,900,000 tons of manufactures, and 2,309,000 tons of merchandise. In 1875, when 4,800 miles of railway were in operation, the corresponding freight tonnage was 5,670,000 tons; so that while the length of railway increased nearly 4·7 times, the tonnage increased nearly 11·3 times. During the same period passengers increased from 5,190,000 to 32,137,000. For 28 railways making returns the average revenue per passenger per mile was 2·232 cents, and for the four principal railways was 2·07 cents. For freight 59 railways showed an average rate of 2·328 cents per ton-mile, and for the five principal railways it was 0·702 cent per ton-mile. The average distance travelled by a passenger was 64 miles, the corresponding figure for the United States being 30·3 miles. The average distance a ton of freight was hauled was 183 miles, as against 132 miles for the United States. In Canada, as the official reporter remarks, there is a small amount of suburban railway traffic and a low density of population.

Besides these three great railway organisations, which in 1907 controlled about 75 per cent. of the mileage in operation, there are a large number of smaller companies, making up a total of about 80. Their total earnings in 1907 amounted to £29,350,000, the total working expenses being £20,750,000, Earnings from freight service were (in round figures) £19,000,000; from passenger service £7,837,000, from express services £655,000, from mails £325,000, the balance coming from miscellaneous items. The total number of persons employed by the railways was 124,000; their salaries and wages amounted to £11,750,000. It was officially estimated that if to the railway employés were added persons employed in factories for rolling stock and railway materials, as well as those engaged in the casual service and shipping, with an allowance for their families, "quite 25 per cent. of the population win their daily bread from the carrying trade" of the Dominion.

The equipment of the Canadian railways in 1907 included 3,504 locomotives, 3,642 passenger cars, and 113,514 freight cars. In the opinion of the official reporter on railway statistics, based chiefly on a comparison of the proportion of rolling stock to mileage in Canada and the United States, a considerable increase of rolling stock is required, and there is a possibility of greater efficiency being obtained in the utilisation of existing freight cars. The manufacturing resources of the Dominion are declared to be fully capable of meeting all requirements, as in 1907 they produced 227 locomotives, 397 passenger cars, and 13,350 freight cars. A reduction of grades and curvatures has been carried out on the principal railways in recent years, and this has permitted the hauling of heavier loads. It is estimated that in 1907 the average earnings per ton of freight hauled were 6/10, and the average earnings per passenger carried were 4/10. The earnings per train-mile were $1.953, and the working expenses $1.381. The total earnings per mile of railway were $6.535.64, and the working expenses were $4.620.9. The working expenses were divided as follows in the official report:—

Maintenance of way and structures	20·13 per cent.
,, equipment	20·88 ,,
Conducting transportation	55·25 ,,
General expenses	3·74 ,,

Allowing two cords of wood fuel to be equal to 1 ton, 5,609,000 tons of fuel—of which 5,578,000 tons were coal—were consumed by Canadian railway locomotives in 1907 in running 100,155,000 miles. The total cost was about £3,027,500, equal to 14·59 per cent. of the working expenses.

From this brief summary of facts some idea may be gained of the rapid development of Canadian railways, their immense capital value and traffic, and the remarkable influence they have had upon the progress and population of the Dominion. It is a matter for satisfaction that British capital and engineering skill have contributed in no small measure to produce this development, and it may be hoped that in the future they may render even greater service.

In her lakes and connecting canals Canada possesses an excellent system of inland navigation, by whose means produce can be cheaply transported. In the construction of one at least of these great waterways, the Soulanges Canal, every modern improvement has been

introduced, while electricity has been used in its equipment, both for power and lighting. It has been stated that if the waterways of Canada were made continuously navigable a struggle for supremacy in over-sea trade must arise between New York, and Montreal and Quebec. This struggle is now in full force as regards grain, and this trade is steadily increasing. On the Great Lakes special grain carriers have been built for this traffic. They are really huge barges of full form and of uniform cross-section for a considerable part of their length. They possess enormous cargo capacity, moderate engine power and speed, with structures of a simple nature which can be largely standardised and made to resemble bridge construction rather than ordinary ship building. They can be built in a short time, the largest vessels occupying about four months in construction.

In the design and construction of these cargo-handling appliances the mechanical engineer has displayed great ingenuity, and the results obtained in rate of shipment and discharge of cargoes of grain, ore and coal are remarkable. Cases are on record where vessels carrying 7,000 tons dead weight have been loaded in four hours and discharged in 10 hours; more than 5,000 tons of ore have been discharged in about four hours. The draught of water of the steamers must be kept within moderate limits and the breadths of the locks are moderate, so that increase in carrying power must be chiefly obtained by increase in length; consequently, as individual cargoes are increased, a greater number of lifting appliances can be brought to bear simultaneously, and the rate of loading or discharge can be maintained or accelerated.

Canada has unrivalled resources in water-power, and its extent and possible utilisation have been made the subject of investigation by engineers for many years past. One of the most important memoirs on the subject was presented to the Royal Society of Canada in his Presidential Address of 1899 by Mr. Keefer, C.M.G. In recent times many other engineers have studied the subject and carried out important works. Exact knowledge of the total power represented by the waterfalls and rapids of the Dominion is not available, nor can any close estimate be made of the power which may be employed hereafter in factories, mills or industrial processes, because profitable employment obviously depends upon commercial considerations, which must be governed largely by the localities in which water-power may be found, and the cost of works and of transmission of energy to places where it can be utilised. It has been estimated that on the line from Lake Superior through the chain of lakes and rivers leading to Niagara and thence through the St. Lawrence to the sea 11,000,000 H.P. may be developed. Mr. Langelier has estimated that in the Province of Quebec the water-power aggregates more than 18,000,000 H.P.; other provinces all possess large resources of the same kind as yet untouched. The most striking example of the utilisation of water-power is that on the Niagara River. The three companies whose works are near the Falls on the Canadian side have provided for a total ultimate development of over 400,000 H.P., and a fourth establishment lower down the river, intended chiefly for the use of Hamilton is to develop 40,000 H.P. In the construction of the works, in the electric generating plant, the arrangements for transmitting power over long distances, and other features of importance remarkable engineering skill and daring have been displayed. The applications of water-power are already very numerous including not merely the creation of electrical energy and its use for lighting and power in towns and factories situated at considerable distances from the Falls, but for manufactures and industrial processes carried on near the Falls. Amongst these manufactures, that of aluminium and carbide of calcium may be mentioned, while paper and pulp mills and sawmills constitute important industries. Great advances have been made in the transmission of electrical power over long distances, and very high pressures are being used. Electric traction on railways and tramways also derives its power from the same sources, and is being rapidly developed. In 1901 there were 553 miles of electric railways, and in 1907 815 miles.

The development of engineering on over-sea transport was the next subject dealt with by the author. He pointed out that since the introduction iron for the structures of ships and of steam as the propelling power marvellous economies have been effected in the cost of over-sea transport. The chief causes contributing to this result have been (1) improvements in steam machinery, leading to great reductions in coal consumption, (2) considerable enlargement in the dimensions of ships, and (3) the supersession of iron by steel for structures and machinery. Further the economy of fuel consumption made possible by the introduction of quadruple expansion engines and the greater speed with which goods could now be handled by mechanical appliances had all contributed to this development.

Turning to some of the latest examples of shipbuilding work, the author instanced the "Laurentic" in which Messrs. Harland & Wolff had made an interesting experiment by introducing a combination of reciprocating and steam turbines and the good results which had been obtained thereby. The "Mauretania," in which turbines are fitted, has by the regularity of her service emphasised the advantages of this type of propulsion, and the writer ventures to assert that equal results could not possibly have been obtained with reciprocating engines in vessels of the same form and dimensions.

In conclusion, the author points to the necessity for the colonies contributing their share towards the maintenance of an Imperial navy, in the execution of which great task all branches of engineering have been and will be freely drawn upon. Mining and metallurgy assist by the production of materials of construction; mechanical and electrical engineers contribute machines and appliances required in shipyards and engine factories, as well as guns, gun-mountings and mechanical apparatus of all kinds required in modern warships in order to supplement and economise manual power; marine engineers design and construct the propelling apparatus, and constantly endeavour to reduce the proportion of weight and space to power developed; naval architects design and build the ships; constructional engineers are occupied in the provision of docks, harbours and bases adapted to the requirements fo the fleet; and other branches of engineering play important, if less prominent parts. The progress of invention and discovery is increasing, rapid changes occur unceasingly, the outlay is enormous, the task is never ending, but its performance is essential to the continued well-being of the Empire, and it must and will be performed.

BUILDING SLIP EQUIPMENTS.*

BY H. H. BROUGHTON.

Summary.—In this article the author sets out the essentials which have to be embodied in the crane equipment of a building slip. The most widely used equipments are those in which either cantilever cranes, overhead travelling cranes, overhead wire cableways, gantry cranes, or fixed or portable tower cranes are used. It is believed that the overhead crane system most nearly satisfies the requirements of yards turning out the largest ships, and particulars of three equipments, which have been installed at Messrs. Beardmore's, Harland & Wolff's and Krupp's, are here given.

Prior to the reading of Mr. Fairburn's Paper on "Methods of Handing Material over Shipbuilding Berths in American

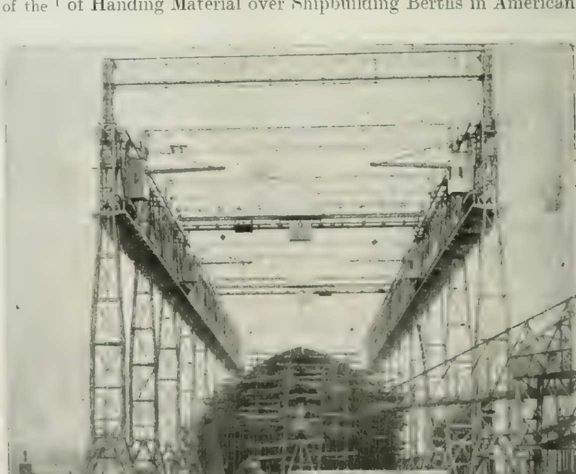
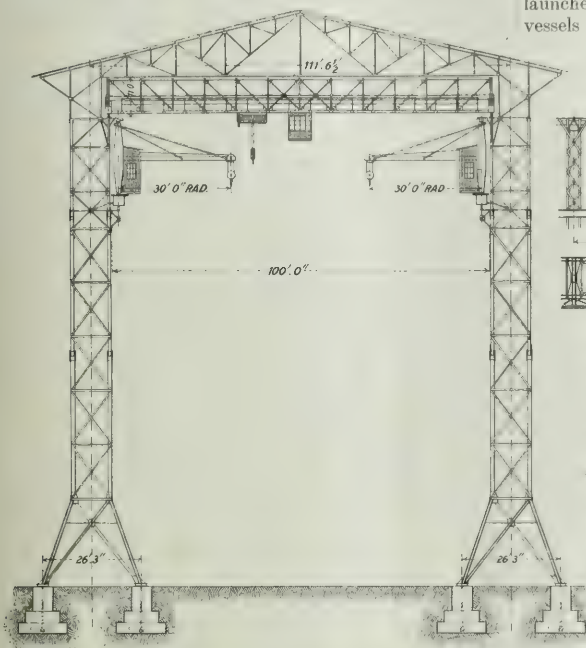


FIG. 1.—VIEW OF SLIPWAY AT MESSRS. BEARDMORE'S.

Shipyards"† it is generally admitted that British shipbuilders paid insufficient attention to the methods of handling material. In many yards the crane service was

† Transactions Inst. N.A., 1902.

of a primitive character unsuited to the work it was called upon to perform. On account of the rapid development of the electric crane, all this has now been changed. At the present time the methods of handling material in British shipyards compare favourably with, and in many cases are superior to, those in use in American or Continental yards.



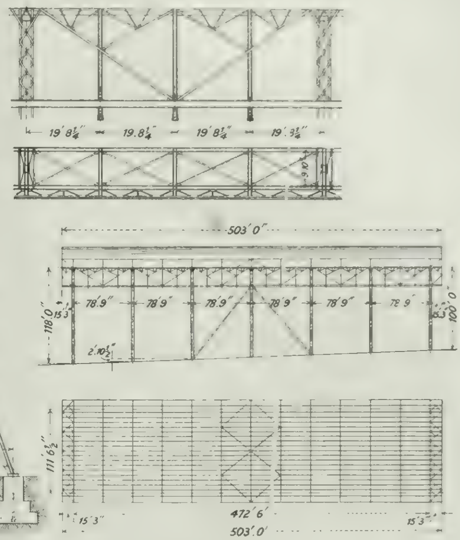


Fig. 2.—Appleby's Overhead Crane System for Building Slips.

In the design of a building slip crane equipment the essentials are:—(1) Efficient service over the whole berth. (2) Many cranes of reasonably large capacity and high speeds. (3) Provision for working the cranes in concert. (4) Minimum interference with operations along the sides of the ship. (5) Minimum obstruction of daylight. (6) Adequate means for manipulating the riveting appliances. (7) Railway service to each crane.

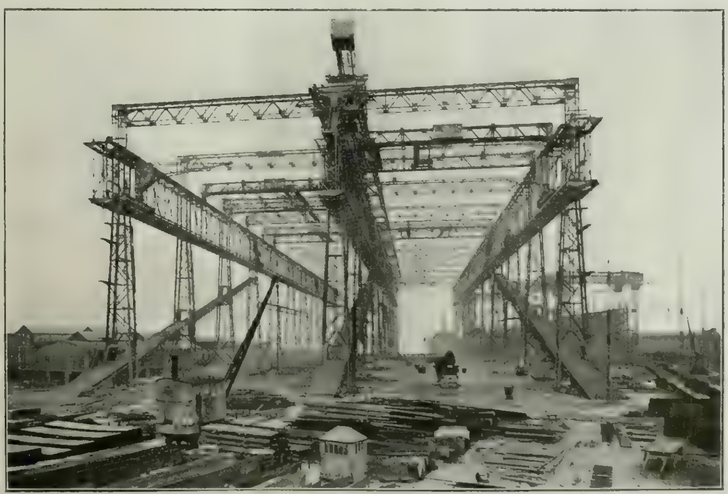


Fig. 3.—View of Slipway at Messrs. Harland & Wolff's.

Equipments which satisfy these requirements promote rapid and economical construction, and enable much machinery to be placed on board before the vessel is launched. It is interesting to note that in some yards vessels are completely finished on the slips.

There are several systems which conform, more or less closely, to the requirements stated above. Of these, the best known and most widely used are :—

(i.) Brown's balanced cantilever shipbuilding crane hoisting and conveying apparatus, with or without side jib travelling riveter cranes, having one or two trolleys. Known briefly as Brown's cantilever system.

(ii.) One or more overhead travelling cranes, with or without swing jib attachment, covering one or more ships. Jib travelling cranes may be provided at each side of the berth, and the whole berth may be open or roofed in as required.

(iii.) Travelling trolleys suspended from wire ropes which span the berth in the direction of its length, the ropes being arranged in such a way as to admit of movement across the berth. Three or four such cableways form an equipment. Known briefly as Henderson's system.

(iv.) Gantry cranes, with or without single or double cantilever extensions, covering one or more ships. In addition, jib travelling cranes may be provided at each side of the berth.

(v.) Fixed or portable tower cranes each side of the berth.

There has been much discussion on the advantages and disadvantages of each of the above systems. The oldest of them dates back but a few years, and no doubt very considerable alterations will be made to existing arrangements before the question as to which is the best is settled. It is probable that each system is peculiarly adapted to a certain class of work or arrangement of yard. No hard-and-fast rules can be laid down. For a given shipyard the best system is the one which enables material to be placed in position at minimum cost.

Descriptions of many of the systems have been given during the last six or seven years,* but the author, in looking up the literature of the subject, failed to find a tolerably complete account of the "overhead crane" system, and it is this which he proposes to describe in this article.

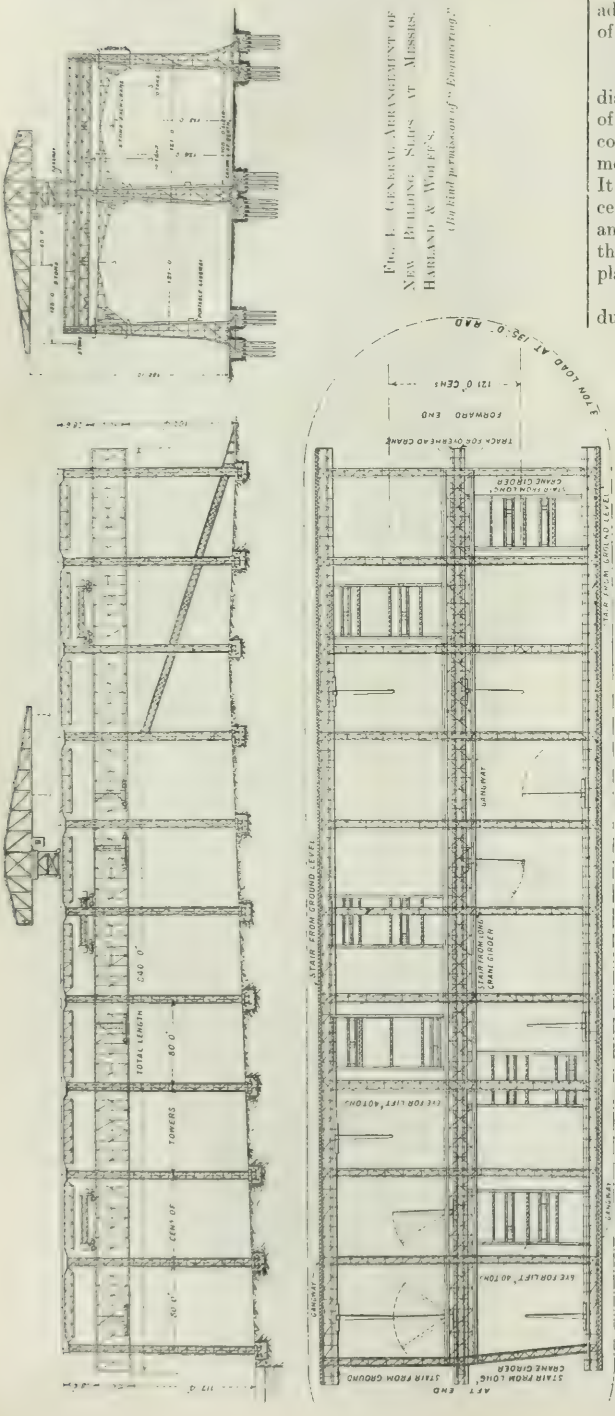


FIG. 1. GENERAL ARRANGEMENT OF NEW BUILDING SLIPS AT MESSRS. HARLAND & WOLFF'S.
(By kind permission of "Engineering.")

The fact that in one form or another the overhead travelling crane system has been extensively adopted in many of the principal shipbuilding yards leads to the conclusion that for yards turning out the largest ships the arrangement most nearly satisfies the requirements.

In Fig. 2 is depicted the crane equipment designed and constructed by the Glasgow Crane Co. (now known as Applebys Limited). From the drawing it will be seen that the gantry upon which the overhead cranes travel is supported by a number of vertical members rigidly held together by means of roof principals, and the berth can be roofed in so that complete protection is afforded, and the work can be proceeded with uninterruptedly. The vertical members also carry the rails or channels which form the tracks for the side walking cranes. These cranes are placed at each side of the berth, and are so arranged that their jibs can be swung round over a vessel under construction or to the side thereof. The general construction of the framework will be understood from the drawings.

Fig. 1 shows the equipment installed over one of the berths at Messrs. Beardmore's. It consists of two overhead travelling cranes and four walking cranes, arranged two each side of the berth. The overhead travelling cranes travel upon a gantry 750 ft. in length. They are 108 ft. span, and are proportioned for a working load of 15 tons, the height of lift being 140 ft. Separate 440-volt motors are used for the three motions. The lifting motors give 50 B.H.P. at 500 revs. per min., the travelling motors 30 B.H.P. at 500 revs. per min., and the traversing motors 10 B.H.P. at 600 revs. per min. The speeds attainable are as follows :—

Lifting.........	With full load, about 40 ft. per min.
	With no load, about 100 ft. per min.
Travelling ...	With full load, about 500 ft. per min.
	With no load, about 750 ft. per min.
Traversing ...	With full load, about 220 ft. per min.
	With no load, about 350 ft. per min.

Each crane is controlled from a cabin fixed to one of the cross girders at the centre of the span.

* Refer to "Transactions" Inst.N.A., 1902, 1906 and 1907; "Proceedings" Inst.M.E., 1901 and 1907; "The Engineer," 1904; "Engineering," 1904 and 1908; THE ELECTRICIAN, 1905.

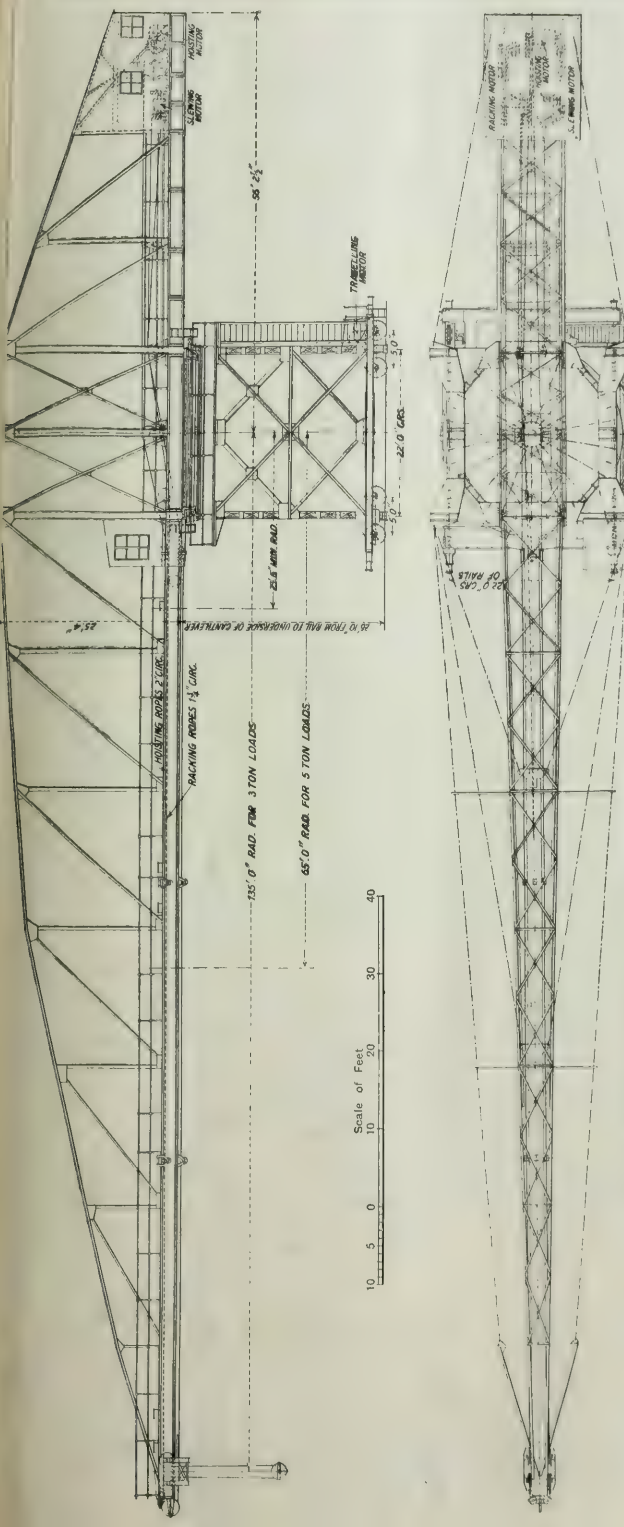


Fig. 5.—General Arrangement of 3-ton Revolving Cantilever Crane.

The walking cranes are designed to lift 5 tons at a radius of 30 ft. They travel on a single rail, the distance between the rail and the overhead guides being 24 ft. The wheel-base is 20 ft., and the height of the lift is 125 ft. Each of the three motions—namely, lifting, travelling and slewing—is operated by a separate series-wound motor. The lifting motor gives 30 B.H.P. at 500 revs. per min., the travelling motor 20 B.H.P. at 600 revs. per min. and the slewing motor 5 B.H.P. at 600 revs. per min. The speeds of the several motions are :—

Lifting.........	With full load, about 60 ft. per min.
	With no load, about 150 ft. per min.
Travelling ...	With full load, about 250 ft. per min.
	With no load, about 450 ft. per min.
Slewing	With any load, about 300 ft. per min.

Each crane is controlled from a cabin attached to the vertical post, and so arranged as to afford the operator an uninterrupted view of the load and of the slip.

After being erected all the cranes in the equipment were tested under a proof load 50 per cent. greater than the normal load.

A number of important modifications have recently been made in the overhead crane system, amongst which may be mentioned the inclusion of a crane of the revolving cantilever type which can travel the whole length of the berth on a track supported by transverse girders at the top of the structure, together with a number of travelling bridges which span the berth and serve to carry two travelling cranes, entirely independent of each other. These cranes are used to manipulate the hydraulic riveters, and may be operated from the riveting position or from the travelling bridge.

Such an arrangement has been adopted by the Harland & Wolff Co., of Belfast, for their new building slips. The equipment is the largest and most complete of its kind in existence. A good general idea of the structure, which was designed, constructed and erected by Sir William Arrol & Co., will be obtained by referring to Figs. 3 and 4. The cranes, of which there are 23, with a total lifting capacity of 215 tons, were designed and constructed by Messrs. Stothert & Pitt, to whom the author is indebted for the drawings from which Figs. 5, 6 and 7 have been prepared. Apart from their great size, they are characterised by the high speeds of the several motions, by the novelty of the designs and by the same soundness of construction which makes all the products of Stothert & Pitt so popular.

The arrangement and principal dimensions of the revolving cantilever crane will be inferred from the drawings (Fig. 5), and the "constants" are set forth below :—

Loads		3 tons at an outreach of 135 ft.
		5 tons at an outreach of 65 ft.
Height of Lift		180 ft.
Speeds	Lifting......	5 tons at 125 ft. per min.
		3 tons at 205 ft. per min.
		No load at about 500 ft. per min.
	Traversing.	Full load at 150 ft. per min. (head
	Slewing ...	Full load at 400 ft. per min. at jib
	Travelling..	Full load at 200 ft. per min.
Motors--	Lifting......	70 B.H.P. at 420 revs. per min.
	Traversing.	15 B.H.P. at 500 revs. per min.
	Slewing ...	15 B.H.P. at 500 revs. per min.
	Travelling.	70 B.H.P. at 420 revs. per min.

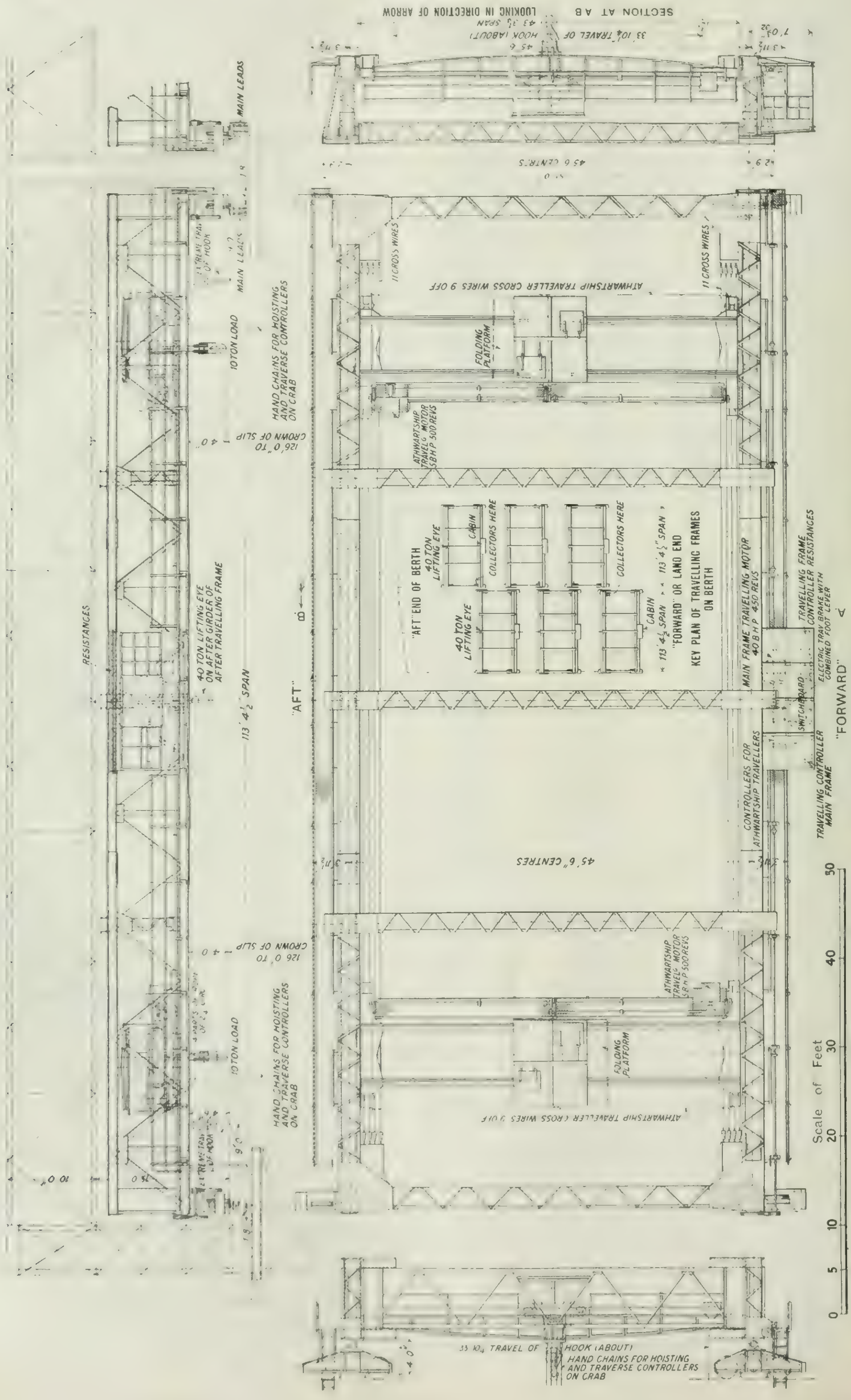


Fig. 6.—Arrangement of Travelling Frame, with two 10-ton Athwartship Travellers.

There are six travelling frames or gantries in all, three per berth, and each serves to carry two 10-ton three-motor athwartship travelling cranes. Referring to Fig. 6, it will be seen that the cross-girders are of the open type, 9 ft. 2 in. deep, 2 ft. 6 in. wide and 115 ft. 2 in. long, pitched at

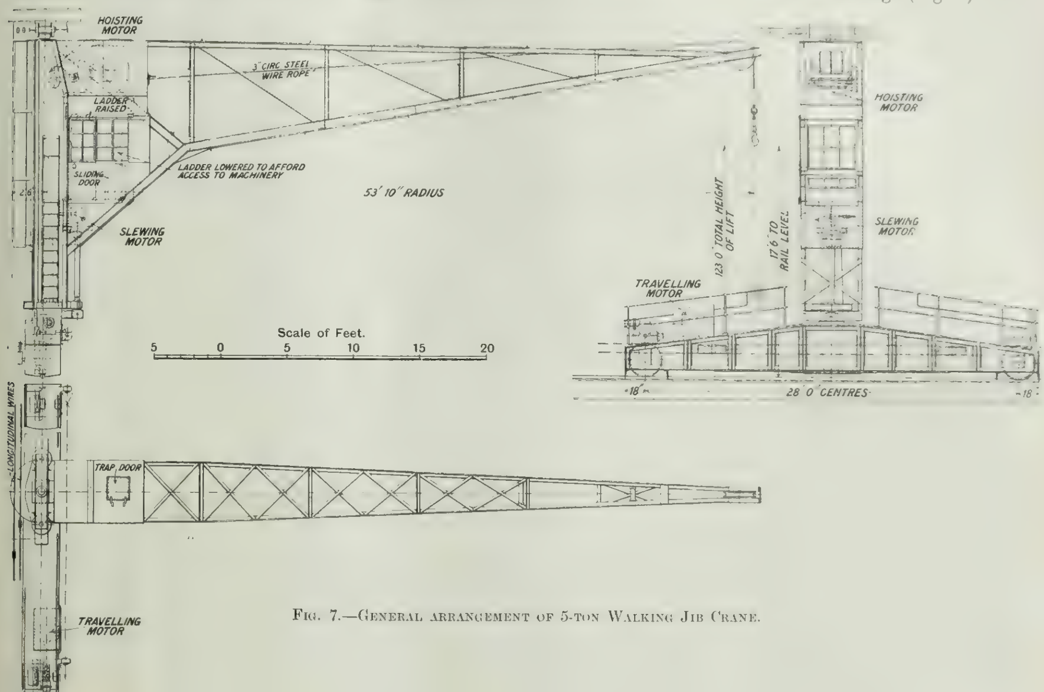


FIG. 7.—GENERAL ARRANGEMENT OF 5-TON WALKING JIB CRANE.

45 ft. 6 in. centres. They are rigidly connected together, and the frame rests upon four two-wheeled compensating trucks. The wheels are 2 ft. 5 in. diameter and 4 in. in width and are pitched at 6 ft. centres apart, the trucks being 45 ft. 6 in. centres apart. Tracks for the travelling cranes are mounted

FIG. 8.—SLIP EQUIPMENT AT GERMANIA DOCKYARD, KIEL.

upon the top flanges of the bottom inside channels of the lower booms of the gantry girders.

The two travelling cranes on each gantry are independent of each other. They can be controlled from the cabin on the gantry or from below. To admit of heavy lifts being made, the two gantries nearest the water are provided with eye-bolts, from which tackle for 40-ton loads can be suspended. The arrangement of the gantries and of the cranes is so clearly shown in the drawings (Fig. 6) as to require no elaboration. The speeds of the several motions and the capacities of the motors are :—

Travelling speed of gantry with 40 B.H.P. motor running at 450 revs. per min., about 100 ft. per min. Lifting speed with 25 B.H.P. motor running at 700 revs. per min., 15 ft. per min. Traversing speed of trolleys with 5 B.H.P. motor running at 500 revs. per min., 15 ft. per min. Travelling speed of cranes with 5 B.H.P. motor at 500 revs. per min., 30 ft. per min.

There are 10 walking jib cranes, five per berth, arranged as shown in the general arrangement drawing (Fig. 4). The construction of these cranes will be inferred from Fig. 7, and the "constants" are :—

Load.....................		5 tons at an outreach of 53 ft. 10 in.
Height of Lift............		123 ft.
Speeds.—Lifting		5 tons at 100 ft. per min.
		No load at 250 ft. per min.
	Travelling ...	5 tons at 100 ft. per min.
		No load, about 120 ft. per min.
	Slewing	Full load at 250 ft. per min.
Motors.—Lifting		50 B.H.P. at 530 revs. per min.
	Travelling ...	20 B.H.P. at 520 revs. per min.
	Slewing	5 B.H.P. at 500 revs. per min.

It should be mentioned that the whole of the spur gears in both of the above equipments are of steel, machine-cut from the solid, excepting the steel slewing curb and pinion of the cantilever crane, which have machine-moulded teeth.

Having briefly described what are perhaps the most complete building slip crane services extant it might be of interest to give the "constants" of a large equipment installed over the slips at the Germania Dockyards, Kiel. As will be perceived from Figs. 8 and 9, the cranes are of the swing-jib type. The equipment was designed and constructed by the Stuckenholz Company, working in conjunction with the technical department of the Krupp firm.

Building Slip Equipment at the Germania Dockyard, Kiel.

Crane No.		1	2	3	4	5	6	7	8
Span ....feet		40·6	40·6	39·5	40·6	27·5	27·5	34·5	37·5
Length of jib ....feet		9	7·75	7·75	9	20·5	20·5	7·75	7·75
Load ....tons		6 & 3	6 & 3	6 & 3	6 & 3	3	3	6 & 3	6 & 3
Height of lift ....feet		90	90	72	72	72	72	72	72
Lifting speed, feet per minute	6 tons...	38	38	38	38	...	...	38	38
	3 tons...	59	59	59	59	59	59	59	59
	No load	115	115	115	115	115	115	115	115
Traversing speed, feet per minute	Full load	66	66	66	66	...	...	66	66
	No load	131	131	131	131	...	...	131	131
Travelling speed, feet per minute	Full load	246	246	246	246	246	246	246	246
	No load	295	295	295	295	295	295	295	295
Slewing speed, feet per min.		295	295	295	295	295	295	295	295
Lifting motor ...	B.H.P..	18	18	18	18	18	18	18	18
	Speed .	510	510	510	510	510	510	510	510
Traversing motor	B.H.P..	3	3	3	3	...	...	3	3
	Speed .	770	770	770	770	...	...	770	770
Travelling motor	B.H.P..	18	18	18	18	18	18	18	18
	Speed .	510	510	510	510	510	510	510	510
Slewing motor ...	B.H.P..	3	3	3	3	3	3	3	3
	Speed .	770	770	770	770	770	770	770	770

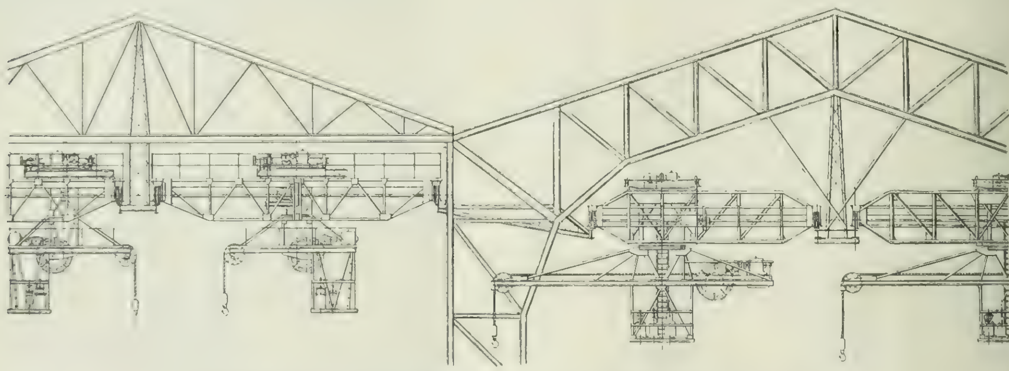


Fig. 9.—Details of Building Slip Equipment at the Germania Dockyard, Kiel.

In comparing these equipments the reader should bear in mind that the Krupp equipment was put into service about eight years ago, and that the cranes over Beardmore's slips were installed four years ago, whereas the Harland & Wolff equipment has been completed quite recently. The examples serve to show three arrangements of the overhead crane system as adopted by some of the foremost shipbuilders.

NEW FIVE AND SIX-SPEED THREE-PHASE MOTOR.

It is needless here to recall the large development which has taken place by the application to the industry generally of three-phase asynchronous motors having a constant and very nearly synchronous speed. Thanks to its great simplicity of construction, and to the reliable way in which it operates, the induction motor is superior to all others for workshop purposes, but there are still a large number of cases for which its employment is doubtful, especially where a large speed variation is necessary, as the latter cannot be obtained with this class of motor except by reducing both the efficiency and the simplicity, and thereby the safety of operation. The large number of proposals which have been put forward for overcoming this difficulty show its importance; and the great value which any system which would solve the question economically would have is thereby made very evident. The most practical proposals have been based on pole-changing arrangements; and as long ago as 1890 the Maschinenfabrik Oerlikon succeeded in constructing two-speed motors, which at both the standard speeds had a high efficiency and satisfactory power factor. The employment of two distinct windings distributed over the stator, or, as the case may be, the rotor, allows induction motors with four speeds in which both the electric and magnetic characteristics were favourable at all the designed speeds to be obtained, thanks to the drum-winding arrangement. By this arrangement a four-speed motor had been obtained, operating under good conditions in all cases, and capable of employment in many industrial operations, in spite of the speed limitations. This was, however, not enough for certain special cases, and a step of real progress was made when the Maschinenfabrik Oerlikon recently succeeded in designing a motor with six speeds, still only employing two stator windings, by arranging the poles in six different ways.

The motor described below has been designed for five speeds. For this purpose the stator is wound with three different windings, the supply current having a frequency of 42 per second. Allowing a certain percentage for slip, speeds of 210, 420, 630, 840 and 1,260 revs. per minute are obtained with a number of poles equal to 24, 12, 8, 6 and 4 respectively. Two of the stator windings are each available for two different numbers of poles having a ratio of 1 : 2. They are for this reason composed of elementary windings which are distributed regularly over the periphery and are divided into $6 \cdot \frac{p}{2}$ groups where p is the minimum number of poles. These are connected in parallel when the number of poles is p, and in series when the number of poles is $2p$. The third winding is only used for a single number of poles. All three sets of windings are embedded in the same stator slots, the windings corresponding to 12 or 24 poles being placed nearest the gap, then the windings for four and eight poles, and, lastly, the windings for six poles, placed at the bottom of

the slot. The output of the motor at 1,260 revs. per min., that is to say, with four poles, is 23 H.P. when the terminal pressure is 280 volts. Naturally the output decreases with the speed, and is only 6 H.P. when the motor is running under the 24-pole condition. The rotor winding is of the squirrel-cage type, and is composed of bars embedded in slots and connected at their ends by a short-circuiting ring of brass.

The pole-changing arrangement employed requires 15 terminals, six of which are intended for each of the two windings that provide two sets of poles, and three for the six pole winding. Owing to the arrangement of the controller quite close to the motor, as is generally the case, most of the disadvantages of this large number of terminals are overcome as regards ease of inspection and economy.

By means of this motor several tests on a method of pole-changing, recently patented by the Maschinenfabrik Oerlikon, have been made possible. This arrangement allows a single winding to be also arranged so that three different numbers of poles are obtainable from it in the ratio of 4 : 6 : 8 or 6 : 8 : 12. For this purpose the winding, which is designed to give 4 : 6 : 8 poles, is divided into $6\frac{p}{2}$ groups of elementary windings, the beginning and end of each group being connected to a terminal. Twenty-four terminals are thus necessary for a winding giving 4, 6 and 8 poles. The distribution of the winding over the periphery is symmetrical both for poles and phases. On the contrary, for six poles the elementary windings are distributed irregularly. Under the first pole face, phase one has two windings in series and phases two and three one single winding only. Under the next pole, phase two has two windings and the other two have only one and so on, but eventually each phase contains the same number of windings.

The sub-division of the windings for 12, 16 and 24 poles is similar to that with 4, 6 and 8 poles, there being 36 coils with 72 terminals. The arrangement of the phases being exactly the same on the two halves of the motors, the windings can be permanently placed in series two by two, so that for all the pole-changing required only 36 terminals are necessary. Twelve further terminals can be suppressed both for 4, 6 and 8 poles, and for 12, 16 and 24 poles, by noting that each winding is open at its two ends, so that common terminals can be arranged at 12 of them. In order to obtain, in any desired order, the speed regulation required 48 terminals are therefore necessary. It is evident that the most economical construction will be to place the controller directly against the motor, the connections are then made most easily and are more open to inspection as well as less costly. Losses at starting are also reduced by this arrangement.

The pole-changing arrangement is very simple, especially when the speed is required to be altered by natural steps, as is generally the case. The contact pieces are arranged round a controller cylinder in such a manner that all crossing of the wires below the contacts is avoided, thus preventing any possibility of short-circuiting. The arrangement of the other parts, especially the contact fingers, has been designed with a view to reducing as much as possible the dimensions of the equipment. The contact fingers are 51 in number, three of which are for bringing up the current to the motor and 48 for pole-changing purposes. Each time the controller is moved the circuit is broken at a given moment and always on the same fingers, which are therefore provided with auxiliary pieces, that can be easily changed. No burning away of the contact fingers themselves need be feared.

Fig. 3 shows the motor on the test-bed. In actual practice the controller is horizontal on the motor as, in this case, the motor frame itself serves as a support and the connecting wires need not come out from the machine.

Figs. 1, 2 and 4 represent the test results, Fig. 1 showing the operation at 260 volts with a frequency of 42 and using five speeds with three windings. Figs. 2 and 4 show the operation of the motor at 280 volts with a frequency of 50, and six speeds obtained from the two windings. From these diagrams it is possible to deduce that the efficiency and power factor is high at all speeds; in fact, the difference between the characteristics obtained and the corresponding value with a one-speed motor, designed specially for a certain number of poles and for the same output, is very small. It is of great importance to discover how the motor behaves at starting, and especially to find out the starting torque and current, supposing starting takes place at the full circuit voltage. In the table given on p. 790 are shown for the different numbers of poles the ratio between the normal current and that at short-circuit, which is produced at starting; as well as the ratio between the normal torque and the starting torque.

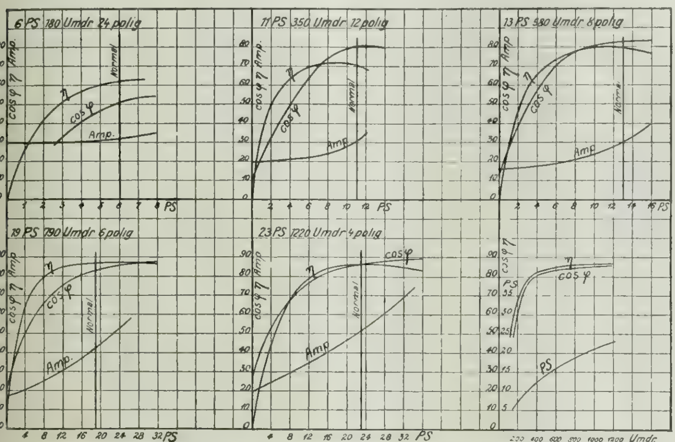


FIG. 1.—CHARACTERISTICS OF FIVE-SPEED 260-VOLT THREE-PHASE MOTOR. FREQUENCY 42.
Umdr. Revs. per min.

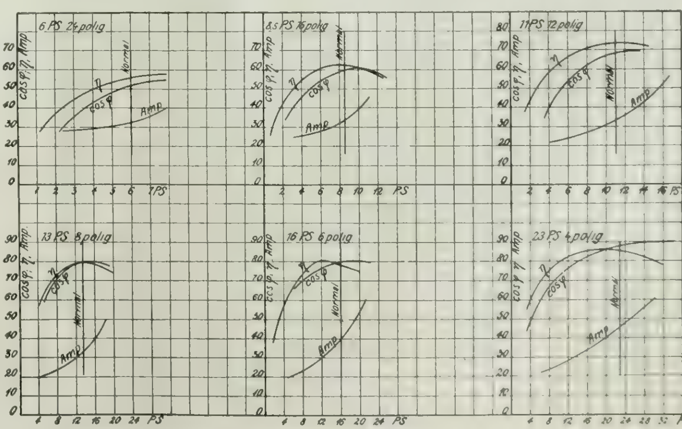


FIG. 2.—CHARACTERISTICS OF SIX-SPEED 280-VOLT THREE-PHASE MOTOR. FREQUENCY 42.

It will be seen that the motor with 24 poles developes a starting torque equal to 1·87 times the normal torque for the corresponding speed, at the same time only taking double the normal current. Changing to a less number of poles—that is to say, to a higher speed—the current increases according to experiment by from 50 to 65 per cent. of the short-circuit current corresponding to this number of poles, which, in a most unfavourable case, as shown by the

Number of poles	Ratio of normal current to starting current (short-circuit).	Ratio of normal torque to starting torque.
24	1 : 2·0	1 : 1·87
16	2·31	1·51
12	3·0	1·16
8	4·3	1·45
6	5·5	1·83
4	8·88	1·455

table, gives a current equal to $4\frac{1}{2}$ times the normal. In the case when the motor has to start at once for running at the highest speed that is, with a four-pole motor—the current naturally reaches its maximum value at starting—that is, 8·8 times the normal—at the same time only developing a starting torque equal to 1·45 times the normal corresponding to that speed. If, on the contrary, the motor is started for running at the lowest speed and changed regularly to the next highest speed there is a much less unfavourable effect on the feeding system than with ordinary squirrel-cage motors, in fact, than with any starting apparatus usually employed. The stoppage or partial reduction of the speed is obtained in the opposite way—that is to say, by making the number of poles on the motor greater. The motor then acts as a generator as long as its speed is greater than the synchronous speed corresponding to the number of poles.

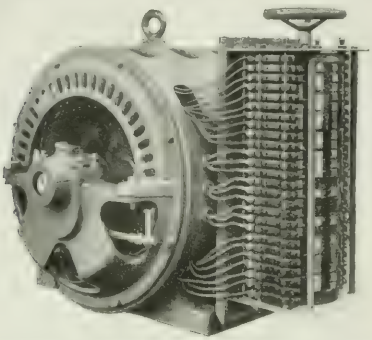


Fig. 3.—Five-speed 260-volt Three-phase Motor arranged for Testing.

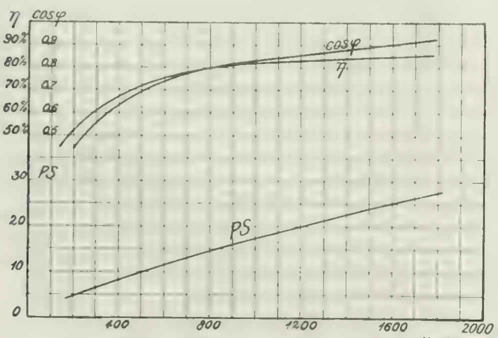


Fig. 4.—Characteristic of Six-speed 280-volt Three-phase Motor. Frequency 50.

This action is less felt and lasts a shorter time in proportion to the number of degrees of speed and the closer these are placed together. From this point of view, also, the six-speed motor constitutes a decided step forward. With regard to its effect on the supply circuit this depends naturally on circumstances independent of the motor, such as the length and capacity of the network and the elasticity of the regulation.

To sum up, it may be said that in the construction of six-speed motors the choice of winding is of the very first importance, for this may be favourable for one number of poles and very unfavourable for the other two, or about equally favourable for all three. Attention should be paid to the importance of each of the speeds from the working point of view: and the motor should be given the highest qualities as regards dispersion, magnetising current, &c., for the speed most often and longest used under working conditions.

It is possible, as mentioned above, to construct motors with five and six speeds with two as well as with three windings. The large number of connecting wires in the case of motors with two windings between the motor and controller may, however, become a source of annoyance when the latter is not placed close to the motor itself. In this case it is possible to obtain five speeds with about one-third of the terminals and six speeds with 24 terminals, when a stator having three windings is used. The sole disadvantage, which it is impossible to avoid in this case, is the necessity for increasing the dimensions of the slots and stator laminations in order that the third winding may be properly embedded. Further, about one-third more copper must be used. Motors with three windings take up, therefore, more room, are both heavier and more expensive without their electric qualities being any better. It is therefore necessary to examine each particular case by itself before deciding on the most advantageous type of winding.

Standard Output 15 h.p.

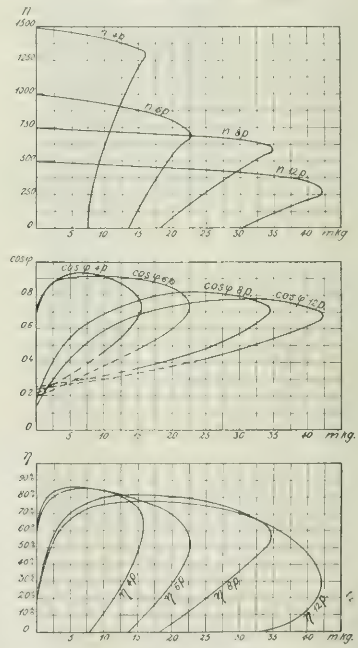


Fig. 5.—Curves of Constant Output from a Four-speed Motor with 4, 6, 8 and 12 Poles in Series.

The operation of motors with five or six speeds is the same under all conditions as that of those motors with two and four poles which have been constructed up to the present. The designer can, if he desires, by the employment of a series or parallel scheme of winding, obtain a practically constant output at all speeds, or, on the other hand, a constant torque. Further, by arranging the two windings in a different manner he can obtain a variable output according to the speed. Driving fans and machines for printing textiles are examples where a large torque is required at high speeds. This cannot be obtained for continuous-current motors fitted with field regulation except by a large increase in field current, necessitating the employment of a more powerful type of motor. On the other hand, the driving of machine tools often requires a very high torque at low speeds. The arrangement of the various windings, therefore, allows a motor of the best design for each case, from the point of view of price and current consumption, to be obtained.

Figs. 5 and 6 give diagrams corresponding to these various hypotheses for all cases of constant output and constant torque respectively. The wider and wider employment of three-phase motors

with several speeds for industrial work is explained by the simplicity of the principles involved, by their good efficiency and their high power factor at all speeds, as well as by the certainty of their operation. From the point of view of regulation they are superior to any others.

They can be particularly used to advantage when the shops have only high-tension two or three-phase current to hand and when to

Standard Torque 20 mkg.

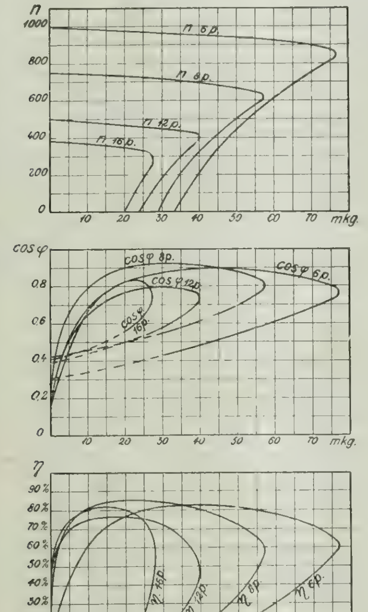


FIG. 6.—CURVES OF CONSTANT TORQUE FROM A FOUR-SPEED MOTOR. 6, 8, 12 AND 16 POLES IN PARALLEL.

use continuous-current motors it would be necessary to instal complicated and costly converters for transforming current.

We have to thank Mr. G. Wüthrich, engineer and manager of the Maschinenfabrik Oerlikon in this country, for the information contained in the above article.

PROF. E. RUTHERFORD'S ADDRESS TO SECTION A OF THE BRITISH ASSOCIATION.*

It is my intention to-day to say a few words upon the present position of the atomic theory in physical science, and to discuss briefly the various methods that have been devised to determine the values of certain fundamental atomic magnitudes. The present time seems very opportune for this purpose, for the rapid advance of physics during the last decade has not only given us a much clearer conception of the relation between electricity and matter and of the constitution of the atom, but has provided us with experimental methods of attack undreamt of a few years ago. At a time when, in the vision of the physicist, the atmosphere is dim with flying fragments of atoms, it may not be out of place to see how it has fared with the atoms themselves, and to look carefully at the atomic foundations on which the great spuerstructure of modern science has been raised. Every physicist and chemist cannot but be aware of the great part the atomic hypothesis plays in science to-day. As an indication of the importance of this theory in the advance of science it is of interest to read over the reports of this Association and to note how many addresses, either wholly or in part, have been devoted to a consideration of this subject. Amongst numerous examples I may instance the famous and oft-quoted lecture of Maxwell on Molecules, at Bradford in 1873; the discussion of the Kinetic Theory of Gases by Lord Kelvin, then Sir William Thomson, in Montreal in 1884; and the presidential address of Sir Arthur Rücker in 1901, which will be recalled by many here to-day.

Towards the close of the last century the ideas of the atomic theory had impregnated a very large part of the domain of physics and chemistry. The conception of atoms became more and more concrete, and while some regarded it as an established fact of Nature, others pointed out that it was only a theory. The latter school was assisted by the possibility of explaining many chemical facts on the basis of thermo-dynamics. But what is wanted is a concrete idea, however crude it may be, of the mechanism of the phenomena. This may be a weakness of the scientific mind, but it is one that deserves our sympathetic consideration. It represents an attitude of mind that appeals, I think, very strongly to the Anglo-Saxon temperament. It has no doubt as its basis the underlying idea that the facts of Nature are ultimately explicable on general dynamical principles, and that there must consequently be some type of mechanism capable of accounting for the observed facts.

It has been generally considered that a decisive proof of the atomic structure of matter was in the nature of things impossible, and that the atomic theory must of necessity remain an hypothesis unverifiable by direct methods. Recent investigations have, however, disclosed such new and powerful methods of attack that we may well ask the question whether we do not now possess more decisive evidence of its truth. In this connection I should like to draw your attention for a short time to a most striking phenomenon known as the "Brownian movement," which has been closely studied in recent years. In 1827 the English botanist Brown observed by means of a microscope that minute particles like spores of plants introduced into a fluid were always in a state of continuous irregular agitation, dancing to and fro in all directions at considerable speeds. For a long time this effect, known as the Brownian movement, was ascribed to inequalities in the temperature of the solution. This was disproved by a number of subsequent investigations, and especially by those of Gouy, who showed that the movement was spontaneous and continuous, and was exhibited by very small particles of whatever kind when immersed in a fluid medium. Exner and Zsigmondy have determined the mean velocity of particles of known diameter in various solutions, while Svedberg has devised an ingenious method of determining the mean free path and the average velocity of particles of different diameter. The experiments of Ehrenhaft in 1907 showed that the Brownian movement was not confined to liquids, but was exhibited far more markedly by small particles suspended in gases.

The particles exhibit in general the character of the motion which the kinetic theory ascribes to the molecules themselves, although even the smallest particles examined have a mass which is undoubtedly very large compared with that of the molecule. The character of the Brownian movement irresistibly impresses the observer with the idea that the particles are hurled hither and thither by the action of forces resident in the solution, and that these can only arise from the continuous and ceaseless movement of the invisible molecules of which the fluid is composed. Smoluchowski and Einstein have suggested explanations which are based on the kinetic theory, and there is a fair agreement between calculation and experiment. Strong additional confirmation of this view has been supplied by the very recent experiments of Perrin (1909). The number of particles was found to diminish from the bottom of the vessel upwards, according to an exponential law—*i.e.*, according to the same law as the pressure of the atmosphere diminishes from the surface of the earth. From measurements of the diameter and weight of each particle, Perrin found that, within the limit of experimental error, the law of distribution with height indicated that each small particle had the same average kinetic energy of movement as the molecules of the solutions in which they were suspended; in fact, the particles in suspension behaved in all respects like molecules of very high molecular weight. This is a very important result, for it indicates that the law of equipartition of energy among molecules of different masses, which is an important deduction from the kietic theory, holds, at any rate very approximately, for a distribution of particles in a medium whose masses and dimensions are exceedingly large compared with that of the molecules of the medium. Whatever may prove to be the exact explanation of this phenomenon, there can be little doubt that it results from the movement of the molecules of the solution, and is thus a striking, if somewhat indirect, proof of the general correctness of the kinetic theory of matter.

From recent work in radio-activity we may take a second illustration which is novel and far more direct. It is well known that the α rays of radium are deflected by both magnetic and electric fields. It may be concluded from this evidence that the radiation is corpuscular in character, consisting of a stream of positively charged particles

* Abstract of the Presidential Address delivered by Prof. E. Rutherford, M.A., D.Sc., F.R.S., on Thursday, August 26th.

projected from the radium at a very high velocity. From the measurements of the deflection of the rays in passing through magnetic and electric fields the ratio e/m of the charge carried by the particle to its mass has been determined, and the magnitude of this quantity indicates that the particle is of atomic dimensions.

Rutherford and Geiger have recently developed a direct method of showing that this radiation is, as the other evidence indicated, discontinuous, and that it is possible to detect by a special electric method the passage of a single α particle into a suitable detecting vessel. The entrance of an α particle through a small opening was marked by a sudden movement of the needle of the electrometer, which was used as a measuring instrument. In this way, by counting the number of separate impulses communicated to the electrometer needle it was possible to determine by direct counting the number of α particles expelled per second from 1 gramme of radium. But we can go further and confirm the result by counting the number of α particles by an entirely distinct method. Sir William Crookes has shown that when the α rays are allowed to fall upon a screen of phosphorescent zinc sulphide, a number of brilliant scintillations are observed. It appears as if the impact of each α particle produced a visible flash of light where it struck the screen. Using suitable screens the number of scintillations per second on a given area can be counted by means of a microscope. It has been shown that the number of scintillations determined in this way is equal to the number of impinging α particles when counted by the electric method. This shows that the impact of each α particle on the zinc sulphide produces a visible scintillation.

The next question to consider is the nature of the α particle itself. The general evidence indicates that the α particle is a charged atom of helium, and this conclusion was decisively verified by Rutherford and Royds by showing that helium appeared in an exhausted space into which the α particles were fired. If the rate of production of helium from radium is measured we thus have a means of determining directly how many α particles are required to form a given volume of helium gas. Sir James Dewar has informed me that his final measurements show that 1 gramme of radium in radio-active equilibrium produces 0·46 cubic mm. of helium per day, or $5{\cdot}32 \times 10^{-6}$ cubic mm. per second. Now, from the direct counting experiments it is known that $13{\cdot}6 \times 10^{10}$ α particles are shot out per second from 1 gramme of radium in equilibrium. Consequently it requires $2{\cdot}56 \times 10^{19}$ α particles to form 1 cubic cm. of helium gas at standard pressure and temperature.

From other lines of evidence it is known that all the α particles from whatever source are identical in mass and constitution. It is not then unreasonable to suppose that the α particle, which exists as a separate entity in its flight, can exist also as a separate entity when the α particles are collected together to form a measurable volume of helium gas, or, in other words, that the α particle on losing its charge becomes the fundamental unit or atom of helium. In the case of a monatomic gas like helium, where the atom and molecule are believed to be identical, no difficulty of deduction arises from the possible combination of two or more atoms to form a complex molecule.

We consequently conclude from these experiments that 1 cubic cm. of helium at standard pressure and temperature contains $2{\cdot}56 \times 10^{19}$ atoms. Knowing the density of helium, it at once follows that each atom of helium has a mass of $6{\cdot}8 \times 10^{-24}$ grammes, and that the average distance apart of the molecules in the gaseous state at standard pressure and temperature is $3{\cdot}4 \times 10^{-7}$ cm.

The above result can be confirmed in a different way by measuring the total charge carried by a counted number of α particles and substituting this number in the value of e/m, which gives the mass of the α particle as equal to $6{\cdot}1 \times 10^{24}$ grammes, a value in fair agreement with the number previously given.

We have seen that under special conditions it is possible to detect easily by an electrical method the emission of a single α particle—*i.e.*, of a single charged atom of matter. This has been rendered possible by the great velocity and energy of the expelled α particle, which confers on it the power of dissociating or ionising the gas through which it passes. It is obviously only possible to detect the presence of a single atom of matter when it is endowed with some special property or properties which distinguishes it from the molecules of the gas with which it is surrounded. There is a very important and striking method, for example, of visibly differentiating between the ordinary molecules of a gas and the ions produced in the gas by various agencies. C. T. R. Wilson showed in 1897 that under certain conditions each charged ion became a centre of condensation of water vapour, so that the presence of each ion was rendered visible to the eye. Sir Joseph Thomson, H. A. Wilson and others have employed this method to count the number of ions present and to determine the magnitude of the electric charge carried by each.

As soon as the idea of the discrete structure of matter had taken firm hold, it was natural that attempts should be made to estimate the degree of coarse grainedness of matter, and to form an idea of the dimensions of molecules, assuming that they have extension in space. Lord Rayleigh has drawn attention to the fact that the earliest estimate of this kind was made by Thomas Young in 1805, from considerations of the theory of capillarity. The development of the kinetic theory of gases on a mathematical basis at once suggested methods of estimating the number of molecules in a cubic centimetre of any gas at normal pressure and temperature. This number, which will throughout be denoted by the symbol N, is a fundamental constant of gases. Knowing the value of N, approximate estimates can be made of the diameter of the molecule; but in our ignorance of the constitution of the molecule, the meaning of the term diameter is somewhat indefinite. It is usually considered to refer to the diameter of the sphere of action of the forces surrounding the molecule. This diameter is not necessarily the same for the molecules of all gases, so that it is preferable to consider the magnitude of the fundamental constant N. The earliest estimates based on the kinetic theory were made by Loschmidt, Johnstone, Stoney and Maxwell. From the data then at his disposal the latter found N to be $1{\cdot}9 \times 10^{19}$. Meyer, in his "Kinetic Theory of Gases," concludes that the most probable estimate of N is $6{\cdot}1 \times 10^{19}$.

A very interesting and impressive method of determining the value of N was given by Lord Rayleigh in 1899 as a deduction from his theory of the blue colour in the cloudless sky. From the data thus available Lord Rayleigh concluded that the value of N was not less than 7×10^{18}. Lord Kelvin in 1902 re-calculated the value of N on the theory by using more recent and more accurate data, and found it to be $2{\cdot}47 \times 10^{19}$. Since in the simple theory no account is taken of the additional scattering due to fine suspended particles which are undoubtedly present in the atmosphere, this method only serves to fix an inferior limit to the value of N.

The value of N can be deduced at once from experimental results depending on the law of distribution in a fluid of a great number of minute granules, and is found to be $3{\cdot}14 \times 10^{19}$. Another very simple method of determining N from radio-active data is based on the rate of transformation of radium. Boltwood has shown by direct experiment that radium is half transformed in 2,000 years. From this it follows that initially in a gramme of radium 0·346 mg. breaks up per year. Now it is known from the counting method that $3{\cdot}4 \times 10^{10}$ α particles are expelled per second from 1 gramme of radium, and the evidence indicates that one α particle accompanies the disintegration of each atom. Consequently, the number of α particles expelled per year is a measure of the number of atoms of radium present in 0·346 mg. From this it follows that there are $3{\cdot}1 \times 10^{21}$ atoms in 1 gramme of radium, and, taking the atomic weight of radium as 226, it is simply deduced that the value of N is $3{\cdot}1 \times 10^{19}$.

The study of the properties of ionised gases in recent years has led to the development of a number of important methods of determining the charge carried by the ion, produced in gases by α rays or the rays from radio-active substances. On modern views, electricity, like matter, is supposed to be discrete in structure, and the charge carried by the hydrogen atom set free by the electrolysis of water is taken as the fundamental unit of quantity of electricity. On this view, which is supported by strong evidence, the charge carried by the hydrogen atom is the smallest unit of electricity that can be obtained, and every quantity of electricity consists of an integral multiple of this unit. The experiments of Townsend have shown that the charge carried by a gaseous ion is, in the majority of cases, the same and equal in magnitude to the charge carried by a hydrogen atom in the electrolysis of water. From measurement of the quantity of electricity required to set free 1 gramme of hydrogen in electrolysis, it can be deduced that $Ne = 1{\cdot}29 \times 10^{10}$ electrostatic units, where N, as before, is the number of molecules of hydrogen in 1 cubic cm. of gas, and e the charge carried by each ion. If e be determined experimentally, the value of N can at once be deduced from this relation.

The first direct measurement of the charge carried by the ion was made by Townsend in 1897, who found that the value of e, the charge carried by each drop, to be about $3{\cdot}0 \times 10^{-10}$ electrostatic units. The corresponding value of N is about $4{\cdot}3 \times 10^{19}$. Sir Joseph Thomson also used Wilson's method to measure the charge e carried by each ion. He found that $e = 3{\cdot}4 \times 10^{-10}$, H. A. Wilson $e = 3{\cdot}1 \times 10^{-10}$, and Millikan and Begeman $4{\cdot}06 \times 10^{-10}$. The corresponding values of N are 3·8, 4·2 and $3{\cdot}2 \times 10^{19}$ respectively. This method is of great interest and importance, as it provides a method of directly counting the number of ions produced in the gas. An exact determination of e by its means is, however, unfortunately beset with great experimental difficulties. Moreau has recently measured the charge carried by the negative ions produced in flames. The values deduced for e and N were respectively $4{\cdot}3 \times 10^{-10}$ and $3{\cdot}0 \times 10^{19}$.

Ehrenhaft, by measuring the charge on ultra-microscopic dust of silver, and Rutherford and Geiger by measuring the total charge on

a known number of α particles, have found values for $N = 2{\cdot}74 \times 10^{19}$ and $2{\cdot}77 \times 10^{19}$ respectively.

The methods of determination of e, so far explained, have depended on direct experiment. This discussion would not be complete without a reference to an important determination of e from theoretical considerations by Planck. From the theory of the distribution of energy in the spectrum of a hot body, Planck found that $e=4{\cdot}69 \times 10^{-10}$, and $N = 2{\cdot}80 \times 10^{19}$.

When we consider the great diversity of the theories and methods which have been utilised to determine the values of the atomic constants e and N, and the probable experimental errors, the agreement among the numbers is remarkably close. This is especially the case in considering the more recent measurements by very different methods, which are far more reliable than the older estimates. It is difficult to fix on one determination as more deserving of confidence than another; but I may be pardoned if I place some reliance on the radio-active method previously discussed, which depends on the charge carried by the α particle. The value obtained in this way is not only in close agreement with the theoretical estimate of Planck, but is in fair agreement with the recent determinations by several other distinct methods. We may consequently conclude that the number of molecules in a cubic centimetre of any gas at standard pressure and temperature is about $2{\cdot}77 \times 10^{19}$, and that the value of the fundamental unit of quantity of electricity is about $4{\cdot}65 \times 10^{-10}$ electrostatic units. From these data it is a simple matter to deduce the mass of any atom whose atomic weight is known, and to determine the values of a number of related atomic and molecular magnitudes.

There has been a tendency in some quarters to suppose that the development of physics in recent years has cast doubt on the validity of the atomic theory of matter. This view is quite erroneous, for it will be clear from the evidence already discussed that the recent discoveries have not only greatly strengthened the evidence in support of the theory, but have given an almost direct and convincing proof of its correctness. The chemical atom as a definite unit in the subdivision of matter is now fixed in an impregnable position in science. Leaving out of account considerations of etymology, the atom in chemistry has long been considered to refer only to the smallest unit of matter that enters into ordinary chemical combination. The advent of the electron has shown that the atom is not the unit of smallest mass of which we have cognisance, while the study of radioactive bodies has shown that the atoms of a few elements of high atomic weight are not permanently stable, but break up spontaneously with the appearance of new types of matter. These advances in knowledge do not in any way invalidate the position of the chemical atom, but rather indicate its great importance as a subdivision of matter whose properties should be exhaustively studied.

The proof of the existence of corpuscles or electrons with an apparent mass very small compared with that of the hydrogen atom, marks an important stage in the extension of our ideas of atomic constitution. This discovery, which has exercised a profound influence on the development of modern physics, we owe mainly to the genius of the President of this Association. The existence of the electron as a distinct entity is established by similar methods and with almost the same certainty as the existence of individual α particles. While it has not yet been found possible to detect a single electron by its electrical or optical effect, and thus to count the number directly, as in the case of the α particles, there seems to be no reason why this should not be accomplished by the electric method.

The idea that the atoms of the elements may be complex structures, made up either of lighter atoms or of the atoms of some fundamental substance, has long been familiar to science. So far no direct evidence has been obtained of the possibility of building up an atom of higher atomic weight from one of lower atomic weight, but in the case of the radio-active substances we have decisive and definite evidence that certain elements show the converse process of disintegration. It may be significant that this process has only been observed in the atoms of highest atomic weights, like those of uranium, thorium and radium. With the exception possibly of potassium, there is no reliable evidence that a similar process takes place in other elements. The transformation of the atom of a radio-active substance appears to result from an atomic explosion of great intensity in which a part of the atom is expelled with great speed. In the majority of cases, an α particle or atom of helium is ejected, in some cases a high-speed electron, while a few substances are transformed without the appearance of a detectable radiation. The fact that the α particles from a simple substance are all ejected with an identical and very high velocity suggests the probability that the charged helium atom before its expulsion is in rapid orbital movement in the atom. There is at present no definite evidence of the causes operative in these atomic transformations.

Since in a large number of cases the transformation of the atoms are accompanied by the expulsion of one or more charged atoms of helium it is difficult to avoid the conclusion that the atoms of the radio-active elements are built up, in part at least, of helium atoms. It is certainly very remarkable and may prove of great significance, that helium, which is regarded from the ordinary chemical standpoint as an inert element, plays such an important part in the constitution of the atoms of uranium, thorium and radium.

The study of radio-activity has not only thrown great light on the character of atomic transformations, but it has also led to the development of methods for detecting the presence of almost infinitesimal quantities of radio-active matter. It has already been pointed out that two methods—one electrical, the other optical—have been devised for the detection of a single α particle. By the use of the optical or scintillation method, it is possible to count with accuracy the number of α particles when only one is expelled per minute. It is not a difficult matter, consequently, to follow the transformation of any radio-active substance in which only one atom breaks up per minute, provided that an α particle accompanies the transformation.

Quite apart from the importance of studying radio-active changes the radiations from active bodies provide very valuable information as to the effects produced by high velocity particles in traversing matter. The character of the effects produced by the α and β particles is most simply studied in gases. The α particle has such great energy of motion that it plunges through the molecules of the gas in its path, and leaves in its train more than a hundred thousand ionised or dissociated molecules. The β particle differs from the α particle in its much greater power of penetration of matter, and the very small number of molecules it ionises compared with the α particle traversing the same path in the gas. It is very easily deflected from its path by encounters with the gas molecules, and there is strong evidence that, unlike the α particle, the β particle can be stopped or entrapped by a molecule when travelling at a very high speed.

There would appear to be little doubt that a careful study of the effects produced by the α or β particle in passing through matter will ultimately throw much further light on the constitution of the atom itself. Work already done shows that the character of the absorption of the radiations is intimately connected with the atomic weights of the elements and their position in the periodic table. One of the most striking effects of the passage of β rays through matter is the scattering of the β particles—*i.e.*, the deflection from their rectilinear path by their encounters with the molecules. Recent experiments of Geiger show that the scattering of the α particles also is very marked, and is so great that a small fraction of the α particles, which impinge on a screen of metal, have their velocity reversed in direction and emerge again on the same side. It can be shown that the deflection of the α particle from its path is quite perceptible after passing through very few atoms of matter. The conclusion is unavoidable that the atom is the seat of an intense electric field, for otherwise it would be impossible to change the direction of the particle in passing over such a minute distance as the diameter of a molecule.

In conclusion, I should like to emphasise the simplicity and directness of the methods of attack on atomic problems opened up by recent discoveries. We can determine directly the mass of each α particle, its charge, and its velocity, and can deduce at once the number of atoms present in a given weight of any known kind of matter. In the light of these and similar direct deductions, based on a minimum amount of assumption, the physicists have, I think, some justification for their faith that they are building on the solid rock of fact, and not, as we are often so solemnly warned by some of our scientific brethren, on the shifting sands of imaginative hypothesis.

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"Transactions of the Canadian Institute." April, 1909. Vol. VIII. Part III. (Toronto: Murray Printing Co.) $2.00.

"Bulletin International de l'Académie des Sciences de l'Empéreur François Joseph I." 1907-1908. Two volumes.

"Sammlung von elektrotechnischen Zeichnungen und Diagrammen." By Prof. Dr. F. Niethammer. (Vienna: Verlag Spielhagen U. Schurich.)

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SCIENCE IN PUBLIC SCHOOLS.

During the last few years there has been much agitation in regard to the teaching of science in our public schools, and much searching of heart in determining whether school programmes were all that could be desired. There was a very general impression, not without reason, that science was still being sacrificed for classics. To those who held that view the report recently issued by the Board of Education will come as something of a relief. It has been prepared by Mr. O. H. LATTER, science master at Charterhouse, and deals carefully with the result of a series of questions which were circulated to 71 schools. Of these schools a number did not reply, and there was even one definite refusal. But, nevertheless, 46 replies were received, and as these included all the leading schools, such as Charterhouse, Clifton, Eton, Harrow, Rugby, Wellington and Winchester, the conclusions deduced should be of distinct value. It appears that 61 per cent. of the boys in these 46 schools are being taught something scientific, and that even the remainder will receive, or have received, something of an education in science. Whether the time devoted to this part of their education is a sufficient proportion of the whole, it is difficult to say, as the time varies very considerably from school to school. What is certain, however, is that the facilities now seem to be reasonably adequate, and are very different from those pro-

-vided in the early days. It is related by the Rev. J. M. Wilson, Canon of Worcester, that when he was appointed Science Master at Rugby in 1859 the fees which were paid by the boys taking up science, and which formed his salary, amounted to £5. 5s. per annum. There was no laboratory, and the teaching was carried on in the cloak room on the ground floor of the Town Hall. Now, however, as mentioned in the present report, one chemical laboratory is to be found in every one of the 46 schools, and at least one physical laboratory in 45 of them.

It would seem, therefore, that the classical yoke has at length been more or less broken, though, doubtless, this has not been effected before a great deal of harm had been done. It is difficult to think of anything much more dulling to the average intellect than continual application to classics. As mentioned in the report, Charles Darwin refers to his school life at Shrewsbury in the following words:—

> Nothing could have been worse for the development of my mind than Dr. Butler's school, as it was strictly classical, nothing else being taught, except a little ancient geography and history. The school as a means of education to me was simply a blank. . . . . I believe that I was considered by all my masters, and by my father, as a very ordinary boy, rather below the common standard in intellect. . . . . My brother worked hard at chemistry, and I was allowed to aid him as a servant in most of his experiments. . . . . The subject interested me greatly. . . . . This was the best part of my education at school, for it showed me practically the meaning of experimental science. The fact that we worked at chemistry somehow got known at school, and as it was an unprecedented fact, I was nicknamed "Gas." I was also once publicly rebuked by the headmaster, Dr. Butler, for thus wasting my time on such useless subjects.

There are some who feel that we are now tending to the other extreme, and that classics are not receiving enough attention. Dr. C. P. Steinmetz is one of these, and in a short Paper, read recently before the American Institute of Electrical Engineers, he lays great emphasis on the value of classics from two points of view; firstly, because they supply the roots of so very many of our words, and, secondly, because classics have great value in general education. He regards the neglect of classics as one of the most serious mistakes of modern education; that the knowledge necessary to an engineering trade cannot be called an education; that modern languages are not in the same class with the classic languages, as they open to students no new world and no field of thought appreciably different from their own; that the utilitarian value of modern languages is negligible, because anything that is worth reading in a foreign language is translated into English, either in full or in abstract.

We doubt if these views will be fully supported. Possibly modern languages may not be as important in America as in European countries, where, from the utilitarian point of view, a knowledge of this kind is of very great use. Apart from utilitarian value, a knowledge of modern languages enables their possessor to gain a greater insight into the ways and thoughts of other countries, and this is certainly of great value in the broad educational sense. What Dr. Steinmetz says in regard to foreign technical articles being translated into English might very well be applied to the classics. As stated by Dean Farrar long ago, it is a great delusion to think that boys who are educated on classics know a serious amount of Latin and Greek, and it is certain that most of them will not open a Latin or Greek book after leaving school. They are not likely, therefore, to reach that proficiency in which they can appreciate the beauty of classical works, as suggested by Dr. Steinmetz. The great majority of people will derive greater benefit by investigating the affairs of Greece and Rome through the medium of translations. To a limited extent we think that Dr. Steinmetz is right, but we seriously trust that his views as a whole will not take root.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Traction Electrique. By G. Sattler. Translated from the German by Pierre Girot. (Paris: Gauthier-Villars.) Pp. vi.—190. Fr.5.

This book, which is a translation into French from the German original, professes to deal with electric traction in general, dealing practically with the calculations and theoretical considerations in connection with tramways and small industrial electric railways. As there is no hint of this in the title it will be as well to draw attention to these limitations. Students who may expect to find in this book special information with regard to Continental practice as to suburban or main line electric railways will be disappointed. The latest developments in traction apparatus are not considered, and single-phase commutator motors are not even mentioned. Under these circumstances it would have been far better if a longer and less ambitious title had been chosen.

Turning now to the subject matter dealt with in the book, it must be said that so far as the electrical apparatus is concerned the treatment is almost purely theoretical. The first chapter deals with the tractive resistance of moving vehicles and is fairly complete, almost unnecessarily so, if tramways alone are concerned. The second chapter is of considerable length and deals with the various methods of controlling motors, rheostatic, series-parallel and field shunting, and shows how the necessary calculations may be worked out in each case. A page and a half are devoted to the shunt motor, but very little information is given and no mention is made of any regenerative system of control such as the Raworth system, which we believe is neither well known nor appreciated in Germany. Three-phase motors with rheostatic control are also referred to very briefly.

Chapter III. contains eight pages on the calculation of energy consumption and gives results showing the influence of gradients and of the number of stops per kilometre. Chapters IV. and V. refer to the calculations of the overhead line and feeder system, dealing with these according to well-known principles, but not very exhaustively, and to the construction of the feeders. Chapter VI. is a long account of the methods of laying out and constructing the track, and Chapter VII. deals with the construction of the overhead line. The latter is the best chapter in the book and gives a good account of how the line should be arranged at junctions, turn-outs and crossings. A few pages are set apart for electric automobiles and the trackless trolley system, and the book concludes with a set of model specifications.

It cannot be said that this book offers any great attraction to the practical student of electric traction in this country as, apart from other considerations, it does not, very naturally, refer specifically to English conditions and methods of construction that are now practically standardised.

E. W. & F. L.

Die normalen Eigenschaften elektrischer Maschinen. By R. Goldschmidt. Pp. 68 + Figs. 34. (Berlin: Springer.) M.3.

This is a very useful little book and will be welcomed by consulting engineers and designers alike. In the small space of 68 pages the author sets forth what may be regarded as the standard performances of continuous-current machines, converters, synchronous generators and motors, induction motors,

single phase commutator motors and transformers. Such information, of course, can only come from one well acquainted with modern practice, and since the figures given can, with few exceptions, be regarded as safe, the booklet will doubtless find its place on many a consultant's table, where it will enable him to decide upon his guarantees in drawing up specifications, or on the capacities of his machines, &c., when laying out schemes. The designer will also find the information acceptable as showing him what may reasonably be expected from his machines. Though little more than $\frac{1}{4}$ in. thick it is pleasing to see that a proper binding has been supplied and not the wretched paper covers which so quickly make a book unsightly. Part of the work has already appeared as a Paper read before the Institution of Electrical Engineers.

In general, the figures given can be taken as fairly reliable average values of what may be expected from present-day electric machinery, and a little experience will soon enable the reader to see where the author has been too optimistic. This latter remark is chiefly applicable to the efficiency figures of continuous-current machines and induction motors of small output. The danger, of course, in giving such figures too high is that consulting engineers are led to expect too much from manufacturers. The power factor figures for induction motors seem quite good—if anything they are a trifle below the listed figures of many firms. Since this, however, is largely a question of air-gap, we are rather inclined to side with the author.

The tables showing standard maximum volts and speeds for given outputs for the various classes of machines should be very useful. We think that the speeds of turbo-alternators are on the low side—though present opinion is still divided. Nevertheless, turbos of 5,000-6,000 kw. are now running at 1,000 revs. per min., whilst outputs of 2,000-3,000 kw. at 3,000 revs. per min. are quite common. It is interesting to recall that the cost of high-speed alternators is not less than that of slow speed—the chief advantage of the former machine being its combination with the steam turbine.

The performance figures for alternators are very typical, though Dr. Goldschmidt ought to have made it clearer what power-factor the efficiencies refer to; also it would have been better to have given the pressure rise instead of the pressure drop for the regulation. It is not quite clear what excitation is referred to in speaking of the short-circuit current of an alternator.

The author is to be congratulated on his work which, on the whole, is so free from fault and at the same time so interesting and useful.

S. P. S. and A. E. C.

LEAKAGE REACTANCE.

BY J. REZELMAN.

(Concluded from page 745.)

Summary.—The article deals with the leakage reactance of the stator windings of alternating-current machines, the rotors being removed. The leakage flux is separated into its component parts, for several machines, by means of experiments; the effect of the type of winding upon the overhang leakage, and the relationship between the reactance of the windings in three-phase and in single-phase working are observed. Formulæ are given by means of which the stator reactance can be calculated.

B. *The Reactance of the Stator of a Three-phase Turbo-alternator* 3,500 *k.v.a.*, 4 *poles*, 50 ~ *per second*, 1,500 *revs. per min.*, 6,600 *volts between phases, the rotor being removed.* (Fig. 7.)

Dimensions.—$D_i = 950$ mm., $\tau = 750$ mm., $l = 1,150 - 26 \times 7\cdot5$, $l = 1,050$ mm., 48 slots (23×80), $t_1 = 62\cdot3$, $s_n = 6$, $p = 2$, whence $q = 4$. The stator is wound with consequent poles, that is to say, there are two coils per phase for the four poles; the end connections of the four slots thus form one coil, Figs. 7 and 8. The lengths of the exterior portions are not the same for the two coils, for that nearest the stator core $l_s = 1,684$, and for the outside coil $l_s = 1,824$. The difference not being great we will use the mean value of 1,754 for our calculations. However, since the end connections are arranged in two planes, the whole winding is symmetrical with regard to the three phases. The length l_s is composed of l_{s_a}, l_{s_c} per phase; $l_{s_a} = 1,010$ with $U_{s_a} = 390$, and $l_{s_c} = 714$ with $U_{s_c} = 585$ mm.

In order to separate experimentally the permeances λ_n, λ_k, and λ_s, auxiliary coils were placed on the inside of the stator for the length of the slots of one pole of phase I. There were five wires in the slit of each of the four slots of one coil, Fig. 7, their end connections were taken along the end plates of the stator core. By means of these auxiliary coils the flux ψ_k could be measured.*

Experiments.—Readings were taken on each phase: (1) In single-phase per phase. (2) In single phase, two phases in series. (3) In three-phase. With regard to the results, the same remarks may be made as for the preceding experiments. The tests were made on the stator with the protection shrouds removed; the increase in voltage with the shrouds in position is negligible, but the watts are increased by 15 per cent. There are $16 \times 6 = 96$ main wires per phase and $8 \times 5 = 40$

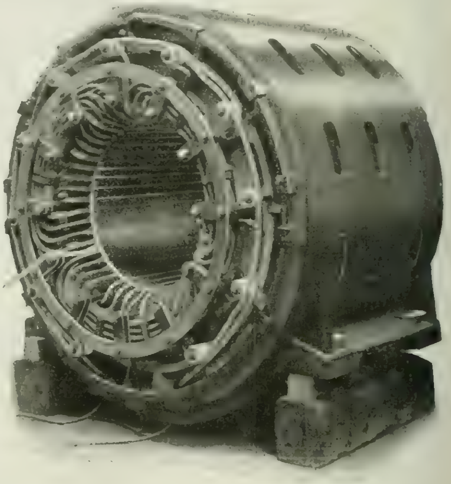


FIG. 7.

auxiliary wires. The E.M.F. induced in that part of the winding, which is in the slots, and corresponding to the flux ψ_k, will be $96/40 = 2\cdot4$ times the E.M.F. induced in the auxiliary coils.

SEPARATION OF THE VOLTAGES.

1. *Single phase.—Phase I.*—The voltage measured on the auxiliary coils was $e_k = 10\cdot83$, then $2\cdot4 \times 10\cdot83 = 26$ volts, and $x_{s_k} = 26/25 = 1\cdot04\omega$. We have also $x_{s_k} = \frac{12\cdot5 \times 50 \times 48^2}{2 \times 4 \times 10^8} \times l_i \lambda_k$; in which $l_i = l_i = 1,050$, then $x_{s_k} = 0\cdot189\lambda_k = 1\cdot04$, whence $\lambda_k = 5\cdot5$.

For four slots per pole and phase

$$\lambda_k = 0\cdot92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 1\cdot4 + 4\log\left(\frac{\tau}{3t_1} \times B\right)\right\} \text{ for } p = 2,\ q = 4$$

$$= 0\cdot92\left\{\log\left(\frac{\pi \times 56\cdot3}{6}\right) + 1\cdot4 + 4\log\left(\frac{750}{3 \times 62\cdot3} \times B\right)\right\} = 5\cdot5$$

Then $2\cdot87 + 4\log(4B) = 5\cdot98$, and $B = 1\cdot5$. We can determine $\lambda_n = 1\cdot25(65/69 + 5/23 + 9/29 + 1/6) = 2\cdot04$, for a length $l_n = l_i = 1,050$; then $x_{s_n} = \frac{12\cdot5 \times 50 \times 48^2}{2 \times 4 \times 10^8} \times 105 \times 2\cdot04 = 0\cdot385\omega$.

There remains for the end connections $48\cdot3 - 26 - 25 \times 0\cdot385 = 12\cdot7$ volts, from which $12\cdot7/25 = 0\cdot507\omega$. We have for λ_a

* In reality the auxiliary coils also measure part of the flux ψ'' produced by l_{s_a} of the end connections; to separate this would, however, lead to useless complication.

$l_s = 1{,}754$; $l_{s_a} = 1{,}010$; with $U_{s_a} = 390$ mm.; $l_{s_c} = 744$; with $U_{s_c} = 585$ mm. Then

$$\lambda_{s_a} = 0{\cdot}46 q_s (A \times \log 2l_s/U_{s_a}) = 0{\cdot}46 \times 4\ (A \times \log 2 \times 1{,}754/390) = 1{\cdot}76 + 1{\cdot}84A.$$

$$\lambda_{sc} = 0{\cdot}46 \times q_s(A + \log 2l/U_{s_c}) = 0{\cdot}46 \times 4\,(A + \log 2 \times 1{,}754/585) = 1{\cdot}435 + 1{\cdot}84A.$$

and

$$x_{s_a} = \frac{12{\cdot}5 \times 50 \times 48^2}{2 \times 4 \times 10^8} \times 101(1{\cdot}76 + 1{\cdot}84A) = 0{\cdot}32 + 0{\cdot}355A.$$

$$x_{s_c} = \frac{12{\cdot}5 \times 50 \times 48^2}{2 \times 4 \times 10^8} \times 74{\cdot}4(1{\cdot}435 + 1{\cdot}84A) = 0{\cdot}192 + 0{\cdot}247A.$$

$$x_{s_a} + x_{s_c} = 0{\cdot}512 + 0{\cdot}582A = 0{\cdot}507$$

whence $A = -0{\cdot}0086 \sim 0$.

2. *Single phase, two phases in series, and three phase.*—From tables of results Nos. 2 and 3, $e_k = 13{\cdot}1$ volts, then $2 \times 2{\cdot}4 \times 13{\cdot}1 = 63$ volts, and $x_{s_k} = 63/25 = 2{\cdot}52$ ohms.

We have found that the reactance x_{sk} for one phase is 1·04 ohms. $2 \times 1{\cdot}04 = 2{\cdot}08$ so that there is an augmentation of $2{\cdot}52/2{\cdot}08 = 1{\cdot}21$. The permeance λ_k of eight slots covering $\frac{2}{3}$ of the pole pitch is thus 21 per cent. greater than that of four slots covering $\frac{1}{3}\tau$. For the preceding two-pole machine with five slots covering $\frac{1}{3}\tau$ an augmentation of 23 per cent. has b en established. We have

$$x_{s_k} = \frac{12{\cdot}5 \times 50 \times 96^2}{2 \times 8 \times 10^8} \times 105\lambda_k = 0{\cdot}378\lambda_k = 2{\cdot}52$$

$$\lambda_k = 6{\cdot}66.$$

By writing

$$\lambda_k = 0{\cdot}92 \left\{ \log (\pi z_1/r_1) + 4{\cdot}2 + 8 \log \left(\frac{\tau}{7 t_1} \times B \right) \right\} = 6{\cdot}66,$$

for $p = 2$, $q = 8$ we find the value 0·92 for B, which again is but little different from unity. The permeance λ_n has the value of 2·04, then

$$x_{s_n} = \frac{12{\cdot}5 \times 50 \times 96^2}{2 \times 8 \times 10^8} \times 105 \times 2{\cdot}04 = 0{\cdot}77 \text{ ohm},$$

and $25 \times 0{\cdot}77 = 19{\cdot}25$ volts. The voltage remaining for the windings exterior to the core is $107 - 63 - 19{\cdot}25 = 24{\cdot}75$ volts. Whence $24{\cdot}75/25 = 0{\cdot}99$ ohm; that is to say, 0·495 ohm per phase instead of 0·507, as found in single-phase for one phase.

The equality of these reactances proves that there is no mutual induction between phases for the exterior portions of the windings, with the arrangement of end connections used for this machine.

Fig. 6 shows the direction of the currents in the end connections of a winding with one coil per phase per pole, and Fig. 8 their direction in the end connections of a hemitropic—or consequent pole-winding. It can be seen that in the first case the direction of the currents is the same for the end connections of the two phases; this is not the case, however, with the second arrangement, which explains the difference in reactance of the two arrangements.

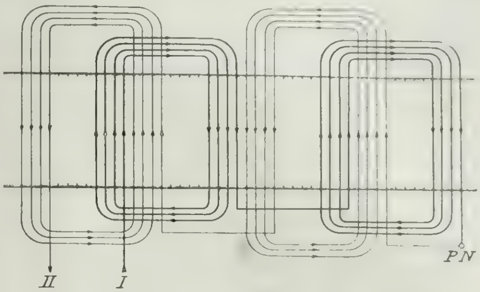


FIG. 8.

C. *Reactance of the Stator of a 1,750 k.v.a. Turbo-alternator; 1,100 volts between phases; 50 cycles/second; 1,500 revs. per min., four poles, the rotor being out.*

Dimensions.—$\phi_i = 850$ mm., $\tau = 670$ mm., $l = 960 - 20 \times 7{\cdot}5$ mm., $l_i = 885$ mm., 48 slots (23×87), $t_1 = 56$ mm, $s_n = 15$, $p = 2$, $q = 4$.

Winding, consequent poles as for machine B: $l_s = 1{,}640$ mm., $l_{s_a} = 940$ mm., $U_{s_a} = 400$ mm., $l_{s_c} = 700$ mm., $U_{s_c} = 540$ mm. The reactance per phase three-phase was found to be $x_s = 12$ ohms.

We have $\lambda_n = 1{\cdot}25\ (67/69 + 8{\cdot}5/23 + 9/29 + 1{\cdot}5/6) = 2{\cdot}38$, and

$$x_{sn} = \frac{12{\cdot}5 \times 50 \times 120^2}{2 \times 4 \times 10^8} + 88{\cdot}5 \times 2{\cdot}38 = 2{\cdot}36\omega.$$

By assuming $A = 0$ for this winding with "consequent" poles $\lambda_{s_a} = 0{\cdot}46 \times 4 \log (2 \times 1{,}640/400) = 1{\cdot}68$, and

$$x_{s_a} = 0{\cdot}01125 \times 94 \times 1{\cdot}68 = 1{\cdot}78\omega,$$

$\lambda_{sc} = 0{\cdot}46 \times 4 \log (2 \times 1{,}640/700) = 1{\cdot}23$, and

$$x_{s_c} = 0{\cdot}01125 \times 570 \times 1{\cdot}23 = 0{\cdot}97\omega.$$

$$x_{s_n} + x_{s_a} + x_{s_c} = 5{\cdot}11\omega.$$

Hence there remains for x_{s_k} $12 - 5{\cdot}11 = 6{\cdot}89\omega$.

Whence $$\lambda_k = \frac{6{\cdot}89}{0{\cdot}01125 \times 88{\cdot}5} = 6{\cdot}93.$$

Experiments No. 1

—		e_{0-1}.	e_{0-2}.	e_{0-3}.	Current I	Watts. W. 1 ph.	Voltages on the auxiliary coils. 5 coils. d. + 5 coils e. + 5 coils. f. + 5 coils. g. = e_k.	c.	cos ϕ.	Ohmic resistance per phase R_1	I^2R_1	W/I^2R_1
Readings with a current of 25 amperes in phase	I.	48·3	6·22	6·2	25	78	2·70 + 2·85 + 2·78 + 2·50 = 10·83	50	0·0645	0·062	39	2·0
	II.	6·2	48·0	6·25	25	78	... + ... + ... + ... = 2·3	50	0·0645	0·062	39	2·0
	III.	6·3	6·4	48·8	25	80	... + ... + ... + ... = 2·3	50	0·066	0·062	39	2·05

Experiments No. 2.

—		e between phases.	e_{0-1}.	e_{0-2}.	e_{0-3}.	I	W. 2 ph.	d. + e. + f. + g. = e_k.	c.	cos ϕ.	Ohmic resistance 2 phases in series R_2.	I^2R_2.	W/I^2R_2.
Readings with a current of 25 amps. in 2 phases in series	I.-II.	105·7	52·9	53·0	0	25	156	3·20 + 3·37 + 3·25 + 3·02 = 12·84	50	0·059	0·124	78	2·0
	II.-III.	105·9	0	52·7	52·7	25	158	0 + 0 + 0 + 0 = 0	50	0·059	0·124	78	2·02
	III.-II.	106·5	53·3	0	53·7	25	158	3·22 + 3·40 + 3·31 + 3·05 = 12·98	50	0·059	0·124	78	2·02

Experiments No. 3.

—		e between phases.*	e_{0-1}.	e_{0-2}.	e_{0-3}.	I	W. 1 ph.	d. + e. + f. + g. = e_k.	c.	cos ϕ.	R_1.	I^2R_1.	W/I^2R_1.
Readings on measuring a current of 25 amps. in phase	I.	93·7	53·2	53·2	55·0	25	72	3·25 + 3·41 + 3·35 + 3·1 = 13·11	50	0·054	0·062	39	1·85
	II.	94·3	53·9	53·2	54·5	25	72	3·25 + 3·41 + 3·35 + 3·0 = 13·01	50	0·054	0·062	39	1·85
	III.	93·1	53·0	53·9	53·8	25	74	3·21 + 3·35 + 3·30 + 3·0 = 12·86	50	0·055	0·062	39	1·90

* For each reading the pressure is practically the same between the three phases.

Since

$$\lambda_k = 0{\cdot}92 \left\{ \log (\pi \times 50/6) + 4{\cdot}2 + 8 \log \left(\frac{670}{7 \times 56} \times B \right) \right\} = 6{\cdot}93,$$
$$p = 2,\ q = 8,$$

we find that $B = 1{\cdot}02$.

The calculation of

$$\lambda_k = 0{\cdot}92 \left\{ 1{\cdot}42 + 1{\cdot}4 + 4 \log \left(\frac{670}{3 \times 56} \times 1{\cdot}5 \right) \right\} \text{ gives } 5{\cdot}45,$$
$$p = 2,\ q = 4.$$

There is thus a ratio of $6{\cdot}93/5{\cdot}45 = 1{\cdot}27$.

We will conclude this research with the tests on a small 8-pole alternator, which is to form the subject of special tests in an approaching research.

D. Reactance of the Stator of a three phase Alternator 75 k.v.a., 115 volts, 50 cycles/second, 750 revs. per min., 8 poles, the rotor being out.

Dimensions.—$\phi_1 = 580$ mm., $\tau = 228$ mm., $l = 270 - 2 \times 10$ mm., $l = 260$ mm., 72 slots $10{\cdot}5 \times 23$, $t_1 = 25{\cdot}3$ mm., $s_n = 1$, $p = 4$, $l_i = 3$.

Hemitropic or consequent pole-winding: $l_s = 460$ mm., $l_{s_a} = 350$ mm., $U_{s_a} = 90$ mm., $l_{s_c} = 110$ mm., $U_{s_c} = 147$ mm. The reactances measured per phase were :—

1. Single phase, one phase only	$0{\cdot}0154\omega$.
2. Single phase, two phases in series	$0{\cdot}0180\omega$.
3. Three phase	$0{\cdot}0174\omega$.

We have

$$\lambda_n = 1{\cdot}25(15/31{\cdot}5 + 3{\cdot}5/10{\cdot}5 + 3{\cdot}5/14 + 0{\cdot}75/3{\cdot}5) = 1{\cdot}6, \text{ and}$$
$$x_n = \frac{12{\cdot}5 \times 50 \times 12^2}{4 \times 3 \times 10^8} \times 26 \times 1{\cdot}6 = 0{\cdot}00312.$$

By assuming $A = 0$ for this winding with consequent poles:

$$\lambda_{s_a} = 0{\cdot}46 \times 3 \log (2 \times 460/90) = 1{\cdot}4, \text{ and}$$
$$x_{s_a} = 0{\cdot}000075 \times 35 \times 1{\cdot}4 = 0{\cdot}00368,$$
$$\lambda_{s_c} = 0{\cdot}46 \times 3 \log (2 \times 460/147) = 1{\cdot}085, \text{ and}$$
$$x_{s_c} = 0{\cdot}000075 \times 11 \times 1{\cdot}085 = 0{\cdot}00090$$
$$x_n + x_{s_a} + x_{s_c} = 0{\cdot}0077$$

There remains for $x_{s_k} = 0{\cdot}0154 - 0{\cdot}0077 = 0{\cdot}0077\omega$. Whence

$$\lambda_k = \frac{0{\cdot}0077}{0{\cdot}000075 \times 26} = 3{\cdot}95. \quad \text{Since}$$

$$\lambda_k = 0{\cdot}92 \left\{ \log \left(\frac{\pi \times 22}{3{\cdot}5} \right) + 0{\cdot}7 + 3 \log \left(\frac{228}{2 \times 25{\cdot}3} \times B \right) \right\} = 3{\cdot}95,$$

for $p = 4$, $q = 3$, we find that $B = 1{\cdot}28$, a value which is practically equal to $(p+1)/p = (4+1)/4 = 1{\cdot}25$. For (2) and (3) the reactance $x_n + x_{s_a} + x_{s_c}$ remains $0{\cdot}0077\omega$; by taking the mean value of $x_s = 0{\cdot}0177\omega$ the reactance $x_{s_k} = 0{\cdot}0177 - 0{\cdot}0077 = 0{\cdot}01\omega$. Whence

$$\lambda_k = \frac{0{\cdot}01}{0{\cdot}000075 \times 26} = 5{\cdot}14.$$

With single phase—one phase only—λ_k was $3{\cdot}95$, so that there is an augmentation of $\frac{5{\cdot}14}{3{\cdot}95} = 1{\cdot}3$. Since

$$\lambda_k = 0{\cdot}92 \left\{ \log \left(\frac{\pi \times 22}{3{\cdot}5} \right) + 2{\cdot}8 + 6 \log \left(\frac{228}{5 \times 25{\cdot}3} \times B \right) \right\} = 5{\cdot}14,$$

for $p = 4$, $q = 6$, we find that $B = 0{\cdot}985$ again very little different from unity.

In order to substantiate further the above results, the tests have been continued in the experimental test room of the Ateliers de Constructions Electriques de Charleroi on several other machines with windings "per pole" and per consequent poles. We shall simply give the results of these tests.

E. Reactance of the Stator of a Three-phase Asynchronous Motor.—200 H.P., 3,000 volts; 50 cycles/sec; 333 revs/per min *18* poles, with consequent pole winding, $q = 3$. The reactance of the end connections were measured by means of auxiliary coils; the value of A was found to be $+0{\cdot}14$, and B $1{\cdot}2$ for single phase, one phase only, and $0{\cdot}97$ for three phase. No mutual induction was established between the phases.

F. Reactance of the Stator of a Three phase Synchronous Motor.—750 k.v.a.; 10,250 volts; 25 cycles per second; 250 revs. per min; *12* poles, with winding "per pole," $q = 2$. By assuming $B = (p+1)/p$ for single-phase—one phase only—the value of A was found to be $+0{\cdot}41$. By assuming $B = 1$ for three-phase, an augmentation of 13 per cent. in the reactance of the end connections was established, produced by mutual induction between the phases.

G. Reactance of the Stator of a Three-phase Alternator.—270 k.v.a., 3,000 volts, 50 cycles/second, 428 revs. per min., 14 poles winding "per pole," $q = 2$. By assuming $B = (p+1)/p$ for single phase—one phase only—A was found to be $+0{\cdot}47$, and by assuming $B = 1$ for three phase, an augmentation of 15 per cent. in the reactance of the end connections, produced by mutual induction between the phases was established.

Résumé.—It follows from the foregoing investigations, that the reactance of the stator of an alternating-current machine, the rotor being removed, can be calculated with a close approximation by considering the three permeances :—

$$\lambda_n,\ \lambda_k, \text{ and } \lambda_s.$$

1. $\lambda_n = 1{\cdot}25(r_4/3r_3 + r_5/r_3 + 2r_6/(r_1 + r_3) + r_1/r_1)$
2. $\lambda_k = 0{\cdot}92\{\log (\pi \times z_1/r_1) + 0 + 2 \log (\tau/(t_1) \times B)\}$ for $q = 2$

$$\begin{aligned}
&= 0{\cdot}92\{\ \text{,,}\quad \text{,,}\quad + 0{\cdot}7 + 3 \log (\tau/(2t_1) \times B)\} \quad \text{,,}\ q = 3\\
&= 0{\cdot}92\{\ \text{,,}\quad \text{,,}\quad + 1{\cdot}4 + 4 \log (\tau/(3t_1) \times B)\} \quad \text{,,}\ q = 4\\
&= 0{\cdot}92\{\ \text{,,}\quad \text{,,}\quad + 2{\cdot}1 + 5 \log (\tau/(4t_1) \times B)\} \quad \text{,,}\ q = 5\\
&= 0{\cdot}92\{\ \text{,,}\quad \text{,,}\quad + 2{\cdot}8 + 6 \log (\tau/(5t_1) \times B)\} \quad \text{,,}\ q = 6\\
&= 0{\cdot}92\{\ \text{,,}\quad \text{,,}\quad + 4{\cdot}2 + 8 \log (\tau/(7t_1) \times B)\} \quad \text{,,}\ q = 8\\
&= 0{\cdot}92\{\ \text{,,}\quad \text{,,}\quad + 5{\cdot}6 + 10 \log (\tau/(9t_1) \times B)\} \quad \text{,,}\ q = 10
\end{aligned}$$

For windings, single-phase, one phase only, in which the q slots per pole and phase cover $\frac{1}{3}$ of the pole pitch, the factor $B = 1{\cdot}65$ for $p = 1$; if $p > 1$, $B \simeq (p+1)/p$.

For the permeance λ_k per phase on three-phase, or on single phase, two phases in series, it is sufficient to take $\pm 1{\cdot}25 \times$ the value of λ_k calculated for single phase, one phase only; to be exact, it should be calculated according to the above table with the number of slots doubled, and covering $2/3\tau$. In this case the factor B disappears, since it becomes equal to unity.

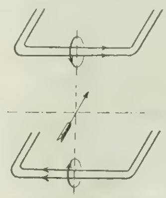


FIG. 9A.—FOUR POLE WINDING PER CONSEQUENT POLES.

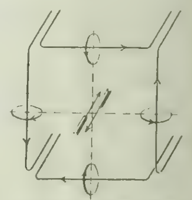


FIG. 9B.—FOUR POLE WINDING PER POLE.

3. *The Determination of λ_s.*—This is a little uncertain; however, it appears from the above that in general :—

(*a*) For a winding by *consequent poles*, $\lambda_s = 0{\cdot}46 \times q_s (\log 2l_s/U_s)$, where λ_s must be split up into two parts a and c; the mutual induction between phases is negligible.

(*b*) For a winding "*per pole*," $\lambda_s = 0{\cdot}46 \times q_s (A + \log 2l_s/U_s)$, where λ_s must be split up into three parts, a, b and c. A will in general have the value of $0{\cdot}4$, and the mutual induction between the phases will increase the reactance of the overhang portions of the windings—in three phase or single-phase, two phases in series—by 15 to 30 per cent., depending upon the distance between the coils of the different phases.

It may also be taken, that

$$\lambda_s = 0{\cdot}46 q_s \times (\log K \times l_s/U_s),$$

where $K \simeq 2$ for a winding "*per consequent pole*"
and $K \simeq 5$ for a winding "*per pole.*"

From the above coefficients it will be seen that, apart from the mutual induction between the phases, a winding wound "per pole" *is equivalent* to that wound with consequent poles; the mutual induction between phases causes the reactance of the overhang portions of the first winding to be 15 to 30 per cent. greater than that of the second. The difference in the factors K may be attributed to the mutual inductions between coils of the same phase being in opposition in the case of the winding "per consequent poles" and zero in the case of the winding "per pole." Figs. 9A and 9B.

As will be seen from an approaching article, this leakage reactance of an alternator stator, with the rotor out, is not the same as that with the rotor excited; its value will be diminished, due to the fact that λ_k is to a large extent counteracted.

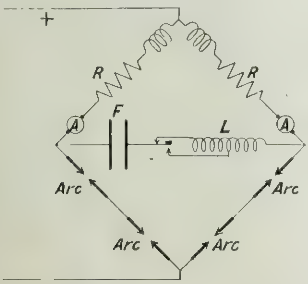
CORRESPONDENCE.

AN IMPROVED FORM OF THE DUDDELL SINGING ARC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue Mr. G. W. Nasmyth, under the above title, describes as "new" a circuit in which two arcs are used in parallel, each with its own resistance and choke coil and the oscillation circuit connected between the two anodes.

I wish to point out that this identical principle was adopted in the connections which I used for my demonstration before the Institution of Electrical Engineers on December 13, 1900. The circuit I employed on this occasion is shown in the accompanying diagram, which is Fig. 12 of p. 265 of the "Journal"



of the Institution of Electrical Engineers, Vol. XXX. The only difference between this diagram and the one given by Mr. Nasmyth is that I was using two arcs in each of the parallel circuits instead of one as he proposes.—I am, &c.,

Westminster, Aug. 24. W. DUDDELL.

RESEARCHES IN RADIO-TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should not have replied to M. Artom's letter of July 26th had this dealt correctly with the question of the Italian Navy Papers signed by me. But since M. Artom has invoked these documents in an equivocal manner, I am obliged to contradict everything which is inexact in M. Artom's citation, since your readers cannot do this themselves, owing to the documents concerned being secret papers.

According to M. Artom I have testified to the good results obtained by the Italian navy in employing the triangular aerial, either for elliptically polarised or for plane waves. All this is incorrect. What my testimony really reduces to is as follows: I testified that, at a receiving station 50 km. from a transmitting station on Artom's system, no circularly or elliptically polarised waves arrived, but only ordinary plane waves. I testified, further, that with a square or triangular aerial one could receive plane waves when the plane of such aerial passed through the transmitting station. And that is all.

There is only a single paper signed by me relating to these trials, and not several, as M. Artom declares. Further, the original cannot be in M. Artom's possession, since it is a confidential and secret document. At the time when I wrote this report I thought that the aerial described was novel, but, later, on becoming aware of Brown's patent, I stated that this aerial had been patented by Brown several years before, not only for reception, but also for the transmission.

As a matter of fact, although M. Artom, in order to prove that he invented the universal triangular aerial, only quotes that part of Brown's specification which relates to the aerial with parallel antennæ; yet in the same specification are to be found the following sentences, which are omitted by M. Artom. These are: "The vertical wires may or may not be closed at the top or joined through a small capacity and a rectangular or other shape may be given to the wires, and the rectangle may consist of more than one turn of wire, so as to enclose an area." The fifth claim also reads: "In wireless telegraphy the combination with the transmitting or receiving apparatus of two wires attached one to each side of the spark-gap or coherer and bent so as to include an area."

And, since the triangle is a figure which encloses a space, the triangular aerial is one of the forms of directive aerial indicated by Brown. I am further able to state, in confirmation of my assertion, that the British Patent Office and the German Patentamt have refused to grant patents to M. Artom for the triangular aerial for plane waves, the Brown patent and others being cited in opposition.

The trials of the Artom method at the Dieppe and Havre stations were carried out by me when I had ceased to belong to the Italian navy, and it was these tests which taught me that the Artom system did not exist.—I am, &c.,

Turin, Aug. 18. E. BELLINI.

ELECTRICAL WORK AT THE PHYSIKALISCH-TECHNISCHE REICHSANSTALT IN 1908.

In considering the advances made by electrical science year by year, the influence of the various national laboratories on this progress should not be underrated. In this country we are able to record the excellent work done by the National Physical Laboratory at Teddington, while there are similar institutions in both France and America. Perhaps more famous than any of these, however, is the Physikalisch-Technische Reichsanstalt at Charlottenburg, partly no doubt on account of the fact that it is the oldest of such institutions and partly from the greater facilities which are available for carrying out the work.

The annual report of the work of this institution during 1908 shows that great advances have been made in every department. We shall, however, confine ourselves to giving a short summary of the work in the electrical department, as this is likely to be of most interest to our readers. The usual routine tests on both instruments and materials were carried out, the number actually tested in this way being slightly greater than in the previous year.

The question of electricity meters is one that is always very much to the fore in these reports. Five continuous-current and nine alternating-current meters examined during the year contained an arrangement by which the angular retardation of the armature by friction was determined as a function of its speed. It was found that the bearing friction added to that of the air depended to a considerable extent on the speed of the meter, while on the other hand the friction of the counting mechanism plus that of the bearings was quite independent of the speed. It was also found that the magnitude of the friction in the counting mechanism differed greatly in individual meters. This is a point which obviously depends to a greater or less extent on the care taken in manufacture. It appears that the transmission of the motion from the armature axis to the counting mechanism in these meters is more usually done by means of a rack than by a worm.

Another question which occupied the minds of the staff at this institution was that of the variation of shellacked manganin coils with the varying humidity. A full account of these researches to date has already appeared in THE ELECTRICIAN, Vol. LXII., p. 14. It will be remembered that the changes in question have been shown by Dr. Lindeck to be so small in the German climate that they are only of importance for resistances equal to or greater than 100 ohms; and even then only for measurements of the highest precision. In the case of the resistances sets of 1,000 and 100,000 ohms, changes during the summer of 1908 amounted only to 5 parts in 100,000, the constancy of all resistances up to 100,000 ohms being secured by keeping them in a hygrostat of 5 per cent. humidity. Work on this subject is still being carried out at the Reichsanstalt, and the comparison of the mercury standards with the manganin coils is also in hand.

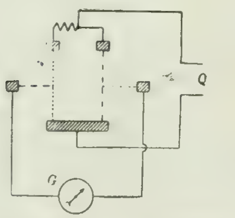
The question of the proper specifications for setting up standard cells is one which has been receiving a good deal of attention just lately; and both the National Physical Laboratory and the Bureau of Standards at Washington have issued specifications for the setting up of these cells, and have given detailed instructions as to the way in which the mercurous sulphate should be prepared. The salt is not to be washed with water, but with dilute sulphuric acid, or with a saturated solution of cadmium sulphate. In opposition to these instructions the Reichsanstalt is of opinion that the way in which the preparation is washed does not influence the result, and that the same E.M.F. is obtained whether the salt be hydrolysed or not.

It is interesting to note that the number of tests made on dry cells has increased during 1908. It will be remembered that in our report of the work done in 1907 we mentioned that a series of tests had been made on these cells, and the effect of intermittently discharging them down to 0·8 volts was being tried. As, however, the Testing Bureau of the Imperial Telegraph Department test these cells on an intermittently closed circuit until the voltage has reached 0·7 volts, this lower limit has also been adopted by the Reichsanstalt. Requests have, however, been made from several quarters that dry cells should be tested on a continuously closed circuit down to 0·4 volts. These requests have been complied with by arranging that the report of the tests shall show the total quantity of electricity yielded in two columns, namely down to 0·7 volts, and from 0·7 to 0·4 volts, in order to render possible a comparison with the intermittently discharged cells. In the case of certain types of cells which have been sent in for test, a quantity of from 160 to 170 ampere hours was obtained from them when the cells were placed on a continuously closed circuit, having a resistance of 10 ohms. These cells weighed about 4½ lb. It was found that the behaviour of cells of this type varied with the quality of the manganese dioxide used. As much as 120 ampere hours were obtained from some cells with pressures above 0·7 volts.

The experiments on the quadrant electrometer with continuous current voltages have been brought to a definite conclusion and the results published. A large electrolytic condenser having 10 aluminium plates, measuring 10 by 16 by 0·1 cm., arranged in two groups of five, is under test. The total capacity is 118 mfd. at a forming voltage of 100. When these condensers were charged with alternating current each behaved as if it had only half the capacity of one electrode, a result which has already been indicated by C. J. Zimmermann. The condensers were tested with various alternating pressures at a frequency of 50, and with a quick make and break. With the condensers permanently in circuit for a week, and with an average thickness which were connected in parallel as shown in Fig. 1. A constantan wire was connected in the middle of the manganin and a manganin wire in the middle of the constantan wire, the connection being made by means of a silver solder. These soldered wires were connected to the galvanometer. The places where the soldering occurred being traversed by either direct or alternating current, and were warmed by it. It was then found that there was no transfer of current from the manganin to the constantan, or vice versa, so that there was no peltier effect. A resistance arranged in this manner allows the current to be so distributed in each wire that nothing passes through the galvanometer circuit.

The researches begun some years ago on the electrolytic behaviour of silver and copper were continued and completed. It was found that silver when immersed in aqueous solutions of hydrochloric, hydrobromic or hydriodic acids and copper when immersed in an aqueous solution of hydrofluoric acid, showed an electric valve working, which was not due, as in the case of other metals, to a gaseous covering but to a permanent layer of some kind.

As a result of experiments on the behaviour of induction coils when used with high frequency on alternating current, it has been found possible to remove one of the most frequent sources of error, namely, the effect of capacity between the various parts of the bridge and earth. For this purpose the single branches of the bridge were protected by conducting sheaths, so that the amount of capacity was known and could be allowed for. A diagram of protected bridge of this kind, which is now being used for such measurements, is shown in Fig. 2, q is the source of current, c a condenser for determining the resonance, t the telephone, l_1 and l_2, the coils which are being compared with the resistances; w_1 and w_2, w_3 and w_4 which are the balancing resistances. Each of the coils is connected with its conducting sheaths s_1 and s_2, &c., while the telephone is covered by two conducting sheets t_1 and t_2, of which the inner is connected to the line, and the other to the end of the bridge and to earth. The



····Manganin. Constantan.

Fig. 1.

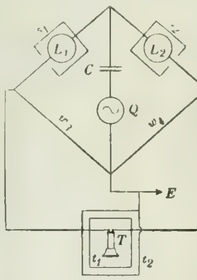


Fig. 2.

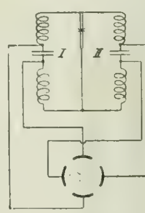


Fig. 3.

potential of 80 volts across them no change in their behaviour was noticed. At pressures below 90 volts the energy losses scarcely increased with the time that the condenser was in circuit, but at higher pressures the losses increased considerably. At 250 volts the power factor increased to 0·3. It, therefore, appears that if it is wished to obviate large energy losses and harmful heating of the condenser the pressure must be under 90 volts, should it be necessary to increase this voltage a number of condensers must be connected in series.

The photometric tests carried out during the year were no less interesting than usual. In this connection it may be noted that the carbon filament glow lamps gave more favourable results as regards life than in the previous year. A series of 24 of these lamps was burned on a 234 volt alternating current circuit, and fifteen were still fit for use after having burned for 2,000 hours. Twelve 110 volt metallic filament lamps and twelve for 220 volts were also tested. Half of each set were burned in a vertical position, the other half being placed with their filaments at an angle of 45 deg. to the vertical. They were run off an alternating current circuit. The result obtained was very interesting as it showed that the latter filaments had a longer life than those hanging vertically. A number of tests were carried out on various forms of flicker photometer, which could be used on a straight photometer bench, with a view to determining whether the employment of this type of instrument should be advocated for testing lamps. It was found, however, that the skilled operator obtains no advantage by using this apparatus, neither as regards rapidity or certainty in adjustment.

The measurement of small alternating currents by means of a thermo couple was carried out with a new arrangement which made it possible to measure small voltages with the least possible consumption of energy, and at the same time to avoid errors. The current passed through manganin and constantan wires of 20 mm. sheaths s_1 and s_2 for the coils consist of cubical boxes with a 50 cm. side, whose inner walls are covered with tin foil to prevent eddy currents. A listening tube is fixed in the two sheaths t_1 and t_2, so that no alteration in capacity is introduced by the presence of the operator. The resistances w_3 and w_4 are left unprotected.

To control wave-lengths over the entire scale it is desirable to have oscillations whose frequencies are in close relation, as this is not the case with the harmonic overtones of an alternating current not of sine form. In the Poulsen generator the higher overtones are in general very weak and can only be increased at the expense of other advantages. A more suitable arrangement for generating oscillations with close frequency relations is obtained by using the Schapira system of connection, by means of which oscillations of very high frequency can easily be obtained. This arrangement consists of fixing a second circuit to that of the Poulsen lamp, which is tuned to have a wave-length many times that of the fundamental. The relation of the two frequencies is then determined by means of a Braun tube. The cathode rays are deflected by two vertical electrostatic fields which can be generated by either of the two circuits as shown in Fig. 3. After the most suitable arrangement for the generation of nearly constant waves of sine form had been determined by preliminary tests with an arc immersed in hydrogen, these oscillations can be used for the calibration of wave meters for the measurements of capacity, self induction and damping. For this purpose the circuit under test is tuned very loosely on the exciter circuit, and the current passing through it is measured by means of bolometer and thermo couple, both before and after the resistance is connected in the circuit.

The magnetic work carried out on Reichsanstalt during the year included the standardisation of the methods used for testing magnetic material. Researches were also made into the homogeneity and permeability of material, and the measurement of high induc-

tion. Special interest has attached to the determination of the influence of heating and chemical operations on the magnetic and electrical properties of iron sheets.

Some interesting experiments were also made with a new type of automatic speed controller for use with motors. As this subject is of general interest we hope to deal with it in a separate article.

It is impossible in the space at our disposal to indicate more fully the work which has been done in the electrical department of the Reichsanstalt, while we have to disregard altogether the activities of the other branches of this institution. Their contributions to science are, however, by no means less valuable than those indicated above.

THE RESISTANCE AND REACTANCE OF ARMOURED CABLES.*

BY J. B. WHITEHEAD.

Summary.—The author calculates the reactance of armoured cables under various conditions. Theoretically this may be from 2 to 4·5 times that of unarmoured cable, the factor increasing with the distance between the go and return cables. Actually the reactance is about 0·7 of the theoretical value. The effective resistance is about 1·6 to 2 times the dead resistance. The impedance with a separation of 12 in. is about 3 times the dead resistance at 60 ∿, and about 1·7 to 2 times that at 25 ∿.

It has been asserted frequently that no form of iron protective covering is permissible for single conductors carrying alternating currents. Experience and simple calculation show this assertion to be well founded with regard to even the thinnest walls, if such walls form a completely closed magnetic circuit about the conductor. In a recent single-phase railway installation it was necessary to carry the trolley circuit across a drawbridge and the nature of the traffic through the draw rendered it advisable to armour the cables, several of which were to be installed for reserve and emergency. Obviously, the use of single-conductor steel-armoured cables was permissible if the reactance and losses in the armour were not prohibitive. There being an apparent absence of data on the subject, and some opinion adverse to the use of such cables, the values of reactance were calculated as explained below. The results showed that even at 60 cycles, and with outgoing and return cables placed close together, the reactance would not be serious; and the subsequent measurements indicate that in cables as manufactured the effect is considerably less than the calculated value, so that for purposes similar to that mentioned the use of the cables is entirely practical.

Calculation.—The usual cable consists of a central stranded conductor, surrounded by rubber or paper insulation, covered by tape, lead, jute and armour in the order named. The armour consists of a number of wires spiralled around the cable, the pitch being from 5 to 10 times the diameter of the cable. The exact expression for the inductance in the armour wires is too unwieldy for direct evaluation. A close approximation to its value may be had by neglecting the spiral, by assuming that the intensity of magnetic force is uniform through the armour and equal to the value at the centre of the section of an armour wire, and by assuming that the lines of magnetic intensity are circles concentric about the centre of the main conductor.

It is obvious that any increase in the inductance due to the armour will take place almost entirely in the region near the circle passing through the lines of contact between the armour wires. This is borne out by the form of integral, which shows that 0·8 of the total induction is within an arc of 10 deg. on each side the point of contact, and indicates that the above assumptions yield results only a few per cent. greater than the exact value. The problem then resolves itself into a determination of the reluctance of a closed magnetic circuit formed by a number of iron wires placed side by side on the circumference of a circle, the magnetic field being at right angles with the length of the wires. The magnetic field is circular and of uniform intensity in the space occupied by the wires. The approximate calculation is further simplified without serious error if the circle of armour wires be considered as laid out side by side in the plane of a uniform magnetic field.

Consider the reluctance of an elementary portion of the magnetic circuit at a distance x from the line passing through all the points of contact, of a width dx, and length equal to the diameter of the armour wire. The length of path in iron is $2\sqrt{r^2-x^2}$, and the length in air is $2(r-\sqrt{r^2-x^2})$, r being the radius of the armour wire cross-section. The total reluctance per unit length of cable of the circular element of thickness dx is then

$$R=\frac{2n}{dx}\left(\frac{\sqrt{r^2-x^2}}{\mu}+r-\sqrt{r^2-x^2}\right).$$

* Abstract of a Paper read before the American Institute of Electrical Engineers.

in which n is the number of armour wires and μ the permeability. The error in neglecting the curvature of the circle of contacts is from 1 to 2 per cent. for 20 to 30 armour wires.

The total flux in the armour alone is

$$\Phi_i=\frac{4\pi i}{10n}\cdot\frac{1}{2}\int_{-r}^{+r}\frac{dx}{r+a\sqrt{r^2-x^2}}=\frac{0{\cdot}4\pi i}{n}\cdot\frac{1}{a}\left\{\frac{\pi}{2}-\frac{2}{\sqrt{1-a^2}}\tan^{-1}\left(\sqrt{\frac{1-a}{1+a}}\right)\right\},$$

in which
$$a=\frac{1-\mu}{\mu}.$$

For
$$\mu=50,\ \Phi_i=13{\cdot}8\ \frac{0{\cdot}4\pi i}{n}.$$
$$\mu=300,\ \Phi_i=36{\cdot}7\ \frac{0{\cdot}4\pi i}{n}.$$

If there were no armour wire the total magnetic induction in the corresponding air space would be equal to $\frac{0{\cdot}4\pi i}{n}$; consequently the presence of the armour increases the induction in the space occupied by it from 14 to 36 times, according to the value of μ.

The effect of the flux in the armour on the total inductance of the cable will depend on the radius of the central conductor and the distance between it and the return conductor—that is, on the proportion of the total field of force which is occupied by the armour. The data of one of the cables on which measurements were made are as follows:—

Single conductor 0 B. & S. gauge; stranded $\frac{8}{32}$ in. of paper, $\frac{1}{8}$ in. of lead, and a jute bedding about $\frac{1}{8}$ in. thick, armoured with No. 10 (B.W.G.) steel wires.

Diameter over strand	373	mils.
„ „ paper insulation	873	„
„ „ lead sheath	1,123	„
Outside diameter, approximate	1,500	„

The values of the inductance of this cable per mile of conductor, at different distances, d, between the outer surfaces of parallel cables, assuming the permeability of the armour to be 1, and applying the formula

$$L=\frac{161}{10^3}\left\{2\log\frac{D-r}{r}+\frac{1}{2}\right\}.$$

d=distance between centres of cables are as follows:—

$d=0$,	L=0·71 millihenry	$d=6$ in.,	L=1·26 millihenrys
$d=2$ in.,	L=1·01 millihenrys	$d=12$ in.,	L=1·45 „

The value of L for the space inside the armour is 0·632. Consequently the difference, 0·078, between 0·71 and 0·632, is the proportion which is increased by the factors 14 to 36 mentioned above. Calling this factor k, the values of L with armour wires in contact over the entire circumference are got by adding 0·078 $(k-1)$ to the values given above. For $k=36$ the values of L are increased by the armour 4·4, 3·4, 2·9 and 2·7 times respectively for the distances of separation given above, and for 6 ft. separation the factor is 2·2. That is, depending on the distance of separation the reactance of the usual single conductor, steel-armoured cable may be from two to four times as great as the reactance of the same cable without steel armour. Obviously, the reactance constitutes no objection to the use of such cables in moderate lengths.

The losses in the armour are not subject to simple calculation. As already stated, about 80 per cent. of the total induction in the armour is within an arc of 10 deg. on each side of point of contact of two adjacent wires. For $\mu=300$ this means an average value of the induction B equal to 166 H within a wall from 0·03 to 0·05 in. thick. At 100 amperes the value of H in the armour of the type of cable under discussion is about 10. It is evident that the resulting losses would not rise to any great value. It is also evident that the assumption that the armour wires are all in contact throughout their length will not be true of the manufactured product. Since the induction in the armour will be greatly decreased for any appreciable air-gap between the individual wires, the reactance and losses should fall below the approximate values as calculated. This conclusion was borne out by the following measurements:—

Single-conductor Iron-armoured Cable.—The description of this cable has been already given. The measurements were made on two lengths each 51 ft. long, at different distances apart, with frequencies of 25 and 60 cycles and various values of current. The quantities measured were current, impedance, resistance and power.

The increase in the impedance with current and with distance between cables is evident but not great. At 60 cycles it varies from 2·2 times the dead resistance, at 67 amperes, with the cables close together, to 2·8 times the resistance at 90 amperes with 12 in. between cables. The decrease in effective resistance and the increase in effective reactance with increasing separation is noticeable at 60 cycles, but not important at 25 cycles.

The reactance per mile of two cables 12 in. apart, as measured at 60 cycles and 90 amperes, is 2·13 ohms; the value calculated as previously explained is 2·94; at 25 cycles the values are 1·80 and 1·23 respectively. The figures for other distances of separation show similar differences, and indicate the measured values to be about 70 per cent. of those calculated for the ideal case. As already stated, this is accounted for by the fact that the armour wires are not in contact at all points.

The effective resistance increases with the current density but varies very little with the distance of separation. The value in the cable here investigated increased at 60 cycles and a current density of 1 ampere per 1,000 circular mils, to about twice the dead resistance.

The effect of connecting the lead sheathing at both ends and also connecting the iron armour at both ends, with 12 in. separation, is to reduce the impedance by each of these secondary circuits. The increase in impedance with increasing current is less marked, however, indicating the low value of reactance resulting from the presence of the closed secondary circuits. A small value of reactance is indicated at 60 cycles, about one-fifth the value of the dead resistance, assuming the effective resistance to be no greater than the dead resistance. At 25 cycles the difference between impedance and dead resistance is so small as to approach the limits of accuracy to which the instruments could be read.

Single-conductor Copper-armoured Cable.—A series of measurements were made on two 48 ft. lengths of cable similar in all respects to that with steel armour, except that the armour consisted of 24 No. 8 B. & S. hard-drawn copper wires. The impedance was measured at different current densities and with different separations of the cables, with the copper armour connected and disconnected at the ends. The impedance was also measured for a return circuit through the armour wire.

At 60 cycles and 12 in. separation the reactance per mile of double conductor, as calculated from the measured values of impedance and resistance at 82 amperes is 1·19 ohms. As calculated from the value of L given by the formula previously stated, the value is 1·196. This indicates a negligible eddy-current loss in the copper armour. The readings with the armours of the two cables connected at both ends indicate a small increase in the effective resistance.

Tests were also made on a double-conductor steel-armoured cable. The conductors were similar to those in the single-conductor cables and spaced at 0·873 in. between centres. The diameter over the lead sheath was 2·025 in. and the armour consisted of 38 No. 18 B.W.G. steel wires. At 91 amperes and 60 cycles the impedance per mile, as measured, was 1·144 ohms. The value as calculated by means of the formula for L and the measured value of the dead resistance was 1·071 ohms. The close agreement of measured and calculated values of reactance in the case of the cables with copper armour indicate that the increase in impedance of the double-conductor cable is due to increase in the effective resistance. This increase is probably due to eddy currents in the lead sheath rather than to any effect of the steel armour.

LONDON ELECTRIC SUPPLY CORPN. (LTD.)

PRESENTATION TO MR. R. STEWART BAIN AND MR. G. W. PARTRIDGE.

An interesting presentation took place in the board room of the London Electric Supply Corpn., in Cockspur-street, London, on Thursday, last week, when the Earl of Crawford presented a piece of plate (in the form of a cup) to Mr. R. Stewart Bain, the managing director, and another cup to Mr. G. W. Partridge, chief engineer, in commemoration of the completion of their 21 years' service with the Corporation.

The Earl of Crawford, in making the presentation, said he thought the occasion (the coming of age of the two chief officers in the service of the company) was an unique one in the history of the electrical industry. He referred to the continuous attention, zeal, energy and devotion of Mr. Bain since he joined the company in 1888, and gave a résumé of his career, how he had taken command in 1894, when the position of the company was precarious, and had successfully steered it through all its troubles, until it occupied its present satisfactory position.

His lordship then referred to Mr. Partridge joining the company as a young man from the old Hammond College, how he had worked his way up from the bottom to the top of the engineering staff, and to the skill and ability he had shown since he was appointed chief engineer. He hoped both these gentlemen would be spared to complete another 21 years in the service of the company, and asked them to accept the handsome cups (which are shown in our illustrations) as a token of the board's appreciation of what they had done for the company.

Mr. Bain, in acknowledgment, said it was very gratifying to receive the handsome piece of plate on the completion of his 21 years' service as a token of the board's appreciation of his work during that time. He should greatly prize the cup, as would those of his family who might come after him. He thanked Lord Crawford for the kind expressions

Cup Presented to Mr. R. Stewart Bain, Managing Director of the London Electric Supply Corpn.

he had used in presenting it. No one knew better than Lord Crawford how eventful the past 21 years had been and the difficulties there had been to overcome. He had never sought to evade the difficulties of the

Cup Presented to Mr. Gerald W. Partridge, Chief Engineer to the London Electric Supply Corpn.

position, and perhaps it was owing to that, as well as to the generosity and large-heartedness and the acute discernment of Lord Wantage, whose memory he hoped would never be forgotten while the company existed.

that the Corporation occupied the position it did to-day. He wished to add that since Mr. Partridge had become chief engineer he had been of great assistance to him in the management.

Mr. PARTRIDGE, in returning thanks, said he was grateful to Lord Crawford for the kind manner in which he had spoken of him. He referred to the consideration he had always received from the board, and especially to the kindness and assistance which he had invariably received from Mr. Bain as managing director. It had been a great pleasure to him to serve the Corporation, and he hoped he would be spared to serve them for many years to come.

It will be seen from the illustrations that Mr. Bain's cup is a copy of a Louis XVI. French cup very richly carved, and that Mr. Partridge's cup is a copy of a Georgian model with a finely chased border of the rose, shamrock and thistle around the body of the cup.

The inscriptions on the cups express the directors' (the Earl of Crawford, Mr. R. H. Benson, Mr. R. D. Norton and Sir W. H. Preece) personal esteem for their recipients.

NEW SIMPLEX FUSE CARRIER.

A field which is being energetically developed and catered for by Simplex Conduits (Ltd.), is that of the supply of distribution boards, fuses and fuse wire. In the latter direction special efforts are being

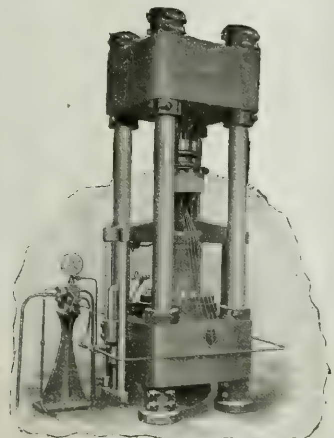


FIG. 1.—ELECTRICALLY-DRIVEN HYDRAULIC PRESS FOR THE MANUFACTURE OF FUSE WIRE.

made to meet the very large demand which exists. The accompanying illustration (Fig. 1) shows a large extruding press, weighing considerably over 10 tons, which has recently been installed at this firm's Garrison-lane works for the purpose of the manufacture of

FIG. 2.—FRONT VIEW OF PORCELAIN INDICATING FUSE CARRIER.

FIG. 3.—BACK VIEW OF FUSE CARRIER.

fuse wire. The working pressure on the ram is 400 tons, and the press is fed by a vertical pump working at a pressure of 2 tons to the square inch

The press has been specially designed with a view to the peculiar requirements of the case; the fitting of special safety valves and facilities rendered for rapid recharging with metal alloy from which the fuse wire is made, contribute to make it one of the most up-to-date extruding press yet designed. The molten metal is poured into the container, and maintained in that state by means of gas rings. The control is at once simple and effective and the pump actuating the press is driven by an electric motor. Having adopted the latest and most up-to-date improvements, the Simplex Co. are enabled to supply fuse wire at strictly competitive prices, and to undertake large contracts for the supply of this material.

A new form of fuse carrier, shown in Figs. 2 and 3, has just been introduced and is the only type of indicating porcelain fuse on the market, departing only slightly from the standard design at present so popular. The fuse will fit any type of board of standard dimensions, and permits fuses being renewed by unskilled persons with the minimum amount of trouble and risk. This fuse carrier is of very novel design. The indicator coloured red is shown on the front at the hole on the front view when the fuse is blown. The fuse wire is carried at the back well out of the way, and the spring of the indicator is attached to the fuse wire by means of a hook provided. Two butterfly nuts bind down the fuse wire and render replacements an easy matter. The price is only a very slight increase on that of the standard form.

ELECTRICAL IMPULSE DIAL MOVEMENT.

It is just 10 years ago since Mr. F. Hope-Jones, in his Paper on "Electric Time Service" before the Institution of Electrical Engineers (*see* THE ELECTRICIAN, Vol. XLIV., p. 306), described the impulse dial movement of the "Synchronome" system. This system was forth-

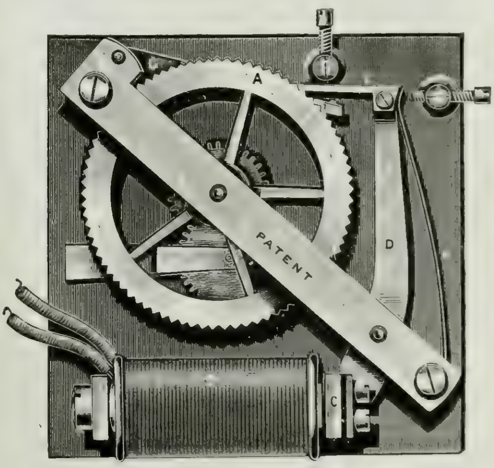


FIG. 1.—ORIGINAL "SYNCHRONOME" SYSTEM.

with adopted for use in electrical clocks in this country, and has thus, it is claimed, placed British practice in this respect ahead of other countries.

We reproduce in Fig. 1 the illustration from the "Journal" of the Institution of Electrical Engineers of that date, which will remind our readers of the step-by-step method adopted in the "Synchronome" system for rotating the hands of the clock. The wheel A, on whose axle the minute hand is mounted, has 120 teeth, the number of half-minutes in an hour. By means of the magnet B and spring F the armature C and lever D are rocked every 30 seconds. This movement draws the pawl E over one tooth of the wheel A, which is prevented from returning to the back-stop click G.

The success of the type of movement in a direction where so many others have failed may be attributed to the lock obtained by the momentum stop H, the shape of the teeth, which are rectangular, and the angle at which the driving click engages the wheel. The effects of this arrangement is, it is claimed, that the click can never jam, but is always free to slide along the surface of a tooth under the influence of the lightest electrical impulse. Further, the momentum of the pointer is instantly checked, and cannot carry the wheel further

than one tooth distance, leaving it perfectly locked in its normal position of rest.

The above is in outline a description of the method used originally in the "Synchronome" clock. But there are few things so good that they cannot be improved, and though the above-mentioned principles have been found essential to the success of any "pick-up one-tooth-at-a-time" movement, Mr. Hope-Jones has just succeeded in designing a still more effective lock.

A reference to Fig. 2 will show that the adjustable screw stop has been dispensed with as a limit to the stroke of the armature lever. Instead, the back-stop lever is lengthened and carries on its end a steel stud, which engages in a semicircular notch at the back of the armature lever. This holds the back-stop lever down with its rectangular click lightly engaging in the wheel when the armature is drawn close to the magnet, and the motion of the steel stud and the semicircular notch being at right angles to each other. The two clicks engaging the wheel are never liberated sufficiently to allow more than one tooth to pass, though they do not prevent the passing of the one upon which each operation depends. Consequently, the wheel is locked, not only when the apparatus is at rest and the armature is away from the magnet, but when the armature is at the other end of its excursion, and close to the magnet, and also at every point in the cycle of operations.

It will be noticed that the driving click is curved on its under side. The object of this is to allow the clicks to be easily disengaged from

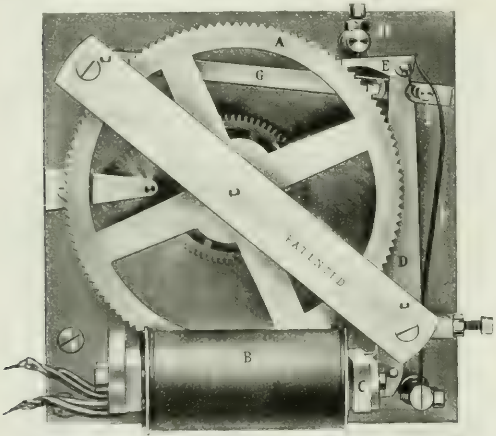


Fig. 2.—Present Improved "Synchronome" System.

the wheel. This is accomplished by lifting the back-stop lever with one finger, thus causing the back-stop click as it rises from the wheel to push out the driving click owing to the wedge shape of the former. It is found to be a great convenience to free the wheel completely, so that it may be rotated in either direction, not so much for the purpose of setting a dial to time as that is rarely wanted, but for the purpose of adjusting it to zero by mechanical or electrical methods, when these steps are used for other purposes than recording time, such as billiard markers, time counters, &c.

NEWFOUNDLAND CABLE MATTERS.

In regard to the dispute which has arisen between the Commercial Cable Co. and the Newfoundland Government in regard to the ratification of an agreement relating to the cable recently laid by the company, we have received for publication the following further communication from the vice-president and general manager of the company (Mr. Geo. G. Ward) to the Secretary of State for the Colonies :—

I have read in the public Press of Aug. 16 the letter of the Anglo-American Telegraph Co. to you of July 8, over a month ago, relative to the agreement between the Newfoundland Government and the Commercial Cable Co. I beg to enclose a copy of my letter to the Newfoundland Government on the same subject dated July 31. I also enclose for your information a copy of the contract of Feb. 18, 1909, between the Newfoundland Government and the Commercial Cable Co. The Anglo-American Telegraph Co., in its letter to you, says that this contract is unfair and prejudicial to them, and creates a monopoly. That is a remarkable statement indeed. It was for the sole purpose of breaking up the monopoly which the Anglo-American Telegraph Co. had of the cable business to and from Newfoundland that we were invited by the Newfoundland Government to connect with their telegraph system. So far from our contract being a monopoly, it was made solely to break up a monopoly which the Anglo-American Telegraph Co. had for 50 years, to the detriment of business interests and which it would continue to have were it not for the Commercial Cable Co. If the Commercial Cable Co. were to sever its connection with the Newfoundland Government, the monopoly of the Anglo-American Telegraph Co. would be restored, and that seems to be the policy of the present Newfoundland Government, although the Anglo-American Telegraph Co., by keeping other companies out of Newfoundland for 50 years, deprived that country of a large revenue from those companies.

As to the 25-year agreement of the Newfoundland Government to exchange business with us, under which we receive a reduced toll, with whom would the Government exchange this cable business if not with us ? It certainly could not consistently exchange business with the Anglo-American Telegraph Co., because the Anglo-American Telegraph Co. competes with the Newfoundland Government, and hence would decline to forego any such portion of its tolls as we do, and for the Government to transfer its messages to the Anglo-American Telegraph Co. would be to re-establish the monopoly that existed before the Commercial Cable Co. connected with Newfoundland. It is to be borne in mind that the Anglo-American Telegraph Co. competes with the Government for local as well as foreign business. The Anglo-American Telegraph Co. has some 590 miles of landlines in Newfoundland and some 50 telegraph offices. It has three telegraph and cable offices in St. John's alone. At all of these offices it competes with the Newfoundland Government, not only for telegrams, but also for cablegrams. The Commercial Cable Co., however, by its contracts with the Newfoundland Government, is excluded from doing any telegraph or cable business in Newfoundland, except through the Government. It is not surprising that the Anglo-American Telegraph Co. should want to prolong its monopoly by joining in the attempted repudiation of our agreement. That company's argument seems to be that repudiation is justified if a British company's interests are advanced thereby, and this seems sufficient. How would Newfoundland get any benefit from transferring these cablegrams over to the Anglo-American Telegraph Co., with no part of the tolls to go to the Newfoundland Government, and what would Newfoundland do with its present cable facilities ? Again, suppose both contracts, the one of 1905 and the one of 1909, were abrogated now by mutual consent, or our 1905 contract was not renewed when it expires in 1915, and the Commercial Cable Co. commenced doing business on its own account in St. John's, where nearly all the Newfoundland cablegrams originate or are delivered, then there would be three competitors for that business—namely, the Anglo-American Telegraph Co., the Commercial Cable Co. and the Government. The Government would get very little business under those circumstances. It would be no answer to say that the Commercial Cable Co. would not be allowed to do business in Newfoundland. President Grant in 1870 refused to allow a French cable to land and operate in the United States unless the French Government allowed American cables to be landed and operated in France, and in December, 1875, in a special message to Congress, he declared that this was the legal right and settled policy of the United States. The Commercial Cable Co. might have appealed to that principle in regard to doing business in Newfoundland. Instead of doing so, however, it submitted to the condition imposed upon it by the Newfoundland Government, namely, that it should not compete with the Government telegraph lines either for landline or cable business.

We have no doubt that the Anglo-American Telegraph Co. considers our contract prejudicial to their interests, inasmuch as it disturbs their monopoly of the Newfoundland business, but public interests should be studied, and the introduction of our competition is decidedly in the interests of Newfoundland and its people. Without that contract the Newfoundland Government would get no part of the cable tolls. The Commercial Cable Co. has not obtained a monopoly in Newfoundland, it has broken up a monopoly, and is to-day giving a competitive service to Newfoundland. The Anglo-American Telegraph Co., in its letter to you, also states that we are practically exempt from taxation in Newfoundland by our contract. They could not have read the contract carefully. The contract obligates us to pay \$4,000 per year for every cable which we run through Newfoundland, and if we should have five cables running through Newfoundland we would have to pay \$20,000 a year to the Government, the same as the Anglo-American Telegraph Co. is now paying. It is true that by the contract we are to receive \$4,000 a year to reimburse us for the expense of establishing and maintaining an office in St. John's for the accommodation of the Government and giving them an alternative route free of charge during interruptions of their Port aux Basques cable or landlines, but that has nothing to do with the \$20,000 per annum mentioned above.

I take this opportunity of calling attention to a statement made by Premier Morris, which appeared in the Press a few days ago, in which he alleges that the first intimation he had of my letter was when it was published in the New York Press. That certainly is a mistake, because I informed him at our last interview on Aug. 4 that my company intended to answer his Government's communication and offered him a copy of our proposed reply to read, which he declined to do—in fact, I had two interviews with him, the first on July 24. My letter was not published in the New York Press or anywhere else until Aug. 11. In Sir Edward Morris's published statement he declares that he considers it unfair that I should publish an ex parte statement of the case without publishing the reasons why the Newfoundland Government refused to carry out

the contract. The only reason I have heard is that such contract required the action of the legislature of Newfoundland, and that reason is clearly and fully stated in my letter, and hence I think that this, too, is a mistake in the report of Sir Edward Morris's statement. My company's position is, that it has made a reasonable contract with a responsible British Government, has invested over a million dollars on the faith of that contract, and has complied with the contract, and it expects that the Newfoundland Government will do the same.

PARLIAMENTARY INTELLIGENCE.

ELECTRIC LIGHTING ACTS (AMENDMENT) BILL.

In the House of Commons on Friday the adjourned debate on this Bill as amended in Standing Committee was resumed.

Mr. SCOTT DICKSON moved to insert at the end of clause 6:—"(4) Nothing in this section shall enable the Board of Trade, without the consent of the undertakers within whose area of supply the premises are situate, to give such permission as aforesaid to any undertakers where the last-mentioned undertakers are by any Act of Parliament specifically prohibited from supplying electricity within the area of the first-mentioned undertakers."—Agreed to.

Sir F. BANBURY moved the omission of clause 16 (the wiring and fitting clause),—Agreed to.

On the motion of Mr. TENNANT, clause 24 (for the protection of county councils) was struck out.

Sir F. BANBURY also moved as an amendment to clause 25, to add tne words "or water" after the word "gas" in the fourth line.—Agreed to.

Mr. DUNDAS WHITE moved an amendment in clause 26 (Definitions) stating that the expression "undertakers" meant any local authority, company, or person authorised to supply electricity "to whom the Electric Lighting Acts apply."—Agreed to. The Bill was read a third time.

London Electric Supply Bill.—This bill, which was promoted by the Board of Trade to constitute the L.C.C. the purchasing authority in respect of the undertakings of the companies who promoted the London (Westminster and Kensington) Electric Supply Companies' Act (1908), has been withdrawn.

Wireless Telegraphy and Shipping.—In the House of Commons on Monday Mr. TENNANT stated, in reply to a question by Mr. Crooks, that the Board of Trade had no records which would be of value in estimating the number of cases in which wireless telegraphy had prevented strandings, collisions and delays to shipping during fogs, as in the ordinary course such cases would not be reported to the Department.

LEGAL INTELLIGENCE.

Patent Revocation Application.

The Comptroller-General of Patents has given his decision in the application of Messrs. Thomas C. Fawcett (Ltd.), Leeds, for the revocation of patent No. 3,677 of 1898, granted to one Kent, of New York, and owned by one Fraser, carrying on business in the name of the Kent Mill Co. in New York, on the ground of lack of adequate manufacture in this country. The patent related to mills for crushing or pulverising rock quartz and other materials of the type in which the material is crushed between a revolving ring and rolls mounted within the ring. In consequence of the passing of the Patents and Designs Act, 1907, the proprietor of the patent (in February, 1908) appointed a sole agent in this country for selling the machines and starting manufacture, and as a result of offers inserted by the agent in various papers in March and April, 1908, a London firm was selected for starting manufacture, and was supplied with a model mill. The manufacture of a machine was started in May, and finished in November, 1908, but it was admitted that many of the parts of that machine were imported from the United States. A second machine was begun in November, 1908, but was not finished until July, 1909, although the application for the revocation of the patent was lodged on March 6, 1909, the explanation of the delay being that the manufacturers were waiting for improved portions of the machine made under a later patent, which were to come from America in the first instance, and that there was no immediate demand for the machine. Seven-eights of the second machine were made entirely in this country, the exception being the rolls and the ring, as to which efforts were being made to obtain here the proper steel for their manufacture. These two machines were sold in the United Kingdom to British firms. A third machine had, according to the Comptroller's decision, been taken in hand, and it was stated that it would be almost wholly made from British materials, and might be completed if necessary within a fortnight. A representative of the firm entrusted with the manufacture in this country said that they were prepared to make 10 or 12 machines a year, and to deliver the machines at any time if a fortnight's notice were given. With the exception of the United States, the patentee's home country, where apparently the manufacture was considerable, the only manufacture abroad was in Germany, where the rate of sale was two machines per year, which was about equal to the demand in this country.

The Comptroller came to the conclusion that, although there was clearly no adequate manufacture in August, 1908, when the year of grace terminated, possibly none when the application for revocation was lodged (March 6, 1909), there was at the date of the decision a manufacture in this country sufficient to meet the present demand for the machines here, and that sufficient reason had been given for the absence of a more extensive manufacture at present. Since the price at which the machines were sold here was the same as in all foreign countries, including America, the Comptroller could not say that the patentee was using his rights to the prejudice of this country, and was of opinion that he ought prima facie to accept this as a reasonable price, and ought not to enter into the question whether the machine could be sold at a less price in this country and a larger demand so created. As the declarations filed by the applicants for revocation showed that they had not taken steps when the application was filed to ascertain the facts in regard to the patentee's manufacture in this country, the Comptroller decided to award the patentee £30. 10s. 0d. as costs.

Phosphor Bronze Co. (Ltd.)—Mr. Justice Hamilton, on Wednesday, granted a motion for the appointment of a receiver and manager of this company. The company asked that the usual order should be made for accounts and inquiries, and that the gentleman appointed as receiver and manager should have liberty to act at once and to appoint a sub-manager. The order was made as asked.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governing Body of Northampton Polytechnic Institute, London, invite applications for the appointment of practical instructor in electric light wiring and cable jointing. Two evenings per week. Particulars and forms of application (to be returned by Sept. 1) from the Principal, Dr. R. Mullineux Walmsley. See an advertisement.

A pupil is wanted for a l.-t. three-wire station in South London area. See an advertisement.

A leading draughtsman is required, with a thorough knowledge of volume and pressure fans, capable of preparing schemes for the various uses to which fans can be applied, &c. See advertisement.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

A foreman of electric light service is required for Dominica, West Indies. Engagement for three years, with possible extension, salary £150 per annum, with free second-class passage to Colony and home again. Applications to the Crown Agents for the Colonies, White Hall-gardens, London, S.W., up to Aug. 31.

Llandilo Council require an engineer to take charge of electrical installation. Applications to the Clerk by Aug. 31.

The lectureship in electrical engineering at University College, Galway, is vacant. Salary £120. Applications to the Secretary, Mr. Robt. Donovan, Royal University-buildings, Dublin, by Aug. 31.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

The Council of the University College of Wales, Aberystwyth, require a demonstrator or assistant lecturer in the department of physics. Salary £150 per annum. Applications to the Registrar by Sept. 16.

Dr. R. K. McClung has been appointed lecturer in physics at the University of Manitoba.

EDUCATIONAL NOTICES.

University of Birmingham.—The full course in engineering extends over four years and students who enter after matriculation, and who pass the examinations at the end of each year, will be entitled to the degree of B.Sc. in the branch of engineering to which they devote themselves. Some particulars of the instruction given in the technical engineering classes, engineering laboratory, &c., are given in an advertisement. The session, 1909-1910, commences on Oct. 4, and detailed syllabus with full particulars of University Regulations, lecture and laboratory courses, fees, &c., may be obtained from the Secretary.

University of Bristol.—The session 1909-1910 commences on Oct. 1. There are full courses of instruction in the faculties of arts, science and engineering, and facilities are afforded for research and post-graduate work in all important branches of science and engineering. Prospectuses, &c., from the Registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Glasgow and West of Scotland Technical College.—The session 1909-10 commences on Sept. 23 for the evening classes and Sept. 28 for the day classes. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, and the courses of study for the diploma usually extend over three sessions. Holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. There are new and well equipped laboratories in the departments of physics, chemistry, electrical engineering, mechanics, metallurgy, &c., and facilities for research are afforded. Calendar (price 1s. 4d.) and prospectus (free) can be obtained on application to the Secretary.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

Hackney Technical Institute, London.—The next session commence on Sept. 20. There are evening lecture and laboratory courses in electrical engineering, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses may be obtained from the Principal of the Institute, Dalston-lane, London, N.E.

South-Western Polytechnic Institute, London.—A complete three years' course in electrical engineering is given at this Institute during the day and a four years' course in the evening. There are also courses of lectures and practical work in various electrical engineering subjects, including electrical design, alternating and polyphase currents, instruments and lamps, wiring and fitting, &c.

Battersea Polytechnic (London).—In the engineering departments of this polytechnic there are day courses which prepare for the engineering degree, B.Sc. London, polytechnic diploma in mechanical, electrical and civil engineering. The entrance examination commences on Sept. 21. There are also evening classes which prepare for the B.Sc. in engineering, the associateship examination of the Institution of Civil Engineering all mechanical engineering subjects, electrical, structional and automobile engineering, telegraphy and telephony, architecture and building, &c. Prospectuses from the Secretary, Battersea Park-road, S.W.

Acton.—£450 is to be spent in the electric lighting of the new public offices, and £100 for inter-communication telephones.

Australia.—The City Council of HAWTHORN (Victoria) is considering the question of erecting electricity works. An attempt will be made to induce the neighbouring Councils of Kew and Camberwell to co-operate in a scheme for the three townships.

The Postal Telegraph Department, MELBOURNE, is calling for tenders for supply of 5,000 telephones of Australian manufacture.

One of the conditions is that any design or pattern submitted will be considered by the Department, but preference will be given to instruments conforming to the sealed pattern. The latter is similar to the Ericsson type without any distinguishing name. On July 15 some of the leading manufacturers waited on the Postmaster-General and pointed out that the adoption of the Ericsson type as the standard was not wise, as a manufacturer in Australia might lay down a plant for the manufacture of that class of instrument which later improvements would render obsolete. If tenderers were allowed to submit the most up-to-date patterns they could manufacture, the industry was more likely to be established on a firm basis in the Commonwealth. Sir John Quick promised to consult the officers.

Brazil.—A report on Telephony in Brazil by the United States Consul-General at Rio de Janeiro states :—

An American company which is constructing a telephone system for the State of Rio de Janeiro secured its concession about three months ago, and already has the construction of the system well under way. One of the chief objects of the enterprise is to afford communication by telephone between the City of Rio de Janeiro and the surrounding country. Although Brazil has 20 States and a territory substantially the same as that of the United States, it has no inter-State telephone line, and, by reason of the inter-State restriction, it has few telephone lines serving rural districts within the several States themselves. The telephone business in Brazil is little developed in either extent or service. According to official returns, there exists in Brazil a total of 39 telephone systems, ranging from 22 to 2,503 subscribers, of which, at the time the statistics were prepared, last year, 15 were Berliner, nine Kellog, three Bell, four American, and the others German, Swedish, Norwegian and French. The total number of subscribers in all the systems is 9,200. The capital of the companies ranges from $900 to $1,190,000. Of these companies only five have more than 500 subscribers—viz., Bahia, Rio de Janeiro, Pernambuco, Pelotas and San Paulo. The concern in Rio de Janeiro (the largest in Brazil) is (continues the report) now owned by the American syndicate which has purchased all the public utilities of the city. It is capitalised at $1,199,000. Since the present owners took charge it has been re-established upon a modern basis with American instruments and underground wires. The system has 2,676 connections and about 21,000 miles of wire. The system in Bahia also has recently been purchased by a new concern, which is introducing a modern American system. At the time the statistics were secured it had 554 instruments and about 1,400 miles of wire. The Bell system is in use. In Pernambuco the system is Norwegian and German. It has 631 instruments, about 1,000 miles of wire, and about as many subscribers as instruments. The system at Peletos, in Rio Grande do Sul, has instruments of diverse makes to the number of 1,479. It has about 2,400 miles of wire and a capital of $180,000. In San Paulo the system is one of the most important in Brazil. It is equipped with 1,997 Kellog instruments, has about 3,300 miles of wire, and a capital of $450,000.

A report from H.M. Legation in Brazil states that there are 25,000 km. (about 15,500 miles) of telegraph line in Brazil and 48,000 km. (about 29,760 miles) of wire, as well as about 24,000 km. (about 14,880 miles) of railway telegraphs.

Bristol.—Effect of Metal Filament Lamps on Electricity Supply.—The city electrical engineer (Mr. H. Faraday Proctor) has issued a circular setting out the effect of the adoption of metal filament lamps on the consumption of electricity.

Mr. Proctor rightly thinks it will interest consumers to know that in actual practice those who have adopted these lamps have, as shown by the following list (picked haphazard from the Bristol register of consumers), effected an average saving of 50 per cent. : —

	1908 Gross value.	1909 Gross value.	Dec. per cent.
Private house	£2 7 6	£1 1 5	53·2
Rope maker	4 15 3	2 4 8	53·1
Hotel	55 17 6	24 1 2	56·9
Dairyman	4 1 9	2 10 8	38·0
Private house	8 6 2	2 13 3	67·9
College master	13 12 8	6 7 6	53·2
Tobacconist	2 12 11	1 6 8	49·6
Draper	31 10 5	14 8 5	54·3
Doctor	4 10 0	2 0 2	55·4
Coal merchant	3 0 9	1 5 11	57·4
Leather merchant	42 18 9	21 4 11	50·5
Manufacturers	14 11 5	7 13 9	47·2

Mr. Proctor is convinced that consumers who are combining with such economy the benefits as regards health, convenience and immunity from damage to decorations and stock, will undoubtedly convince others that electricity, far from being a luxury only, is an economical necessity, and that the electricity undertaking, as well as consumers, will ultimately benefit.

Brumby and Frodingham.—The Council have appointed a committee to consider a proposed electricity supply scheme, estimated to cost £2,500, which includes the taking of electricity in bulk from the Frodingham Iron & Steel Co. at $1\frac{1}{2}$d. per unit.

Burnley.—The mayor elect is Ald. Jas. M. Grey, J.P., chairman of the Electricity committee.

China.—In connection with a scheme for the construction of an electric tramway, 10 miles in length, from Swatow to Cheng Hai a prospectus has been issued. The capital is to be 300,000 dollars, but it is stated that the shares are not being taken up readily.

The Eastern Trading Co. are about to erect electricity supply works at Nanking. The plant, which will include engines and boilers by Belliss & Morcom and Babcock & Wilcox, will be entirely of British manufacture.

Colombia (Central America).—The Government have issued a decree that contracts concerning purchases, construction, transport, and every service entailing expenditure by the Treasury are to be made by public tender.

Cowdenbeath (N.B.)—The Council have decided to apply for a provisional electric lighting order.

Customs Duties and Internal Taxes.—Under the law of July 15 last, which comes into force on Oct. 1 next, the internal taxes on certain electric lighting materials for use in Germany, whether of German or foreign make or origin (in the latter case in addition to import duty) will be :—

Incandescent lamps (carbon filament) up to 15 watts 5 pf. each, 25 watts 10 pf., 60 watts 20 pf., 100 watts 30 pf., 200 watts 50 pf., and 25 pf. for each 100 watts in excess of 200. For metal filament lamps, Nernst lamp burners and other incandescent lamps the taxes are double the

above rates, with 40 pf. for each 100 watts in excess of 200; arc lamp carbons, pure, 60 pf. per kilog., combined with other materials (and all other carbons) 100 pf. per kilog; burners for mercury vapour and similar lamps, up to 100 watts 100 pf. each, and for each 100 watts in excess 100 pf.

Dawson City (Klondike).—The Northern Light, Power and Coal Co., of Canada, recently acquired the existing power station at Dawson City, together with the local telephone undertaking, waterworks, &c.

The company is making considerable extensions of the generating plant, the whole of which has been purchased in Great Britain and is now in transit to Dawson city. The new plant will have a total capacity of 10,000 H.P. and will be erected near the company's coal mine, which is about 40 miles from Dawson City. The existing station is supplied with wood fuel owing to the high price of coal. The transmission line from the mine to Dawson City will be in duplicate, one line being of copper and the other of aluminium. Among the contractors for the new plant are Messrs. Babcock & Wilcox, Willans & Robinson, Siemens Bros. Dynamo Works, Siemens Bros. & Co., C. & J. Weir and the British Aluminium Co. Mr. C. J. Wharton is consulting engineer to the company.

District Council's Finance.—A Blue Book has been issued dealing with the accounts for 1906-7 of 811 Urban District Councils in England and Wales.

The receipts from electricity supply, gas, water, tramway and light railway undertakings, &c., were sufficient to cover 94·3 per cent. of the expenditure on the undertakings, including interest and repayment of loans. The venue of the undertakings showed large increases during the last four years, while the annual expenditure also increased considerably. The total capital expenditure during 1906-7 was £2,835,487, or £260,614 less than for 1905-6. Large decreases appeared in the expenditure on account of electric lighting, waterworks, &c. The expenditure on elementary education and on tramways and light railways showed an increase. The total debt of the urban councils rose in the four years ended March 31, 1902-3 by £6,999,521, or 33 per cent., whereas in the four years ended March 31, 1907, it rose only by £3,206,498, or 9·8 per cent. The total outstanding loans at the end of 1908 was £35,622,307, an increase on the year of £1,150,000.

Dudley.—An inquiry was held on Friday into the application of the Council for sanction to borrow £11,000 for extensions of the electricity undertaking.

Particulars of previous loans, &c., were supplied by the deputy town clerk (Mr. J. S. Morris) and the electrical engineer (Mr. C. E. Savage). Outstanding loans included £69,200 for electric lighting. In April last it was decided to increase the capacity of the plant at the power station by the provision of a storage battery, booster, motor generator, &c., together with buildings and erecting, at an estimated cost of £6,000. The actual tenders, however, amounted to £5,872, which sum it was now proposed to borrow. £5,639 was also required in connection with the undertaking. In April, 1908, it was agreed to ask for sanction to a loan of £4,630 for laying cables within the borough (£4,000 for extensions, and £630 overspent on a previous loan); but it was afterwards considered advisable to lay a further feeder at a cost of £2,400, and as £1,700 had then been spent on account of the loan of £4,000, it was decided that the total amount of the cable loan be increased to £5,000, plus the amount overspent.

Electricity in Mining.—In reporting upon the use of safety lamps in Mines, Mr. J. S. Martin, H.M. Inspector of Mines for the South-Western district, states that during 1908 the total number of lamps in use was 38,987, compared with 36,317 in 1907, and 29,233 in 1904. With the exception of an explosion in 1902, all the explosions recorded since 1887 have occurred in mines where naked lights were used. Rapid strides are being made in the adoption of electricity in the mines in Cornwall, Gloucestershire (Bristol and the Forest of Dean), Kent, Monmouthshire and Somersetshire. It is employed for pumping, underground haulage and the working of a few coal cutters. The inspector hopes, however, that no attempt will be made to work electrically-driven coal cutters at the face of any of the more fiery mines of Monmouthshire, for the working of which his advice would be to erect air compressors underground as far in-bye in the intake airway as it may be safe to work electrically, and supply compressed air to the coal cutters at the face. Electricity has been a disappointment to some, especially in Cornwall, but in Mr. Martin's opinion the explanation is that the parties obtained their generating plant from the makers without having had the scheme gone into by an efficient and experienced electrical engineer on their own behalf in order to see whether it was suitable for the proposed work.

Hastings.—On Wednesday an inquiry was held into the application of the Council for sanction to borrow sums of £1,100 and £1,002 for the electricity undertaking.

The town clerk (Mr. Ben. F. Meadows) explained that the £1,000 was for laying a higher tension main from the electricity works to the substation in Shepherd-street, and the other sum was for the purchase of eight additional transformers.

Hay.—The Council have appointed a committee to inquire into the question of erecting electricity works.

Ilkeston.—The tramways manager (Mr. A. C. Gilbert) [illegible] found it necessary to dismiss summarily two employés, but the Council resolved that the two men should be reinstated, and the natural sequel was reported at a meeting of the Tramways committee on Wednesday, that Mr. Gilbert had tendered his resignation. The tramway employés, who had given notice of intention to go out on strike, have now withdrawn their notices.

Inquest.—The adjourned inquest on Owen David and David Thomas, colliers who met their death at the Cribbwr Fawr Colliery, Pyle, on 12th inst. was resumed on 19th inst.

JOSEPH LLEWELLYN stated that about 7 o'clock on the morning of the accident he was riding down the slant in company with Owen David and others. After proceeding about 250 yards David [illegible] back of the tram and witness saw him grip the [illegible]. Witness rushed forward, caught hold of David by the [illegible], and pulled him away, but their faces coming in contact witness received a shock which rendered him unconscious.

DAVID JOHN WILLIAMS, assistant overman, stated that when he saw the two men struggling he went forward and placed David on a tram and immediately rushed him to the surface. Artificial respiration failed.

WILLIAM WILLIAMS, who went down in the same tram, stated that after the accident to David he walked up the slant, and on the way—about 200 yards nearer the mouth—he found the apparently lifeless body of David Thomas lying across the road underneath the cable. Witness added that he had heard an official warning the men that morning not to touch the cable.

Mr. THOS. JOHN NELSON, electrician at the colliery, stated that on Aug. 5 some trams, which ran wild, came in contact with the electric cable, causing a kink. Though the tests were satisfactory, witness earthed it as a precaution. Subsequently he received a report that a man had had a slight shock, and it was further reported to him that the fuse at the generating station had blown out, indicating a leakage. As a further precaution, witness cut the armouring near the kink, and pressed it back, and the subsequent tests which he made were satisfactory. Witness considered the cause of the accident was due to the defective earth, owing to the soil becoming dry, and he added that he proposed to guard against that in future by having a large earth-plate at the surface.

Mr. R. NELSON, H.M. Electrical Inspector of Mines, thought the management of the colliery had not been altogether well advised electrically. While he considered the arrangements made such an accident very improbable, they would like to see it made impossible, and he thought it could be made so. The suggestion of the electrician for an earth arrangement at the surface would make the installation safe, and he had explained to the electrician more delicate tests which might be periodically made. He added that a larger earth-plate should be provided.

After medical evidence, a verdict of accidental death was returned.

Italy.—The Executive Council of the Italian State Railways have sanctioned the proposal to erect an electric generating station at Vado, on the Ventimiglia-Savona line, at a cost of 1,500,000 lire (about £58,000).

Japan.—The "Japan Chronicle" announces that the Middle District Railway Office has decided to dispense with steam engines on the Hachioji-Kafu line, and to use electric locomotives. Fifteen motor carriages have been ordered from the Osaka Railway Carriage Mfg. Co. The change will effect a saving of over an hour on the journey.

Two new departments (the Bureau of Electricity and the Bureau of Postal Deposits) have been added to the Japanese department of Communications.

Mr. Nakakoji, Vice-Minister of Communications, explains that the rapid growth of electric enterprises necessitates the organisation of a special office. Five years ago the capacity of the electricity works in Japan was 58,000 kw., but it is now 170,000 kw., and applications have been sanctioned which will raise the figure to 380,000 kw. In fact, out of 817 manufacturing industries existing in Japan, 198 use electric power. In the case of hydro-electric power the increase has been equally remarkable. Five years ago the capacity of the plants was 16,000 kw., while at present it is 62,000 kw., and permits have been given which will raise the total to 220,000 kw.

Kettering.—An unopposed inquiry was recently held into the application of the Council for sanction to a loan of £2,000 for extensions of mains, meters, public lighting, &c.

Kirkcaldy-Dysart Tramways.—Dysart Council have approved the draft agreement with Kirkcaldy Council for the extension of the Municipal tramways to Dysart.

Lamp Theft.—Before the Manchester magistrates on Saturday two young men named Withers and Brocklebank were charged with stealing 100 Tantalum lamps, valued £9. 10s., the property of Messrs. Drake & Gorham.

The police evidence was to the effect that a number of the lamps had been stored by prisoners at a draper's shop, and prisoners had secured them from the premises of Messrs. Drake & Gorham by concealing themselves about the premises on a Saturday before closing time. Withers

was formerly in the service of the firm, and Brocklebank had bought small quantities of lamps from them at various times. In addition to the 100 missing lamps another box of 100 was found placed outside the building, apparently ready for removal.

Mr. G. HAMILTON, managing director of prosecutors, said that, as a result of taking stock, they had missed about 6,000 of these lamps, valued at between £500 to £550.

To give the police an opportunity of tracing these and other goods the magistrate remanded both prisoners, who pleaded guilty.

Licensing Wiremen and Wiring Contractors.—The members of the Electrical Association of Victoria (Australia) recently discussed the question of licensing wiremen and wiring contractors, and it was generally agreed that a system of licensing would improve the character of wiring work. It was, therefore, decided to recommend the Council to take steps to see whether they could co-operate with kindred societies in the matter.

Light Railways. The Light Railways Commissioners have submitted to the Board of Trade for confirmation, Orders made by them amending the Southend and Colchester and the Mid-Suffolk Light Railways Orders, and an Order extending the time in the case of the Southend-on-Sea Light Railway Order.

L.C.C. Tramways.—On Monday the cars on the Highgate Hill cable tramway ceased running, as London County Council, who recently purchased the line, will reconstruct for electric traction and link it up with their northern system. The line which was opened May 29, 1884, is stated to have been the first cable tramway constructed in Europe.

Londonderry.—At a recent meeting of the Lighting committee the city electrical engineer (Mr. R. V. Macrory) reported that he had received an application for a large supply of power, and possibly lighting also, for the new locomotive works of the Lough Swilly Railway Co. at Pennyburn. In order to deal with that supply it would be necessary to extend the cables at an estimated expenditure of £889. Mr. Macrory also reported the receipt of other applications for current, and owing to steady increase of consumers he anticipated that a considerable extension of generating plant would be required next year.

After discussion Mr. Macrory was directed to prepare a specification of the amount of extra capital required and the probable number and revenue from new consumers.

Mansfield.—The Council have applied for sanction to a loan of £500 for water softening plant, &c.

Middleton.—The Middleton offices of the Heywood and Middleton Water Board are to be wired for the electric light.

Morecambe.—The Council have applied for sanction to a loan of £7,635 for extensions of the tramways.

Mr. W. Ryle Wright, of 13, Victoria-street, Westminster, has been engaged by the Council to prepare a report upon the present position of the electricity undertaking and especially upon its financial condition. Mr. Wright, it will be remembered, was borough electrical engineer at Bootle and Burnley, and subsequently superintended the construction of the Wellington, N.Z., tramways, and he has only recently returned from the work of superintending the construction of the Shanghai tramways.

Non-stop Tube Trains.—The Charing Cross, Euston and Hampstead Railway Co. has decided to experiment with an express train service. The stations selected for the experiment are Euston to Golder's Green. The ordinary service will not be interfered with.

Oldham.—The charge for electric current for the tramways is to be reduced from 1½d. to 1¼d. per unit for all energy above 3,500,000 units per annum.

Ontario (Canada).—A company has been formed to construct a new electric railway from Morrisburg to Ottawa. Power stations will be located at Morrisburg and Billings Bridge, Ottawa.

Paignton.—The Council have accepted the offer of the Paignton Electric Light and Power Co. to alter and adapt existing gas lanterns for 50 c.p. lights for £2. 10s. per annum per lamp, the contract to be for not less than three years.

P.O. and the Telephone Night Service.—A complaint was recently made that where the telephone is under the control of the Postmaster-General it is only open for the same period as the telegraph office.

In reply, the Postmaster-General states that at several of the more important Post Office telephone exchanges attendance is given at all times. In other cases regard is had to the needs of the district, and if it is found that a service is necessary after the usual hours of telegraph business arrangements are made as far as possible to meet the requirements. Where the National Telephone Co. are now giving continuous service, the Post Office will, in all probability, do so after the transfer of the company's system to the State.

Presentations.—Portsmouth Corporation tramway staff have presented a set of silver fish knives and forks as a silver wedding gift to Mr. W. R. Spaven (general manager) and Mrs. Spaven.

Mr. H. H. Holmes, the sales manager at West Ham, who was recently appointed to a similar position at Marylebone, has been presented with a marble timepiece by the West Ham staff and employés.

St. Petersburg.—It is now reported that the statements made a few months ago that the Municipal Council had rejected the proposals of an international syndicate for the reorganisation of the tramway system were inaccurate, as negotiations are still actively proceeding.

The syndicate includes the A.E.G. and Siemens & Halske (of Berlin), and is being backed by the Deutsche Bank and the Société Générale. The scheme consists in the purchase from the city of all the lines, with the rolling stock and the municipal electrical works, at 20,000,000 roubles; also the extension of the system at a cost of about 30,000,000 roubles. The tramways would subsequently be worked by a company to be promoted by the syndicate, and the municipality would share in the net profits up to a maximum of 7½ per cent.

Sheffield. The Firth Park tramway extension was opened for traffic on Wednesday.

South Africa. Roodepoort Council propose to erect electricity works.

The "Natal Mercury" states that further extensions and improvements of the Transvaal telephone system are in hand. Every town is to be linked up and the trunk lines are to be carried to every point where the railway lines cross the border, with the view of ultimate extension to the coastal parts and Bulawayo. The scheme also contemplates connection with farmhouses and the establishment of call offices in rural districts.

Taunton.—The Rowbarton tramway route was recently opened for traffic.

U.S.A.—The report of Acting Consul-General Erskine on the Chicago district states that at the new steel works at Gary (Indiana), the gases from the 16 blast furnaces (which will each have a capacity of 450 tons a day and six of which are already in operation) will be utilised for the generation of electric power. Gas engines have been worked successfully in this manner in steel works at South Chicago.

Vice-Consul H. G. Meredith, in his report on the Detroit district, says it is believed that trains will be running by October next through the international tunnel which is being constructed by the Michigan Central Railroad. The trains will be hauled by electric locomotives using direct current, and the tunnel will be lighted electrically. The electrification of the St. Clair tunnel was completed by the Grand Trunk Railway and formally opened in November last. Single-phase a.c. is used, and the tunnel is brilliantly lighted by incandescent electric lamps.

Wireless Telegraphy Notes.—A correspondent to "The Times" announces that a fund has been started at Chamonix for the construction of a wireless telegraph station, either on or near the summit of Mont Blanc.

The Postmaster-General states that the capital cost of the Post-office wireless telegraph station at Bolt Head has been about £2,000, and its annual cost (allowing for interest and depreciation) is estimated at about £750. The work of the station hitherto has been chiefly experimental, and in connection with the arrangements for giving effect to the International Radiotelegraphic Convention. A considerable number of ships report their position to Bolt Head in passing, but happily no messages have had to be received from ships in distress.

An unfortunate fire occurred at the Glace Bay station of the Marconi Co. on Saturday last. The fire will cause a cessation of business for some weeks and will retard the erection of some additional plant and apparatus which had arrived before the fire broke out. No damage occurred to this new plant and material.

The importation of wireless telegraph apparatus into British India is prohibited, except by persons to whom a licence has been granted by the Government.

The equipment of what are becoming generally known as "airships" with wireless telegraph apparatus has not hitherto been regarded as altogether desirable, owing to the risk of ignition. It is reported by "The Times" that the German military authorities have been successful in isolating the danger zone of the airship, rendering the employment of wireless telegraph apparatus possible and safe.

Wireless Telephone Notes.—It is announced that further experiments in wireless telephony have been carried out by Naval Lieuts. Jeance and Colin, between Toulon and Port Vendres, a distance of 155 miles.

It is announced that the principal ships of the Japanese navy are being fitted with Prof. Missuno's wireless telephone apparatus, of which particulars have appeared from time to time. These vessels are already fitted with wireless telegraph equipments.

Siemens' "Tantalum" Outing.—At Clacton-on-Sea last Saturday, the staff and employés of Messrs. Siemens Brothers' lamp department held their annual outing. Luncheon was provided at

the Clacton Palace, where the party (numbering upwards of 200 employés) sat down.

Mr. Barfield, the genial manager of the sales department, was unable to be present, and the toast of the kindred firms (Messrs. Siemens Bros. & Co. and Messrs. Siemens Bros. Dynamo Works) was proposed by the works manager (Mr. W. H. Le Marechal). This was seconded by Mr. A. B. Holmes, who proposed a vote of thanks to the committee for arranging such a successful outing.

Sports. Leeds Corporation Tramway Employes Social and Athletic Society held their annual sports on Wednesday.

The proceedings were interrupted by rain, but the programme was subsequently completed. A London United tramways team defeated Manchester in the final of the tug of war. By a curious coincidence the first three in both the 100 yards and 220 yards open flat races were Foster (Bradford), Wright (Birmingham) and White (Leeds).

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—The accounts of the Corporation tramways department for the year ended May 31 show total capital expenditure £318,594.

Revenue was £71,680 (against £71,930 in previous year), working expenses were £40,195 (£38,670), gross profit was £31,485 (£33,261), interest required £9,300 (£10,459) and sinking fund £3,742 (£3,629). For depreciation £3,291 (£3,213) was allowed, and £214 (£1,040) for preliminary and Parliamentary expenses, &c., the balance, £14,938 (£14,920), being placed to renewal account. Cost of electrical energy was £9,565 (£8,972), or 1·477d. (1·375d.) per car-mile, and total working and general expenses (including power) were 6·21d. (5·93d.) per car-mile. 1,553,978 (1,566,119) car-miles were run and 1,959,932 (1,955,858) units used for traction.

Acton.—On the past year's working of the Electricity department there was a deficit of £4,944, after paying all expenses (including interest and sinking fund), compared with £2,935 in 1906-7.

Bath.—The accounts of the electricity supply department for the year ended March 31 show total receipts £20,342, including £18,841 net from sale of current for public and private lighting.

Total expenditure was £10,281 and gross profit £10,051. After paying interest, instalments of principal, &c., there was a deficit of £1,661. The total capital expended is £164,418, an increase of £4,995 on the year. 1,475,811 units were sold, including 1,053,298 to private consumers, 20,721 by contract, and 401,792 to the public lamps. The total maximum supply demanded was 1,078 kw.

Glasgow.—The accounts of the electricity department were approved at the meeting of the Corporation last week.

Bailie STEWART, who moved their approval, said the gross revenue was £245,672, and the expenditure £104,902, the net result, after providing for interest, sinking fund and depreciation, being a deficiency of £3,544, which had been met from reserve. Capital expenditure for the year was £168,378. The small shrinkage in revenue was due to a small extent to the depression which had affected every industry in the country. It was also due to the reduction of rates conceded to certain classes of consumers, which represented a considerable saving to them. Another cause was the introduction and very extensive use of metal filament lamps which they had urged their customers in their own interests to adopt. A further cause was the closing of the annual accounts eight days earlier than usual. That resulted in £3,400 not being brought into the accounts. The shrinkage in revenue had been more than counterbalanced by a reduction in expenditure (about £10,000) due to the more favourable terms on which they had purchased fuel, and also to a considerable extent to economies effected in the consumption of coal and a material reduction in the standing charges. They had provided during the year as a contribution to sinking fund £36,308, and written off for depreciation £53,259—in all £89,567, or about 5 per cent. on the net capital expenditure. They had maintained the works in first-class order out of revenue. They were anxious to keep their capital account in such a condition that they might be able to meet any change either in traction or otherwise. One very satisfactory feature in regard to capital expenditure was that the rate of that expenditure to the kilowatt of plant installed had been steadily falling, and last year represented a reduction on the previous year of 14·2 per cent. They recognised that they had virtually a monopoly within the city area, and so it was their aim and their duty to endeavour to supply current at the lowest possible cost consistent with ordinary business prudence, and, as a matter of fact, the cost of generation, distribution and management had been reduced by 0·0933d. per unit sold. As an indication of the progress of the department, and as showing that they had broadened the basis of the business, he mentioned that they had added 1,232 new consumers (7½ per cent.) 439 of whom were power consumers, representing in the aggregate 5,757 H.P., which meant the closing down of some 40 to 50 boilers and chimneys, and showed that the department was a valuable auxiliary to the health department of the city in their effort to purify the atmosphere.

Portsmouth.—The traffic revenue of the municipal tramways for the year ended March was £99,450, and the total revenue £101,154.

Working expenses were £48,879, gross profit £52,275, and after paying interest (£20,428) sinking fund (£17,347) and income-tax (£1,032), the net balance was £13,615, out of which £2,000 was applied in relief of rates. Capital expended was £683,480, an increase of £4,549. 21,735,613 passengers were carried, an increase of 488,565.

The income of the electricity department for the patt year was £48,631, including £47,264 from the sale of current for private and public lighting. The expenses were £24,442, and the gross profit was £24,189. Interest absorbed £9,718 and repayment of loan £10,541, leaving a net profit of £3,930, out of which £573 was transferred to reserve fund. £2,000 to the general district rate and £1,357 was voted to capital outlay purposes. The total capital expended is £330,783, an increase of £16,844. 10s. 1d. during the year. 3,476,730 units were sold, including 2,704,209 to private consumers, 25,693 by private contract and 746,823 to the public lighting department. There are 266 large arcs, 166 flame arcs and 463 incandescents for street lighting, and the total maximum supply demanded was 2,750 kw.

At the last meeting of the Corporation the Deputy Mayor presented the accounts of the Electric Lighting committee and said that the return upon the capital expended was 7·8 per cent.

Councillor MACTAVISH objected to the grant of £2,000 towards the reduction of rates. The great majority of householders in the town compounded for their rates in their rent, and so would not benefit from that dole, which would benefit only those who paid their rates direct—about 20 per cent. of the townspeople. The money could be better expended in encouraging the use of the electric light in small houses and in side streets.

The DEPUTY MAYOR, in reply, said that employing the profits over as suggested would enable the Health committee to improve the conditions of the people in whom Councillor Mactavish professed to be interested. It was illegal to use the money for free wiring, as their provisional order said it must go to relief of the urban rate.

South Shields.—The report of the Municipal tramways department for the past year was presented to the tramways committee on Tuesday.

The income was £29,580, a decrease of £182. 14s. 10d. compared with 1906-7. After meeting all expenses, interest, sinking fund charges, &c., the net balance was £423. 10s. 9d., which it is proposed to transfer to reserve. The traffic receipts amounted to £26,270 and £2,499. 7s. 9d. was received from Jarrow Electric Traction Co. in respect of cars running on the South Shields lines. Traffic expenses amounted to £7,548, against £6,807. Total general expenses were £2,719. 1s., and total working expenses were £19,405, against £18,003. The gross profit was £10,174. 19s. 7d., out of which £5,852. 7s. 5d. has been paid in interest and £3,899. 1s. 5d. on sinking fund. The car miles run were 812,157, against 788,059, and the total number of passengers carried 7,149,451, against 7,202,418. Capital expenditure is £171,746.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

LONDON County Council invite tenders for (1) the manufacture, delivery and erection in certain of the Council's substations of two 500 kw. and one 150 kw. motor generators, and (2) the manufacture, delivery and erection of h. and l.t. switchgear for Woolwich and other substations. Tenders, on forms to be obtained from the Clerk (Mr. G. L. Gomme), County Hall, Spring Gardens, S.W., by 11 a.m., Sept. 21. See also an advertisement.

LONDON County Council also invite tenders for the manufacture, delivery and laying of about 6½ miles of 0·075 sq. in. three core lead-covered h.t. cables, &c., and about 46 miles of single core lead-covered l.t. cables, telephone cables, &c.; manufacture (but not erection) of 50 tramway feeder pillars; laying about 16 miles of stoneware cable ducts, including necessary manholes, repaving, &c., and manufacture and delivery of 140,000 ducts of glazed stoneware for electric cables. Drawings, &c., at the County Hall, Spring Gardens, S.W. Tenders to the Clerk by 11 a.m. Sept. 14.

London County Council also invite tenders for the roadwork and platelaying required for the reconstruction of the tramway in Highgate Hill. Tenders to the Clerk, Spring-gardens, S.W., by 11 a.m., Sept. 7.

London County Council also invite tenders for the partial reconstruction of the bridge carrying Lower-road, Deptford, over the East London Railway, and reconstruction and widening of the bridge carrying the same road over the Grand Surrey Canal. Tenders to the Clerk by 11 a.m., Sept. 14.

London County Council also require tenders by 11 a.m., Sept. 21 for the manufacture, delivery and erection at Greenwich of steam, exhaust, feed and drain pipes, valves, water tanks, &c. Tender forms, &c., from the Clerk.

Tenders are invited for supply of 2,550 common battery telephones and protectors to the Postmaster-General's Department, New South Wales. Tender forms, &c., may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also an advertisement.

Leyton Urban District Council invite tenders for wiring and electric light fittings for the extension of the public offices now in course of erection. Specification, conditions and form of tender may be obtained from the architect (Mr. Wm. Jacques, A.R.I.R.A.), 2, Fen-court, Fenchurch-street, London, E.C. Tenders must be delivered at the meeting of the Council, to be held at the Town Hall, Leyton, on Tuesday, Sept. 7, at 7 p.m.

Leyton Urban Council also invite tenders for public lighting lanterns with clock switches for incandescent electric lamps. Tenders to the Clerk, Town Hall, Leyton, by 7 p.m. Sept. 7.

Tenders are invited by Leeds Corporation for supply of paper-insulated cables required during one, two or three years (at the option of the Corporation, to be declared on the acceptance of the tender), commencing Jan. 1, 1910. Copies of specification, conditions of contract and form of tender from the manager of the electric lighting department, Mr. H. Dickinson, 1, Whitehall-road, Leeds. Tenders to the town clerk, Mr. Robt. E. Fox, by 10 a.m. Tuesday, Sept. 7.

Edinburgh Corporation invite tenders for the supply at the McDonald-road electricity supply station of a motor-alternator. Specification, form of tender, &c., can be obtained at the engineer's office, Dewar-place. Specification, general conditions and drawings can be seen at (but not obtained from) the office of the consulting engineer, Sir A. B. W. Kennedy, 17, Victoria-street, London, S.W. Tenders to the Town Clerk, City-chambers, Edinburgh, by Sept. 4.

Edinburgh Corporation also want tenders by Sept. 4 for the electric lighting installation at the new slaughter houses. Specification from the Engineer, Dewar-place, Edinburgh.

The Metropolitan Asylums Board require tenders by 10 a.m. Sept. 1 for supply of electrical accessories, ironmongery and miscellaneous stores. Forms of tender from the offices, Embankment, E.C.

Felixstowe and Walton Council want tenders by Sept. 10 for supply of electricity meters. Specifications, &c., from Mr. R. P. Wilson, 66, Victoria-street, Westminster, S.W.

At the Servian State Railway Offices, Belgrade, tenders will be received until Sept. 14 for the supply of new plant for the Segme mines, including hauling apparatus, centrifugal pumps, electric conductors and signal apparatus, &c.

Tenders will be received at the Bourse, Brussels, until Sept. 8 for supply and laying of underground cables for the Brussels–Delbeek and the Rouppe–Roue light railways.

The Société National des Chemins de Fer Vicinaux, Brussels, require tenders by Sept. 8 for supply of c.c. cables.

Tenders are invited for the provision of electricity supply at Corumba-Matto Grosso, Brazil. Tenders to the Municipal Offices by Oct. 5.

TENDERS RECEIVED AND ACCEPTED.

The following tenders have been accepted for the Government Departments named:—

War Office: Electric cable, Callender's Cable & Construction Co., W. T. Henley's Telegraph Works Co., Hooper's Telegraph & India Rubber Works, India Rubber, Gutta Percha & Telegraph Works Co., Johnson & Phillips, Siemens Bros. & Co.; Copper conductors: W. F. Dennis & Co.

General Post Office: House telephone apparatus, Gent & Co.; Cable (paper core): W. T. Henley's Telegraph Works Co., British Insulated & Helsby Cables; Submarine cables: Siemens Bros. & Co.; Bell receivers: General Electric Co.; Portable telephones: British L. M. Ericsson Mfg. Co.; Hard drawn copper wire: 800 lb., British Insulated & Helsby Cables, T. Bolton & Sons, R. Johnson & Nephew, Shropshire Iron Co., London Electric Wire Co., and Smiths; Electric lifts at Post Office telegraph stores (Birmingham): A. & P. Steven; Telephone service and equipment, extension at Ealing Telephone Exchange: Western Electric Co.

Luton Council have accepted the tender of W. H. Allen, Son & Co. for supply and erection of a 500 kw. steam-driven generator at £2,370 (there were 22 tenders), and that of the Brush Co. (out of 18 tenders) for condensing plant at £780. 10s.

Sheffield Education committee received 13 tenders (ranging from £94. 7s. to £328) for electric lighting work at the Training College Hall of Residence for men, and the tender of Hall & Matthews (at £127) was accepted.

A sub-committee had recommended the acceptance of the tender of the Corporation Electricity Department, at £155, but exception was taken to this course, and ultimately the second lowest tender was accepted.

Rawtenstall Corporation have accepted the tender of J. W. Kidd for wiring the municipal offices.

The contract for wiring the Sheriff Court Buildings, Kilmarnock, has been let to Wm. Dow.

Gas Engine Contract.—The Electrolytic Alkali Co. have placed an order with the Key Engineering Co., 4, Queen Victoria-street, E.C., and Manchester, for a 500 h.p. Ehrhardt & Sehmer gas engine for driving an electric generator at their works at Middlewich.

Dock Pumping Plant.—The contract for a very interesting pumping plant, that for the Newport (Mon.) Docks Co., has just been settled.

The pumping plant proper consists of two main pumps coupled direct to two triple expansion steam engines, two separate 500 kw. generating sets being installed for lighting and power. These pumps will be capable when working simultaneously, of pumping 50,000,000 gallons of water from the river Usk into the dock extension in five hours, the average quantity of water delivered during this period by one pump being 80,000 gallons per minute. Owing to the big quantities and comparatively low heads the pumps are dealing with, the average speed will be 90 revs. per min. The same pumps will be used for emptying the graving dock which will be built at a future date. In this case the pumps will work against a total head of 42 ft., and will each deliver an average quantity of 100,000 gallons per minute, running at speeds varying from 90 to 120. The maximum power required by each pump during this period will be between 1,100 and 1,200 b.h.p., from which data it will be seen that the pumps will be the biggest dock pumps hitherto built. Two schemes differing in principle have been carefully weighed with regard to this pumping plant. The question was whether the pumps should be driven direct by steam engines or whether electrically-driven pumps should be installed, and it was decided that the direct steam-driven pumps would give much greater economy under the existing conditions. This is due to the fact that steam engines are more adaptable to the different loads at the respective speeds which must be provided for in view of the varying heads against which the centrifugal pumps have to work. The main contractors for the whole of the scheme are Messrs. Cole, Marchent & Morley, while the pumps are being built to the designs of Messrs. Jens Orten-Boving & Co. (of London) by Messrs. Willans & Robinson.

BUSINESS NOTICES.

The E.M.F. Mfg. Co. have amalgamated their interests with those of Mr. O. H. Bishop (for many years sales manager of the Edison & Swan United Electric Light Co.), and Mr. Bishop, Mr. Bein and Mr. Grose will be joint managing directors of the company, who have also acquired the business and works of Mr. T. H. Satchwell, of Walsall. In future the company will be known as E.M.F. (Ltd.), and it will continue to make a leading feature of high-grade incandescent lamps (metal and carbon), while other specialities will be mill, ship, car and street lighting fittings, switchboards, switchgear, &c.

In future all correspondence, &c., intended for Mr. Vincent S. Allpress, consulting electrical and mechanical engineer, 39, Victoria-street, S.W., or to Southwick, Sussex.

Mr. A. W. Blake, who is severing his connection with Messrs. Mills English & Co., has taken offices at 66, Wind-street, Swansea, where he will practice as a consulting engineer.

Domenico Santoni and Kurt Fiedler (trading as the Ely Electrical & General Agency), 24, Hatton-garden, London, E.C., have dissolved partnership.

The Acme Electrical Co. have commenced business at 248, Stanley-road, Bootle, Liverpool, as electric light and power engineers and contractors.

Telegraph Patents Development.—The owners of certain patents relating to "Improvements in printing telegraphs, typewriters &c.," and "Apparatus for punching strips of paper and like materials, suitable for use in telegraph transmitters, &c.," desire to enter into negotiations with the view of granting licences under same. Information may be obtained from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C. See also an advertisement.

Patents Development.—The Proprietors of patent No. 226 of 1904 relating to "Improvements in electrical conductors for illuminating purposes such as lamp pencils or filaments," desire to sell the patent or to grant licences. Inquiries to Messrs. Hyde & Heide, 3, Broad-street Buildings, Liverpool-street, E.C.

The proprietors of patent No. 19,979/1904, for "Improvements

in magnetic wheels or electromagnetic motors," desire to enter into arrangements by way of licence and otherwise for exploiting the same. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

For Sale. Messrs. Stagg & Robinson, Selby, advertise for sale a number of new single and double deck motor 'bus bodies.

"**The Journal.**"—Part CXCVI. of "The Journal" of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

CATALOGUES, &c.

Lundberg Switches.—Messrs. A. P. Lundberg & Sons are well known in electrical engineering circles for the ingenuity displayed in their various switches. This ingenuity shows no sign of falling off, and in fact we may say that a perusal of their latest catalogue will show that it is developing. The catalogue fully describes the "Duplex" switch movement, which, it will be remembered, is specially adapted for use in positions where vibration is likely to occur. Locked covers for use in places where there is likely to be interference with the fittings are also treated, and a number of diagrams showing the application of the "Duplex" switch to various conditions may also be particularised.

Ignition Coils.—Messrs. Siemens Bros. & Co. send us a supplement to their catalogue No. 509, in which is described ignition coils for use with dry cell batteries, and particularly with Siemens-Obach dry cells. These coils are divided into two classes, trembler and non-trembler, and are supplied for use with single, two, three and four cylinder engines. It is claimed that Siemens-Obach dry batteries, used in conjunction with these coils, form a most economical and reliable ignition system, and that the advantage of being able to use dry cells instead of accumulators are obvious.

Electrical Switchgear.—Messrs. James Ferguson & Co., of Glasgow, have recently issued a new catalogue, in which their switchgear is fully dealt with. This includes automatic circuit-breakers, quick-break knife switches and porcelain bridge replacement fuses. Ironclad switches and fuses are also illustrated and described. Full details, both electrical and mechanical, are given of all the equipment dealt with in the catalogue.

Non-Association Cables.—Messrs. Donovan & Co. have issued a leaflet dealing with non-association cables of various sizes and insulation.

Silent Electric Clocks.—Mr. G. B. Bowell sends us a copy of his latest catalogue dealing with his series of silent electric clocks. This system can be equally well worked either from batteries or from direct-current lighting circuits, and is specially adapted for factories, schools, hotels and other large buildings. The patent dial movement can easily be fitted to ordinary clocks, and a speciality of this work is made when the system is employed in private houses.

Electric Heating and Cooking Apparatus.—The Foreign Department of the A.E.G., London, send us a copy of their latest catalogue dealing with electric heating and cooking details. The wide range of this apparatus made by this firm are illustrated and described, and full details of their capacity and the price charged for them are given.

Trinidad Lake Asphalt.—The subject of Trinidad asphalt is not without interest for electrical engineers, and we recommend those who care to go further into the subject to obtain a copy of a pamphlet recently issued by Messrs. Previté & Co., of London. The whole subject is fully dealt with therein.

Disc Grinders.—Some interesting information on the subject of disc grinders and their applications in engineering work is given in a leaflet to hand from Messrs. Perkin & Co., Leeds.

Lamp-holders and Accessories.—The lighting season being now close at hand, engineers will be interested in the price list of lamp-holders and accessories just issued by the Adnil Electric Co.

Resistance Materials.—The Electrical Alloy Co., of Morristown, New Jersey, U.S.A., forward us a copy of their latest catalogue, which gives all the most important data concerning the principal resistance materials made by the company and other useful cognate information.

BANKRUPTCIES, LIQUIDATIONS, &c.

A meeting of the creditors of Herbert Shuttleworth, Cross-court, Briggate, Leeds, electrical engineer, was held on Wednesday. The liabilities were £465. 8s. 11d. and the deficiency was £390. 17s. 5d. No resolutions were passed.

A meeting will be held at 20, Copthall-avenue, London, E.C., on Sept. 22 to receive an account of the winding up of the Deep Leads Electric Transmission Co. (Ltd.).

The liquidator (Mr. H. de V. Brougham) of the Electric Timber Seasoning & Preservation Co. (Ltd.) has been released.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications [illegible] inspection until after acceptance of Complete Specification. [illegible] inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

July 20, 1909.

16,894 Dulen. Magnetic [illegible]

16,895 Evershed, Kilb[illegible] & Evershed & V[illegible] El[illegible] of sound waves for signalling to a distance.

16,904 Siemens Bros Dynamo Works. (Siemens-Schuckertwerke G.m.b.H., [illegible]) Arc lamps.*

16,924 Proctor. Arc lamps.

16,928 Siemens & Halske Akt.-Ges. Connections for automatic sub-station switchboards with several exchange double leads. (Date applied for, 20/8/08.)*†

16,931 Mills. (Abraham Van Winkle, U.S.) Electroplating baths.

16,943 Rogers. Electric controlling and distributing mechanism for sparking devices. (Date applied for, 7/8/08.)*†

16,950 Scattergood & Bray. Electric wiring and switching systems.

July 21, 1909.

16,985 Siemens & Halske Akt.-Ges. Insulating former wound coils or the like. (Date applied for, 21/7/08.)*†

17,023 Bransom. Impressing upon electric dynamos or motors electrical pressures of various magnitudes.

17,031 B.T.-H. Co. & Wedmore. Protective devices for electrical transmission and distribution systems.

17,043 Boult. (Deutsche Elektro-Sparlicht G.m.b.H., Germany.) Small transformers.*

July 22, 1909.

17,101 Hirst & Coates. Insulating device for electric lamp-holders.

17,104 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.

17,106 Munro & Railless Electric Traction Co. Crossings and junctions for electric traction systems.

17,107 Romer. Intercommunication telephone instruments.

17,114 Mackie. Electrically-operated switches.

17,137 Foss. Sound intensifiers for telephone mouth pieces and the like.*

17,138 Compagnie pour la Fabrication des Compteurs et Materiel d'Usines a Gaz. Electric meters indicating maximum consumption. (Date applied for, 3/8/08.)*†

July 23, 1909.

17,160 Barr & Stroud. Torsion meters.

17,189 Midgley & Vandervell. Dynamoelectric generators for generating systems.

17,190 Lavy. Switching devices.

17,199 Allgemeine Elektricitats Ges. Regulation of dynamoelectric machines. (Date applied for, 23/7/08.)*†

17,215 Eisenstein. Beams particularly applicable for use as masts of wireless telegraphy stations.*

17,217 Eisenstein. Production of electric impulse charges for the purpose of wireless telegraphy. (Addition to No. 10,019/08.)*

July 24, 1909.

17,230 Wardle Engineering Co. & Wardle, jun. Electric incandescent lamp fittings and the like.

17,252 Thompson. Motor and steering telemotors.

17,254 Greenwood & Chapman. Windings for the armatures of dynamoelectric machines and the like.

7,271 Schultz. Switches.

July 26, 1909.

17,326 Munro & Railless Electric Traction Co. Hangers and the like for electrical conductors.

17,342 Aktiebolaget Elektrometall. Electric furnaces. (Date applied for, 1/8/08.)*†

17,353 Berry. Electrical heating apparatus.*

17,355 Graham. Telephone apparatus.*

17,368 Gottschalk. Telephone transmitters.*

17,370 B.T.-H. Co. (A.E.G., Germany.) Control of polyphase motors and the like.*

July 27, 1909.

17,406 Thompson. Testing meters.

17,448 Carbone. Arc lamps. (Date applied for, 9/11/08.)*†

17,473 Stragiotti. Telephonic transmitters. (Date applied for, 11/8/08.)*†

17,490 Steinert & Stein. Electromagnetic separator with rotating magnet drum. (Date applied for, 27/7/08.)*†

July 28, 1909.

17,520 Holmes. Induction motors.

17,555 Heurtley. Electrical and other recording, signalling, measuring instruments and the like.

July 29, 1909.

17,663 Mueller. High-tension magnetos. (Date applied for, 4/8/08.)*†

17,664 Mueller. Magneto-electric machines. (Date applied for, 25/2/09.)*†

July 30, 1909.

17,696 McMillan & Carey. Reversible turbines.

17,711 Thompson. Pendant electric light fittings.

17,739 Taylor & Scotson. Regulation of dynamo-electric machines.

17,740 Evans. Flexible tubular conduit systems for electric installations.

17,742 Giglio. Rectifying alternating currents. (Date applied for, 29/4/09.)*†

17,758 Allgemeine Elektricitats-Ges. Control of polyphase motors and the like. (Date applied for, 31/7/08.)*†

17,763 B.T.-H. Co. (G.E. Co., U.S.) Recording devices for use with measuring instruments.*

17,774 Brown, Judd & Hardie. Electric telegraphy.

July 31, 1909.

17,790 Imbery. Indicating rise in potential of trolley standards or other metal [illegible] of electric tramcars.

17,814 Chambers. Wireless telephony.

17,835 Bone, Simmons & R. Waygood & Co. Electric magnets or solenoids for use with single-phase alternating currents.

17,863 Maggiora & Sinclair. Electric motors.

SPECIFICATIONS PUBLISHED.

1908 Specifications.

15,802 Hookham. Electricity meters and other measuring instruments. (Complete Application, 2/19/09.)

18,017 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Regulation of speed of electric motors.

18,038 Dommerque. Three-wire telephone systems.

18,623 Sandycroft Foundry Co. & [illegible] Electric [illegible] switches using liquid resistance.

18,811 Denieport. Electrical ignition devices.

19,475 Lambert. Apparatus for sanding railway, tramway and like rails.

19,572 List & Atkinson. Point-operating mechanism for railways and tramways.

22,377 Pollet. Electrical driving gear.

23,007 MacGahan. Manufacture of electric conductors. (Date applied for, 8/11/07.)

23,709 Fraser & Tudor Accumulator Co. Brush gear for dynamoelectric machines.

28,368 Bellis & Morcom, Morcom & Masterman. Surface condensers. (Application for Patent of Addition to No. 15,071/08.)

1909 S[illegible]

[illegible] Alternating-current magnets for resonance apparatus.
[illegible]
4.801 BELLINI & TOSI. Directed wireless telegraphy. (Date applied for, 7/3/08.)
4.997 GILES. Safety device for the dissipation of excess voltage in electrical systems [illegible]
5.018 BENNETT, ESTES & EVANS. Trolleys or rotary collectors for electric cables.
5.119 B.T.-H. CO. (G.E. Co., U.S.) Electric motor-generator sets.
5.318 ALLGEMEINE ELEKTRICITATS GES. Control of electric motors. (Date applied [illegible]
[illegible]
5.578 EISENSTEIN. Wireless telegraphy. (Addition to No. 10.019/08.)
5.821 B.T.-H. CO. (G.E. Co., U.S.) Process for reducing oxides.
[illegible]
5.904 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
5.958, 5.961 and 5.962 GIBBS. Production of metallic articles by electro-deposition and the articles so produced. (Date applied for, 27/2/08.)
6.004 HACKETT. Combined tramway and telegraph pole. (Date applied for, 14/8/08.)
6.062 THOMAS, THOMAS & HARRIES. Operating tramway points from the vehicles.
6.088 AKTIEBOLAGET ELEKTROMETALL. Electric production of iron and steel and other metals and furnaces for carrying out the same. (Date applied for, 1/8/08.)
6.106 COOPER & SHARP. Electrical resistances.
6.187 VOLKERS. Rotary field-magnet. (Date applied for, 23/4/08.)
6.267 STEINERT & STEIN. Electromagnetic separation. (Addition to No. 6,323/08. Date applied for, 21/3/08.)
6.429 PAULING. Working of electric arcs in series.
6.523 NICHOLSON. Telephones.
6.962 SHARMAN. Induction coils. (Date applied for, 4/6/08.)
7.081 HANSELL. Supporting telephones. (Date applied for, 4/2/09.)
7.198 FRANCOIS. Electrical measuring instruments. (Date applied for, 11/4/08.)
7.203 AKT.-GES. BROWN, BOVERI ET CIE. Cooling of enclosed dynamo-electric machinery. (Date applied for, 30/3/08.)
7.396 GRUNWALD. Electrical induction furnaces. (Date applied for, 15/8/08.)
7.635 LEDER. Electrical rail bond. (Date applied for, 6/6/08).
7.795 VENNING. Overhead conductor frogs and crossings for electric tramways. (Date applied for, 15/4/08.)
8.191 FELTEN & GUILLEAUME-LAHMEYERWERKE AKT.-GES. Indicators operated by alternating current. (Date applied for, 11/7/08.)
8.263 SIEMENS BROS. DYNAMO WORKS. (Siemens & Halske Akt.-Ges.) Fuse fittings.
8.521 MAHONEY & MCCURDY. Magnetic brakes. (Date applied for, 20/4/08.)
8.535 SCHMAHL & HENDERSON. Fuse and switchboards.
8.570 TIMAR & ZIEGLER. Time relay for electric currents. (Date applied for, 12/12/08.)
[illegible] ELEKTRICITATS-WERKE AKT.-GES. [illegible] with metallic filaments. (Date applied for, 18/2/09.)
9.516 BLECKLY & BROWN. Arc lamps.
9.592 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges.) Switch plugs for telephone exchanges.

COMPANIES' MEETINGS AND REPORTS.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—Mr. Geo. Richardson stated at the meeting last week that the receipts were £11,794, or £890 more than in the lean half of 1908, and the revenue charges £8,162, or £487 less than in the previous half-year. There was an increased expenditure on the maintenance of permanent way, the cost of relaying 6 miles of line being included in the revenue charges. The cost of materials only £4,656, had been taken out of depreciation reserve. There were still 7 miles of line to renew, which would be carried out as required by their own staff. The decision of the House of Lords that their undertaking was a railway and entitled to quarter rating would make a difference to them in rates of £800 per annum. They proposed to pay the usual dividend, and place £1,250 to reserve.

ISLE OF WIGHT CENTRAL RAILWAY CO.—Mr. Percy Mortimer, who presided at the meeting of the company on Wednesday, said that they had had two proposals for the electrification of their line. Neither made any definite offer and one was still alive. The idea was to buy the undertaking. They would give any such proposal careful consideration.

MERSEY RAILWAY CO.—Mr. Jas. Falconer, M.P., stated at the meeting on Wednesday that, notwithstanding the continued bad trade in the districts which they served, and particularly in the shipping industry, the results of the half-year showed marked progress. During the half-year they had been reaping to a large extent the advantages due to the change they had made in transferring the head office to Birkenhead and in consolidating the whole of the staff there. The whole of the business was now being done at the central station at Birkenhead, with not only a saving of salaries but an increase in efficiency of supervision. They had been paying attention to the increase of efficiency and doing all they could to popularise the line. The real comparison which was of interest to the proprietors was the difference between the company's position now and what it was when they began electric traction in 1903. During the last half-year of steam working the number of booked passengers, as distinguished from season-ticket holders, was 2,800,000, whereas in the period under review the number was 5,800,000, and season-ticket journeys had increased from 512,980 to 1,381,467, an increase of 169 per cent. In the same way the total receipts had increased from £29,470 to £53,228, an increase of £23,000 for the half-year. These were figures with which they might be fully satisfied.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

HAMMERTON & CO. (LTD.) (104,626.)—Reg. Aug. 18, capital £5,000 in £1 shares, to promote, construct, equip, maintain and work railways and tramways in the U.S.A., or elsewhere, and to carry on the business of rolling stock manufacturers, engineers, &c. Private company.

MALCOLM & ALLAN (LTD.) (7,252.)—Reg. in Edinburgh on Aug. 20, with a capital of £20,000 in £1 shares, to carry on in the U.K. or elsewhere the business of contractors, engineers, founders, electricians, suppliers of electricity, &c. Private company. First directors, W. G. Malcolm, J. Allan and J. A. Mathers. Reg. office, 499, Eglinton-street, Glasgow.

PRESTWICH & BURT (LTD.) (104,596.)—Reg. Aug. 16, capital £1,500 in £1 shares, to acquire the interest of E. C. Lea in the business carried on by him at Kingston-on-Thames as Prestwich & Burt, and to carry on the business of manufacturing electricians, electrical and mechanical engineers and contractors, dealers in electrical accessories, &c. Private company. First directors, A. Vandam, C. Zee and C. Lea (all permanent). C. Zee is the first secretary.

ROBERT BOWRAN & CO. (LTD.) (104,648.)—Reg. Aug. 19, capital £10,000 in £1 shares (3,000 preference), to take over the businessof a general and electrical engineer and agent, iron and steel merchant, &c., carried on as Robert Bowran & Co., at Newcastle-on-Tyne. Private company. First directors, R. Bowran and W. Latimer. Reg. office, 4, St. Nicholas-buildings, Newcastle-on-Tyne.

SAMUEL MUCKLOW (LTD.) (104,662.)—Reg. Aug. 20, capital £5,000 in £1 shares, to take over the business of manufacturers of and dealers in railway, tramway and telegraph fastenings, &c., at Old Hill, Staffs. Private company. First directors, S. Mucklow and Pollie Haynes.

STERRY-SINGLETON CO. (LTD.) (104,598.)—Reg. Aug. 16, capital £1,000 in £1 shares, to carry on the business of financiers, promoters, agents, contractors, electrical and general engineers, dealers in oil, sleepers and rails, manufacturers of and dealers in engines, accumulators, dynamos, motors and rolling stock, &c. Private company. First directors, F. W. Sterry and W. A. Singleton (joint managing directors) and B. McCraith.

MORTGAGES AND CHARGES.

IMPERIAL LAMP WORKS (BRIMSDOWN) (LTD.)—Particulars of £40,000 debentures created Aug. 4, 1909, filed pursuant to sec. 93 (3) of the Companies (Consolidation) Act, 1908, amount of present issue being £15,000. Property charged: Company's undertaking and property, present and future, including uncalled capital. No trustees.

RECEIVER.

KINETIC-SWANTON CO. (LTD.)—J. H. Moritz, 8, Queen-street, E.C., ceased to act as receiver and manager on Aug. 16.

CITY NOTES.

MEMORANDA (Aug. 26).—**Bank rate 2½ per cent. (since April 1, 1909). Price of silver, 23⅝d. per oz. Consols 84⅛—84⅜ for money and for account. Consols Pay Day, Sept. 1; Stock and Shares Continuation Day, Sept. 8; Ticket Day, Sept. 9; Pay Day, Sept. 10; Mining Shares Carry Over Day, Sept. 7.**

PRICES OF METALS (London).—*Copper*, cash, 59$\frac{5}{16}$; three months 60¼. *Lead*, English, 12¾—13; foreign, cash, 12½; three months, 12$\frac{11}{16}$—12¾. *Spelter*, cash, 22¼—22½. *Tin*, English, 135½—137½; foreign, cash, 137⅝; three months, 138—138¾. *Iron*, Cleveland, cash, 50/11, and three months, 51/8. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

ABERDEEN SUBURBAN TRAMWAYS CO.—The directors report that for the half-year ended July 31 the profit was £775. A dividend of 2 per cent. for the past year is declared.

ASCOT DISTRICT GAS & ELECTRICITY CO.—The directors have declared an interim dividend at the rate of 5 per cent. (5s. per share), less tax, for the past half-year.

BRITISH INSULATED & HELSBY CABLES (LTD.)—The directors have declared an interim dividend at the rate of 8 per cent. per annum.

MACKAY COMPANIES.—The regular quarterly dividend of 1 per cent. on the preferred shares and the regular quarterly dividend of 1 per cent. on the common shares in the Mackay Companies will be paid on Oct. 1 to shareholders of record as they appear at the close of business on Sept 11. The transfer books will not be closed.

STEWARTS & LLOYDS (LTD.)—The directors have declared the following interim dividends for the half-year ended June 30: 6 per cent. per annum on the preference shares and 10 per cent. per annum on the preferred ordinary shares.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Aug. 27 a special settling day in and have granted a quotation to £77,200 4½ per cent. £100 prior lien gold bonds of the *Montreal Water & Power Co.* The committee have also granted quotations to £50,000 4½ per cent. debenture stock of the *Anchor Cable Co. (Ltd.)* and a further issue of £50,000 4 per cent. redeemable debenture stock of the *Oriental Telephone & Electric Co. (Ltd.)*. Applications have been made for official quotations for £150,000 6 per cent. cumulative preference stock of the *Melbourne Electric Supply Co. (Ltd.)* (in lieu of the preference shares of the Electric Lighting & Traction Co. of Australia, Ltd.), and 20,000 £5 7 per cent. first cumulative preference shares and a further issue of £100,000 5 per cent. first mortgage debenture stock of the same company.

UNITED ELECTRIC CAR CO. (LTD.)—The directors recommend a dividend for the year ended June of 2½ per cent. on the ordinary shares, against nil for the preceding year.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Amount.	Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 18	1,759	+ 160	11	17,768	− 605
Airdrie	,, 11	234	+ 21	32	6,937	− 115
Anglo-Argentine	,, 19	40,862	+ 6,558	33	1,281,697	+ 76,694
Ayr Corporation	,, 21	506	+ 18	11	5,812	− 225
Baker St. & Waterloo Ry.	,, 21	2,695	+ 45	7	20,575	+ 865
Barnsley	,, 15	180	− 10	32	5,331	− 270
Barrow	,, 11	325	+ 46	32	7,370	− 660
Bath Electric Trams, Ltd.	,, 18	951	+ 36	33	25,488	+ 1,097
Birmingham Corporation	,, 21	6,252	+ 118	20	135,459	+ 3,555
Birmingham & Mid.	,, 6	1,126	− 61	31	26,139	+ 270
Blackburn Corporation	,, 18	1,125	− 100	21	23,982	− 852
Blackpool and Fleetwood	,, 21	1,663	− 85	...	...	...
Bolton Corporation	,, 22	2,297	− 41	21	49,529	− 790
Bombay	July 22	R35,561	+ R1,753	28	R1,011,637	+ R63,926
Bournemouth Corporation.	Aug. 18	2,486	+ 125	20	35,938	+ 89
Bradford Corporation	,, 11	5,125	+ 579	13	97,170	+ 1,671
Brighton Corporation	,, 22	1,282	+ 110	21	21,913	+ 805
Bristol Trams & Carriage	,, 20	5,986	+ 972	13	77,887	+ 2,203
Burnley Corporation	,, 21	1,308	+ 21	21	27,093	− 186
Burton Corporation	,, 22	240	+ 1	21	5,662	− 147
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	,, 21	R49,931	+ R3,200	7	R319,628	+ R23,923
Camborne-Redruth	,, 21	121	− 11	31	4,150	− 130
Cardiff Corporation	,, 11	2,515	+ 337	20	41,967	− 3,2
Cavehill	,, 13	152	+ 31	32	2,819	− 154
Central London Railway	,, 21	4,473	− 2,055	7	31,955	− 11,059
Charing C., Euston & H'stead	,, 21	3,355	+ 3,0	7	25,845	+ 3,335
Chatham & Dist. Lt. Rys.	,, 19	1,034	+ 124	33	26,771	+ 1,484
City & South London Rly.	,, 22	3,053	+ 176	7	21,163	+ 1,259
City of Birmingham	,, 13	2,530	− 68	32	80,789	+ 741
Colchester Corporation	,, 18	237	+ 6	7	1,615	− 858
Cork Electric Trams Co.	,, 19	550	− 5	7	14,473	− 811
Croydon Corporation	,, 20	1,693	+ 251	20	31,706	+ 793
Devonport & Dist. Trams	,, 13	439	− 99	32	11,830	− 2,817
Dover Corporation	,, 21	301	+ 2	21	4,619	− 475
Dublin & Lucan Railway	,, 20	167	− 6	4	1,214	+ 6
Dublin United	,, 20	6,200	+ 392	7	43,957	+ 817
Dudley-Stourbridge	,, 13	1,052	+ 9	32	26,013	− 779
Dundee Corporation	...	...	...	...	...	...
East Ham Council	,, 21	1,023	+ 97	§20	21,153	+ 2,905
Exeter Corporation	,, 20	375	+ 8	21	7,455	+ 505
Gateshead & Dist. Trams	,, 13	1,013	+ 46	32	31,852	− 310
Glasgow Corporation	,, 21	17,231	+ 462	‖12	196,700	− 3,720
Glossop Trams	,, 21	138	− 7	31	4,116	− 125
Gravesend—Northfleet	,, 13	256	+ 15	32	6,633	− 172
Great Northern & City Rly.	,, 21	1,176	+ 10	7	8,678	− 22
Gt. Northern, Piccadilly, &c	,, 21	4,390	+ 110	7	31,535	+ 755
Greenock & Port Glasgow	,, 13	740	+ 134	32	17,378	+ 337
Hartlepool Tramways	,, 13	351	+ 60	32	7,116	− 201
Hastings Elec. Trams Co.	,, 19	1,649	− 5	7	9,856	− 396
Hong Kong	,, 21	$8,555	− $1,061	...	...	...
Huddersfield Corpn.	,, 21	1,741	+ 96	20	31,605	+ 771
Hull Corporation	,, 21	2,659	+ 250	20	51,811	+ 1,219
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 18	151	+ 4	20	2,758	− 202
Ipswich Corporation	,, 21	522	+ 28	21	8,789	+ 57
Isle of Thanet Co.	,, 21	1,918	− 52	§33	25,063	− 54
Jarrow	,, 13	158	+ 37	32	3,776	+ 339
Keighley Corporation	,, 13	193	+ 12	20	3,581	+ 92
Kidderminster & District	,, 13	159	+ 26	32	3,475	− 238
Kilmarnock Corporation	,, 21	112	− 1	11	2,193	− 82
Lanarkshire Trams Co.	,, 19	1,525	+ 160	33	41,920	− 938
Lancashire United	,, 13	1,517	− 181	33	43,039	− 148
Leamington	,, 13	248	+ 48	32	5,558	+ 173
Leeds Corporation	,, 14	7,161	+ 903	20	135,513	+ 1,519
Leicester Corporation	,, 21	2,288	+ 105	7	16,145	− 283
Leith Corporation	,, 21	668	+ 147	11	9,263	+ 1,081
Lincoln Corporation	,, 21	125	+ 3	21	2,625	+ 102
Liverpool Corporation	,, 14	11,161	+ 430	‖32	345,546	− 2,766
Liverpool Overhead Rly.	,, 23	1,501	+ 21	§8	11,985	+ 19
Llandudno & Colwyn Bay Ry	,, 20	771	+ 41	38	10,001	+ 1,761
*London County Council	,, 7	38,585	+ 369	§18	672,818	+ 21,641
London United	,, 21	7,370	− 760	‖35	202,901	− 20,967
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 22	211	− 7	20	3,941	− 312
Manchester Corporation	,, 21	14,863	− 205	20	313,445	− 3,792
Mersey Railway	,, 21	1,811	+ 13	7	13,410	+ 500
Merthyr	,, 13	228	+ 12	32	6,875	+ 85
Metropolitan Dist. Railway	,, 21	8,475	+ 311	7	66,555	+ 5,260
Metropolitan Elec. Trams	,, 13	7,312	+ 1,120	32	196,289	+ 15,014
Middleton	,, 13	475	+ 65	32	10,816	− 831
Nelson Corporation	,, 21	115	+ 5	§20	2,930	− 103
Newcastle-on-Tyne Corp.	,, 21	3,903	+ 156	20	80,798	− 1,117
Newport (Mon.)	...	...	...	...	...	...
Northampton Corporation	,, 20	517	+ 60	§21	10,310	+ 250
Oldham, Ashton & Hyde	,, 13	655	+ 30	32	17,895	− 1,134
Oldham Corporation	,, 22	1,783	− 203	21	40,833	− 2,948
Perth (N.B.) Corporation	...	...	...	...	...	...
Perth (W.A.) Elec. Trams	,, 20	1,379	+ 119	33	46,601	+ 22
Peterborough	,, 13	153	+ 7	32	3,754	− 339
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 13	1,533	+ 20	32	56,613	− 1,415
Preston Corporation	,, 18	733	+ 30	7	5,117	− 45
Rotherham Corporation	,, 19	608	− 31	20	12,099	− 515
Rothesay	,, 13	695	+ 81	32	6,460	− 201
Salford Corporation	,, 23	4,351	− 161	‡21	96,703	− 3,487
Sheerness	,, 13	77	− 5	32	1,695	− 211
Sheffield Corporation	,, 22	5,477	− 73	§21	120,570	− 1,520
Singapore Trams	,, 21	$3,963	− $319	...	...	...
South Metropolitan	,, 13	1,153	+ 23	32	25,231	− 683
South Staffs	,, 13	853	+ 53	32	26,775	− 1,410
Southend Corporation	,, 18	964	+ 102	20	11,987	+ 1,932
Southport Tramways	,, 13	502	+ 35	32	9,339	− 241
Stalybridge, Hyde, &c., Jt. Bd.	,, 21	813	− 187	§20	16,203	− 803
Sunderland Corporation	,, 23	1,193	− 31	21	24,796	− 905
Sunderland District	,, 13	171	− 47	42	19,324	− 803
Swansea Trams	,, 13	1,198	+ 105	32	30,612	+ 471
Swindon Corporation	,, 18	170	+ 13	...	...	...
Taunton	,, 13	71	+ 8	32	1,212	− 80
Tynemouth and District	,, 13	614	+ 198	32	7,822	+ 413
Tyneside Trams Co.	,, 18	476	+ 18	7	3,341	+ 203
Wallasey District Council	,, 21	902	− 19	§20	20,073	+ 601
Walsall Corpn.	,, 21	540	− 2	33	16,944	− 1,153
Warrington Corpn.	,, 13	390	+ 12	20	7,772	+ 45
West Ham Corporation	,, 12	2,419	+ 273	19	48,005	+ 2,035
Weston-super-Mare	,, 13	530	+ 39	32	4,651	+ 216
Wolverhampton Co.	,, 13	429	+ 8	32	13,387	− 1,300
Wolverhampton Corpn.	,, 18	878	+ 4	7	5,953	− 218
*Worcester	,, 13	376	+ 46	32	8,893	− 90
Wrexham	,, 13	120	+ 13	32	3,110	− 143
Yorkshire W.R. Trams	,, 22	1,233	+ 15	34	40,245	...
Yorkshire Woollen District.	,, 13	1,072	+ 133	32	28,862	− 468

(a) These comparisons are with the corresponding period last year. § Plus 3 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shre.	Last Dividend	Name.	Price Wed., Aug. 25.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Aug. 25: Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	6/0	†Bournemouth & Poole Elec. Sup. Ord	9¼–9¾	6 3 [illegible]	Mar, Sep	..	—
10	4/6	†Do. 4½ per Cent. Cum. Pref.	9½–10	4 [illegible] 9	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. Second Pref.	10–10½	5 14 [illegible]	Feb, Aug	10½	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99–103	4 7 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½–4¾	5 15 9	April, Oc	..	..
St.	4½%	Do. Do. 1st Debs.	93–96	4 16 0	May, No	..	..
5	4/6	†Brompton & Kensington Elec. Sup. Ord.	7½–8	6 12 0	March ...	..	..
5	3/6	†Do. 7 per Cent. Pref.	7½–8	[illegible]	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97–100	4 0 0	June, Dec	..	—
5	2/6	†Charing Cross (W. End & City) El. Sup. Co.	4–4½	5 16 6	Feb, Aug	..	—
5	2/8	†Do. 4½ per Cent. Pref.	4½–4¾	4 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96–99	4 1 0	Jan, July	97	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	99½–101½	4 [illegible]	..	101	99¾
5	2/8	Do. City Undertaking 4½% Cm. Pref.	3⅝–4⅛	5 2 6	Jan, July	-	..
5	2/6	Chelsea Electric Supply Ord.	3⅝–4⅛	4 3 3	March ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101–103	4 7 0	June, Dec	..	—
10	5/0	City of London Electric Lighting Ord.	10½–11½	5 10 0	Feb, Aug	[illegible]	10⅝
10	6/0	Do. 6 per Cent. Cum. Pref.	12–12½	4 11 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121–124	4 0 [illegible]	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99–102	4 8 9	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	2¼–3¼	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3–3½	3 11 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅝–8½	3 3 9	Feb, Aug		..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½–11	5 9 0	Mar, Sept	10⅝	10⅝
St.	4½%	Do. 4½% Deb. Stock (red.)	103–106	4 5 [illegible]	Jan, July	104	..
St.	4½%	Do. Second Deb. Stock	100–103	4 7 6	May, Nov	—	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅝–5¼	5 9 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5–5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97–100	4 10 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7½–7⅞	5 11 6	April, Oct	—	..
5	4/0	†Kensington & Knightsbridge Ord.	6⅜–6⅞	5 16 6	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	5⅝–6⅜	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95–98	4 2 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98–101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85–89	5 1 9	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞–2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅛–5¾	5 11 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93–97	4 2 0	Jan, July	..	—
5	2/6	†Metropolitan Electric Sup. Ord.	4⅛–4⅝	5 19 0	April, Oct	[illegible]	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝–5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105–108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½–86½	4 1 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	94–97	4 12 6	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4¾–5	4 2 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	84–88	5 5 11	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4–4½	2 10 8	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅝–5⅛	4 19 0	Feb, Aug	—	—
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97–99	4 1 8	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	99–101	4 19 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89–91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	11–12	5 16 9	March ..	—	—
5	4/6	Oxford Electric Ord.	6–6½	5 8 0	March ..	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95–98	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8½–9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7–7½	4 13 4	Feb, Aug	—	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84–88	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord.	9/16–13/16	—	Feb	..	..
5	4/0	South London Electric Supply Ord.	2⅝–3	6 16 0	April	..	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	101–103	4 17 0	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	—
1	0/8⅗	Do. 7 per Cent. Cum. Pref.	1 1/16–1 3/16	5 7 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	102–105	4 6 0	April, Oct	—	—
5	2/6	Urban Electric Supply Ord.	½–1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1½–2	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	77–81	5 11 6	April, Oct	..	—
5	5/0	†Westminster Elec. Sup. Ord.	8⅝–9⅛	5 8 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5–5⅜	4 4 0	Jan, July	..	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	99–101	3 19 0	Jan, July	100	99½
1	..	Bath Elec. Trams Pref. Ord.	¼–⅜	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87–91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88–91	4 19 0	Jan, July	89½	..
10	6%	Bristol Tramways & Carriage Ord.	8–8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8–8¼	4 14 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100–101	3 19 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	[illegible]	—	June, Dec	..	—
10	8/0	Do. 6 per Cent. Cum. Pref.	2–2½	12 0 0	Feb, Aug	[illegible]	[illegible]
St.	5%	Do. 5 per Cent. Perpetual Debs.	85–88	5 13 0	April, Oct	85¼	...
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63–67	6 14 0	May, Nov	80	..
St.	3%	†Central London Ordinary Stock	61–63	5 3 0	Feb, Aug	62½	..
St.	4%	†Do. 4 per Cent. Pref. Stock	83–85	4 14 0	Feb, Aug	—	..
St.	2½%	Do. Deferred Stock	43–45	5 11 0	Feb	—	..
100	4%	Do. 4 per Cent. Debs.	101–103	3 18 0	Jan, July	.	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92–94	4 6 0	Jan, July	9[illegible]	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾–5½	4 15 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97–101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	31½–32½	4 12 0	Feb, Aug	32	31½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	108–110	4 11 0	Feb, Aug	..	..
St.	5%	Do. (1896)	104–107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100–103	5 2 6	Feb, Aug	..	—
St.	5%	Do. (1903)	93–96	5 4 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	100–102	3 18 0	May, Nov	—	..
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾–13¾	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	½–1	..	Feb, Aug	..	..
10	..	G. Northern, Picc. & Brompton 4% G.Pf	8–8½	—	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	91–93	4 3 6	Jan, July	91½	91½
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¾–2¼	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	75–81	5 11 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4–4½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5–6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80–83	5 10 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅜	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58–63	6 7 0	Jan, July	..	—
10	6/0	Lanarkshire Tramways	9 13/16–10 1/16	5 18 6	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Do. St.	85½–90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	5–6	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82–84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	1¾–2¼	..	Jan, July	—	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68–71	5 12 6	Jan, July	69	..
St.	—	Mersey Con. Ord. Stock	1–2	—	Feb, Aug.	..	..
1	10⅗	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April.. .	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	[illegible]	6 1 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95–97	4 12 9	Jan, July	[illegible]	..
St.	1%	Metropolitan Railway Consolidated	39–39½	1 18 0	Feb, Aug	39¼	39½
St.	2¾%	Do. Surplus Lands Stocks	65–67	4 5 6	Feb, Aug	65½	..
St.	3½%	Do. 3½ per Cent. Preference	88–90	3 17 9	Feb, Aug	..	..
St	3½%	Do. 3½ per Cent. "A" Preference	84–83	4 1 0	Feb, Aug	86	—
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84–86	4 1 0	Feb, Aug	85	84½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92–94	3 14 6	Jan, July	94	93½

In calculating the yield allowance has been made for accrued interest but *not* for redemption.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., Aug. 25.	Rate % Yielded £ s. d.	Dividend Due	Business Week to Aug. 25 Highest	Lowest
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 3	Jan, July	9[illegible]	..
St.	..	Metropolitan District Railway Ord.	17 —17½	—	Feb, Aug	17¼	17
St	..	Do. Extension Pref. (5 per Cent.)	49 —51	..	Feb, Aug	—	..
St	3½	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rys. Co. of London, Ltd.)	65 —67	5 3 0	Feb, Aug	66½	65½
St	3%	Do. 3 per Cent. Corp. Rent-charge	76 —78	3 17 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St	..	†Do. Guar. Stock 4 per Cent	94 - 97	4 2 6	Mar, Sept	95	95
St	6	Do. 6 per Cent. Perp. Deb. Stock	142 —144	4 . .	Jan, July	143½	..
St.	4	Do. 4 per Cent. Ditto	94 —96	4 4 0	Jan, July	95½	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	½—¾	..	April, Oct	..	—
1	0/6	†Do. 5 per Cent. Cum. Pref.	½—¾	6 11 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	[illegible]	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	81 —85	5 18 0	Jan, July	..	..
..	..	UndergdE.Rys.Lon.6% In.bds. with coup. 3	36 —38	..	June, Dec	36⅝	36⅛
..	5	Do. 5% Prior Lien Bonds	103½ —103¾	4 16 6	..	10[illegible]	103½
..	4½	Do. 4½% Bonds with coup. 3	88 —91	5 0 0	..	88½	88¼
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	[illegible]	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1 —2¼	—	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —8[illegible]	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	[illegible]	..	..	—	..
1	1/1½	Do. 6% Cum. Pf.	[illegible]—⅞	6 17 0	April, Oct	—	—
1	2/4	Babcock & Wilcox Ord.	4[illegible]—4	4 13 0	April, Oct	..	..
1	0/7½	Do. Pref.	1⅜—1½	4 0 0	..	..	..
5	6 0	British Insulated & Helsby Cables Ord.	7½—7⅝	6 7 0	July, Feb	7⅝	7½
5	3 0	Do. 6 per Cent. Pref.	6⅜—6½	4 12 0	Jan, July	6½	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	104¼	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —96	4 13 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	[illegible]	..	Feb, Aug	¾	—
100	6	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	35 —42	9 10 0	Jan, July	..	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1st Deb. Stock	43 —48	9 8 0	Mar, Sept	..	..
St	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	10½—11	5 18 0	Jan, July	10[illegible]	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	104½—106½	4 5 6	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	2 —2¼	5 18 0	May, Nov	2	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.).	105 —108	4 3 6	Feb, Aug	105½	..
	1/0	Chadburn's (Ship) Telegraph Ord.	1⅝—1[illegible]	6 11 9	March ..	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	5 6 6	April, Oct	..	..
1	0/7	Consolidated Electrical Co.	⅜—½	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1¼—1½	8 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1	6 0 0	April, Oct	[illegible]	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	⅞—1⅛	13 7 0	Jan, July	..	..
100	5	Do. 5 per Cent. 1st Mort. Debs. (red.).	90 —93	5 7 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
	2/0	Dick, Kerr & Co. Ord.	1[illegible]—1½	8 0 0	Sept	..	..
	0/7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1[illegible]	4 16 9	Sept	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	½—⅝	..	Feb, Aug	..	—
	2/6	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	—
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅛—[illegible]	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅞	..	May, Nov	⅝	..
St	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 0 0	Jan, July	..	—
2	..	Electric Construction Co.	7/16—11/16	..	Jan, July	..	—
2	2/9	Do. 7 per Cent. Cum. Pref.	1[illegible]—1[illegible]	9 16 0	July	..	..
St	4	Do. 4 per Cent. Perp. 1st Mort. Debs.	65—69	5 16 0	Jan, July	—	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71 77	6 10 0	...	..	...
10	5/0	General Electric (1900) 5% Cum. Pref.	[illegible] —8¼	6 1 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	86 —88	4 11 0	Mar, Sept	..	..
5	10/3	Henley's Telegraph Works Ord.	12⅞—13½	5 11 0	Feb, Aug	12	..
5	2/3	Do. 4½ per Cent. Pref.	5[illegible]—5⅞	4 2 0	Feb, Aug	5[illegible]	—
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14¼—15½	6 9 0	Feb, Aug	15⅛	14[illegible]
10	5 4	Do. 5 per Cent. Cum. Pref.	10½—10[illegible]	..	..	10[illegible]	..
100	4%	Do. 4 per Cent. Debs. (red.)	100 —102	3 19 0	April, Oct	..	—
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—½	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]—¾	..	May, Nov	—	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock	82 —86	5 4 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1½	—	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	1/0	Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	35½	34¾
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	10[illegible]	..
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.	2[illegible]—2¼	4 9 0	—	2[illegible]	2[illegible]
1	0/6	†Do. 5 per Cent. non-Cum. Preference	1⅛—1¼	4 0 0	—	1[illegible]	..
St	5%	†Do. 5 per Cent. non-Cum. Preferred	107 —110	4 11 0	..	107½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	101½—103	3 17 6	June, Dec	103½	103
St.	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
10	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	105½	..
10	..	J. G. White & Co. 6% Cm. Pref.	9½—10½	8 6 0	..	10[illegible]	..
1	1/9	Willans & Robinson Ord.	⅞—⅞	3 15 0	Apr, Oct	..	..
	1/0	Do. 6 per Cent. Cum. Pref.	2⅝—3⅛	9 12 0	Apr, Oct	2[illegible]	2[illegible]
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	76 —80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3⅜	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	95 —96	5 4 0	June, Dec	..	..
St.	3/0	Anglo-American	61½—62½	5 3 6	F,My,Ag,N	60½	..
St.	6/0	Do. Preferred	103½—104½	5 15 6	F,My,Ag,N	104½	103¾
St.	3 0	Do. Deferred	21 —21¼	1 18 6	F,My,Ag,N	21⅛	21⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	90	90
10	6/0	Cuba Submarine Ord.	8¼—9	6 13 6	Feb, Aug	8[illegible]	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	.	..
5	3/0	Direct Spanish Ord.	2⅞—3⅜	5 18 0	April, Oct	..	..
	5/0	Do. 10 per Cent. Cum. Pref.	7⅞—8⅛	5 12 9	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99% - 101%	4 9 0	Jan, July	..	..
20	[illegible]	Direct United States Cable	12⅞—13⅜	6 7 3	Ja,Ap,Jy,O	12¼	..
100	4½	Direct West India Cable 4½% Rg. Db. (rd.)	99½—101½	4 9 0	June, Dec	..	..
		Eastern Ordinary	129 —132	5 6 0	Ja,My,JyO	131	130
	3/6	Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,JyO	..	..
	4	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	106	10[illegible]
St	[illegible]	Eastern Extension	11⅞—11⅞	5 19 3	Ja,Ap,Jy,O	11[illegible]	11[illegible]
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	..	..
		Eastern & S. Af. 4% Mauritius Sub. Debs.	100 —102	3 18 0	May, Nov	.	..
		G. N. Copenhagen, with Coupon 77	26 —27	6 13 6	Jan, July	.	—
		Great Northern 1st Mt. Db. red.)	99 —101	4 9 0	June, Dec	..	..
		[illegible]	61½—62½	5 16 9	May, Nov	[illegible]	..
	$1	[illegible] Common	80 —81	4 16 0	Ja,Ap,Jy,O	—	..
	$1	[illegible]	74 —79	5 1 0	Ja,Ap,Jy,O	..	..
		[illegible] West Indian Teleg. Co.	[illegible]	..	April	.	..
		[illegible] 1st 4% Guar. Dbs. red.)	99½—101½	3 19 0	June, Dec	—	—
		[illegible] America	1⅞ —1⅞	4 12 0	May	..	..
		[illegible] per Cent. Debs.	99½—101½	3 19 0	Jan, July	..	..
1		West India & Panama	½—⅝	..	May, Nov	..	..
	1/0	Do. [illegible] per Cent. 1st Pref.	[illegible]	7 1 0	May, Nov	8[illegible]	..
10	[illegible]	Do. [illegible] 2nd Pref.	8 —9	6 15 6	May, Nov	—	—
		Do. per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
10	6/0	Western Telegraph	13⅛—13⅜	5 2 6	Mr,Jn,O,D	13⅜	13
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	103 —105	3 16 0	June, Dec	..	..

Share	Last Dividend	Name	Price Wed., Aug. 25	Rate % Yielded £ s. d.	Dividend Due	Business Week to Aug. 25 Highest	Lowest
		TELEPHONES.					
100	2⅝	Amer. Telephn. & Telegh. Cap. St.	141 —145	5 10 0	..	145	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	97 —99	4 1 0	Jan, July	—	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103½—105½	4 16 0	Mar, Sept	..	—
5	5/0	Chili Telephone	8 —8⅜	4 15 6	August ..	..	—
1	0/7½	Monte Video Telephone Ord.	[illegible]	6 8 0	Nov	..	—
1	0/6	Do. 5 per Cent. Pref.	⅞—⅞	5 14 3	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106 —107½	5 11 6	Feb, Aug	107	..
St.	6%	Do. Def. Stock	123 —125	4 18 6	Feb, Aug	123¾	123
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—10¾	5 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—10¾	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5[illegible]—5[illegible]	4 8 0	Feb, Aug	5[illegible]	5[illegible]
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	..	..
St	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Oriental	1[illegible]—1[illegible]	5 7 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1[illegible]—1[illegible]	5 1 9	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85½—87½	4 11 6	Jan, July	8[illegible]	8[illegible]
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100 —102	4 8 0	Jan, July	101½	..
5	5/0	United River Plate	6[illegible]—7[illegible]	5 11 0	July	7⅜	6[illegible]
5	2/6	Do. 5 per Cent. Cum. Pref.	5½—5⅝	5 10 6	June, Dec	..	..
St	4½%	Do. 4½ Deb. St. Red.	103½—105½	4 5 0	Jan, July	—	..
		FINANCIAL INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..	..
10	5/6	Globe Telegraph & Trust	10½—10¾	6 7 0	SpDcMrJu	10[illegible]	10½
10	3/0	Do. 6 per Cent. Pref.	13[illegible]—14[illegible]	4 4 0	SpDcMrJu	14	13½
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	..	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	—	Anglo-Argentine 5% Cum. 1st Pref.	4[illegible]—4[illegible]	5 1 8	April, Oct	4[illegible]	4[illegible]
5		Do. 5% Cum. 2nd Pref.	4[illegible]—4[illegible]	5 7 0	Jan, July	..	..
St.	4%	Do. 4% Deb. Stock	9[illegible]—95½	4 6 0	June, Dec	93[illegible]	92½
St		Do. 4½% Deb. Stock	96 —98	..		9[illegible]	96½
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	—	..
5	3/6	Brisbane Electric Trams. Invest. Ord.	6⅝—7	4 6 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	100	..
St.	8%	British Columbia El. Ry. Df. Ord.	147 —151	5 6 0	Mar, Sept	..	..
St.	6%	Do. Pref. Ord. Stock	122 —126	4 15 6	May, Nov	123	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	108 —111	4 10 0	Jan, July	109	108[illegible]
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	103[illegible]
100	4½%	Do. Vancouver Power Debs.	101 —104	4 7 0	Jan, July	—	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	101½—103½	4 7 0	..	103	—
St.	5%	†Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	92 —96	6 5 0	Feb, Aug	94	..
5	2/0	Calcutta Tramways (1 to 137,610)	4[illegible]—4[illegible]	4 2 0	Mar, Sept	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	4[illegible]	..
1	4½%	Do. 4½% 1s. Deb. Stock (red.)	97 —100	4 10 0	Jan, July	98½	98½
St.		Cape Electric Tram Shares	¼—½	..	..	..	..
5	1/3	†City of Buenos Ayres Trams Co. (1904) Sh.	5[illegible]—5[illegible]	4 4 0	F,My,A,N	5⅝	5¼
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	—
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	—
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	—	..
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	90 —93	5 7 6	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	66 —79	8 12 0	Jan, July	..	..
5	1/0	Lisbon Elec. Trams. Ord.	[illegible]—1[illegible]	4 4 9	July	1[illegible]	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1[illegible]	5 1 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	98 —102	4 18 0	Jan, July	—	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..	..
..	5%	†Manila Elec. Ry. $1,000 Gold Bonds	96 —97	5 3 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	124 —127	3 18 9	..	127	125½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	9[illegible]—9[illegible]	5 2 6	..	97½	96½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,000)	102 —104	4 6 6		..	..
1	0/6	Perth Elec. Trams Ord.	⅝ —⅞	8 0 0	May	—	..
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅝—5¾	5 4 8	..	—	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	—	—
100		Rio Janeiro Tram, Lt. & P. Co.	90 — 92	..	..	92	91
..	5%	Do. 30 yr. Gold Bnds.	93½—95[illegible]	5 4 0	..	94[illegible]	94[illegible]
100	5%	Do. 50 yr. Mt. Bnds	84½—85½	5 17 0	..	85½	84[illegible]
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	148 —151	6 15 0	..	150	148[illegible]
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102½	101
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —105	4 12 6	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5⅝	5 11 0	Mar, Sept	..	..
10	6/0	†Bombay E. S. & T. 6% Cm. Pf.	9[illegible]—9[illegible]	6 2 6	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	93½—94½	4 18 6	Jan, July	94½	93½
..		Do. 5 per Cent. 2nd Mort. Deb. Stock	93½—95½			94[illegible]	
5	4/9	Calcutta Elec. Supply Ord.	6 —6½	6 8 0	April, Oct	..	..
100	$1¾	Canadian Gen. Elec. Co. Com. St.	122 —127	5 13 0	..	123[illegible]	123[illegible]
100	$3½	Do. 7% Cm. Pf. Stock	118½—120½	5 17 0	..	120	
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	—	..
500	5%	Elect. Development Co of Ontario	85 - 88	5 11 0	..	—	—
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	—	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	..	..
108	[illegible]	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	6 18 3	April, Oct	[illegible]	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83 —85	5 10 0	..	84½	83[illegible]
St.	$1	Mexican Lt. & Power Co. Com. St.	71 —75	5 19 0	..	74	72
500	5%	Do. 5% 1st Mort. Gold Bnds.	86 —88	5 11 0	..	87½	87½
100	$1	Montreal Lt. Ht. & Power Co. Cap. St.	127 —131	4 15 0	F,My,A,N	129	128¼
1	1/6	River Plate Electricity Co. Ord.	1[illegible]—1[illegible]	5 11 0	April	..	..
1	1 2	Do. 6 per Cent. non-Cum. Pref.	[illegible]—1[illegible]	5 1 6	May	1[illegible]	—
St	5%	Do. 5 per Cent. Deb. Stock	102 —105	4 15 0	Jan, July	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅝—5⅞	5 6 6	April, Oct	..	..
5	..	Do. 2nd Pref.	5⅝—6	5 0 0	—	..	..
100	$1	Shawinigan, Water & Power Co. Ca	95 —97	4 2 6	..	97	96½
..	5%	Do. 5 per Cent. Bds.	104 —106	4 14 3	Jan, July	106	98
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	98 —99	4 11 0	—	98½	98½
St.	4%	Toronto Power Co. 4½% Db. St.	99½—100½	4 9 6	..	100½	..
..	6d.	Victoria Falls Power Co. Pref.	1[illegible]—1[illegible]	5 14 0	Jan, July	..	..

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NOTES.

The Reliability of Electrical Machinery.

APART from considerations of economy and convenience, the electric motor should appeal to power users on the score of its reliability, but if this last-mentioned advantage is to be fully realised particular attention must be paid to the installation, both as regards its design and its operation. An excellent epitome of the failures which result if such precautions are not taken is always provided by the annual report of Mr. MICHAEL LONGRIDGE, chief engineer to the British Engine, Boiler & Electrical Insurance Co., and the report for the year 1908, to which we refer in detail elsewhere in this issue, will probably be found to be of more than usual interest. Although we are here mainly concerned with that section of the report dealing with electrical matters, we may also draw attention to the valuable contribution made to the subject of the stresses in gas engine shafts. That some such investigation is necessary is indicated by the variety of dimensions adopted by different makers and by the fact that a considerable increase is shown in the number of failures of gas and oil-engine shafts, such failures now amounting to 9·1 per cent. of the total failures, compared with 4·7 per cent. in 1907 and 5 per cent. as the average for 24 years previous to 1907. Mr. LONGRIDGE's report also serves a useful purpose in drawing attention to the rapid increase during recent years of the number of breakdowns of steam engines due to breakage of valves and valve gear, and he suggests that some improvement in the design and manufacture of these parts is desirable. Failures of valves and valve gear in the case of gas and oil engines also largely outnumber those due to other causes, and indicate faulty design or manufacture.

TURNING now to electrical plant, it is gratifying to notice that the rate of breakdown among electric motors shows some improvement, the figures for the year 1908 being 1 in 9·2 for continuous-current and 1 in 11·3 for alternating-current motors, compared with an average figure for the two types of machines of 1 in 7·9 for 1907 and 1 in 8·2 for 1906. The figures given above for electric motor breakdowns in 1908 compare favourably with the figures of 1 in 9·1 for gas engines and of 1 in 9·4 for steam engines, the more so when it is remembered that electric motors have generally to operate under much more unfavourable conditions and in situations where they are more liable to damage from extraneous causes. Much light is thrown on the breakdowns by an examination of the tables showing their causes, and it will be seen that dirt and neglect are responsible for at least 30 per cent. of the failures, whilst the manufacturers must be held accountable for quite 11 per cent. of the total breakdowns. In this connection, we hope that due attention will be paid to Mr. LONGRIDGE's remarks in regard to the very large majority of breakdowns of electrical plant being due to the deteriorating effect of oil, dust and damp on insulating materials. In addition to improved arrangements to prevent oil throwing, which is probably the most fruitful source of trouble, the breakdowns seem to indicate that more care is necessary to secure the efficient locking of spiders, core plates, pole-pieces, &c. There is no doubt that it is a great advantage to have particulars of such breakdowns, as in this way attention is drawn to defective design and improvements are facilitated, which is all to the advantage of the power user.

[illegible] in Municipal Trading.

[illegible] most confirmed unbeliever in municipal trading [illegible] nevertheless agree that there are certain directions in [illegible] the activities of Corporations can be safely exercised [illegible] their falling foul of or entering into competition [illegible] with, private enterprise. We may, for instance, mention the control of libraries, swimming baths and the removal of refuse, which, though of a trading character, could not well be carried out by private individuals. The supply of electricity or gas for lighting and power purposes from a municipally-owned works is also legitimate, for in such a case legal restrictions generally prevent any competition between a municipality and a company. But the matter assumes an altogether different aspect when a municipality wishes to control a purely trading concern and to enter, without let or hindrance, into competition with private undertakings. Then the situation becomes Gilbertian: a private trader supports a municipality by the rates he pays, which municipality enters into competition more or less successfully with the aforesaid private trader. If the Corporation makes its trading department pay, the trader possesses a powerful competitor whom he helps to support; while if the venture is unsuccessful there is a tendency to cut prices so that the trader has to make up his competitor's deficit and lose his own business at the same time. It may, therefore, be assumed that any arguments which seek to support this method of procedure are economically unsound.

THERE is yet another side to the question, however—a side which is well illustrated by certain occurrences which have recently been taking place at Sheffield. The work of the Corporation in that town is naturally controlled by a number of departments, including one for supervising the education of the city and another for superintending electrical matters. A short time ago the former of these called for tenders, through its consulting engineers, for wiring the Training College. Certain firms tendered, as did also the Corporation Electricity Department, which, in spite of the fact that it had not sent in the lowest tender, was recommended for the work by the Training College managers, thus cutting out a firm with a lower tender who had ample experience of the work required. It may be mentioned that the tenders sent in wandered, as is usually the case, over a considerable range. As was properly remarked, in a discussion on the question, if the committee had decided that a Corporation department was to do the work no tenders should have been called for; and certainly no Corporation department should have been allowed to tender in competition with private firms for Corporation work. We have lately heard of engineers acting as their own arbitrators, but here is a case of a Corporation department assuming the rôle of Pooh-Bah, and acting as customer, testing authority and contractor all in one. In spite, however, of a certain amount of opposition, the amendment proposed was adopted, and the tender of the private trader accepted, the Committee generally agreeing that a great mistake had been made in the procedure followed throughout the matter. It is impossible not to fall in with this conclusion, for, indeed, the whole discussion only indicated a profound ignorance of the functions of a municipality. A municipal authority may be allowed to take over and run anything, or everything, for the good of the community, though we must confess this would lead to disastrous practical results, or it may confine itself to controlling certain branches of trade; but it must not on any account enter into competition with private enterprise.

Different Points of View at the B.A.

PROF. H. E. ARMSTRONG has the faculty of disagreeing with most of his contemporaries, and, therefore, what he writes is generally interesting. This applies particularly to his Address to the Chemical Section of the British Association, more particularly when it is read in conjunction with the Addresses of Sir J. J. THOMSON and Prof. RUTHERFORD, who are essentially exponents of the electron. To Prof. ARMSTRONG the electron, like the subject of ionisation, is by no means a desideratum, and he calls attention to the "horrible pitfalls" which should render conclusions on such subjects of doubtful value. Prof. ARMSTRONG evidently has no liking for the period of sensational discovery through which we have been passing, a period, he remarks, in which advertisement is favoured and the desire for notoriety is rampant. We do not doubt that there is a tendency at the present day to rush into print unnecessarily instead of carrying investigations to a logical conclusion. But how this can be remedied is difficult to see. As to the theories, apart from their experimental verification, we think that trouble arises from the fact that the physicist seldom has a good knowledge of chemistry, and we think it might equally be said that the chemist generally has an extremely poor knowledge of physics; and that neither cares very much about the work of the other. In investigations dealing with questions on the border line of physics and chemistry a good all-round knowledge of both subjects is very desirable; and, what is more, it seems to be a fact that an intimate acquaintance with mathematics is also necessary before many of these theories can be seen in their true light.

Municipal Business Methods.

WHEN the proprietors of a commercial concern engage a general manager to conduct its affairs it is usually a recognised principle that this manager should be allowed to select his own staff and personnel, and to terminate their period of service should their work not prove satisfactory. The system is not ideal, but it has worked well for many years and under varying conditions. It would seem, therefore, only natural that municipalities undertaking trading work should follow the same course as that outlined above, and appoint a general manager in whom they can have implicit trust and in whose hands the general conduct of the work is placed. Such, however, is not the opinion of the councillors of the up-to-date town of Ilkeston. They appointed a manager for their tramways, Mr. A. C. GILBERT, who, in the course of his duties, found it necessary to dismiss summarily two employés. Much hub-bub was the result, the Trades Union concerned moved in the matter, and a committee of the Council forthwith determined, thus taking into their own hands work deputed to their manager, that the men should be reinstated. As the Council endorsed the action of their committee, Mr. GILBERT has naturally tendered his resignation, his views on the question not having been sought.

It will not be denied that [illegible] an undertaking such as a municipally [illegible] system, discipline of some sort is necessary, since certain unruly members may not always comport themselves as they should. To deal with these cases must, however, be the duty of the manager alone, and though, theoretically, appeal from his decision to the committee may be allowed, procedure such as that apparently common in Ilkeston can only lead to chaos. and, logically, to the working of the undertaking on a system of sans-culottism, which would be little to the liking of the town's inhabitants. It is perhaps too much to hope that the same thing will not occur again, and we cannot but feel that the reputation of Ilkeston as a place where loyalty to their staff is a point on which great emphasis is laid by the councillors has certainly sunk very nearly to absolute zero in the opinion of those engineers whose services municipalities should endeavour to obtain and retain.

British Association.—The Rev. T. G. Bonney, D.Sc., F.R.S., has been elected president of this Association for the year 1910.

Iron and Steel Institute.—As previously announced in The Electrician, the autumn meeting of this Institute will be held in London from Monday, September 27th, to Friday, October 1st, inclusive. The secretary's office will be established at St. Ermin's Hotel, Westminster, and the meetings will be held in the hall of the Institution of Civil Engineers, Great George-street, Westminster. Among the Papers down for reading are: "On the Determination of the Power Consumption of Reversing Rolling Mills," by Mr. C. A. Ablett, and "On the Refining of Steel by Electricity," by Mr. E. J. Ljungberg. Visits will be paid, among others, to the works of Messrs. Siemens Bros. & Co. at Woolwich, to the London County Council generating station at Greenwich, to the Royal Doulton Potteries at Lambeth and to the National Physical Laboratory. Other information with regard to the meeting can be obtained on application to the secretary, Mr. G. C. Lloyd, at 28, Victoria-street, London, S.W.

Wireless Telegraphy in Military Operations.—As is doubtless well known, wireless telegraph apparatus has for some time now formed an integral part of the equipment of an army on the march, or taking part in manœuvres, both in this country, on the Continent, and in the United States. It will, therefore, be of interest to hear how the apparatus works under what must be arduous, and what are certainly novel, conditions. For this reason we reprint a paragraph on the subject from an article in "The Times" on the conduct of the recent cavalry operations. From this it would appear that much has still to be done to fit the apparatus for military work, or else that "Tommy" is not yet sufficiently acquainted with its technicalities to operate it with any degree of ease or certainty. The paragraph runs:—

> It is a disappointment to have to record that the results achieved by wireless telegraphy were anything but encouraging. Much had been expected of this novel development: and having regard to its successful use a year ago when its employment stood out as a feature in the reconnaissance scheme carried out by the Household Cavalry, it is permissible to hope that its failure during the last two days is one of only a temporary nature for which some satisfactory reason will be forthcoming. In a subject bristling with such abstruse technicalities only an expert can detect flaws, but to the layman it certainly appeared that the pack stations were decidedly wanting in mobility. The contact squadron that was captured probably owed its misfortune to its having constantly to wait for the engineers, who in order to justify their existance should be provided with horses capable of keeping up with cavalry.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tangier—Cadiz	May 19, 1909	—
Tourane—Amoy	June 17, 1909	—
Assab—Perim	July 8, 1909	—
Gibraltar—Tangier	Aug. 7, 1909	—
Cueta—Tangier	Aug. 7, 1909	Aug. 27, 1909
Melilla—Chafrinas	Aug. 7, 1909	Aug. 30, 1909
Dakar—Conakry	Aug. 19, 1909	—

Factory and Workshop Acts, 1901 and 1907.—The following order was made by the Secretary of State for the Home Office on July [illegible] last, under [illegible] of the Regulations for the generation, transformation, distribution and use of electrical energy in premises under the Factory and Workshop Acts, 1901 and 1907:—

> In pursuance of [illegible] of the [illegible] Regulations, I hereby direct that [illegible] in which the following special conditions [illegible]:—
>
> No electrical [illegible] purpose [illegible]; and the floor [illegible] machinery [illegible] any [illegible] in contact; and no process rendering the floor wet is carried on; and [illegible]:
>
> such conditions shall be deemed for all the purposes of the Regulations adequately to prevent danger.

Electric Steel Furnaces.—We understand that the largest electric steel furnace in regular commercial operation at the present time in Europe is a Röcheling-Rodenhauser single-phase furnace in use by the Gebrüder Röchelings Co. (of Voelklingen, a S), with a capacity of 8 tons. The steel supplied to this furnace is taken direct from a Thomas converter after five or six minutes' treatment to get rid of the silicon and carbon. It is then treated for a time varying from three-quarters of an hour to $1\frac{1}{4}$ hours in the electric furnace, the time depending upon the quality desired. At the end of this treatment it is cast into ingots and is rolled into rails, for which there is a regular demand for the Prussian Government. When first started the furnace was shut down every week-end for overhauling, but now it is run continuously night and day for periods of a fortnight, at the end of which it is shut down for repairs to be made to the lining.

Apparatus for Drying Transformer Oil.—An interesting apparatus for this purpose is described in a recent number of "Helios." It consists of a frame with vertical resistances, composed of metal pipes insulated by porcelain rings. This frame is completely immersed in the oil, the terminals being connected to the low-tension circuit. The heat produced in the resistance pipes makes the oil pass through them in a strong current, cooler oil entering at the bottom. The circulation is so violent that every particle of oil in the tank is, it is claimed, certain to circulate through the pipes and to become heated on the way. The warm layer of oil will therefore gradually increase in thickness, and within a short time all the oil will have reached a sufficient temperature to ensure all traces of moisture being removed.

Patents and Designs Act, 1907.—Sec. 27 of this Act, which enables persons to apply for the revocation of a patent, after it has been in existence four years, if the manufacture of the patented article or process be carried on exclusively or mainly outside the United Kingdom, has now been in operation for 12 months. During this time 69 applications for revocation of foreign patents were made, but in 10 cases only were patents revoked. In four of those cases the patentees appealed to the High Court, and in two cases (the Bremer and Högner patents, relating to improvements in electric arc lamps) the decision of the Comptroller-General was reversed, evidence having been adduced which was not placed before the Comptroller-General. The two other appeals were unsuccessful, so that the number of patents finally revoked was eight; while in another case a conditional order of revocation was made. Of the other applications four were dismissed by the Comptroller-General; 28 were withdrawn after they had been lodged (in many cases, it is understood, because evidence was forthcoming of "adequate" working), and of the 26 still officially pending a few have lapsed through effluxion of time. The effect of the Act of 1907 on the number of foreign patents taken out in this country cannot yet be fully appreciated: in this connection the following numbers may be of interest: Sixteen fewer patents were taken out in 1909 by American subjects than in 1908, and 331 fewer than in 1907. The decrease in German patents has been consistent—2,000 in 1907, 1,822 in 1908, and 1,735 in 1909; and the same may be said of Austrian patents—253, 234 and 192 respectively. French patents, which were 620 in 1907 and 670 in 1908, decreased to 560 in 1909.

ELECTRIC HEATING.*

BY W. S. HADAWAY, JR.

It may assist in a better understanding of the terms used in discussing electric heating to state at the outset that the words heat, potential, &c., are employed more specifically than has generally been found necessary in discussing heat effects apart from electricity. The term "electric heating" is commonly used to express the frittering down of the higher potential energy of electricity into the lower potential energy of heat. There is no well defined line of demarcation; the result is inseparable from the conveyance or utilisation of electricity in any degree. The expression is, therefore, a meaningless one from the heat engineer's standpoint and it fails accurately to express the performance of useful work by the transmission of heat energy to a distance by means of electricity.

The feature of the subject we are to consider is the practical adaptability of commercial electricity for heating purposes and for performing useful work under the conditions imposed in general industrial and domestic life, and particularly in connection with other heat distributors for a multipotential heat supply. These applications may be roughly divided into two classes according to the degree of concentration of the heat energy used. The first class includes low-temperature heating, generally diffused and in large volume; the second includes high-temperature heating, generally localised and in small quantity.

In heating on a small scale no adequate classification is possible; it is the blending of high-potential heat energy into low-potential heat work for many useful operations that primarily suggests the feasibility of heat transmission by electricity. An arbitrary line of temperature demarcation for heating on a large scale has been drawn at 250°F. As examples of the first class may be cited the heating of rooms and of water at atmospheric pressure; examples of the second class are electric ovens, sad-irons and soldering-irons.

To show what the heating efficiency of different methods of application may mean, the following experiments, reviewed in THE ELECTRICIAN for November 2, 1894, are cited. The determinations were the relative heating values of combustion and electricity, by a resistance method. The same wires were heated, first in a flame and then by electric current. It was found that with a platinum wire held in a flame less than 0·5 per cent. of the thermal energy produced in the flame was transferred to the wire, while 90 per cent. of the electrical energy used appeared as heat. In another case an iron bar weighing about 20 lb. was heated by charcoal and then by electricity. In the former case about 0·75 per cent. of the thermal energy was transferred to the bar and in the latter case 88 per cent. The heat capacity of the work performed is sufficiently large to express the relative differences in combined efficiency, and the lower the temperature of the work, the larger the area heated; and the greater the capacity the less the difference in ratio between heating by combustion and by electricity. We may readily determine the conditions where the ratio is an inverse one.

In room-heating apparatus on a continuous run we may estimate that 1 watt-hour, 3·41 thermal units, will heat 1 sq. ft. of common radiator surface through 1·26°F.; that 1,000 watt-hours, or 3,412 thermal units, will heat the surface approximately 126°F. above the room temperature—that is, for room heating from 85 to 110 watt-hours are practically the equivalent of the steam at low pressure condensed by 1 sq. ft. of radiator surface with the above stated difference between the room and the radiator temperatures. This, of course, takes no account of the heat capacity of the apparatus, which is practically eliminated by the imposed conditions of continuous running. We may safely assume that a fair average price for a unit from large steam electric stations is 3½d. It would, therefore, cost 0·3d. average to run 1 sq. ft. of direct radiation surface for one hour, or the electrical unit would keep about 10·3 sq. ft. of radiator surface at the temperature difference noted for one hour. Direct comparison of this value with practical steam heating is difficult, owing to the variables involved. We may, however, compare it with a central station steam distributor as quoted by Unwin in his work on the "Development and Transmission of Power," referring to a New York steam company. The unit of heat used by this company is defined as the "kal," which is stated to be the heat required to evaporate 1 lb. of water from 100°F. at 361°F., or at 85 lb. pressure per square inch. One kal is therefore about 1,110 thermal units. On a sliding scale the charge is stated to be 2s. 11d. per 1,000 kals to small users, and 1s. 8d. per 1,000 to large users. As the price of 3½d. per electrical unit is to a fairly large user, we shall compare it with the 1s. 8d. per 1,000 kal rate. For 1s. 8d. the consumer obtains 1,110,000 thermal units from the steam station, compared with 20,400 thermal units from the electric station, a ratio of nearly 54 to 1, or practically 50 to 1 as a loss must be figured in the case of steam, dependent upon the temperature at which the condensed water is allowed to escape. It is interesting to note in passing that while the relative efficiencies of generation are about as 12 to 1, the commercial rates quoted are as 50 to 1. The ratio of the cost of heat energy from the electric station to the cost from the steam station is therefore practically four times as great as the ratio of the relative costs of production. This disparity should be considered in discussing the influence and importance of the load-factor as discussed by Crompton in his Paper on "Electric Energy." *

* Abstract of a Paper read before the American Institute of Electrical Engineers.

Clearly, the steam-driven electric light station ranks low as a heat distributor for house warming on any considerable scale. And yet notwithstanding the great disparities in the cost of heat energy on a large scale, the uses to which small electric air heaters are put are surprisingly numerous. We are all more or less familiar with the use of gas stoves for room warming, but it has been found by wide experience that the electric air heater for auxiliary room warming, for bath and dressing rooms, for libraries, cabins on yachts and steamships, in mild climates in early morning and evening, serves its purpose with fair economy, and without vitiation of the air and by-products always evident from gas. It is then on a comparatively small scale and in intermittent service that the electric air heater is useful when power is derived from the steam electric station and when the heat supplied is derived from electrical resistance.

In considering the uses of electricity in diffused heating on a large scale the author is of the opinion that the deductions made by Lord Kelvin "On the Economy of the Heating or Cooling of Buildings by Means of Currents of Air"† should not be overlooked. Lord Kelvin's deductions therein may prove to be wrong until more perfect thermal insulation is developed, but to anyone familiar with thermodynamics and electrical development the possibility of using a positive force to control and direct a less definite form of energy must appeal with singular emphasis.

When electricity is derived from water power we might expect a far wider availability of energy from heat of resistance for applications requiring heat in large volumes than when electricity is derived from steam power. Careful deductions show that for house warming the cost of a horse-power year must not exceed 24s. in order to compete directly with high grade coal at 20s. per ton.

The consideration of the relative values of gas and electricity for heating purposes is a matter that can only be inadequately discussed here, for the problem is a complicated one and demands the most thorough consideration. We must not underrate the facility with which gas may be stored, the economy of rapid and continuous generation and available heat from combustion and discharge of by-products, whereas in electric lighting and electric heating every unit of light and heat secured represents an appreciable loss or depreciation of the energy converter. There are many advantages to be considered on the other side such as localisation, immersion of heater in working chamber, as in ovens, sad-irons, and water heaters, freedom from by-products, &c. In electric heating and cooking for domestic uses the real difficulty is how to provide a hot-water supply economically. The same thing is true in the use of gas, though in a lesser degree. On a broad scale it appears easier to arrange for this on a multipotential heat supply system than on any system using gas. In his treatise on gas engines, Donkin shows examples of these engines of large size furnishing power at rates less than can be obtained from other prime movers. For high-potential heat distribution from isolated plants this form of energy transmitter is generally available; but it may be seriously questioned whether in isolated plants for domestic use the hot water supply as usually provided can be economically heated, unless of course the combined economies permit the use of individual gas-heated water supplies.

It may be safely concluded from the foregoing illustrations that we cannot afford to use electricity for general diffused heating purposes on a large scale. It is proper to point out, however, that practical experience shows that these deductions may lead to unsafe conclusions. Individual applications must be considered, and the combined results of these will be far different from any considerations controlling a fixed system. One of the reasons contributing to the slow growth of electric heating development is the necessity in many cases of devising apparatus to do work more effectively than could be done by the old methods.

The author then gives illustrations of operating plants in America for the purpose of showing that under certain conditions heat energy, as steam, may be economically distributed to a distance, and he proposes a multi-potential arrangement system in which the steam, either live or exhaust, or both, is used for low-temperature work,

* THE ELECTRICIAN, Vol. XLIV., p. 215, et seq.

† Glasgow Philosophical "Proceedings," Vol. III., Dec., 1852, and "Cambridge and Dublin Mathematical Journal," November, 1853.

and electricity from generators in the same station is employed for all work requiring temperatures in excess of that of the steam; that is, from about 250°F. upward. In domestic work the steam heat would be employed for house heating and water heating for bathing, laundry and cooking purposes. Electric heat would be used for lamps, ovens, broilers, small stoves, sad-irons and all purposes requiring a high temperature localised heat. And a feature of such a combination not to be overlooked is the facility with which ventilation and heat regulation can be secured, since all the elements are at command to force an abundant supply of heated pure air through the building to be warmed. There are no new or untried features in such a combination; practically all of the elements necessary for the work are already employed, though in a somewhat disjointed form so far as complete flexibility of heat supply from one centre of distribution is concerned.

Careful study of the question of multi-potential heat supply, from both engineering and business standpoints, can hardly fail to give the utmost confidence that results of the greatest value can be obtained along this line. A total fuel efficiency exceeding 35 per cent. for both low and high temperature heating is certainly attainable, and probably a still higher efficiency may be secured from operations on a large scale. It is in this direction that we must look for the best immediate results of electric heating in domestic life. Electrical engineers realise that the ordinary light and power station is wasteful as a heat generator and distributor, and one of the ways to improve these conditions is to introduce a basis of supply in which the load factor is a larger percentage of the station capacity and in which low temperature steam distribution may also be utilised. This study deserves the greatest possible care, and while data are occasionally available there is still much to be learned.

In the modern "apartment house" we find it possible to effect a comparatively high distributive heat efficiency. The rooms are heated by low-pressure steam or hot water radiation and the hot water for laundry, bathroom and cooking purposes is also supplied. Electric lighting is available, but low heat efficiency is found in cooking except in cases where gas is available. No one can question the value of gas as a fuel in cooking; we may, however, take the ground that when a boiler plant is required for room and water heating, and the electric plant for lighting, the use of gas in cooking is unnecessary and comparatively expensive, for it is a form of heat supply not as effectively localised as electricity and is accompanied by many disagreeable features. In these houses electricity is already in use instead of alcohol for heating conveniences, also for heating sad-irons for laundry work and pressing; and it appears to be a question of time only when electric ovens and other cooking utensils will replace the range or the gas stove on a considerable scale. The "apartment house" supplied with its own boiler and electric lighting plant, approaches more closely the proper conditions for electric heating than any other mode of domestic life, as all the conditions essential to economical working are already present.

The foregoing deductions have been introduced to indicate broadly wherein the true economical basis of electric heating lies. Like all general considerations they are qualitative rather than quantitative in character. We find in industrial and commercial practice a great number of heat applications, either at high or moderate temperatures, in which close regulation and facility of control are necessary and where electric heating on some scale is applicable.

The introduction of electric lights and motors has brought into use in central stations and isolated plants a vast amount of electrical generating apparatus, so that at the outset our problem is largely one of applying electric heating apparatus on circuits already established, primarily for other purposes. On these circuits we are usually able to supply apparatus to do the work required better than it is at present accomplished. First cost and cost of operation are not the sole considerations in any apparatus; in addition to the cost, the collateral advantages derived from its use must be considered.

In domestic work there have been large numbers of household conveniences sold. Perhaps novelty was in many cases the reason for first purchase and use, but once used the value of the method of heating is well appreciated and extensions are made to more and different work. In this slow and conservative way electric heating in households is progressing, and there are indications of a more rapid general reception and use

There are some installations in which all or nearly all the cooking is done by electricity. These are generally successful and economical, according to the degree to which extensive water heating is eliminated. Laundry and pressing irons are found almost uniformly satisfactory. Some of the devices used in the dining-room are counted great conveniences when electrically heated. When it comes to the kitchen the same feeling of cleanliness and refinement of methods as for the dining room is expressed and hoped for, but the housewife is not so intimately in contact with the apparatus, an ignorant manipulation is encountered, which, however, generally does no other harm than to add to the expense of running. But, fortunately, the manipulation and control of the devices is so simple and saves the servant so much mork that an honest effort is usually evidenced to use it economically.

In industrial work the progress of electric heating has been more rapid than in domestic applications, with the exception of the electric sad-iron. There are cases where heating by electricity is found cheaper than by fuels, setting aside all collateral advantages. In electric cars the more equable distribution of heat; on a satisfactory basis of effective warming is sufficient to employ the method and apparatus even at considerably greater cost than former methods of heating.

We have before us for the future two methods for the distribution of heat; the first, a multipotential heat system in which steam and electricity simultaneously are the means of transmission; secondly, a constant-potential heat system in which electricity is employed as an agent for diffused heat work in large volume, and the heat of resistance, either directly or with the additional heat of combustion of carbon, is used for high temperature purposes. The first is a combination of well-known engineering practices and represents elements in successful use at the present time.

The second method is more difficult, as it includes new methods of applications and untried apparatus. For the present we have to approximate the probable final conditions by using materials at hand so far as they will go with reasonable economy, using every energy to broaden the general conception of the help and convenience arising from central station heat supply.

It has been thus far assumed that the development of electric heating depends solely upon engineering conditions without reference to the state of the art of the appliances themselves. Unfortunately, the lack of sturdy resistances of high rates of heat impartivity has materially retarded commercial progress. Factors of safety have been too low and rates of working too slow. We are still without a satisfactory heat insulation, and in practically the same position as the electrical industries prior to the use of mica.

A circular gas burner will impart heat at a rate equivalent to 35 watts per superficial square inch. Electric stoves made for 110 volts will work at about one-third this rate. This is a serious hindrance to electric cooking and high temperature applications. Far better apparatus could be made for lower voltages, and in this respect the state of the art closely resembles the situation of tungsten and tantalum lamps which are simply high temperature heating applications.

Since Dr. Lindeck's Paper on "Material for Wire Standards of Electrical Resistance" was presented before the International Electrical Congress in Chicago in 1893, the only alloy that has been offered for resistance purposes is the nickel-chromium product; that is, in 15 years, notwithstanding the marked development in electrical furnace work, there appears to have been but one new alloy brought out in commercial form.

Attention is called to these points to emphasise the need of further research work in materials and processes for good commercial work. The heaters on the market to-day are greatly improved over the product of 15 years ago but there are still wide gaps to be filled Localisation of heat at high temperatures with negligible heat capacity are the prime requisites of an electric heater. Without adequate heat insulation, with resistance material of comparatviely low specific resistance and high voltages in commercial practice the average design is far removed from the ideal.

DISCUSSION.

Mr. C. E. WADDELL said that when comparing electric heating with fuels in the realm of domestic heating, the fact should never be lost sight of that by means of electrical measuring instruments the quantity of heat delivered by the electrical apparatus could be accurately determined; whereas in the case of fuel apparatus, while the calorific value of the fuel itself might be known, the efficiency of such apparatus was so variable and uncertain that its economy was largely a matter of conjecture. In the case of a thickly populated district, the use of exhaust steam for heating had been demonstrated as profitable and desirable; and, as Mr. Hadaway suggested, conditions might be such that it might be profitable to generate electricity for high-potential applications and use the exhaust steam for quantity work. It would appear that the scope of such a plant might be widened by applying the electric heat in districts too remote from the generating station to justify the installation of underground steam mains. It would not do to dismiss the whole subject as one unworthy of serious consideration. It must be remembered that the world's coalfields were being rapidly depleted, that natural gas areas were limited, and that wood as a fuel had even now virtually disappeared. Sooner or later electricity must necessarily become a factor in the field of heating. Where electricity generated from water power was obtainable, and where storage of the water through the night hours was impracticable, electrical energy for heating could be obtained at figures

closely competitive with fuels. The problem in such cases became one of storing the energy of the water power in the form of heat, which brought up the all-important feature of heat insulation. Supplying electricity for heat as a by product, with a view to maintaining a high load factor on the plant, either steam or water, was a subject that would bear careful investigation in the majority of small steam and all hydro-electric plants. Another point was that not only the quantity but the intensity of heat in domestic applications was essential to success. Formerly the speaker attributed the asserted inferiority of the large, low-temperature electric radiator as compared with a small open fire to the idiosyncrasy or psychical peculiarity of the individual rather than to any physical difference. More recently he had revised these views, and had found that in many instances a smaller quantity of heat with which was blended an even smaller quantity of high temperature radiation was extremely grateful. If electric heating was to be introduced upon a large scale into house warming, it would be necessary to accord the art of heating and ventilating more scientific attention than was now usually bestowed upon this class of work. The argument that heat obtained from electricity equivalent to that obtained from fuels was so high in cost as to be practically debarred from general use was scarcely logical in view of modern experience. The incandescent light, for instance, though more costly than either candles or kerosene lamps, had in a large measure supplanted both. Finally, there was one other class of quantity work to which attention had not been directed. In drying materials on a large scale—lumber, cotton yarn, &c., the heat that was supplied was merely a means artificially to accelerate a natural process. With a moderate amount of heat applied where needed and a skilful use of air currents, an apparatus more efficient than ponderous steam apparatus appeared possible.

Mr. W. N. Ryerson said that Mr. Hadaway had pointed out the limitations in the use of electricity for maintaining an equable temperature in buildings during the season of cold weather, and at the present time his remarks were undoubtedly to the point. There were instances, however, in which comparison between the use of electricity and other heating agents on the basis of cost led to erroneous conclusions. An instance in point was the office building of the Ontario Power Co. at Niagara Falls which was equipped, under the plans of the architects, with a low-pressure steam heating system, having an auxiliary hot-air system with forced draught; the idea being to maintain a pressure in all the outside rooms sufficient to prevent cold air coming through the cracks in the window frames, &c. The air in this auxiliary system was intended to be heated by a steam coil in the discharge of the circulating fan. Before this system was put in use, the speaker designed an electric heater to take the place of the steam coils, and after having been in use for the last two winters it had been found that the low-pressure steam system was entirely unnecessary, a comfortable temperature being maintained in the coldest weather by the electrically heated hot air. During the last winter it was found that the use of the boiler was only necessary for 25 days, and that during the remainder of the time the electric heaters in the office building and switchboard room were sufficient for all purposes. For the present and until some material capable of delivering heat at a higher rate than any resistive metal now known was found, the principal application of electricity would be in articles where the heating must be closely confined. The superiority of these articles was well recognised.

Mr. W. S. Andrews considered the use of electricity for performing ordinary cooking operations. The real difficulty consisted in providing a hot-water supply economically. At the price of 2½d. per kilowatt-hour, the cost of heating a gallon of water from faucet temperature to boiling at an efficiency of, say, 80 per cent. was a little more than 1d., which, to many people, would be a prohibitive price, especially as the same results could be accomplished with gas for very much less. Apart from the question of water heating, however, the operations of baking, broiling, frying, toasting, &c., by electricity could be accomplished at a reasonable expense, when electricity was sold at the rate of 2½d. per kilowatt hour, taking into due consideration the collateral advantage of being able to raise utensils to a high temperature with localised heat, thus keeping the kitchen much cooler in hot weather than was possible when using a coal or gas range. For several years past the speaker used electricity for cooking purposes in his home during the summer months. Water only was heated by a gas arrangement attached to the kitchen boiler, but all other heating and cooking was done by electricity at an average cost of 18s. per month. He estimated that the average cost of heating water by gas amounted to about 6s. per month, making an average total expense of 24s. per month for cooking three meals per day for a family of four. This outlay also included the heating of water for laundry work and the use of an electric iron. His experience showed that an ordinary breakfast, including cereal, coffee, toast, and broiled meat, sufficient for two or three people, could be cooked by electricity with an expenditure of about 1 kw.-hour, the various devices averaging as follows, on a liberal basis :—

Cereal cooker,	600	watts for	20	min.	= 12,000	watt-minutes.
Coffee percolator,	600	,,	20	,,	= 12,000	..
Bread toaster,	600	..	10	..	6,000	..
Meat broiler,	1,500	,,	20	,,	= 30,000	..
					60,000	..

Or 1 kw. hour at a cost of 2½d.

These instances showed that good service could be rendered at a reasonable expense by existing devices, but he quite agreed with Mr. Hadaway in his statement that we were still far removed from ideal conditions. In a recent lecture on this subject Dr. Steinmetz went to the root of the whole matter, in discussing the possibilities of greatly reducing the cost of electricity by improving the station load factor, aiming to get a steady and uniform load throughout the 24 hours of the day, when he said: "When we have accomplished that, electric power will be much cheaper than anything else and then the end will come for gas and kerosene. And that time *will* come some time and we will probably see it." Mr. Hadaway cited some favourable cases, such as first-class apartment houses in large cities, where steam heat, hot water, and electricity were supplied to tenants, and where, therefore, electric cooking might be performed economically, provided only that the price of electricity was reasonable. It was nevertheless generally true that the cost of heating water by electricity for domestic purposes, at ordinary rates for current, presented an almost insuperable obstacle to its common use, excepting in a small way, such as for hot-water urns, coffee percolators, and similar table devices. The speaker believed with Mr. Hadaway that the field of industrial application would eventually be found equally if not more extensive and profitable than the domestic side. There was thousands of operations where heat was now applied to various parts of machines in a cumbersome and inconvenient way by steam and gas where electric heat would be not only more cleanly and hygienic, but also more economical in the long run, on account of the especially favourable feature of being able to localise the heat where it was required, and other considerations covered by a variety of special conditions. In regard to the heating of air in buildings, Mr. Hadaway had shown in a general way that the present cost of electricity when supplied from large generating stations made extended applications prohibitively expensive. In a few special and isolated places it was applicable, also for emergency cases where a maintenance or rise of temperature might be the means of saving valuable property, as in conservatories and greenhouses, the value of these appliances was very evident.

Mr. H. P. Ball said the feature of the electric heating subject with which he was most interested was the design of the apparatus. Mr. Hadaway gave some comparative figures, stating that a circular gas burner would impart heat at a rate equivalent to 35 watts per superficial square inch, and electric heaters about one-third of this amount, or about 12 watts to the square inch. He did not say how this gas burner was measured, but it might have been an annular surface, the surface of the flame, or the area of a circular disc; in any event this rate could be exceeded. It was perfectly feasible by using modern materials, such as the new nickel-chromium metal and infusible insulating materials, to operate with watts running up as high as 20 on open stoves, and as high as 25 or even 30 on stoves which were used in connection with percolators or water heaters. It appeared that high temperature was the immediate field for electric heating devices, with the wide distribution of heat as something for the future, perhaps, but to-day the business to be had was in sad-irons and other devices where the heat was concentrated in small areas. He called attention, therefore, to the absolute necessity of getting away from easily fusible materials, and adhering to the use of very high melting resistances mica, as the insulator, on account of its extreme thinness and high insulation test, standing, as it did, from 1,000 to 1,500 volts per mil of thickness, and metals, such as aluminium-bronze, which would readily oxidise in the air at high temperatures. As to the problem of heating rooms, the ideal arrangement would be the use of an exposed resistance conductor in the form of a thin but wide band, so as to have a maximum radiating surface, causing the conductor to operate at the lowest temperature; for it was a well-known fact that if a conductor was surrounded with insulating material the conductor would run at a higher temperature for the same dissipation than if it were exposed in the open air. In a sad-iron or water heater it was necessary to enclose the resistance, and in doing this it must be supplied with a maximum surface by using flat ribbon resistances, and a material with a minimum thickness be used, such as mica, in order to get the heat out of the conductor into the thing being heated with the least possible thermal drop. In a sad-iron the unit could be run at a very high current density on account of the specific capacity for heat of the surrounding iron; but in the water heater must be restricted to lower densities, and care must be exercised to see that the surrounding material was a minimum thickness, in order that the electrical energy and time taken in raising the temperature of the device up to its working temperature was the least possible.

Mr. Max Loewenthal thought that there were many figures to prove that electrically heated appliances were as efficient, and frequently more efficient, than the same appliances heated by other means. He took the case of an oven. The efficiency of an ordinary cooking-stove using solid fuel was only about 2 per cent., 12 per cent. being wasted in obtaining a glowing fire, 70 per cent. going up the chimney, and 16 per cent. being radiated into the room. In a gas stove, considering that the number of heat units obtainable from the gas at a certain price was but small compared with solid fuel, the ventilating current required for the operation alone consumed at least 80 per cent. of the heat units obtained by burning the gas. In the case of an electrical oven more than 90 per cent. of the heat energy could be utilised; and thus, although possibly 5 to 6 per cent. only of the heat energy of the fuel was present in the electrical energy, 90 per cent. of this, or 4·5 per cent. of the whole energy actually went into the food. Thus the electrical oven was practically twice as economical as any other oven, whether that oven was heated by solid fuel or by gas. Furthermore, the comparative operating cost of electric and gas cooking depended upon two conditions; the relative rates for gas and electric heat units, and the relative heat efficiencies of gas and electric apparatus. A third quantity, the effect produced by the different rates and modes of heat applications in the two classes of utensils, might effect the efficiency slightly, but the existence of this effect was not yet verified. Starting with the heat of coal, which might

be fairly estimated as 12,000 B.T.U. per pound, the relative efficiency of the heat conversion was computed as follows:—

Gas.	Electricity.
1 lb. of coal produces 5 cubic ft. of gas. 5 cubic ft. of gas contain 3,000 B.T.U.	1 lb. of coal produces 0·25 kw.-hour. 0·25 kw.-hour 853 B.T.U.
Efficiency of heat conversion is $\frac{3{,}000}{12{,}000}$ 25 per cent.	Efficiency of heat conversion is $\frac{853}{12{,}000}$ 7·1 per cent.

$$\frac{\text{Efficiency electrical heat conversion}}{\text{Efficiency gas heat conversion}} \quad 28{\cdot}4 \text{ per cent.}$$

With manufacturing processes of equal cost per pound of coal converted, it was apparent that an electric heat unit must cost nearly four times as much as a gas heat unit, but with present processes the relative rates were:—

Gas.	Electricity.
4s. per 1,000 cubic ft.	0·48d. per kw.-hour.
1 B.T.U. 0·000083d.	1 B.T.U. 0·001465d.

$$\frac{\text{Electric B.T.U. } 0{\cdot}00293}{\text{Gas B.T.U. } 0{\cdot}000167} \quad 17{\cdot}5$$

It was known that the efficiency of electrical apparatus was about four times that of gas, and consequently, as the gas utensils require four times as many B.T.U., the above figure of 17·5 was reduced to 4·4. If, then, the rate for electricity was reduced to one-quarter of that assumed, or 2·5 cents per kilowatt-hour, this figure of 4·4 was changed to 1·1 and they had practically identical operating costs. This ratio had been borne out by numerous tests.

Mr. C. P. Steinmetz said that when using electric energy in producing heat energy for heating, cooking, baking, &c., they were confronted by the enormous handicap of the inefficiency of the thermo-dynamic engine. As electric power at the switchboard of a station they got only from 8 to 10 per cent. of the energy of the fuel burned under the steam boilers, and had lost 90 per cent. or more. When converting again this electric energy into heat energy, they could get only the same very small percentage of the heat energy of the fuel that was contained in the electric energy and this greatly handicapped the use of electric energy in those cases where large amounts of heat were required, as in water heating. Therefore they always heard electric heating engineers refer to the use of gas or hot water or steam for the cases where large amounts of heat were required, as in water heating, or house heating, and reserving the use of electric heating for those applications where the heat capacity was small, as in cooking and baking, or for intermittent use, or where the convenience, and cleanliness of electric heating outweigh other considerations. They looked to future improvements in the production of electric power, and to improvements in the load factor, to bring the cost of electric power down to such values as to compete in economy even in such fields as house warming, water heating, &c. It was this statement of the inefficiency of electric heating, due to the inefficiency of the conversion of the heat energy of fuel into electric energy, that they desired to challenge. It was true that each kilowatt-hour of electric energy contained only a definite number of units of heat energy and that the heat energy produced by the conversion of the electric energy into heat could therefore never exceed 850 calories of heat energy per kilowatt-hour, or about 8 to 10 per cent. of the original heat energy of the fuel. The problem of electric heating was, however, not to produce heat energy from electric energy, but to raise the temperature of the air or some other objects by increasing the quantity of heat contained in them. This did not necessarily require producing the quantity of heat; it could be done by raising an existing quantity of heat to higher temperature, or higher heat level. In the thermodynamic engine, they supplied a quantity of heat, at higher temperatures. Of this, a small part, say 10 per cent., was converted into mechanical energy, the remaining 90 per cent. being given off, "rejected," as heat at atmospheric temperature. The thermodynamic cycle, however, was reversible, and by performing it in the reverse direction, they could take the 90 per cent. of heat at atmospheric temperature; that is, from the air, or the water supply, and by the conversion of the 10 per cent. of mechanical energy into heat in the reversed cycle raise the other 90 per cent. of heat from atmospheric to the higher temperature, and thus supply again the 100 per cent. of heat at the same theoretical temperature at which they were supplied to the thermodynamic engine in the direct cycle. In this case they would supply at the higher temperature 10 times as much heat as corresponded to the consumed electric energy; but this heat was not produced from electric energy, 90 per cent. had merely been raised from a lower level, lower temperature, to a higher temperature. It was thus possible to supply, at the moderate temperature rise required by electric heating devices, many times more heat than the calories of heat energy corresponding to the consumed electric power, a larger quantity of heat even than the total number of units of heat energy of the fuel consumed in producing the electric energy, without infringing the law of conservation of energy. With a relatively moderate expenditure of electric power, such a thermodynamic engine could be operated between two temperatures, one above and one below atmospheric, and thus used to heat the houses in winter or cool them in summer. Air, taken at atmospheric temperature, was heated by adiabatic compression; its heat was abstracted; then the air was expanded and thus cooled below atmospheric temperature, and heat supplied to it until atmospheric temperature was restored. Thus between compression and expansion, heat was given off above atmospheric temperature; and between expansion and compression heat was taken in below atmospheric temperature; that is cold given off, and as the work done by the expansion supplied most of the work of compression, electric power had to supply only the differences; that is, a part of the energy representing the heating or cooling effect. Obviously, in summer the higher temperature, in winter the lower temperature, would be rejected by exhausting into the air and taking in a fresh volume of air at atmospheric temperature. Such a thermodynamic heating apparatus should be able even with the present cost of electric power to make the cost of electric heating comparable with that of direct heating by fuel.

Mr. T. Wolcott (communicated) thought that Dr. Steinmetz's statements about thermodynamics were misleading. It was not true that, by reversing the cycle, the original temperature could be restored to the whole amount of heat, even theoretically; for the fall from fire to boiler temperature was a completely non-reversible process, and entirely outside the reversible cyclic process. To be sure, if they were able to work down to absolute zero, all the energy of heat of any finite temperature would be available, and the drop between fire and boiler would be of no consequence; but, with a finite lower limit of temperature, such as Mr. Steinmetz used this drop was of the greatest importance. Secondly, if the expansion was carried below atmospheric temperature, as Mr. Steinmetz said, efficiency was sacrificed; it was precisely because the expansion was isothermal at atmospheric temperature, in the apparatus described by Lord Kelvin, that the efficiency was high.

Mr. W. S. Hadaway, Junr., in reply, said concerning some of the criticisms of the Paper, it had been his effort to make it very conservative. The logical way to look at the matter was to conserve the fuel supply so far as it could be made to go. From a business standpoint, and it was really the business standpoint that determined the engineering features, it had been shown conclusively that a demand for electric heating apparatus had been created which must be met. It had become in many ways not so much a question of what the efficiency was as of results attained. In the construction of apparatus the one important factor which remained to be solved at present was the question of heat insulation. If they were building ships in which they had to figure a certain percentage of tonnage capacity set aside for pumps to keep the ship afloat, they would be in relatively the same position as the manufacturer of electric heating devices to-day so far as energy inputs were concerned. They had no practical method of confining heat at high temperatures. The statement that the gas burner corresponded to something like 35 watts per square inch was based on laboratory work, in which gas stoves of ordinary construction with annular burners, and with outside dimensions of approximately 6 in., were compared with an electric heater upon which a vessel of the same size was used on the two devices. It should be added, however, that the limitation of the watts per square inch was not necessarily as low as 12 watts, because on low voltages apparatus had been successfully used up to as high as 40 watts per square inch. The voltage situation, however, particularly on 220 volts, was a difficult proposition to handle, because apparatus built for this voltage had one-fourth the resistance cross-section of apparatus built for 110 volts, and the electrical insulation had also to be somewhat increased. The logical development in voltages was towards a decrease rather than an increase in the same way that the logical development of quantitative work in heating was the centralisation of all the heating values at one point and the distribution of them over short distances to secure the highest fuel efficiencies in combination with the advantages which the electric heating devices gave.

THE REV. H. B. GRAY'S ADDRESS TO THE EDUCATIONAL SCIENCE SECTION OF THE BRITISH ASSOCIATION*

The Educational Factors of Imperialism.

Notoriously difficult as it is to gauge the temper of an age while we live in its midst, yet the phenomena in England at the beginning of the twentieth century seem so unmistakably marked that even a superficial thinker can hardly fail to recognise the spheres in which the symptoms of change and unrest are clearly operating. They are surely in these two—the sphere of education and the sphere of Imperial sentiment. It may not appear inapposite, therefore, if, meeting as we do in this city of phenomenal growth and minute enterprise, our thoughts were to be directed in my inaugural address on the Science of Education towards discovering what may be either called the Imperial factors in education or conversely, and perhaps more properly, the educational factors in Imperialism. It may be perhaps safely said in this great Dominion what might possibly be disputed in the academic groves of our ancient English universities, that there was no width of educational outlook within our own little island until the last 30 years of the nineteenth century.

The only strongholds of learning which presumed to give the lead to English secondary education were to be found on the banks of the Isis and the Cam. In these antique, I hesitate to say antiquated,

* Abstract of the Presidential Address delivered by the Rev. H. B. Gray, D.D., at Winnipeg.

fastnesses the "grand old fortifying classical curriculum" was, till lately, regarded as the main, if not the only, highroad to educational salvation. Opprobrious epithets have been bestowed on the study of the natural sciences, while those modern linguistic achievements which opened the door to the treasures of French and German literature are still nothing accounted of in the great schools of England. But (more marvellous than all) even the scientific acquisition of and familiarity with the literature of the mother tongue have been entirely neglected, because no room could be found for it in a time-table, three-quarters of which is confined for the great mass of boy students in the historic schools of England to the exclusive study of the grammar, literature, and composition of the languages of ancient Greece and Rome. And the particular methods pursued in this confined curriculum have rendered the course more straitened still. The acquisition of the literatures of the two dead languages and of the great thoughts buried with them have given place to a meticulous study of the subtleties of scholarship, and students are taught to wanton in the abnormalities of the words and phrases in which those literatures were enshrined, so that in the mind of the classical scholar the form has become, or at any rate became till quite lately, more important than the substance.

There has been no serious attempt made till the twentieth century by the leaders of our best-known places of secondary education to discover the bents and aptitudes of the boys committed to their charge and to give them any educational chance, if they have not possessed that particular kind of perception which could find its way through the subtleties of a Euripides or a Horace. Boys have been entirely denied the opportunity of showing their mental powers in any other sphere of learning. In how many, or rather how few, places of learning in England, at the present time, can the establishment of scientifically equipped carpentering and engineering shops be found in which a young mind which finds it impossible to digest the crude morsels of Latin and Greek grammar can find resource and development? In how few schools has the connection between mind and hand and eye been scientifically trained? Such establishments, even in the first decade of the twentieth century, can be counted on the fingers of one hand.

What remedy have I to propose? My answer is this: I want to force upon the attention of English educationalists certain Imperial factors which should occupy an indispensable place in the educational curricula of the great schools in the Mother Country. I would give a prominent place to the scientific teaching of geography, and particularly to historical geography, with special reference, of course, to the origin, growth, and progress of the British Empire. Such a volume as the "Sketch of a Historical Geography," by Keith Johnston, should be placed in the hands of every boy, and be known by him from cover to cover. It can hardly be realised that in many of our great classical schools to this day not more than one or at most two hours a week are devoted to this subject, and that it is often not taught at all beyond the middle classes in a school. Again, I would enforce an elementary knowledge of science on every boy who passes through the stage of secondary education. I am aware that many hard things have been said about the teaching of science in secondary education. A learned professor, who is the President of another Section of the Association, has passed his opinion that, as taught in our schools, it has proved of little practical or educational value. But because the methods employed have been halting, insufficient, and unscientific, it by no means follows that it should be left out of the category of school subjects. On the contrary, it appears astounding that two-thirds of the public school boys of England should grow to man's estate without even an elementary knowledge of the laws of the world in which they live. To one who aspires to seek his fortune in the wide and half-unexplored continents of Greater Britain the value of the knowledge of chemistry, geology, botany, and arboriculture, can hardly be over-estimated. And yet many present here could bear critical witness to the fact that a large proportion of young men go out to the North-West totally unequipped after their public school training with even the most elementary knowledge of those departments of science to which I have alluded. No wonder "No English need apply." Every youth we export to you ought educationally to bear this label on his back: "Every seed tested before being sent out."

But above and beyond all there should be brought into the foreground a co-ordinated study of English language and English literature. Nothing impressed me more in my visit to the United States in 1903 as one of the Mosely Commission, than to observe how greatly the cultivated classes in the Federation outstripped our island-bred people in the facility and power with which they manipulated the English tongue. Awkwardness, poverty of expression, and stammering utterance mark many Englishmen of high academic distinction. But the American who, on account of the incessant tide of immigration, has to assimilate the congeries of all the nations of the earth in the shortest possible space of time, has so co-ordinated the study of his ancestral tongue in the schools of his country that the pupil emerges completely equipped for the use of persuasive and oratorical language wherein to express his thoughts and wherewith to gain his ends. In connection with this may I add that it was, indeed, a happy augury that, at the eve of the meeting of the British Association in this great Dominion, there should have been a gathering of delegates of the Imperial Press in the centre of our small island home.

Let me touch on one further educational factor of Imperialism. The sentiment of patriotism, unlike that of charity, is not equally capable of indefinite intension and extension. The peculiar system of education which finds vogue in England in most of our greatest institutions—the institutions from which are drawn the future leaders of the nation—is, as everyone knows, the barrack system, otherwise called the boarding system. It is not the time or place here to enlarge on the obvious advantages of that system, its unique characteristics, its power of moulding character and developing enterprise. But it has its cramping and confining side—it has a tendency to localise patriotism, to narrow a young man's mental horizon, and to ignore whatever lies outside its immediate survey. Hence the abnormal and gladiatorial devotion to games and comparatively selfish amusements, which absorb, and, in my opinion, not seldom paralyse and stifle wider, more generous, more enlightened—in fine, more Imperial instincts. However much in the field of sports the individual youth may subordinate his own self-regarding impulses to the welfare of the tiny community for which he is exercising his energies, his horizon is not wide enough to bid him rise to a sentiment of self-sacrifice and self-abandonment on behalf of a greater and more abstract ideal—love of Fatherland and loyalty to Empire.

But it is a welcome thing to be able to point to a larger sentiment lately awakened in this direction. There is no doubt that the patriotic spirit in our schools and colleges has, from whatever cause, received a great impetus in the last two years, and that the general principles of an intelligent defence of our shores from foreign aggression have been taught and construed into terms of scientific training and co-operative action with a rapidity equally surprising and welcome to those who, a few years ago, looked with something more than apprehension on the supineness of the youth of England in all patriotic regards.

"The flannelled fool and muddied oaf."

though they have not yet received their quietus, have been less rampant lately in our educational institutions, and something like an Imperial instinct, born of increasing knowledge both of the glory and dangers of our vast Empire, has, at least in the more cultured classes, taken the place of apathy, disregard and ignorance. In hours formerly lavished to an abnormal extent on trivial amusements, and even in hours hitherto devoted to more academically intellectual training, we find young men in our schools and colleges now with arms in their hands, shooting, signalling, scouting, and studying scientifically the art of defensive warfare. This at least is "a beam in the darkness, of which we pray that it may grow."

In criticising the old mediæval system of education which prevailed in England till comparatively recent years, and which still has far too great a hold on the more venerable and important institutions of our island home, I would not have you suppose that I am an advocate of a complete, or even approximately complete, basis of utilitarian education. I have little hesitation in expressing my belief that the time has come (and I speak as one whose training was that of a classical scholar, for I was brought up in the straitest sect of academical Pharisees) when the study of the two ancient languages should be reduced to one for all except scholastic specialists, but also that both should yield pride of place in our educational system to the claims of English, modern languages, mathematics, natural science, and, not least, manual training, so that our young men should be fitly equipped to put their hand to any work which may confront them amid all the complex problems and critical situations to be found within the world-wide boundaries of the British Empire. Germany, France and the United States have been beforehand with us in the working out of such a reformed system of education. I am by no means one of those who believe that we should be wise in copying the methods in their entirety of any of these three peoples in their educational methods. Undoubtedly in all three there has been a more organised connection between the actual teaching given in their respective schools and the industrial, social, and political needs of the respective peoples. But no one nation is exactly like another nation in its temper and genius, and I should be sorry to advocate, for instance, the highly organised system of State education in Germany, under which it could be predicted to a certainty that boys and girls in every secondary or primary school on any given Friday morning should be studying (say) the geographical importance of

Natal or the outlines of the coast of Lincolnshire. There must be many educational differences, because the idiosyncrasies of each nation differ from those of another, and I do not think we need ever fear that our intrinsic individuality will be crushed into any Teutonic cast-iron mould or ground down beneath the heel of some bureaucratic educational despotism. But that we ought to change our ways still more than we have, and adopt saner educational models, many searchings of heart through a long educational career have gradually, but overwhelmingly, convinced me. If we are apt to think, speak, and act Imperially, our education must take form from a strong Imperial sentiment, and must aim at instilling Imperial instincts in the young lives which that education is meant to control and develop.

As regards the subject of University education, whether Oxford and Cambridge—particularly Oxford—will ever so reform themselves as to contribute largely to such solution remains to be seen. Personally, I look with far greater confidence to the more recently organised universities—those of London, Leeds, Sheffield, Manchester, and the like—to equip men educationally with those moral, physical, and intellectual qualities which are most in requisition in our great dependencies and commonwealths.

There is still one more educational factor on which I would ask attention. It is the necessity of a closer touch educationally (in the sense of "academically") between the secondary schools and colleges of the Mother Country and similar institutions in the great Dominion and commonwealths which own her parentage. How this can be effected without great modification of our existing English system it is hard to see. But one point is quite clear. We must give up that part of our system which insists on choking the passage of the student from point to point in his educational career by subjecting him to countless examinations on entrance and throughout his academical course. It would be of incalculable advantage to the Empire at large if an extension of educational intercommunion, such as was inaugurated by the noble benefactions of the late Cecil Rhodes, could be secured throughout the Empire. Undoubtedly examination would be the surest test for determining the question of the admission of a student to the privileges of further education, if such examination could be conducted within a limited geographical area. But it is quite an impossible system if adopted as between the outlying parts of a great empire. The United States of America have taught us a better way. For instance, in the State of Minnesota, the university has legislated that if and when the principal of a high school of recognised position certifies that a student has successfully pursued for a specified length of time those studies in that high school that would entitle him to admission to the university, he should be admitted thereto without further delay or hindrance. What a paralysing curse the Charybdis of examination has been to all true learning, only those who have suffered from it for 30 years can bear adequate testimony. It would be one of the most fertilising sources from which to secure good and progressive citizens, if instead of admitting within her borders all or any who came of their own spontaneity or from compulsion (leaving their country perchance for their country's good) the Government authorities in the Dominion could get into closer touch with the educational authorities of the Mother Country, who would act as guarantee that the material sent out by the Mother Country should be of an approved and first-rate quality. This might be worked on the American "accredited school" system, under which the authorities of the school sending the pupil should feel the maximum of responsibility in recommending his admission to the academical, or the technical, or the industrial organisations existing in the Dominion.

Since penning the first sentences of the above paragraph last June the author noticed an article which appeared in the columns of the "Times" on the 28th day of that month, which deals with this subject and which was quoted verbatim in the address. In it are given particulars of a new educational movement to provide for the interchange of University students among the English-speaking peoples. It is quite certain that I am interpreting the sentiments of all here assembled in wishing God-speed to the development of the scheme, which seems likely to prove, if carried into effect, a great, if not the greatest, educational factor of Imperialism.

The last point on which I would insist in dealing with the educational factors of Imperialism is to emphasise the importance of what the educationists of the United States call "civics" as the binding power which should fasten together all the separate educational faggots in any Imperial scheme of education—the duty of personal service to the State, the positive obligation which makes us all members incorporate in one Imperial system. In our love of individual freedom, in our jealousy of interference with our individual liberty of action, in our insular disregard and depreciation of intellectual forces working in our sister communities beyond the seas, we have lost sight of this civic responsibility which has ever lain on our shoulders and from which we can never dissociate ourselves, so long as our Empire remains as part of our ancestral heritage. It is this positive duty towards each other and our race beyond the seas which those who live in our island home have been slow in realising, and it has been a real blot on our educational system that such ideas as Imperial responsibility and Imperial necessities have not been inculcated in the young people in our schools and colleges. As an illustration, I may observe that it has been even debated and doubted in some responsible quarters in England whether the Union Jack should wave over our educational institutions on the days of national festivity and national observance.

To sum up. By these, and other kindred means, I would urge a closer educational touch between the Mother Country and the Empire at large. Long ago a great Minister was able to say: "Our hold of the Colonies is in the close affection which grows from common names, from kindred blood, and from similar privileges. These are ties which, though light as air, are strong as links of iron." But times have changed. To-day we are confronted with the problems of a vast and complicated Empire—great commonwealths, great dominions, sundered from each other by long seas and half a world, and however closely science has geographically brought them together, we cannot in soul and sympathy, nor ultimately in destiny, remain attached, affiliated as mother and children should be, unless we grapple to each other and understand each other in the greatest of all interests—the educational training which we give to our children in the one part of our Empire, to make them suitable citizens in another.

THE CALCULATION OF CHARGING CURRENTS IN THREE-PHASE CABLES.*

BY PROF. E. W. MARCHANT, D.SC.

The determination of the capacity current flowing into a three-phase line consisting of an overhead system with three wires, or of a three-core cable, is a subject which has not been dealt with to any great extent in England, though many formulæ have been given and tables have been prepared for this purpose. Lichtenstein also has given a formula for determining the charging current to a three-core cable.

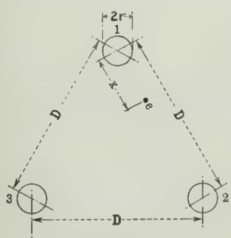


FIG. 1.

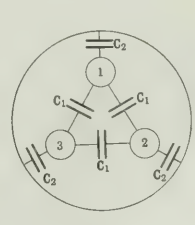


FIG. 2.

In the first place, it should be noted that the determination of the charging current flowing into any branch of a three-phase system cannot be determined by calculating successively and adding the charging currents which would flow due to the capacity between one part of the system and another, assuming that the voltage between these two parts of the system is known—that is, if C_{12} be the capacity between (1) and (2), and $V_{12} \sin pt$ be the voltage between (1) and (2), C_{13} be the capacity between (1) and (3) and $V_{13} \sin \overline{pt - \theta}$ the voltage between (1) and (3) and so on, then the total charging current flowing into (1) is not given by the vector sum of $(C_{12}V_{12}p)$ and $(C_{13}V_{13}p)$ and so on. The reason for this apparent anomaly is that the charges on the cores due to the various potentials of the different parts of the system are not in phase with each other, and that in determining the work done in carrying unit charge from one core to the other—that is, in determining the P.D. between two cores—corresponding with a given distribution of charges, the magnitude of the charges on the different conductors *at a particular instant* must be assumed and not the R.M.S. values of the charges.

Let us take, as an example, the simplest case—that of a three-wire overhead line, with the three wires arranged so as to form the three corners of an equilateral triangle (*see* Fig. 1).

* Paper read before the British Association, at Winnipeg.

The capacity between (1) and (2) per kilometre

$$=\frac{10^5}{4\log_e\left(\frac{D}{r}\right)}\text{ E.S. units}=\frac{1}{36\log_e\left(\frac{D}{r}\right)}\text{ microfarads.}$$

where D is the distance between the centres of the wires and r is the radius of the line wire, both quantities being measured in the same units and D being assumed large compared with r.

Assume now that the line shown in Fig. 1 is supplied with three-phase current.

Let the charge per centimetre on (1) $= Q\sin pt$, (2) $= Q\sin pt-2\pi/3$, (3) $= Q\sin pt+2\pi/3$. Then the work done in taking unit charge (e) from (2) to (1)

$$\text{due to the charge on (1)} = -\int_{D-r}^{r}\frac{2Q\sin pt\,dx}{x}.$$

$$\text{.. .. (2)} = -\int_{r}^{D-r}\frac{2Q\sin pt-\frac{2\pi}{3}dx}{D-x}$$

$$\text{.. .. (3)} = 0,$$

since (1) and (2) are equidistant from (3).

The total work done,

$$=2Q\sin pt\log_e\frac{D-r}{r}+2Q\sin pt-\frac{2\pi}{3}\log_e\frac{r}{D-r}$$

$$=2\log_e\frac{D-r}{r}(\sin pt-\sin pt-2\pi/3)$$

$$=2\sqrt{3}Q\log_e\frac{D-r}{r}(\sin pt-\theta),$$

where $\theta=\tan^{-1}\frac{1}{\sqrt{3}}=30$ deg.

If we put the P.D. $v=V\sin pt-\theta$,

$$V=2\sqrt{3}Q\log_e\left(\frac{D-r}{r}\right)$$

or

$$Q=\frac{V}{2\sqrt{3}\log_e\frac{D-r}{r}}=\frac{V}{2\sqrt{3}\log_e\frac{D}{r}},$$

since D is usually large compared with r.

The "effective" capacity per unit length is therefore $=\frac{1}{2\sqrt{3}\log_e\frac{D}{r}}$ in E.S. units, and the R.M.S. charging current per kilometre $=\frac{Vp}{31{\cdot}18\times10^6\log_e\frac{D}{r}}$ amperes, where V is the R.M.S. P.D. between the lines in volts and $p=2\pi\times$ frequency.

If we compare this result with the charging current that would flow in each line were two of them used for a single-phase installation and the other insulated, it is seen that the charging current with the three-phase supply is $2/\sqrt{3}$ or 1·155 times that with the single-phase supply. This result was first given by Baum and Perrine for an overhead line and has since been verified experimentally.

Assume now that we have a cable as shown in Fig. 2. Let the capacities between the two cores be C_1 and between each core and the sheath C_2. These quantities may be calculated or determined by measurement, by any of the ordinary methods.*

Let $v=V\sin pt$ be the P.D. between (1) and (2). The charging current due to the capacity C_1 may be determined very approximately by the same method as for an overhead line, when the cable is supplied with three-phase current, if the effect of the sheath is not considered.

It was shown above that the phase of the charge on core (1) was 30 deg. ahead of the P.D. between cores (1) and (2). Let the vector (OV_1) represent the star P.D. between core (1) and the sheath, and similarly for (OV_2) and (OV_3). Then the P.D. between cores (1) and (2) is given by (OV_{12}) which lags 30 deg. behind (OV_1). It follows, therefore, that the vector representing the charge on core (1) is in phase with (OV_1), the pressure between core (1) and the sheath, and may be represented by (OQ). The charging current corresponding to the charge Q leads by 90 deg. on the vector OQ, since i the charging current $=dQ/dt$. It may, therefore, be represented by a vector (OI_{c_1}) 90 deg. ahead of OQ.

Since the charge at any instant due to the P.D. between the line is in phase with the star pressure, and, therefore, with the charge on the core due to the capacity between the core and the sheath, the total capacity current flowing to the core may be determined by adding numerically the charging currents due to the capacities C_1 and C_2.

The maximum value of the charging current due to $C_2=\frac{V}{\sqrt{3}}C_2p$ amperes, since the P.D. between each core and the sheath is $V/\sqrt{3}$. The maximum value of the charging current flowing to each core is, therefore, given by

$$\frac{Vp}{\sqrt{3}}(2C_1+C_2)\text{ amperes,}$$

where V is in volts and C_1C_2 are measured in farads.

The same expression holds good for the R.M.S. value of the charging current, if V is taken to be the R.M.S. volts between the cores.

The capacity determined by a ballistic test between one core and the other two connected to sheath is equal to $2C_1+C_2$, and if we call this capacity $\overline{C}$, the charging current per line = star pressure $\times C\times p$.

Effect of Harmonics on Charging Current.—It is interesting to notice that, if a star-connected three-phase alternator be coupled to a transmission line or three-core cable, there will be no component of the charging current of triple frequency, however large the component of triple frequency may be in E.M.F. wave. The E.M.F. wave, in all such machines, is similar in the three phases, provided the windings are symmetrical, and therefore there will be no component of triple frequency in the P.D. *between two lines*. This fact is of some importance, as it eliminates the risk of resonance with triple frequency. There may be large triple-frequency currents flowing along the line connecting a three-phase generator and a

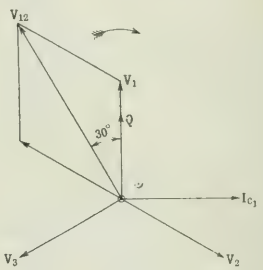


FIG. 5.

three-phase motor, both star wound, if the central points are connected to earth, but there can never be resonance on an overhead line. In a three-core cable, in which the neutral serves as the return, there is a charging current of triple frequency, but this is due simply to the capacity between each line and the sheath, and, in determining whether resonance is likely to occur with triple frequency, it is the capacity between the core and the sheath only that has to be taken into account. We know, further, that with a transmission line coupled to a mesh-connected generator or motor there can be no triple-frequency *current* in the line, and therefore with this connection there can be no resonance due to triple frequency components of the E.M.F. waves of the generators.

These results hold good not only for triple frequency harmonics but for any harmonic whose frequency is a multiple of three times that of the fundamental wave.

* Fleming's "Electrical Measurement," Vol. I.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Steam Power Plant Piping Systems." By Wm. L. Norris. (New York: McGraw-Hill Book Co.) 21s. net.

"Drawings for Medium Sized Repetition Work." By R. D. Spinney. (London: E. & F. N. Spon) 3s. 6d. net.

"Wireless Telephone Construction." By Newton Harrison. 1st edition. (London: E. & F. N. Spon.) 1s. 6d. net.

"Examination Questions in Electrical Engineering set by the City and Guilds Institute, 1900-1908." (London: S. Rentell & Co.) 1s. net.

ELECTRIC CRANES.*

BY H. H. BROUGHTON.

(*Continued from page 293.*)

Summary.—The author here deals with the mechanism required for effecting the traversing and travelling motions. The article opens with a brief discussion on the determination of the size of motor required for each motion, and "constants" of American cranes are given. Then follow notes on slipping drives, axles, axle-boxes, roller bearings and track wheels. Constants are given in order to enable the several parts to be correctly proportioned. Traversing and travelling mechanism arrangements are also described.

Travelling and Traversing Mechanism.

In order to determine the sizes of motors required some designers take all the resistances into account by assuming a tractive effort of a certain amount per ton of moving load. Thus, suppose that a crane fully loaded weighs 60 tons, and travels at the rate of 240 ft. per minute. If a tractive effort of 40 lb. per ton is assumed, and the mechanical efficiency of the gearing is 75 per cent., then obviously

$$\text{B.H.P. of motor} = 40\times 60\times 240/0{\cdot}75\times 33{,}000 = 23.$$

If the motor is large enough to enable the crane ultimately to attain its rated speed, the average draughtsman is satisfied, but an examination of existing cranes shows that the thoughtful designer varies the rate of acceleration according to the service for which the crane is intended. If the above crane is arranged to attain full speed in 24 seconds, the average acceleration will be $\frac{4}{24}=\frac{1}{6}$ ft. per second per second, and during the accelerating period a force of $2{,}240\times 60/32{\cdot}2\times 6=692$ lb. will have to be exerted to produce rectilinear acceleration alone. Additional force is required to accelerate the revolving parts of the crane—namely, the motor armature, gear wheels, brake wheel, shafts, axles and truck wheels. This force depends upon the size, shape, weights and speeds of the revolving parts, and its determination involves considerable labour. As a first approximation, the force required to produce rectilinear acceleration can be increased by about 10 per cent. in order to make some allowance for the revolving parts. In the case under consideration a force of $692+69=761$ lb. is required to accelerate the crane.

Still keeping to the same crane, suppose it is desired to attain full speed in 8 seconds. The average acceleration is $\frac{4}{8}=\frac{1}{2}$ ft. per second per second, and the force required is equal to $1{\cdot}1\times 2{,}240\times 60/32{\cdot}2\times 2=2{,}284$ lb.

In a Paper read before the Engineers' Society of West Pennsylvania, Mr. Wales gave the following method of determining the sizes of the travelling and traversing motors :—

Let W_l=working load, in tons ;
W_b=weight of bridge complete, in tons ;
W_t=weight of trolley complete, in tons ;
F_t=propelling force, in pounds per ton ;
S=speed, in feet per minute.

The horse-power of the motor required for the travelling mechanism is equal to $(W_l+W_b+W_t)F_bS/33{,}000$.

The horse-power of the motor required for the traversing mechanism is $(W_l+W_t)F_tS'/33{,}000$.

In table XIX. are set forth the weights and propelling forces given by Mr. Wales for different spans and loads.† It was stated that the table was approximately correct for cranes in which the ratio, diameter of axle bearings to diameter of wheels, was between 1 to 5 and 1 to 6.

Table XIX.

	Bridge.		Trolley.		
Span in feet.	W_b.	F_b in pounds per ton.	W_l in tons.	W_t.	F_t in pounds per ton.
25	0·3 W_l	30	1–25	0·3 W_l	30
50	0·6 W_l	35	25–75	0·4 W_l	35
75	1·0 W_l	40	75–150	0·5 W_l	40
100	1·5 W_l	45	...	...	...

Commenting on these figures, Mr. Kenyon suggests* that the propelling force required by the bridge should be multiplied by 1·5 and that the propelling force required by the trolley be multiplied by 1·25, so as to cover unfavourable operating conditions. Substituting these values in the above equations, the standard ratings of the motors required for the service are obtained.

Assuming the track to be straight and level, the tractive effort required at uniform speed is only that necessary to balance the frictional resistances at that speed. The force f_r acting at the radius of the main spur wheel has to overcome the resistances due to bearing friction, rolling friction and windage. Reliable data relating to the magnitude of these resistances are much needed. In the majority of cases, outdoor cranes excepted, wind resistance is negligibly small compared with the other resistances.

Let W=total weight of the fully-loaded crane, or trolley, in tons ;
R=radius of truck wheels, in inches ;
r=radius of axle bearings, in inches ;
α=bearing friction coefficient ;
β=rolling friction coefficient.

Then

Tractive effort f to overcome frictional resistances, in pounds per ton$=2{,}240(\alpha r+\beta)/\text{R}$.

Total tractive effort, $\text{E}=\text{W}f$
$=\text{W}\times 2{,}240(\alpha r+\beta)/\text{R}$.

A number of tests indicate that for a certain type of crane the bearing and rolling friction coefficients are equal to 0·06 and 0·09 respectively. Substituting these values in the above equation, we get

$$\text{E}=2{,}240\text{W}(0{\cdot}06r+0{\cdot}09)/\text{R}.$$

As an example, take the case of a crane, fully loaded, weighing 60 tons, with truck wheels 36 in. diameter and axles 4 in. diameter.

$$\text{E}=2{,}240\times 60(0{\cdot}06\times 2+0{\cdot}09)/18$$
$$=1{,}568 \text{ lb.}$$

Collecting our results, we find that a crane, weighing 60 tons, arranged to accelerate at the rate of $\frac{1}{6}$ ft. per second per second, requires a motor which will give a tractive effort of $761+1{,}568=2{,}329$ lb. during the period of acceleration, and that the same crane arranged to accelerate at the rate of $\frac{1}{2}$ ft. per second per second requires a tractive effort of $2{,}248+1{,}568=3{,}852$ lb. Notwithstanding the fact that the same power is required to drive both cranes at the same speed, it does not follow that the motor which would be used for the first crane would be suitable for the second; in fact, the heavy current required to produce the necessary starting torque to give the higher rate of acceleration would result in violent sparking at the commutator, and if the crane is started frequently, the heavy current might damage the windings on the machine.

We cannot devote more space to the subject, but before passing on to the next section we would strongly urge users, in comparing designs by different firms or in drawing up

† The reader should compare the weights of these American cranes with the weights of the English and German cranes given in Figs. 64 and 65, The Electrician, January 8, 1909.

* "Standard Handbook for Electrical Engineers," p. 1,092.

specifications for new cranes, to take the matter into consideration.

Slipping Drive.—In order that a crane or trolley may start, attain full speed and stop in the least time, a slipping clutch or an elastic connection of some kind should be provided between the motor and the load. This may be unnecessary where the starting resistances are properly graded and the controllers "fool proof"; but in practice the re-

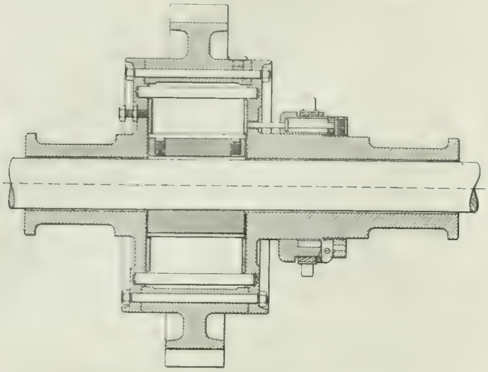


FIG. 102.—NO. 14 TYPE "PQ" 28 H.P. AT 100 REVS.
Scale 1 : 10.

sistances are not always suitably proportioned, and the controllers are sometimes operated by an unskilled attendant, whose knowledge on the effects of inertia is rapidly improved if he manages to retain his position.

Many makers trust to an excess of material for absorbing the severe inertia stresses, and in some cases, no doubt, this is amply sufficient; but the designer who gets the

Prof. Hele-Shaw summed up the conditions which seem to be involved in the problem of the friction clutch as under :—

1. It must have sufficient gripping power.
2. Undue wearing of the surfaces must be avoided.
3. Provision must be made for conveying away the heat where there is much slipping contact in the clutch.
4. Motion should be imparted to the driven shaft without shock.

To these might be added :—

5. Adjustment for taking up the wear must be provided.
6. Where the surfaces in contact are such as to require it, ample provision must be made for lubricating.

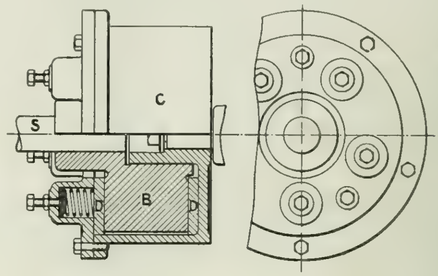


FIG. 103.—SLIP COUPLING AND BRAKE DRUM.

7. It must be enclosed, in order to prevent particles of grit and dust getting between the friction surfaces.
8. All parts subject to wear must be readily and cheaply renewable.
9. The design should be simple and the construction as robust as possible.
10. It must be inexpensive.

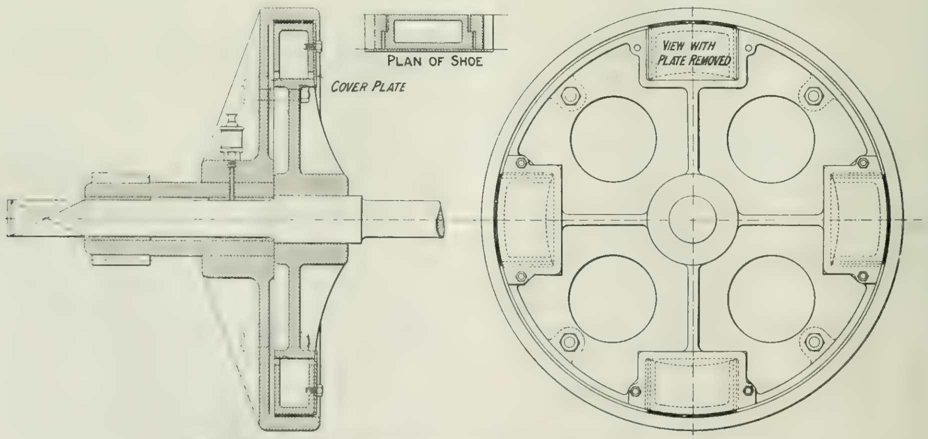


FIG. 104.—SLIPPING CLUTCH FOR LONG TRAVERSE DRIVE ON 50-TON CRANE.
Scale 1 : 10

utmost value out of the material at his disposal wisely provides an elastic connection, so as not to endanger the safety of the structure for which he is responsible.

The author has been emphasising this for upwards of 10 years, and, in the hope that this article will come before the notice of more makers and users than he can reach privately, he again brings the matter forward.

In a Paper on "A New Form of Friction Clutch,"*

* "Proceedings" Inst. Mech. Engineers, July 29, 1903.

Several forms of slipping clutch have been designed for crane service, and we have selected for description a few types which are known to have given satisfaction.

We are indebted to the British Hele-Shaw Patent Clutch Co. for the drawings from which Fig. 102 has been prepared. In the construction shown the clutch is formed in the boss of the spur wheel. The end covers of the clutch case are extended to form bearings, so that the wheel is supported independently, and the shaft revolves through

the clutch free from the weight of the wheel and clutch. The core is secured to the shaft with a feather key, which is kept in position by means of countersunk screws. The clutch case serves to hold a quantity of oil, introduced through plugged holes in the rim.

When the clutch is let in, the pack of plates is compressed by spring-controlled presser pins, actuated by a sliding sleeve which, by an arrangement of triggers, is self-locking after a certain length of travel. The sliding sleeve is operated by a fork, which can be interlocked with the controller.

The triggers hold the pressure on the plates while the clutch is in gear. When the sliding sleeve is withdrawn, the triggers are turned down into their housings and the pressure is relieved.

Putting in the clutch causes the **V** projections of the outer plates, which revolve with the wheel, to enter the **V** grooves of the stationary inner plates and gradually bring them to an equal speed. Before the surfaces actually touch, however, the oil has to be pressed out from between them, and in this way the oil acts as a cushion, which gives the necessary time element to the action of the clutch, and makes a fierce engagement impossible.

The clutch or slip coupling depicted in Fig. 103 has been used by Pickerings.* The clutch case C, made in the form of a brake drum, is mounted on the motor spindle. A boss in the interior of the clutch case serves as a bearing for the block B keyed to the end of the shaft S which carries the driving pinion. The block and the renewable discs D are pressed together by means of springs housed in suitable pockets provided in the cover of the clutch case. On account of the braking effort being exerted on the rim of the case, it follows that the momentum of the moving parts carries the central block round for a few turns against the friction due to the pressure of the springs, and so prevents undue shock in bringing the crane to rest.

The slipping clutch depicted in Fig. 104 is used by Broadbent & Sons. The inner member of the clutch, keyed to the extended motor spindle, is provided with a number of pockets, which serve to accommodate a like number of leather-faced shoes, shaped as shown. The motor pinion is provided with a long boss for the purpose of carrying the outer member of the clutch. The boss is bored out, and bronze bushings are provided at each end of the hole to form a bearing. In the drawing, four bolts are shown which connect the two halves of the clutch together. With the clutch in normal running condition the bolts are not used. Should it be desired to drive positively, on account of the clutch being out of order, or other cause, the bolts can be used to lock together the two members.

(To be continued.)

ELECTRIC CRANES AT SALINA CRUZ AND COATZACOALCOS.

An extremely fine series of electric cranes has recently been completed by Messrs. Stothert & Pitt to the order of Messrs. S. Pearson & Son, who have constructed the National Tehuantepec Railway. We are indebted to the former firm for the illustrations accompanying this article and to the latter firm for permission to publish them.

Fig. 1 shows one of the cranes in the manufacturers' yard. 18 of these were supplied, each capable of lifting 3 tons at 48 ft. radius. The crane is of the all-round type mounted on elevated platforms or pedestals and running on rails of 56 lb. per yard and spaced 14 ft. 9 in. centre to centre. The centre of the jib head pulley is 60 ft. above the level of runway rails with a maximum radius of 48 ft. The jib is made to clear 36 ft. above rail level at 12 ft. 6 in. from the centre of rotation. The speed of lift is 150 ft. per minute for 3 tons on a single rope, increased to about 220 ft. per minute for loads up to 1 ton. A revolving speed of about 400 ft. per minute is attained at the hook for 3-ton and other loads. The travelling speed is about 35 ft. per minute. The pedestals are arranged for locomotive engines to pass underneath them, with a clearance of not less than 16 ft. in height and 12 ft. in width, and are constructed of mild steel throughout.

The undercarriage of the crane is built up of rolled steel sections, the sections being double channel with gussets riveted in between the channels, this forming a very stiff and substantial construction with excellent attachment for the gussets. As will be seen, the crane runs on six wheels, the maximum load per axle not exceeding 10 tons. The wheels are steel tyred, double flanged on the wharf edge side and single flanged

Fig. 1.—Electric Crane for Coatzacoalcos.

on the inner rail, to allow for crossings. A ring of live rollers supports the superstructure, the upper and lower circular roller paths being constructed of cast steel. The jib is of mild steel, well stiffened and lattice braced, and provided with a powerful luffing gear for altering the radius of the jib from 48 ft. to 40 ft. For driving the motors three-phase alternating current at 220 volts and 60 ~ per second is employed.

The lifting motor consists of a 45 B.H.P. Westinghouse motor, "C" type, variable speed, running at about 770 revs. per min. when developing 45 B.H.P. This is geared to the barrel shaft by spur gearing, the first reduction running in an oil bath. The lifting motor is not reversing, but works in conjunction with Messrs. Stothert & Pitt's patent free barrel arrangement.

The slewing and derricking motor is of 15 B.H.P., running at about 800 revolutions. It is geared to the slewing pinion through a train of spur and bevel gearing, a check brake being provided for taking up the momentum of the crane when necessary, this brake being made to act equally in both directions. The derrick motion is actuated from the slewing

* The reader is referred to "Engineering," March 20, 1908, for a description of an overhead travelling jib crane which possesses several novel features, amongst which is the slip coupling *provided on each motor*.

motor, there being a worm and wheel on the derrick barrel and a self-acting safety brake for preventing the jib taking charge when lowering out. All gearing, with the exception of the worm wheels, is of cast steel, with machine-cut teeth, gearing guards being provided in the crane house where necessary.

The switchboard is mounted on a marble base and carries switches, fuses, one ammeter, one voltmeter and overload circuit-breaker, for the hoisting motor. Carbon brushes are provided for the centre pin collector. The cable on the truck is lead covered and is connected to a cable drum, 50 ft. of flexible cable with suitable junction box plug being provided.

The cranes described above have been erected at Coatzacoalcos. Fig. 2 shows the type erected at Salina Cruz, of which

Fig. 2.—Electric Crane at Salina Cruz.

there are also 18. These latter are capable of lifting 3 tons at 54 ft. radius and are consequently much heavier cranes, but otherwise are very similar to those at Coatzacoalcos. They are, however, mounted upon eight wheels instead of six, the gauge being the same, viz., 14 ft. 9 in.

ATMOSPHERIC LOSS OFF WIRES UNDER DIRECT-CURRENT PRESSURES.*

BY E. A. WATSON, M.SC.

The subject of what is commonly termed the corona effect on high-voltage transmission wires is of considerable importance, and has been studied closely in connection with alternating currents by Scott, Ryan, Mershon, Jona and others. The corresponding direct-current case, although not of such immediate importance, is yet of considerable interest in view of the development of high-tension direct-current transmission systems in the Continent of Europe. It is felt, therefore, that no apology is needed for the tests which form the subject matter of this Paper, and which were carried out at the electrical engineering laboratories of the University of Liverpool. It is assumed by most workers on the subject of alternating-current corona effects that the loss which occurs is chiefly due to the ohmic resistance offered by the film of air immediately surrounding the wire to the charging current flowing to the outside boundary of the corona. This involves the assumption that the corona exists continuously, and is not reformed at each alternation of the voltage wave. This may, of course, be the case, although another perfectly feasible method of treatment is to consider the loss as being due to successive breakdown of the layers of air which surround the wire as the voltage rises from zero to the maximum value. Each layer of air just previous to breakdown has a certain amount of energy stored in it in virtue of its action as the dielectric of a condenser, and when it breaks down this is converted into heat. Whichever of these theories is correct, we see from a consideration of the processes involved that, if the frequency of alternation were to be reduced, the loss should be reduced also, and that, assuming all the losses which took place were due to either of these phenomena, that for direct current should be zero; this, of course, is not the case, and there is a loss off a direct-current line worked at too high a voltage, just as off an alternating-current one. Consider a wire carrying a steady charge, q, per unit length of wire. If other bodies, such as the earth, on other conductors are at a distance large compared with the diameter of the wire, the maximum stress at the surface will be

$$R_{max} = \frac{2q}{a}$$

where a = the radius of the wire.

If this electric stress exceeds a certain value, it is an established fact that breakdown of the air will occur, this breakdown being the cause of the corona.

With an alternating stress it is possible for the breakdown to occur as often as the charge on the wire alternates in value, so that a continuous loss might take place. With continuous stress, however, we might at first expect that once a breakdown had taken place conditions would adjust themselves, and there would be no further or sustained loss; this, however, leaves out of account the mechanical forces acting upon the disrupted air in virtue of its electrical condition, which forces will tend to cause a motion of the disrupted air away from the conductor, a fresh supply coming up, to be broken down and driven away in turn. Hence a loss might reasonably be expected with steady charges, but would take place in a different manner than is the case with alternating ones. It is a well-known fact that a brush discharge from a point produced by a steady charge

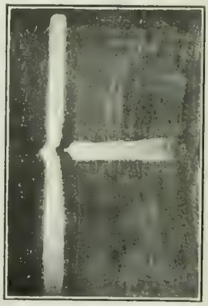


Fig. 1.—Effect of Air Blast.

is accompanied by a well-marked wind proceeding from the point, which wind would be quite explainable on the principles which have just been outlined.

It is possible to make a rough calculation of the speed at which the disrupted air would be driven away from the corona, assuming a free access of air to take its place. The calculation gives a velocity of about 10 metres per second. Various experiments which have been made by different workers, more especially by Righi, on the discharge of electricity from points, have shown that this explanation of the mechanism of discharge is not really the correct one, and that the air does not really behave as if every particle were broken down, but rather as if only a small portion of it were affected, while the rest remained unchanged.

Righi's fundamental experiment consisted in placing an electrified point opposite a sheet of ebonite with a backing of tinfoil connected to earth. Some object cut out of ebonite or other insulating material was interposed between the point and the ebonite sheet. After the point had been electrified for a short interval the ebonite sheet was removed and dusted over with a mixture of red lead and suphur. The shadow of the object interposed was at once apparent.

The explanation given of this was that electrified particles of air (ions) had travelled from the point to the ebonite plate, charging up the latter in the parts which they had reached, so that on dusting the red lead and sulphur over it they had adhered to certain parts and not to others, thereby bringing out the shadow of the interposed object.

The experiment was then tried of directing a blast of air across the space which the charged particles had to cross in order to obtain some estimate of their velocity. The result is seen in Fig. 1. It will be seen that a displacement of the particles occurred, but that this

* Paper read before the British Association, at Winnipeg.

was only small, although the air jet was moving rapidly, and it was evident that the velocity of the particles actually carrying the charge was very many times greater than that of any wind leaving the point. From this it seems probable that the charge dissipated by the point is carried, not by the whole of the air contained in the corona, but by certain portions of it only, which move with a very considerable speed; their velocity has, indeed, been measured, and is given by Sir J. J. Thomson and others as 1·5 cm. per second for a field of 1 volt per centimetre.

An experiment which shows fairly conclusively that the charge is not carried by the whole of the air, but only by a portion of it, consists in placing an electrified point inside a metal box with a perforated zinc window, which the point is arranged to face. The wind shot off by the point comes freely through the window, and can be felt outside, but it carries no electrical charge whatever. If, however, the window is removed, the issuing wind is found to carry a charge which may be detected by an electroscope or electrostatic voltmeter suitably arranged.

The foregoing brief account is intended to convey some idea of the mechanism by which the loss from a steadily charged wire takes place. The charges appear to be carried by agglomerations of molecules forming a small part, perhaps 2 per cent., of the whole air surrounding the wire. The molecular clusters have attached to them electrical charges which impel them away from the wire at a speed depending upon the potential gradient. In their passage they may, under certain circumstances, but probably not in the case of a wire, push the whole body of air along with them, forming the "electrical wind" observed from charged points; this wind, however, is not the actual carrier of the charge, but is a secondary effort produced by the carriers.

With these introductory remarks we pass on to describe the actual tests. These fall under two headings:—

(*a*) Tests made on a wire arranged inside a concentric cylinder.

(*b*) Tests on two parallel wires arranged out of doors.

The object of the (*a*) tests was to determine the effect of changes in barometric pressure upon the critical voltage at which loss commences. The wire was enclosed in a galvanised-iron cylinder 8 in. diameter and 6 ft. long, which could be exhausted of air by means of a small motor-driven pump. The degree of humidity of the air was also under control. Experiments would be made at various pressures from atmospheric down to 350 mm.

The use of a wire in a concentric cylinder, although not representing the actual conditions of a transmission line, is yet very convenient when it is desired to have various factors under control. It possesses, moreover, the advantage that considerably lower pressures (less than half) are required to produce the same electric stress around the wire.

Theoretically, the critical voltages for a wire in a cylinder and two parallel wires have a direct ratio, which can be calculated when the dimensions of the wires, cylinder and spacing are known.

The expressions for obtaining the electric stress at the wire are as follows:—

Wire in cylinder.

$$R_{max.} = \frac{V}{a \log_e \frac{b}{a}}. \quad \ldots \ldots \quad (1)$$

Two wires.

$$\frac{V}{2a \log_e \frac{d}{a}}\left(1 + \frac{a}{d}\right). \quad \ldots \ldots \quad (2)$$

Where V=P.D. between wires,
a=radius of wire,
d=distance apart of wires,
b=radius of cylinder.

Of these formulæ, (1) is exact, while (2) is only approximate, but is very nearly correct for all ordinary cases where a is small compared to d, and the wires are well above the earth.

As it was felt that it was hardly safe to trust to the ratio deduced from these formulæ without an experimental verification, tests (*b*) were arranged for. In these tests two wires were stretched out of doors parallel to each other and at a distance apart of 1 metre, the length of wire employed being 12 metres.

Method of Test.—The source of power was an influence machine of special design and large output, driven by an electric motor. This machine was excited by means of an ordinary Wimshurst machine; across the terminals of the latter was connected a "spark" gap with adjustable electrodes terminating in needle points, the brush discharge from which kept the voltage of the "exciter" from rising above any desired limit. By sliding the electrodes any required excitation voltage, and, consequently, any required output from the main machine, could be obtained. The excitation voltage was measured by an electrostatic voltmeter, with compressed air insulation capable of working up to 200,000 volts.

The main generator would give voltages up to 70,000 volts; these were measured by a 100,000 volt electrostatic compressed air voltmeter connected across the terminals. From the machine, leads consisting of $\frac{3}{8}$ in. brass tubes were taken in the earlier tests direct to the testing apparatus; it was however, found, that when this was done oscillations of voltage occurred, so that a steady voltage was not impressed on the wire. In the later and accepted tests, therefore, an arrangement of condensers across the machine terminals, combined with a high resistance and inductance in the leads to the apparatus, was adopted, and this was successful in suppressing all the oscillations and giving a steady pressure on the wire. The current flowing into the wire was measured by a reflecting micro-ammeter, enclosed in a potential screen and mounted on a large 75,000 volt insulator.

Precautions taken against Leakage.—In order to guard against the experiments being vitiated by leakage occurring at other points than the wire itself, the micro-ammeter was placed as close as possible to the end of the wire, and the insulating terminals where the wire passed through the ends of the tube were fitted with leakage guards.

The same principle was employed in the tests on the parallel wires. In these tests another high-tension voltmeter reading up to 35,000 volts was connected between one wire and the earth in order to ensure that the two wires were equally and oppositely electrified.

Results of Tests.

(*a*) *Wire in Cylinder.*—As was to be expected, some difference was found to exist between the case where the wire was positive to the cylinder and when it was negative to it, these differences occurring both in the appearance of the corona and in the measurements relating to it.

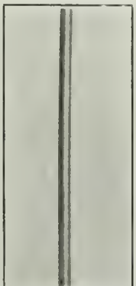


Fig. 2.—Ordinary Appearance of Wire.

Fig. 3.—Corona Wire Positive.

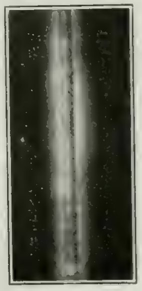


Fig. 4.—Corona, Wire Negative.

When the wire was positive to the cylinder it appeared, if viewed in a subdued light, to be surrounded with a thin luminous film. If viewed in complete darkness, under certain conditions the space surrounding the wire for a distance of 1 cm. or 2 cm. radially was seen to be full of fine branching bluish purple brushes, darting about all the time and never remaining stationery on any point. The discharge made a slight hissing noise.

When the wire was negative the luminous film was absent, but the wire was surrounded by a halo consisting of short straight reddish-coloured discharges about 3 to 5 mm. long, practically stationary and much brighter than the corresponding positive discharge. This discharge was accompanied by a loud hissing noise plainly audible above the hum of the motor and influence machine.

The negative corona was greatly affected by the presence of particles of dirt upon the wire. If the wire was dirty the discharge seemed to concentrate itself upon the particles of dirt, from each of which a bright tuft of reddish light emanated not much longer, however, than the previous brushes from the clean wire. The discharge was much less noisy, and, in fact, if the wire were dirty enough, nearly silent.

Figs. 2, 3 and 4 illustrate this, Fig. 2 being a photograph of the wire itself when "dead," Fig. 3 the same wire surrounded by a positive and Fig. 4 the wire surrounded by a negative corona. The bright spot in the middle of the wire seen in Fig. 4 is due to one of the "tufts" just mentioned.

As regards the quantitative differences between the positive and negative corona with a perfectly clean wire, the negative corona

appeared to require a very slightly higher voltage to start it than the positive one. The difference, however, was small, not exceeding 3 per cent. at the outside.

The chief difference was in the voltage current characteristic of the discharge. When the wire was negative the curve was more nearly parallel to the axis of current than when it was positive—*i.e.*, dI/dV was greater for a negative than for a positive corona. This can be seen on reference to Fig. 5, where the chain dotted curve is taken from a positive corona and the full line one from a negative.

With regard to the effect of dust and dirt upon the "quantitative features" of the corona, the positive discharge seemed but little affected, and the critical stress and shape of the curve were the same whether the wire was clean or dirty. When the wire was negative, however, this was by no means the case; a few particles of dirt producing the tufts of light just mentioned caused considerable lowering of the critical stress, and a pronounced charge in the

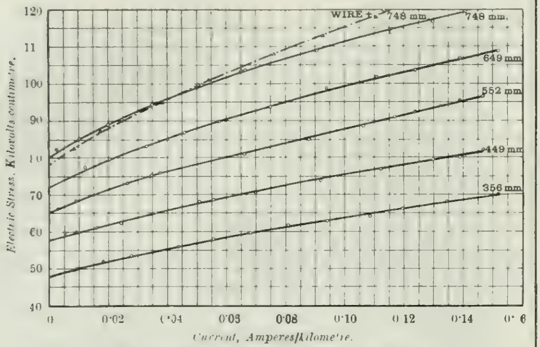


FIG. 5.—WIRE 0·70 MM. DIAMETER, NEGATIVE.

shape of the curve, which, instead of beginning abruptly at a definite voltage, as it did for a clean wire, began gradually and bent round the knee of the curve occurring at the point of true critical stress—*i.e.*, the point at which the loss for a clean wire would commence.

Figs. 5 and 6, for wires of 0·70 mm. and 9·53 mm., are given as representative of the series of curves obtained with gradually increasing wire diameter up to 12·76 mm., or just over ½ in. Both these were for negative corona. The positive ones could not be taken beyond wires of 6 mm. diameter, as a disruptive discharge occurred from the wire to the cylinder. The negative ones showed no sign of this at all over the whole range.

The most noticeable features of the series of curves are, firstly, their increase of dI/dV with increasing wire diameter, and, secondly, the decrease of electric stress required to start a corona. Of course, the actual voltage required to start the corona increased steadily

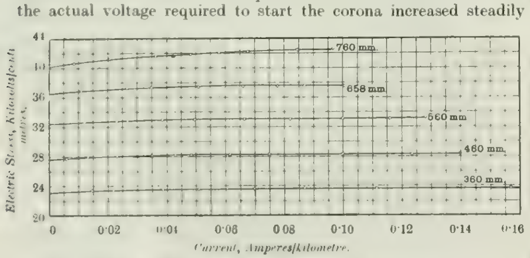


FIG. 6.—WIRE 9·53 MM. DIAMETER, NEGATIVE.

with the diameter of the wire, but the electric stress due to this voltage, as deduced by the formula already given, steadily dropped from about 80 Kv.-cm. for the small wire to 40 Kv.-cm. for the large one.

The relation between critical stress and wire diameter for different atmospheric pressures is plotted in Fig. 7. It will be seen that the critical stress drops rapidly at first, but tends to get nearly constant for large wires.

This, it may be said, agrees substantially with Prof. H. J. Ryan's results. In Ryan's Paper before the American Institute of Electrical Engineers are given a series of tests made under somewhat similar conditions as regards arrangement of conductor. The tests were, however, made with alternating current, and the point of formation of the corona was observed by watching the wire in a dark room for the first appearance of luminosity. Prof. Ryan gives the results of the tests in a slightly different way, believing that the corona does not start at the surface of the wire, but at a small distance away from it. He also uses the expression of "dielectric flux density" expressed in coulombs per square inch in place of electric stress or potential gradient, as used in the present Paper. Both quantities have the same dimensions and are mutually convertible, the relation between them being

Electric Stress volts/cm. $= 175 \times 10^{10} \times$ coulombs per square inch.

Taking figures from pp. 306 and 307 of Vol. XXI. of the "Proceedings" of the American Institute of Electrical Engineers, we obtain the following :—

Wire diameter.		D.	$R_{max.}$
Inches.	Cm.	Coulombs per sq. in.	Kv-cm.
0·03	0·762	460×10^{10}	80·5
0·05	1·27	410 ,,	71·8
0·10	2·54	370 ,,	64·8
0·20	5·08	281 ,,	49·2
0·30	7·62	245 ,,	42·9
0·40	10·16	227 ,,	39·7
0·50	12·7	216 ,,	37·8

If these points are compared with the results given in Fig. 7 it will be found that the first two and last three points fall absolutely upon the curve there given. The reason that the other two do not, appears to be due not to any inaccuracy of observation but to an error in drawing of the curve on p. 307 of the American Institute of Electrical Engineers' "Proceedings," as this curve, which is intended to be a continuation of that on p. 306, does not join up with it. If the curve be altered, and a new one drawn to continue that on p. 306, a much closer agreement for these two points is obtained.

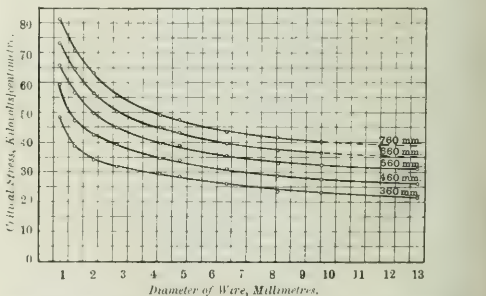


FIG. 7.—VARIATION OF CRITICAL STRESS WITH WIRE DIAMETER.

The agreement with Ryan's analysis of the results obtained at Telluride are not so good, but are fair. The Telluride results converted into kilovolt-centimetres are :—

Wire diam., cm.	$R_{max.}$	Wire diam., cm.	$R_{max.}$
1·52	70·4	4·06	50·6
2·032	70·0	5·08	50·9
2·54	65·8	7·62	43·8
3·04	60·5	10·16	40·5
3·56	57·4	...	...

It seems, therefore, fairly well established that the voltage of formation of the corona is very nearly the same whether the stress be alternating or steady, provided that in each case the maximum value and not the root mean square be taken. One would not, therefore, expect it to be influenced by any change of frequency within the ordinary limits.

The second conclusion to be drawn from the curves is the effect of changes in barometric pressure upon the critical stress. These are plotted in Fig. 8.

In a previous Paper by the author, on the effects of pressure higher than atmospheric upon the electric strength of air, it was pointed out that the curves connecting electric strength and pressure when produced backwards did not pass through the origin, but indicated an appreciable electric strength for a zero air pressure. The same effect is also shown in Fig. 8, the curves (which are, as far as can be seen, straight lines) cutting the axis of stress at points having quite considerable values. Hence we conclude that a reduction of the pressure to, say, one-half of the atmospheric does not halve the voltage, which can be applied before the corona is formed. The

amount of reduction seems, however, to be nearly the same for all the wires, and may be expressed approximately by the relation

$$R=R_0\left(0{\cdot}2+0{\cdot}8\frac{p}{760}\right),$$

i.e., a reduction of pressure to 50 per cent. of the atmospheric reduces the critical stress to 60 per cent. of its value. These relations obviously do not hold as far back as the zero line—our knowledge of vacuum tube discharges precludes any possibility of that; probably somewhere between half atmosphere and zero they bend round, but between one atmosphere and half atmosphere the degree of accuracy of the experiments did not allow of any departure from a straight line law being detected.

An attempt was made to ascertain whether the presence of water vapour had any effect upon the critical stress. In order to do this an arrangement was made so that air could be drawn into the cylinder either through a quantity of calcium chloride or through a mass of cotton waste well soaked in water.

No change could be observed in the point at which the corona was formed, and it is hence concluded that for a clean wire the true cirtical stress is only affected to a very small and quite unimportant effect by the presence of water vapour.

The temperature at which the experiments were carried out was constant at 17°C.

We have now to consider the tests which were made upon the two parallel wires. These do not claim to be so complete as the tests which were made upon the wire in the cylinder, as the limitations imposed by the apparatus available were much greater. To obtain coronæ on wires of the sizes normally used in transmission work would have required a voltage of 200,000 to 300,000 volts. As already mentioned, the influence machine available could only give

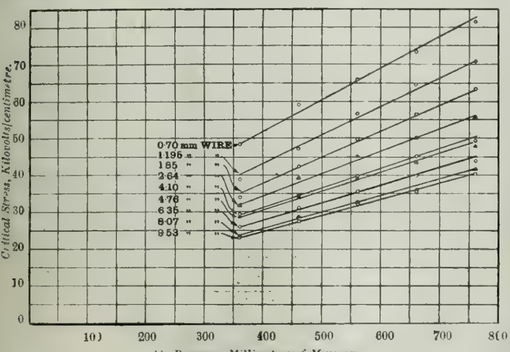


FIG. 8.—EFFECT OF AIR PRESSURE ON CRITICAL STRESS.

70,000. It would have been possible to have put two or more machines in series in order to obtain the voltage, but no machine of ordinary design could give enough current to be of any use, and the machine employed was the only one of its kind existing. An attempt was made to increase the voltage by placing a machine which was the equivalent of an ordinary eight-plate Wimshurst in series with the main generator, but the current this was capable of giving was so small that it was impossible to say whether the critical point were reached or not.

It was, therefore, necessary to be content with tests carried out on the three smaller sizes of wire only, and to attempt to predict from these what would be the behaviour of larger ones were it possible to employ them.

Of these tests, that carried out on the smallest size of wire—viz., the one 0·70 mm. diameter—is the most complete and affords most information. The first thing that will be observed is that the critical stress obtained from this test is considerably lower than was obtained from the tests on the wire in the cylinder, being for the wire when dry only 65 kv./cm, against 80.

Secondly, it will be observed that two curves are given for the case when the wire was dry and when it was wet. The first of these was taken on a dry summer's day with very little water vapour present in the air. The second on a day of fairly heavy fine rain with a driving wind—about the worst conditions which could exist, especially when it is remembered that the tests were carried out in a seaport town, with the wind at that time blowing off the sea, and, moreover, with a not inconsiderable amount of smoke and fume generally present in the atmosphere. These two curves may, therefore, be taken as representing the extreme limits between which the curves of loss may lie.

The third feature of the curves is that they are not nearly as steep as those for the wire in the cylinder (it is to be noted that the scales of abscissæ are not the same)—that is, a given increase of stress above the critical does not produce such a large increase in the current per kilometre as it does for the former tests; in fact, the two curves cut one another, and although the loss of the parallel wire begins with a lower stress than the loss of the wire in the cylinder, yet for a loss of 10 milliamperes per kilometre the stress in the case of the parallel wire is the highest.

It will also be noticed that the two curves for the wet and dry conditions of the wire, while starting at widely different values, gradually approach each other and appear inclined to run into one. This must be viewed in connection with the result found from the effect of water vapour on the critical point of the wire in the cylinder, when it appeared as if the presence of moisture did not affect the critical stress. This is believed to really be the case: the effect of water vapour is to cause a loss prior to the formation of the true corona, but it is not believed to have any appreciable effect upon the corona itself. This will also account for the tendency of the two curves to get closer together as the voltage and current are increased, the pre-coronal loss then becoming relatively smaller.

The explanation of the low value of the critical stress probably lies in the fact that the wires were dirty; this, as has been mentioned already, has the effect of lowering the critical stress very considerably.

The explanation of the decreased value of dI/dV, as compared with the wire in cylinder tests, is not quite clear. If the electric stresses in the medium surrounding the wires were governed only by the ordinary electrostatic laws the value of dI/dV should be the same for both conditions, as the field at any distance from the wire causing the motion of the ions away from it should be the same in either case.

From a theoretical standpoint, it is practically immaterial whether a given electric stress be produced at the surface of a wire by placing

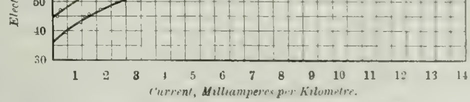


FIG. 9.—PARALLEL WIRES 1 METRE APART.

it inside a small cylinder or at a much larger distance from another wire; the equipotential lines in the immediate neighbourhood of the wire will be the same in each case, and if these only determined the rate at which the ions were carried away, it should make no difference to the relation between stress at the surface of the wire and loss off it.

It is, however, very doubtful whether, once a corona has formed, the electrostatic laws do hold, as the air, being full of charged particles, cannot be expected to act as a true dielectric. It is, in fact, extremely doubtful whether the stresses shown in the curves as existing after the corona is formed really exist at all.

The other two curves of Fig. 9 are for larger-sized wires, and were taken in fairly dry weather; they could not be carried to such a point as was the first one owing to the limitations imposed by the generator.

It was hoped when the experiments were commenced upon the parallel wires that sufficient data would be obtained to enable one to say what factor of safety should be allowed on the figures already obtained if designing an actual line. It can hardly be claimed that these figures allow one to fix a very definite factor which could be used for wires of large sizes. A factor of safety of 2 would, however, it is believed, be ample for all ordinary cases.

It is true that, judging from the curves in Fig. 9, the factor of safety required is larger for the large wires than the small one. This may be due to the loss at the ends of the larger wires being greater than the average owing to the proximity of the insulation disturbing the distribution of flux. For these wires the corona was not sufficiently well marked, owing to the limited voltage, to be able to say whether it was uniform or not.

These tests may well be compared with those carried out by Mershon at Niagara, using alternating current, when he obtained

values of the critical stress considerably lower than those given by Ryan. The ratios which he obtained varied from 1·73 for a wire 2·5 mm. diameter to one of 1·59 for a wire of 10 mm. diameter.

Mershon's tests, it may be remarked, were carried out on an actual line hung out of doors, and not on a wire in a cylinder. They gave curves starting gradually and bending round, not commencing suddenly, like the wire and cylinder test, and they also showed the influence of water vapour in the atmosphere.

GENERAL SUMMARY OF RESULTS.

1. That there is a definite critical stress for which loss occurs from a direct-current line just as for an alternating-current one.

2. That the direct-current stress required to produce this loss is the same as the maximum alternating-current one.

3. That this stress is substantially the same whether the wire is positive or negative, provided that it is clean.

4. That for dirty wires the electric stress is lowered much more for negative than positive charges.

5. That the critical stress is greater the smaller the wire diameter.

6. That the critical stress is reduced by reduction of the air pressure, but not proportionally.

7. That the presence of water vapour in the air does not affect the loss or critical stress for a clean wire.

8. That an actual transmission line does not behave exactly like a perfectly clean wire, but that a factor of safety varying from 1·5 to 2 should be allowed; also that the loss is affected by the presence of water vapour in the atmosphere, especially for low values of the electric stress, and that a considerable loss takes place before the wire is uniformly enveloped in a corona or becomes noticeably luminous.

In conclusion, the writer would express his thanks to the University of Liverpool for facilities for carrying out the work, to Prof. E. W. Marchant for much advice and assistance during its progress, and to Mr. C. J. Watson for the photograph forming Fig. 1 and the account of the experiments in connection with the same.

ELECTRIC LOCOMOTIVES FOR THE BRITISH COLUMBIA ELECTRIC RAILWAY.

In view of the rapid developments taking place in the design of electric locomotives, the following particulars which we are able to give of three locomotives recently supplied to the British Columbia Electric Railway should prove of no little interest. These locomotives were built and supplied by Messrs. Dick, Kerr & Co., the electrical equipment being manufactured at their electrical works at Preston, and the trucks and mechanical portion at their general engineering works at Kilmarnock.

The locomotives are of the articulated truck four-axle type, with one motor mounted upon each axle. The maximum rated tractive effort is 16,000 lb. drawbar pull, and the maximum instantaneous effort is 25,000 lb. A feature of special interest in the truck arrangement is that the body of the locomotive rests upon two four-wheeled trucks coupled together by a massive hinge having lateral flexibility but vertical rigidity, thereby enabling the rear trucks to resist any tendency to tilt under the action of the forward truck, and vice versa. The centre pins and cab platform framing are not subjected to any longitudinal stress, except that due to its own inertia when starting and stopping, the whole pull of the motors being transmitted direct from the motors through the trucks. Suitable arrangements are

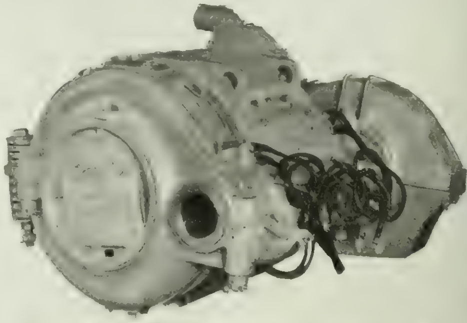


FIG. 2. ONE OF THE MOTORS EMPLOYED.

made to allow the trucks to radiate when passing round a curve. The spring suspension is of the locomotive type, the weight being carried by semi-elliptic springs resting on the journal box saddles.

Fig. 3 shows the general appearance of one of the locomotives, and Fig. 1 gives a view of the interior of the cab. Here can be seen the two master controllers, one at each end of the cab, the contactor boxes, circuit-breakers, switches, &c. The control equipment is of the standard Dick-Kerr multiple-unit type, with series magnets operating the various contactors. The resistances are placed in the sloping ends of the superstructure.

The motor equipment consists of four Dick-Kerr 12A motors. When operating on a 600 volt circuit each motor will give a tractive effort of 4,040 lb. on the periphery of the 42 in. wheels, and a speed of 15 miles per hour at the one-hour rating. Each motor is fitted with reduction gear having a ratio of 3·64 to 1. The armature bearings of the motor are lubricated by oil rings, which are specially designed to prevent flooding when running at high speeds. The axle bearings

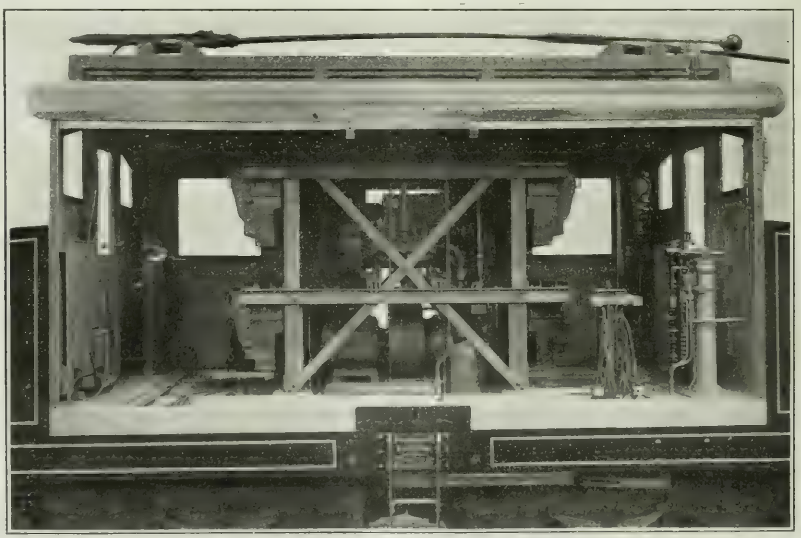


FIG. 1. VIEW SHOWING INTERIOR OF CAB OF LOCOMOTIVE.

are lubricated by a system of wicks which are immersed in oil wells. No grease is used as an emergency lubricator. The whole of the gearing of the motor is contained in a malleable iron oil-tight gear box, which is provided with suitable stiffening ribs. It is supported by the axle bearing at one end and by the pinion bearing and motor shell at the other end. The motors are designed and arranged for forced ventilation, the air being blown into the motor shell at the end farthest from the commutator, and passing out at suitable openings provided at the commutator end. Fig. 2 shows the type of motor employed.

The air for the forced ventilation is obtained by means of a centrifugal blower situated in the centre of the cab (see Fig. 1) and driven by a Dick-Kerr motor. The controller for operating this motor is situated near the right-hand master controller, seen in Fig. 1. In addition to the blower for the motors, there is an electrically-driven air compressor with suitable air reservoirs for the air-brake equipment, the locomotive being fitted with combined straight and automatic air brake. The compressor for the brake equipment is mounted above the motor-driven blower in the cab.

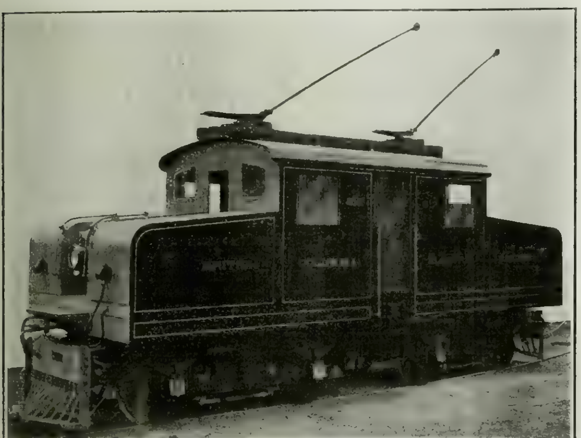


FIG. 3.—ELECTRIC LOCOMOTIVE FOR THE BRITISH COLUMBIA ELECTRIC RAILWAY.

Two current collectors are provided, these being of the straight under-running trolley type, the current being collected from an overhead trolley line. The trolleys are equipped with retrievers. The following details of the equipment are of interest :—

Number of Motors	4
Gear Ratio	3·64 to 1.
Number of driving wheels	8
Diameter of driving wheels	42 in.
Total wheel base	24 ft. 6 in.
Wheel base of each truck	8 ft.
Length overall	35 ft. 7 in.
Length of main cab	16 ft. 5 in.
Height of cab above rail level	14 ft. 1½ in.
Width of cab	9 ft. 8 in.
Total weight of locomotive	50 tons.

THE DISTRIBUTION OF DIELECTRIC STRESS IN THREE-PHASE CABLES.*

BY PROF. W. M. THORNTON, D.SC., D.ENG., AND O. J. WILLIAMS, B.SC.

The problem, of which an approximate solution is given in this Paper, is to find the voltage gradient at any point in the cross-section of a three-core cable as used for three-phase currents at any time during the cycle of electrification. The capacities between the conductors have been fully worked out in theory and practice,† but in so far as the life of a cable depends on the nature and magnitude of the electric stress in the insulation it is necessary to know the general nature of the change of stress, more especially in the space between the conductors, before a final conclusion can be deduced from breakdown tests.

* Paper read before the British Association at Winnipeg.
† A. Russell, "Alternating Currents," Vol. I.

It is clear that in the dielectric between any conductor and the adjacent sheath there will be a simple rise and fall of voltage at the main frequency of supply, but in the interspace the conditions are complicated by the reactions between the conductors and the sheath.

On consideration of the problem it seemed impracticable to attempt to solve it analytically by finding and superposing the fields between the various conductors in turn. The problem being two-dimensional, recourse was had to the stream-line method used by Profs. Hele-Shaw and Hay* for the solution of otherwise indeterminate problems, in the distribution of magnetic fields of force.

In an electrostatic case it is only necessary to replace permeability by the dielectric constant, so that the relation given by them that the permeabilities of two adjacent areas of the stream-line film were in proportion to the cube of their thickness applies directly to dielectric constants also. The cable case is rather simpler than the magnetic, since the conductors have in effect an infinite induction constant. The form of the field will, therefore, be the same whatever the dielectric constant of the insulation may be, provided that this is small and the same everywhere. In applying the stream-line

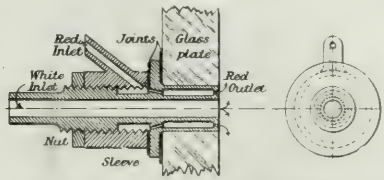


FIG. 1.—INJECTOR NOZZLE FOR WHITE GLYCERINE WITH RED STREAM LINES.

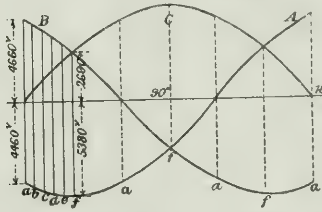


FIG. 2.—RELATION OF DIAGRAMS TO THE THREE PHASES.

method to electrostatic problems it is then only necessary to make the "dielectric" areas thick enough to give good contrast in the stream lines and to make the cavities representing conductors as deep as possible (Fig. 3).

The representation of the voltage relations in a three-phase cable was carried out as follows : Two circular glass plates 6 in. in diameter 0·5 in. thick were prepared, and found to have good plane surfaces. Three holes were drilled through one of them 3 in. apart, and equidistant about the centre (*see* Fig. 3) Into two of these brass nozzles were cemented to which indiarubber pressure tubing was attached, fitted with screw-pinch cocks. For the third, a special injector was made, illustrated in Fig. 1. The other plate was then coated with paraffin wax, planed and cut to template, to represent to scale the section of a three-phase cable. The cavities cut in the wax coincided with the nozzle openings in the first plate. An annular cavity surrounding all represented the sheath.

The plates being clamped together with a ring cut from a sheet of thin drawing paper forming a joint, red and white glycerine were injected by the one nozzle, and allowed to flow away by the other two, the one acting as a source, the other as sinks. Part of the liquid entered the annulus from the source, and, passing round the side, escaped by way of one of the sinks ; no liquid escaped from the edges of the slide. The sheath of a cable is, in practice, always at zero potential, and only conveys induction to and from the charged conductors.

The algebraical sum of the flow between the three openings is zero, whatever the total flow may be. The distribution of the line of force in an actual three-phase cable does not depend upon the magnitude of the voltage applied. In the same way the lines of flow in the model do not depend upon the total quantity passing, but only on the relation between the flow in the two sinks. (In the analogy between hydrodynamic and electrostatic or magnetic problems,

* Phil. "Trans.", Vol. CXCV., pp. 303-327.

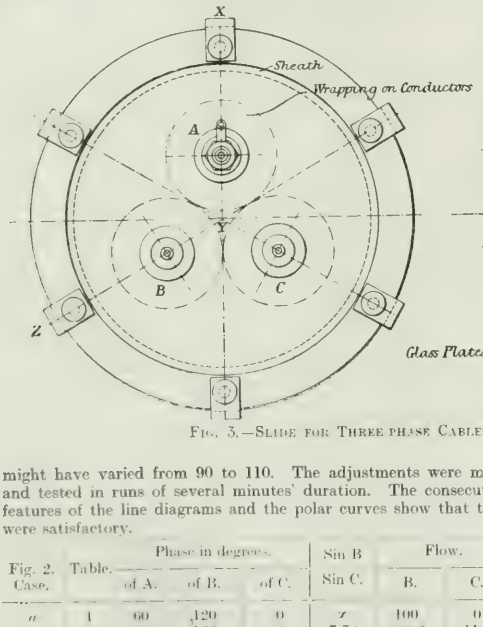
velocity of liquid flow is comparable with intensity of stress.) If the sinks are adjusted to have the same discharge from each we have the electrical case of one wave at maximum voltage above the neutral, the other two equal and opposite to it in phase, and each one-half of it in magnitude—that is case *f* (Fig. 2).

If one is closed, all the liquid entering leaves by the other, and we have case *a* Fig. 2. These two cases are the limits, and recur at intervals of 30 deg. continually, so that a set of stream-line diagrams covering a convenient number of cases from *a* to *b* completely determine the conditions throughout a cycle of stress. Four intermediate positions were chosen, and the figures given later correspond to phase positions of 0, 6, 12, 18, 24 and 30 deg. on one of the phases—that marked C.

The flow of glycerine was adjusted by the screw clips on the discharge nozzles. The drops from these were counted with a stop-watch, and after practice the adjustment could be made to about three drops in 100. The accuracy of the diagrams as representing the electrical state is in direct proportion to this.

While the voltage in phase C is increasing that in B the other sink is decreasing, the corresponding phase angles being 60, 54, 48, 42 36, 30 deg.

The adjoining table gives the phase relation for the diagrams which follow. In the last columns the relative flow from B and C is given on the assumption that the total flow is constant, and numerically equal to 100 (drops a minute). As a matter of fact, it was not possible to adjust each to the required quantity, and as long as the ratio was obtained the total flow was not measured. It might have varied from 90 to 110. The adjustments were made and tested in runs of several minutes' duration. The consecutive features of the line diagrams and the polar curves show that they were satisfactory.



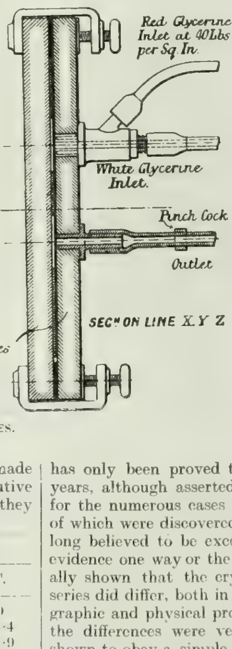


Fig. 3.—Slide for Three phase Cables.

Fig. 2. Case.	Table.	Phase in degrees. of A.	of B.	of C.	Sin B / Sin C.	Flow. B.	C.
a	1	60	120	0	∞	100	0
b	2	66	126	6	7·78	88·6	11·4
c	3	72	132	12	3·57	78·1	21·9
d	4	78	138	18	2·17	68·4	31·6
e	5	84	144	24	1·44	59·0	41·0
f	6	90	150	30	1·00	50·0	50·0

The photographs of the stream lines obtained were not so good in contrast as those in the magnetic cases. It was not possible to photograph through the clear plate—*i.e.*, that holding the nozzles—and since the wax could not be conveniently deposited on this plate, there was always a film of wax between the red stream lines and the camera. This film was of necessity thick. The greatest obstacle to obtaining sharp impressions was, however, the spreading out of the lines from the injector by reason of the enlargement of the area of flow. To steady the flow, and so to work with very slow streams, an attempt was made to suck the glycerine through the plate, and to measure the discharge into a vacuum, but this did not prove convenient in working. Another difficulty was that the shadows of the leading in and out pipes and nozzles were never quite avoided. If clear impressions could have been obtained the work would have been much less. (*To be concluded.*)

THE SEVEN STYLES OF CRYSTAL ARCHITECTURE.*

BY DR. A. E. H. TUTTON, F.R.S.

The proverbial importance of the number seven is once more illustrated in regard to the systems of symmetry exhibited by solid matter in its most perfectly organised form, the crystalline. For there are seven such systems or styles of architecture of crystals, just as there are seven distinct notes in the musical octave, and seven chemical elements in the octave or period of Newlands and Mendeléeff, the eighth or octaval note or element being but a repetition on a higher scale of the first.

The purpose of this discourse is not so much to dilate upon the seven geometrical systems of crystals, as to show how they are occasioned by differences in the internal structure, and to demonstrate this internal structure in an ocular manner, unfolding at the same time some interesting phases of recent investigation. To the Greeks, whose wonderfully perfect knowledge of geometry we are ever admiring, the cube was the emblem of perfection, for "The length and the breadth and the height of it are equal." Moreover, even when we have added that all the angles are right angles, these are not the only perfections of the cube, for they carry with them, when the internal structure is developed to its highest possibility, no less than 22 elements (13 axes and 9 planes) of symmetry. At the other extreme is the seventh, the triclinic, system, in which the symmetry is at its minimum, neither planes nor axes of symmetry being developed, but merely parallelism of faces, sometimes described as symmetry about a centre, and in which there are no right angles and there is no equality among adjacent edges. Between these two extremes of maximum and minimum symmetry we have the five systems known as the hexagonal, tetragonal, trigonal, rhombic, and monoclinic, possessing respectively, 14, 10, 8, 6, and 2 elements of symmetry. All crystals do not possess the full symmetry of their system, each system being sub-divisible into classes possessing a definite number of the possible elements. Altogether, there are 32 such classes, and their definite recognition we owe to the genius of von Lang and Story Maskelyne.

The characteristic property possessed in common by all crystals is that the exterior form consists of and is defined by truly plane faces, inclined, in accordance with one of the 32 classes of symmetry, at specific angles which are characteristic of the substance. This has only been proved to be an absolute fact within the last few years, although asserted by Haüy so long ago as the year 178?; for the numerous cases of so-called "isomorphous" salts, the first of which were discovered by Mitscherlich in the year 1820, were for long believed to be exceptions, and until the year 1890 no actual evidence one way or the other was forthcoming. But it was eventually shown that the crystals of the members of an isomorphous series did differ, both in their angles and in all their other crystallographic and physical properties, although in the cases of the angles the differences were very small. Moreover, the differences were shown to obey a simple but very interesting law, namely, that they were functions of the atomic weight of the chemical elements of the same family group whose interchange gives rise to the series.

All crystals possess one other obvious property, that of homogeneity, and we now know that it is the character of the homogeneous substance which determines the external form. There are no less than 230 different kinds of homogeneous structures, neither more nor less, the elucidation of which we owe to the independent recent labours of Schönflies, von Fedorow and Barlow. And it is a significant fact that the whole of them fall naturally into the 32 classes of crystals, leaving no class unaccounted for. Of these 230 modes of regular repetition in space 14 are the space-lattices long ago revealed to us by Bravais, and all recent investigation concurs in indicating two facts: first, that it is the space-lattice which determines the crystal system and, second, that it is the arrangement of the chemical molecules which is represented by the space-lattice. Each cell of

* Abstract of the First Evening Discourse, delivered before the British Association on Thursday, August 26th.

the space-lattice corresponds to a molecule. The structure is certainly not solid throughout, however, part only being matter and the rest ether-filled space, the relative proportions and the shape of the material portion being as yet unknown. We limit ourselves, therefore, to considering each molecule as a point, and we draw the lattice as a network of three systems of parallel lines, parallel to the directions of the three principal crystal edges, analogous, according to the system of symmetry, to those of the cube. The points of intersection we consider as those representing the molecules, inasmuch as any point within the limits of the cell may equally well be taken to represent the cell and the molecule, provided the choice is analogously made throughout the structure.

It has recently been found possible to determine the relative dimensions of these molecular cells, the distances of separation of the points of the space-lattice, in those cases where we know that the structure is similar, as in isomorphous salts; and the interesting discovery has been made that the "molecular distance ratios," as these space dimensions are called, are functions of the atomic weights of the interchangeable members of the family of chemical elements constituting the series, just as the crystal angles have been shown to be.

We are now able, moreover, to take yet one further step, for the chemical molecules are composed of atoms, and it has been indubitably shown that the atoms occupy definite positions in the crystal. For when we replace, say, the alkali metal in a sulphate or selenate, by another, we observe a marked alteration in the crystal angles and the molecular distance ratio along a particular direction, this direction being the same whichever metals of the group are interchanged; whereas if we replace the sulphur by selenium, a similar kind of alteration occurs, but along a totally different direction. Now we know that the atoms are arranged in the chemical molecule in what is known to chemists as their stereometric arrangement, depending on the maximum satisfaction of their chemical affinities. Hence this important experimental fact of the occupation by the atoms of definite positions in the crystal proves, firstly, the homogeneous similarity of arrangement of the molecules and, secondly, explains why we have classes or subdivisions within the systems. For it is the arrangement of the atoms within the molecule which causes the variations of the degree of symmetry, within the limits prescribed by the system and space-lattice; in other words, which determines the class.

Now, obviously, any one of the atoms in the molecule may be chosen to represent the latter, and the points thus chosen analogously throughout the structure will constitute the molecular space-lattice. Hence the whole structure may be considered as made up of as many interpenetrating similar space-lattices as there are atoms in the molecule. The crsytal structure will thus be dependent on two factors, the space-lattice and the scheme of interpenetration of the space-lattices, the former dominating the style of architecture, the crystal system, and the latter the vagaries of the style, the crystal class. Sohncke has shown that there are 65 such vagaries possible, which he terms regular point systems, and these coincide with 65 of the 230 possible modes of partitioning space.

These are the broad simple facts, now proved up to the hilt, which explain the majority of crystal structures, all, in fact, but a very few, of the more complicated classes of the 32. For the remaining 165 ways of appropriating space all fall into a very small number of crystal classes. They are of very great interest, however, and involve an entirely new principle, that of "reflective" or "mirror-image" symmetry, enantiomorphism, as it is technically termed, and include those crystals which possess the remarkable property of rotating the plane of polarised light. These are the cases whose geometrical possibility has been accounted for by the simultaneously independent work of Schönflies, von Fedorow and Barlow, and to which we were experimentally introduced by the discovery of the right and left-handed varieties of tartaric acid by Pasteur. The latter has since been followed by the revelation of many similar cases of two forms of the same chemical substance, related crystallographically and structurally like a right-hand to a left-hand glove, and optically differing by the direction in which they rotate a beam of plane polarised light.

With their discovery and explanation the elucidation of the seven styles of crystal architecture and their 32 subdivisions becomes *un fait accompli*, and although many difficult problems still confront the crystallographer, problems of vast importance to chemistry, the groundwork is now securely laid, the memorable achievement of the last 20 years. The results, moreover, are in entire accordance with the now well-proved fact that the chemical atom is composed of electronic corpuscles. For the definite orientation of the atom and its sphere of influence within the molecule and the crystal is thereby accounted for, the motion in the solid state so frequently hitherto attributed to the atom being a myth, such motion relating, in fact, to the corpuscles within the atom.

The rest of the discourse was devoted experimentally to demonstrating, with the aid of a projection Nicol-prism polariscope of original construction, firstly, the optical behaviour of the simpler kinds of crystal structure and, secondly, that of the interesting cases of mirror-image symmetry. Quartz in particular afforded not only some magnificent phenomena by reason of its right or left-handed structure, but also a most instructive example, in its repeatedly twinned and all-but-molecularly alternating variety of amethyst, of the phenomenon of "pseudo-racemism." For it is the display of this phenomenon which often renders a crystalline inactive substance so difficult to distinguish from a truly "racemic" substance, which, as in the case of racemic acid itself, the optically inactive variety of tartaric acid, is a truly molecular compound of the right and left-handed active varieties, the optical activity being neutralised and destroyed by the act of combination.

MERCUROUS SULPHATE FOR STANDARD CELLS.*

BY C. J. J. FOX, B.SC., PH.D.

It is now well established that the chief cause of inconstancy in cadmium cells is usually due to irregularities in the mercurous sulphate. F. E. Smith has investigated this matter pretty exhaustively,† and has suggested four different methods for preparing reliable Hg_2SO_4.‡ The present author wishes to suggest a fifth method which he has used, and which for simplicity and reliability seems to be superior to any of them.

There is no difficulty in purchasing Hg_2SO_4 which is quite free from foreign metals. But these commercially pure preparations, taken as they are, are unsuitable for use in standard cells because they have usually been precipitated from the nitrate solution in the cold, and are therefore not well crystallised; free nitrate and basic sulphate are also present. But if commercially pure Hg_2SO_4 be heated together with a little pure Hg and dilute H_2SO_4 for a day or so at 120 deg. to 150 deg. in either a sealed tube (1 mm. to 2 mm. walled tubing) or bottle with wire-bound stopper, and occasionally agitated, a white crystalline preparation will be obtained even from a specimen of Hg_2SO_4 which is initially discoloured almost black. On opening the tube or bottle it will usually be noticed that the pressure has risen a little, and that there is a trace of NO_2 formed; a little care should therefore be employed if there is more than a trace of nitrate in the original Hg_2SO_4. But the Hg_2SO_4 obtained in this way is itself free from nitrate, and especially if the H_2SO_4 be filtered off and renewed during the heating process; it is also, of course, quite free from basic salt. It is filtered off, ground up in a mortar with one or two successive quantities of diluted H_2SO_4, and then with several quantities of saturated cadmium sulphate solution; it is filtered off in a Büchner funnel after each washing. In this way it is possible with very little trouble to prepare quite large quantities of very reliable, well crystallised, white Hg_2SO_4 in every suitable way for standard cells.

By heating with HCl and Hg, it is also a very convenient method of preparing crystalline calomel; but in this case the heating takes about twice as long owing to the small solubility of calomel compared with Hg_2SO_4.

Electrical Operation of the Cascade Tunnel.—Dr. Cary T. Hutchinson, consulting engineer for the electrification work of the Great Northern Railroad's tunnel through the Cascade Mountains (U.S.A.), has, according to the "Electrical World," concluded exhaustive tests of the electrified section, which is now in successful operation, heavy freight trains being hauled a distance of about 4 miles from the yard at one end of the tunnel to the yard at the other portal. Four three-phase locomotives are at present in use, each of which weighs 115 tons; and the recent tests show that they are fully capable of performing more work than required by the specifications. When very heavy freight trains are hauled through the tunnel three of the locomotives are used. In addition to the trains a heavy steam locomotive is at present pushed through in order to take the train at the end of the electric zone. So far as the brief operation of this short stretch of electric road has shown, it is an entire success. Upon the ultimate success of this piece of track depends the electrification of about 60 miles of the Great Northern through the entire Cascade Range.

* Abstract of a Paper read before Section B of the British Association.

† F. E. Smith, B.A. Report, Cambridge, 1904, p. 33.

‡ F. E. Smith, B.A. Report, South Africa, 1905, p. 98.

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SOME ELECTRIC HEATING PROBLEMS.

In the development of every "benefit of civilisation" history will show that certain well-defined stages are passed through before a state of workable perfection is reached. This is particularly true in the development of engineering achievements. An invention, in its conception, may result from the desire of a valve-boy to relieve his labours or from a mere chance coming-together of two or more essential conditions. After its birth the invention proceeds along practical lines, often rule-of-thumb, for a time; but it then begins to feel the need of a scientific basis on which to rest and to search for the reasons why it works at all. This is its salvation.

The development up to its present-day position of heating by electrical means has not unfaithfully followed this course. One of the earliest electricians discovered that by an electrical agency heat could be generated, and it is upon this idea that most of the commercial apparatus is built. The method is scientifically efficient, but trouble arises from the fact that not sufficient cognisance is taken of the conditions under which such apparatus has to work, or of quite what is required of it; also that, from the first, considerations of first cost are of prime importance.

The whole question of electric heating falls naturally into two classes. In one we require a high-potential heat, concentrated in a small space, for irons, ovens and other

similar apparatus. In the other we require a low-potential heat, or heat at a comparatively low temperature, for warming rooms or large quantities of water.

In a Paper by Mr. W. S. HADAWAY, recently read before the American Institute of Electrical Engineers, and of which an abstract appears on another page of this issue, this classification is employed, and the subject of electric heating is considered from a refreshingly novel point of view. The author is, however, strictly non-committal, and, while he provides plenty of points for discussion, we are not able to discover that he comes to many very definite conclusions.

A usual American practice is to distribute heat from a central point by means of steam. The author considers the relative efficiencies of this arrangement and electrical heating for "low potential" requirements; and comes to the conclusion that for this purpose electricity is much more expensive than steam. We do not criticise his figures, seeing that they apply to American conditions, but it may be pointed out that electrical energy is charged at the rate of 3½d. per unit—a very high figure for this country, when current is employed purely for heating purposes.

On the other hand, for high-potential work electricity has undoubted advantages. It can be localised to a much greater extent than any other heating agent, it vitiates no atmosphere and produces no by-products; such by-products are of course a vehicle for heat energy, while the heat energy derived electrically is independent of these phenomena. This should be taken into account in comparing the two systems.

The question may then be asked: Are we to confine electric heating to high-potential work alone—to concentrate our attention on the design of apparatus which shall allow us to localise heat in a small space, and not to attempt to solve such problems as the heating of large rooms by electrical means? The answer is an emphatic No! But we must devise new methods for performing these low potential operations, in which the heat from electrical sources is used to the best advantage. One such method was instanced by Mr. W. N. RYERSON in the discussion on Mr. HADAWAY's Paper. By using an electric heater, over which the air was passed, it was found possible to maintain a comfortable temperature throughout a large building at Niagara Falls, even during the coldest weather, without recourse being necessary to any other system of warming. In England we are wedded to the open fire, and the tendency has been, when electric heating is adopted, simply to replace this by a radiator—the results obtained being by no means always what was desired. In the same way, when motor cars were first introduced the horse was replaced by an engine, the carriage remaining the same; since then, however, improved and more efficient designs have been adopted to meet the new problems which came up for solution, and the same will have to be done in the case of electric heating. We have now reached the scientific basis stage of the question, and the problem we have to solve is how to adopt the equipment at our command in order that from it the best results can be obtained.

Mr. HADAWAY's suggestion is to use the exhaust steam from the generators for generally heating the rooms and also the water for domestic purposes; and to use electrical means for other services. In large buildings and blocks of flats with their own plant this would doubtless work well, but we fail to see how exhaust steam is to be transmitted along the streets, and for considerable distances, for the purpose of supplying the wants of ordinary householders.

There is something to be said in favour of the idea of placing in the basement of the building a large heating coil over which air would be drawn, heated in transit and delivered to the various rooms. These rooms might also be fitted with separate radiators serving the double purpose of providing extra heat and of generating that psychological sensation of comfort which appears to be such an important factor in the consideration of heating problems. There is still the question of heating water; and at present a way of doing this economically by electrical means does not appear to be available. A course of thermodynamics appears not to be without its uses in this direction.

We cannot afford to grope about wildly in search of the best means and apparatus to employ for electrical heating purposes. The question requires that the whole resources of physical science be enlisted on our side, and in making this evident Mr. HADAWAY, in spite of his inconclusiveness, has done the industry a service.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

L'Electrotechnique Exposée a L'Aide des Mathématiques Elémentaires. By N. A. PAQUET, A. C. DOCQUIER and J. A. MONTPELIER. Vol. I. (Paris: H. Dunod and E. Pinat.) Pp. xv.–328. Fr. 7·50.

This is an elementary text-book with chapters headed Magnetism, Electrostatics, the Electric Current, Electromagnetic Phenomena, Units, Capacity, Self-Induction and Electrical Measurements.

The treatment is on usual lines and calls for little comment, but the book bears evidence of having been compiled hastily, with the result that a number of inaccurate statements and misprints have found their way into the text. Among the most striking inaccuracies the following might be pointed out. In Figs. 11 and 13, showing the direction of the lines of force produced by magnets, some lines appear passing directly between poles of the same sign, and other lines are shown with intersecting directions. In the chapter on resistances, notwithstanding the fact that the mistake of speaking of specific resistance as the resistance per unit volume is pointed out, the error is made of calculating the ratio of the specific resistances of copper and aluminium *for equal weights*, and an example is worked out comparing the sections to be given to conductors of these two metals to obtain equal resistances without the length being mentioned. The work done in a magnetic cycle is stated to be the area of the hysteresis loop instead of $1/4\pi$ times this value. An ampere passing through an ohm is said to dissipate 10^7 ergs. In several instances units of work and power are confused, and Fig. 150 shows a section of a Ruhmkorff coil with the wires running along parallel to the core instead of round it. Many useful tables are given in the text, but in some cases values are stated to an excessive number of significant figures; this remark applies particularly to the values of specific resistances of insulating materials and of sparking voltages between spherical knobs, which are given to five significant figures. The fact that these tables are copied from other works is not sufficient justification for the inclusion of figures which are far beyond the possibilities of experimental determination and give to the student a false idea of the limits of accuracy obtainable.

Among the printer's errors, which are very numerous, some of the most serious are stated below. In Fig. 51, F should be substituted for P; p. 110, read 120 for 20 volts; p. 121, delete kilogrammetres from the right-hand side of the first two equations and read joules for kgm.: in the fifth equation, p. 139, delete "*m*" each time that it appears in the first equation; p. 216, the Steinmetz expression for hysteresis losses appears in the mutilated form W = 1·6 erg; and p. 280, line 22, r^2 should be substituted for r.

In a book of this kind, which is to be put into the hands of beginners, accuracy in the writing, and afterwards in the printing, is of the first importance, and it is to be hoped that more attention to such details will be given in the second and third volumes on the production of electrical energy and the transformation and distribution of electrical energy, which are stated in the introduction to be in preparation.

A. J. M.

La Consommation des Chaudières à Vapeur et L'Économie de Combustible. By D. Sidersky. (Paris: Gauthier-Villars. Pp. 174. Fr 2.50.

Many engineers in recent years, and for various reasons, have been studying the question of how to produce steam in the most economical manner. So important a subject can be and should be viewed from various standpoints. The book under review, which is written by an engineer-chemist, and forms a part of the engineering portion of a French scientific encyclopædia, considers the subject almost entirely from a chemical standpoint. Although there is little in the book that will aid engineers in the designing of boilers, yet to those concerned in the management of steam plants it will be interesting.

The causes of low efficiencies of existing installations, and economies that might be made in their working expenses, are considered. The manner of conducting tests upon steam boilers and the tabulating and working out of the data obtained are fully treated, excepting that the method of obtaining the calorific value of the fuel is not indicated. The feeding of air to the furnaces and the form of fire-bar and ashpan best suited for this purpose is considered. It is rather surprising that whilst the advantages to be derived by an acceleration of the draught are shown, the best known system of forced draught is not even mentioned

The importance of flue-gas analysis is made clear in the three chapters in which it is considered. Various apparatus for ascertaining the amount of carbon dioxide in flue-gas, including one designed by the author, are described and illustrated. Continuous carbon dioxide recorders and apparatus for measuring the temperature of the flue-gas are also described. After showing how great the quantity of heat rejected in the flue-gas is, the author disposes of the subject of utilisation of this heat, in some measure by feedwater heaters, in less than one page.

The report of the Minister for Public Works (France) upon the then existing laws respecting accidents in connection with steam boilers, and the laws as modified, are appended to the subject matter.

A. C.

Recherches sur La Préparation Électrolytique des Composés du plomb. By Carl Duvivier. (Malines: L. & A. Godenne. Pp. 19.

This little monograph deals with the preparation of various compounds of lead by electrolytic means. For example, white lead, chrome yellow, naples yellow, lead peroxide, lead nitrate, &c.

The author commences with a description of the various electrolytic methods which have been suggested for making white lead and describes them under the two headings—direct and indirect methods. Under the first heading we find the processes of T. D. Battome de Hoosick, in which lead electrodes are employed in a mixed solution of ammonium and sodium nitrate, at the same time carbon dioxide being blown through the electrolyte. The process of Luckow, in which the electrolyte consists of sodium chlorate and carbonate also comes under this heading. There is only one indirect process given, that of A. B. Brown, in which the electrolyte is a solution of sodium nitrate, the anode and cathode compartments being separated. Consequently, at the anode lead nitrate is produced and sodium hydroxide at the cathode. By mixing these, lead hydroxide is formed, and this with sodium bicarbonate, gives basic lead carbonate. It is a cyclic process, and theoretically there should be no loss of sodium nitrate, as it is recovered when the lead nitrate reacts with the sodium hydroxide.

Lead chromate is next taken, and the author remarks upon the beautiful colour of the product. This effect, however, is not invariable because if the electrolysis is allowed to continue for some time the beautiful yellow invariably becomes dirty in appearance.

After white lead the most important product of lead which can be made by electrolytic means is undoubtedly lead peroxide. The author treats this part of the subject in greater detail; or rather he treats of the preparation of oxides of lead in detail, and one of them is the valuable lead peroxide. This little monograph will be found useful, but it does not treat of the subject in very great detail; it is more an indication of possibilities.

F. M. P.

PROF. ARMSTRONG'S ADDRESS TO SECTION B OF THE BRITISH ASSOCIATION.*

It was my privilege in 1885 to discuss a variety of problems which then seemed to be of special importance in relation to the subject of chemical change, our main province of study. I find the same problems dominant now—still unsolved but yet nearer solution. The history of progress, of discovery, during the intervening period is wonderfully rich in incident—how rich perhaps few realise, as it is obscured by a mass of blinding detail.

In discussing chemical action, I commented on our failure to arrive at any understanding as to the conditions which determine the occurrence of chemical change—a failure all the more remarkable in view of the clearness of Faraday's early teaching. Basing my remarks on the thesis which he propounded in 1834, that the forces termed electricity and chemical affinity are one and the same. I discussed current views on electrolysis, and arrived at a conclusion entirely adverse to the explanation put forward by Clausius, that the conductivity of electrolytes was conditioned by the presence of a small proportion of separate ions; this was at a time when the views of Arrhenius were not yet spread abroad although they had been communicated to the Swedish Academy; I knew of them only from Ostwald. In justice to the attitude of complete antagonism which I have always maintained towards the speculations of the Arrhenius-Ostwald school, I may point out here that in drawing attention to the views expressed by Arrhenius and Ostwald as to the correlation of chemical with electrolytic activity (and I was the first English writer who called attention to them), I took occasion to say: "There cannot be a doubt that these investigations are of the very highest importance." In the interval Ostwald has charged his test tubes with ink instead of with chemical agents, and by means of a too facile pen has enticed chemists the world over into becoming adherents of the cult of ionic dissociation—a cult the advance of which may well be ranked with that of Christian science, so implicit has been the faith of its adherents in the doctrines laid down for them, so extreme and narrow the views of its advocates. At last, however, the criticism which has been far too long delayed is being brought to bear and the absurdity of not a few of the propositions which the faith entails is being made evident; it is to be hoped that we shall soon enter on a period in which common-sense will once more prevail, that ere long an agreement will be arrived at, both as to the conditions which determine it and as to the nature of chemical change in general. The lesson we shall have learnt is one of no slight import if it but teach us the ever-present need of questioning our grounds of belief, if it serve to bring home to us the danger of uncontrolled literary propagandism in science, if it but cause us always to be on our guard against the intrusion of authority and of dogmatism into our speculations.

Before attempting to deal with any of the problems which concerned us at Aberdeen, I will first briefly pass the more salient features of advance in review. Few probably are aware how extraordinary is the command we now have of our subject. In 1885, in defending the tendency of chemists to devote themselves to the chemistry of carbon, I could speak of the great outcome of their labours as being the establishment of the doctrine of structure. Everything that has

* Abstract of the more physical parts of the Presidential Address delivered by Prof. H. E. Armstrong, Ph.D., LL.D., F.R.S., at Winnipeg, on Thursday, August 26th.

happened in the interval is in support of this contention. When properly understood, nothing could be more rational and logical than the way in which our theory of structure has been gradually built up on an impregnable basis of fact, with the aid of the very simple conceptions of valency postulated by Frankland and Kekulé. Our security lies in the fact that the postulates of our theory have been tested in an almost infinite variety of cases and never found wanting; this is not to say they are applicable in all cases, but merely that whenever we are in a position to apply them we can do so without hesitation. It will be well if physicists make themselves acquainted with our methods and with the results we have won, with a minimum of speculative effort, by the cultivation of an instinct or sense of feeling which experience shows to be an effective guide to action. Now that physical inquiry is largely chemical, now that physicists are regular excursionists into our territory, it is essential that our methods and our criteria should be understood by them. I make this remark advisedly, as it appears to me that of late years, while affecting almost to dictate a policy to us, physicists have taken less and less pains to make themselves acquainted with the subject-matter of chemistry, and especially with our methods of arriving at the root-conceptions of structure and of properties as conditioned by structure. It is a serious matter that chemistry should be so neglected by physicists and that the votaries of the two sciences should be brought so little into communion.

The central luminary of our system, let me insist, is the element carbon. The constancy of this element, the firmness of its affections and affinities, distinguishes it from all others. It is only when its attributes are understood that it is possible to frame any proper picture of the possibilities which lie before us, of the place of our science in the Cosmos. And yet we continue to withhold the knowledge of the properties of carbon from students until a late period of their development.

It is remarkable how much our conceptions are now guided by geometrical considerations. Our present conception is that the carbon atom has tetrahedral properties in the sense that it has four affinities which operate practically in the direction of the four radii proceeding from the centre towards the four solid angles of a regular tetrahedron.

More than analogical significance—to use Larmor's expression—must be accorded to this symbol on account of its remarkable accordance with the facts generally, whether derived from the study of asymmetric optically active substances or from observation of the activity of ring structures of various degrees of complexity. Nothing is more suprising than the completeness with which the vast array of facts included in organic chemistry may be ordered by reference to the tetrahedral model. In the future, when our civilisation is gone the way of all civilisations, and strangers dig on the sites of our ruined cities for signs of our life, they will find the tetrahedron and the benzene hexagon among the mystic symbols which they have difficulty in interpreting; if, like the ancient Egyptians, we made our tombs records of our wisdom, such symbols would long since have acquired sacred significance, and the public would probably have learnt to regard them with awe and to respect them as totems. Chemists might at least wear them on aprons, in imitation of the Freemasons; perhaps no two other symbols have so great a significance—they reach into life itself.

Nothing is more striking than the remarkable diversity of properties manifest both in the materials which at present we are content to call elements and in the compounds formed by their interaction; the range of variation met with in the case of the compounds of carbon with hydrogen and oxygen alone is almost infinite. We are almost compelled to attribute this diversity more to differences in the complexity and structure of the molecules than to differences in their material composition. The chemist, of necessity, must be a dreamer, knowing as he does that things are not as they seem to be. But this is not sufficiently remembered; indeed, students are systematically trained up in an atmosphere of pretence. The beginner is allowed to regard elementary oxygen, for example, as a colourless gas, which is generally harmless until things are presented to it in a more or less heated condition, whereat it takes umbrage and burns them up. He would regard elementary carbon as a soft black substance, which if smeared on the face of the white man makes him look like a nigger, were it not that he also learns that at times it is the hardest and whitest substance known; of organic chemistry, which alone can give him honest ideas of carbon, he is not allowed to hear, as I have said. The sting of awakening conscience is salved by the introduction of a long Greek word when he is told that the two substances, soot and diamond, are allotropic forms of the element carbon; nevertheless, he regards them both as elementary carbon. Gradually, perhaps, he awakens to a sense of the wrong that he has suffered at the hands of his teachers, as he realises that from no one substance can he gather what the properties of an element are, that after all the elementary substance is but an ideal—in other words, a mere concept.

Names are needed for the elements which would serve to distinguish the ideal elementary substances from the forms in which they are known to us. No more appropriate name than oxygen could possibly be selected for the fundamental material; if the *gen* terminal could be applied to elementary materials generally it would be an advantage; it would not be easy, however, if this were done, to devise an appropriate separate name applicable to the active constituent of air.

In 1885 I closed my address with a reference to the structure of the elements which implied that their behaviour was that of compound substances; the feeling that this is the case has long been general among chemists. Our present attitude towards this problem is a curious one and not altogether satisfactory—it is impossible to deny that we have somewhat lost sense of proportion, even if our methods have not savoured of the unscientific. The discovery of radium appears to have upset our balance—we have been carried away by the altogether mysterious and unprecedented behaviour of this weird and wondrous substance. But may we not ask: Is radium an element? Has it not been too generally, too hastily assumed that it is? Little as we know of it, does not its behaviour straightway outclass it as an element? Surely it does! Is not the established fact that an emanation proceeds from it, which in turn decomposes and gives rise to helium, a proof of its compound nature? Again, is the evidence of such a character as to justify us in asserting that uranium is the parent of radium? If it be such, must not uranium also disappear from the list of elements; must it not, indeed, be removed on the ground that it gives rise to uranium without any reference to its supposed relationship to radium?

The answers given to such questions must depend on our definition of an element. At present we seem to be without one. The conception that the breakdown of radium is spontaneous and apart from all external impulse or control is also one which should be received with caution. There is reason to suppose that in all ordinary cases in which compounds undergo decomposition spontaneously the decomposition is conditioned by an impurity; the effect, moreover, is usually cumulative. This is true of highly explosive substances, such as chloride of nitrogen and guncotton, for example. It might be supposed that something similar would happen in the case of radium—but apparently such is not the case; it is assumed that occasionally a molecule explodes spontaneously, not only without being incited thereto, but also without in any way affecting its neighbours.

The alternative explanation that radium in some way acts as a receiver, transforming energy from some external source to which ordinary substances fail to respond, and being thereby stimulated to decompose, is at present out of favour, although perhaps more in accordance with its peculiar behaviour.* The liberation of helium as a product of radio-active change is in itself a significant fact, in view of the possibility that helium may be an element of intense activity. Nothing in connection with the problem is more surprising, however, than the apparent production, in course of time, of a whole series of degradation products which differ greatly in stability. Such behaviour is entirely without precedent and not at all becoming in elements.

No such remarkable and inspiring problem has ever before been offered for solution. We can only wonder at the results and admire the genius which some have displayed in interpreting them, Rutherford in particular. Yet outsiders may well hold judgment in suspense for the present; whilst it is permitted to workers to make use

* I may here put on record the opinion Lord Kelvin expressed on this question in a letter to me dated September 13, 1906:—

"Ever since, nearly four years ago, we heard of the hundred calories per hour given out by radium, I have had on my mind the question of some possible mechanism such as that which you suggest by which energy from surrounding matter (far or near) could automatically come into radium to supply the energy of the heat which it gives out. The more I think of the question the less I see of that possibility. At present I can see nothing else than that the energy given out is taken from a previously existing store of potential energy of repulsive force between separable constituents of radium.

"The 'disintegration of the radium atom' is wantonly nonsensical. It is nonsense very misleading and mystifying to the general public, because, if what is at present called radium can be broken into parts, it is not an atom.

"'Energy of an atom' implies a thorough misunderstanding of the meaning of the word energy, which is capacity for doing work.

"I admire most sincerely and highly the energy of the workers in radio-activity, and the splendid experimental results which they have already got by resourceful and inventive experimental skill and laborious devotion. I feel sure that as things are going on we shall rapidly learn more and more of the real truth about radium."

of hypothesis in every possible way in extending inquiry, the public are in no wise called upon to accept such hypothesis as fact.

But apart from the suggestion that elements may give rise to others spontaneously, we have been entertained of late with stories of elements being converted into others under the influence of the energy let loose by the breakdown of radium. There is reason, however, to suppose that the powers of radium may have been greatly over-painted; energy of almost any degree of intensity in the form of high-tension electricity is now at our disposal, and the effect which radium produces on living tissues, glass, &c., is of the same character as that effected by the Rontgen ray discharge, the only difference being that the effect is produced somewhat more rapidly. It is not to be imagined, therefore, that the discovery of radium has put any very novel intensity of power into our hands.

It is right that the public should understand that the statements published have been based on preliminary observations which lack verification, such as would never have been divulged in days gone by when a sterner sense of duty pervaded our ranks. We have been living in a time of sensational discovery—in a period when advertisement is favoured and the desire for notoriety rampant. Unhappily that caution which appeared to be regarded as a priceless prerogative of the scientific worker in the earlier part of the last century, of which Faraday was so pre-eminent an exponent, is no longer our recognised watchword. I fear I am one of those who are old-fashioned enough to lament the way in which our claim to be safe and honest guides of public opinion is being endangered—who lament the manner in which the reputation of scientific workers is likely to be besmirched if we do not see the evil of our ways and mend them. It is impossible to avoid noticing how the cancer grows—how the example is spreading among the younger men and loose habits of work and thought are being engendered. I know that not a few who have laboured steadfastly and seriously in an old-fashioned, exact and painstaking way have been deeply hurt by the manner in which their efforts fail to meet with encouragement, whilst those who have thrown caution to the winds are favoured.

In discussing the chief attributes of the elements none is so difficult to deal with as that of valency, using the term in the broadest possible sense, not merely as indicative of the number of units of affinity, but as including the, at present, all but incomprehensible problems of residual affinity and elementary character.

Of late there has been talk of electrons in this connection, but what is said is little more than superficial paraphrase, in the advanced scientific slang of the day, of the ideas which have long been current. When, following Odling, we represent valency by dashes written after the elementary symbol, we give clear expression by means of a simple convention to certain ideas that are well understood by all among us who are versed in the facts; to speak of electrons and use dots instead of dashes may serve to mislead the unwary, who hang on the lips of authority, into a belief that we have arrived at an explanation of the phenomena; but those who know that we have reached only the let-it-be-granted stage, and who feel that the electron is possibly but a figment of the imagination,* will remain satisfied with a symbolic system which has served us so long and so well as a means of giving simple expression to facts which we do not pretend to explain. Not a few of us who listened to the discussion of the nature of the atom at Leicester could not but feel that the physicists knew nothing of its structure, and were wildly waving hands in the air in the endeavour to grasp at an interpretation which would permit of mathematical interpretation being given to the facts. Until the credentials of the electron are placed on a higher plane of practical politics, until they are placed on a practical plane, we may well rest content with our present condition and admit frankly that our knowledge is insufficient to enable us even to venture on an explanation of valency.

In 1885, and again in 1888, I ventured to call in question the interpretation of valency which Helmholtz had given in the Faraday lecture in 1881. On the present occasion I would insist still more emphatically on the insufficiency of the atomic charge hypothesis; especially that it affords no satisfactory explanation of variable valency and of those fine shades of difference which are manifest, especially in the case of nitrogen, when the radicle attached to the dominant element is varied. In 1885 I discussed this question with reference to the nature of electrolytes, and questioned the conclusion Helmholtz arrived at that electrolytes belong to the class of typical compounds the constituents of which are united by atomic affinities, not to the class of molecular aggregates.

* In my opinion the experimental evidence is in no way satisfactory. It appears to me to be desirable that in studying the phenomena of electric discharge in gases, and especially in vapours of complex substances, the horrible pitfalls should be taken into account with which the field of work is studded; unless every precaution to secure purity—precautions such as Baker and Dewar have taught us to use—be taken at every step, the conclusions based on all such observations must be open to grave doubt.

The position is not very different now. Although the propagation of the ionic dissociation cult has assumed the form of a fine art, we are still as far as ever from agreement as to the nature of chemical change; the speculation has not helped us in the least to clarify our ideas; at most we learn that interactions are between ions, and even these, as a rule, are supposed to remain apart until they enter into the solid state. Throughout all these years I have never varied my opinion that the dissociation hypothesis is incompatible with the facts. On more than one occasion I have stated definite reasons which induce me to deny its usefulness, and these arguments have never been met; in fact, there has been little but a conspiracy of silence on the part of the upholders of the creed.

I venture to think there is only one point of view from which the problem of chemical change can be approached—that, namely, which we owe to Faraday—to which hitherto justice has in no way been done—on which I dwelt persistently in my previous address: that the forces termed chemical affinity and electricity are one and the same. In every case of chemical change there is a coincident electrical change, an electric flux; on the other hand, every case of electrical change is accompanied by chemical change, some alteration in molecular configuration is effected; the force of chemical affinity is in some way disturbed by a momentary displacement of the molecules when a current passes through a conductor. Such being the case, the conditions determinative of chemical change can only be those which permit of an electric flux. Two substances in apposition do not give rise to a current; at least three are required to determine a slope of potential. Chemical change can only take place if one of the three be an electrolyte. In all cases, apparently, the chemical change supervenes upon the electrical, the electrolyte being resolved into its ions, one of which at least combines coincidentally with the adjacent electrode. Apparently these considerations are applicable to changes generally. And it should be added that, according to this view, the catalyst actually determines the occurrence of change.

The only other criterion which it is necssary to apply in order to decide whether change be possible in any given case is to consider if the change contemplated be one involving development of energy. It is important to remember, also, that a change which could not otherwise take place becomes possible when a suitable depolariser is introduced into the circuit.

The evidence that similar considerations apply to the gaseous and the liquid states cannot well be gainsaid. Before framing a theory of chemical change it is therefore necessary to formulate a definition of an electrolyte. It is doubtful if any single substance be an electrolyte; the conductivity of fused salts may well be, and probably is, conditioned by some admixture. Aqueous solutions of alkalies, acids and salts without exception are electrolytes. Everything points to the fact that in such solutions the solvent and solute act reciprocally; the contention that the solute alone is active cannot be justified. As water is altogether peculiar in its activity as a solvent, and is a solvent which gives rise to conducting solutions, an explanation of its efficiency must be sought in its own special and peculiar properties.

Since 1886 this conclusion has been impressed upon me with indisputable force, and I have frequently ascribed the effect produced by the one constituent upon the other in a solution to the residual affinity of the negative elements in the two compounds which act reciprocally. It was only recently, however, that I saw my way to postulate a complete theory which would serve to account for the properties of solutions and generally that I realised how the reciprocal effect might be produced.

I would substitute for the misleading conception that liquids are comparable in their behaviour with gases the idea that the liquid state is one in which the residual affinity of the negative elements in particular always comes into play, and causes the formation of molecular aggregates of various degrees of complexity; moreover, that the alteration in the properties of any given solvent by the dissolution in it of another substance is largely and, in some cases, mainly due to a disturbance of the equilibrium natural to the solvent by an alteration in the proportion in which the several aggregates are present. The alteration in some particular property produced in a given mass of the solvent may, from this point of view, be taken as the measure of the activity of a substance, just as the alteration in the pressure of a particular volume is taken as the measure of the alteration produced in a gas. In the case of non-electrolytes, if only a small amount of the solvent be withdrawn by combination with the solute, the alterations may be regarded as almost entirely due to the "mechanical" interference of the substance introduced, opportunity being given for the simpler, more attractive molecules of the solvent to exist in greater proportion because of the diminution of the chance of re-uniting which is conditioned by the presence of practically inert molecules of another kind; if a more or less considerable amount of the solvent become associated with the solute the conditions become

more complex, but similar considerations apply. From such a point of view a liquid is rendered more active by the addition of any soluble substance. Its vapour pressure is therefore diminished, the internal "osmotic" stresses are raised, its freezing point is lowered.

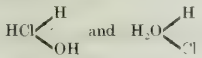
Although it is generally admitted that water is not a uniform substance, but a mixture of units of different degrees of molecular complexity, the degree of complexity and the variety of forms is probably under-estimated, and little or no attention has been paid to the extent to which alterations produced by dissolving substances in it may be the outcome and expression of changes in the water itself. The attempt to extend the "laws" which are applicable to the gaseous state to liquids has led us away from the truth by narrowing our conceptions. If the contention be justifiable that the alterations attending dissolutions are very largely alterations in the character of the water, attention has been directed of late far too exclusively to the dissolved substance.

To give emphasis to the view, I have advocated the restriction of the name water to the liquid mixture, and have proposed that the simple molecule represented by the symbol OH_2 be termed hydrone. The generalised expression

$$(H_2O)x \leftrightarrows xOH_2$$

may be considered to be representative of the state of equilibrium in water—that is to say, of the character of the change which it undergoes when the conditions are varied either physically or by dissolving substances in it—in the sense that it pictures the resolution of the more complex into simpler forms and vice versa, without taking into account the variety of molecular forms (x, x^1, x^2 . . . .) which are present.

To explain the effect produced by substances which give rise to conducting solutions when dissolved in water (acids, alkalies and salts), it is necessary to consider the special nature of the changes which may be supposed to attend dissolution in such cases. Why, it may be asked, is an aqueous solution of hydrogen chloride a conductor whilst that of alcohol is a non-conductor? I believe the answer to be that it is because, in the former case alone, the two components of the solution are reciprocally distributed; that is is because two correlative systems—



are produced which interact under the influence of the electric stress. In the case of alcohol no such interchange takes place.

It is essentially an association theory, although it involves the dissociation of the interacting substances, but never the production of separated ions. In the case of aqueous solutions the amount of the distributed substances may be taken as the measure of the activity—of the degree of ionisation, so-called.

It has been asserted that the association hypothesis does not admit of quantitative treatment, and that, therefore, it is at a disadvantage; but if the quantitative meaning given to various results in accordance with the tenets of the dissociation hypothesis be more often than not one which is inadmissible, little is gained by applying the speculation quantitatively.

The ionic dissociation hypothesis is a beautiful mare's-nest, which fails apparently to fit the facts whenever it is examined. "And the moral of that is," to quote the words of the classical duchess so well known to children, "we must not use the words ion and ionisation in any speculative sense, but confine their application to cases such as were contemplated by Faraday when he introduced the term ion; the conception of activity, whether electrolytic or chemical, should alone be attached to such words; no idea of actual, separate, individual existence should enter into our minds in using them: the ion is to be thought of merely as the potentially active, transferable radicle in a compound, not as a separated particle enjoying independent existence." It is so easy to speak of dissociation when it is desired to give expression to the idea; the first thing the scientific speaker or writer should guard against is ambiguity.

It is undeniable that in England for many years past chemistry has suffered from the recognised fact that there has been little money in it—parents have been led, therefore, to prefer other careers for their sons, and the subject has not secured its due proportion of intelligence, and is suffering in consequence. Too many of those who have entered works have had neither the intelligence nor—to speak plainly—the presence and manners that are required to secure confidence. The presence of men of gentlemanly bearing and instincts, who have received thorough training in science, is urgently needed at the present time in many of our manufacturing establishments to take the place of foremen of the old type, who have learnt all they know in the works and whose conceptions necessarily lack breadth; it is almost impossible to convince such men that improvements are possible, too often they adopt a selfish attitude and advisedly retard progress. Another direction in which an approach of interests is required is between chemist and engineer. The latter has too long occupied a dominant position in many works, and in not a few cases has done its utmost to exclude the chemist, fearing his competition apparently. The gas industry perhaps affords the most striking illustration of the effects of such a policy. On the engineering side it has been carried to a high pitch of perfection, but on the chemical it has ever fallen, year after year, to a lower state. Now the quality of coal gas is such, especially since the withdrawal of the sulphur clauses from the acts of Parliament by which the industry is regulated, that gas is almost unusable.

But the iron industry is an even more striking case. The appliances are wonderful examples of constructive skill, but the engineer is clearly nonplussed when he seeks to understand the processes he nominally controls; the chemist has been kept so closely confined to his bench in the laboratory that he has had no proper opportunity of studying the processes of manufacture systematically. No systematic study of steel has yet been made! Considering the magnitude of the industry and its importance, our knowledge of the subject is phenomenally slight. What we do know of the relation of strength and structure to composition is due to the pioneer labours of the distinguished Dr. Sorby, an amateur unconnected with the industry, and to a fruitful conjunction of the labours of engineers and chemists outside the works, who in self-protection have tested the materials before use.

In Germany the chemist and the engineer have been placed on an equality and required to work together, with results which are altogether satisfactory. We need to adopt a similar practice. Any attempt to fuse the two into one will meet with failure, I am persuaded; they are called upon to work from different points of view. Our future engineers should study chemistry and chemists should study engineering, in order that they may understand one another and work together—not in order that they may supplant one another. The chemist has to some extent allowed himself to be pushed into the background, perhaps because the average chemist in the past has been too tame a person; moreover, being forced to work in his laboratory, he has had less opportunity of gaining freedom and breadth of outlook than the more fortunate engineer, whose work has carried him out into the world.

You will be wise in Canada if you take care to select no small number of your abler students—young men of promise physically as well as intellectually—and train them as chemists. Of late years attention has been called from every side to the inconsiderate manner in which raw materials, especially coal, iron and wood, are being used up in all civilised countries. It is difficult to interest the public in such a subject, as few can appreciate the consequences, owing to the general ignorance of science and to the existence of an optimistic belief in the power of scientific discovery. But nothing will compensate for the exhaustion of your coal and iron supplies. It is your bounden duty to economise these in every possible way. The chemist and engineer will be required to help you in effecting economies by improving present methods of treatment. But the further question arises whether it be not also your duty, here in Canada particularly without loss of time, to effect still greater economies by utilising the vast stores of energy in your possession in the form of uplifted water which now runs to waste. The falls of Niagara are the most glorious and entrancing sight in the world I have witnessed next to the total eclipse of the sun, yet I question whether it be permissible to allow any part of their available energy to be dissipated—whether the claims of posterity do not forbid us to allow æsthetic considerations to prevail in such a case.

To conclude, I have treated my subject very widely and at times vaguely, having ranged over a great variety of subjects—somewhat from the point of view of modern opera, perhaps; indeed, I am willing to confess that I have been much influenced of late years by music and by the recognition of the obvious desire reflective musicians have shown to secure breadth of effect and harmonious development of all the elements which go to compose a dramatic situation. Chemistry touches the drama of life at every point. If ever we are to understand life and regulate our actions in accordance with understanding it will be in no slight measure because we appreciate the lessons which chemistry alone affords.

Hydro-Electric Plant in the Highlands.—An interesting hydro-electric installation has recently been set to work at Blair Castle, the seat of the Duke of Atholl. Three Pelton wheels, each of 60 H.P. capacity, are used, these being direct-coupled to dynamos. Not only the house but also certain of the surrounding villages are to be lighted from this plant. An important feature, which appears to be successful, is that no accumulators are installed, while the plant runs day and night without an attendant.

CORRESPONDENCE.

THE RESISTANCE AND REACTANCE OF ARMOURED CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the article under the above title in your issue of to-day's date, abstracted from Mr. J. B. Whitehead's Paper read before the American Institute of Electrical Engineers, the author shows that the inductive losses due to the steel wire armour of the short lengths of single conductor cable were not prohibitive to their use.

I would like to point out that the losses would have been greatly reduced had one of the steel armour wires been replaced by a bronze wire. Single conductor cables for use with alternating current and armoured as described were manufactured over five years ago.—I am, &c.,

Messrs. Johnson & Phillips (Ltd.), F. J. O. HOWE.
Charlton, Kent, Aug. 27.

REVIEW OF DR. GOLDSCHMIDT'S "NORMALE EIGENSCHAFTEN ELEKTRISCHER MASCHINEN."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Please note in our review of this book, in your last issue, the statement "outputs of 2,000 kw. to 3,000 kw. at 3,000 revs. per min. are quite common" should read "at 1,500 revs. per min." The error in the proof quite escaped our notice.—We are, &c.,

Birmingham, Aug. 28. THE REVIEWERS.

STREET LIGHTING IN BERLIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In view of the report presented by the deputation of the Streets Committee of the Corporation of London who recently visited the Continent, we were surprised to find during our visit to Berlin a few days ago that the principal streets—such as Unter-den-Linden, Friedrichstrasse, Leipzigerstrasse, Potsdamerstrasse, &c., corresponding to Regent-street, Oxford-street, Piccadilly, Strand, &c.—were lighted by arc lamps (white flame) mostly suspended in the centre of the streets on span wires fixed to the buildings, and with automatic contact lowering gear, with arrangements for drawing to the side for trimming.

Only the less important streets were lighted by gas, and, judging from the effect, we can only imagine that the Berlin City Fathers, being progressive (as is shown by the beauty of their charming city), are not likely to take the retrograde step of putting in more gas lighting than they can possibly help.

With regard to the recommendation that all lamps (both gas and electric) shall be on lowering gear, we believe we pointed out to you some months ago that our lowering gear is equally applicable to gas as to electric light by the substitution of a gas connection for the usual electrical coupling, and there is no difficulty to us in dealing with this problem either for swan-neck poles, centrally hung carriers, or cross street suspension gear.—We are, &c., *pro* THE LONDON ELECTRIC FIRM,

Croydon, Aug. 31. G. A. HUGHES.

FARADAY HOUSE.

The Governors of Faraday House have appointed Dr. Alexander Russell, M.A. (Cantab), D.Sc. (Glasgow), M.I.E.E., to be Principal in succession to the late Mr. H. E. Harrison.

Dr. Russell took the degree of M.A. at Glasgow University in 1882 with first-class honours in mathematics and natural philosophy. In the same year he obtained the first prize in Lord Kelvin's senior natural philosophy class. He then went to Cambridge, and was 14th wrangler in 1885. For two years he was an assistant lecturer to Caius College, and was afterwards a mathematical master at Cheltenham College and the Oxford Military College. When Faraday House was started in 1890 he was offered and accepted the post of lecturer on applied mathematics and head of the physical laboratory department. Since his appointment he has written more than 50 Papers on subjects connected with electrical engineering. He has also written an advanced treatise on "Alternating Currents" (two volumes, Cambridge University Press), which has been translated into French by Dr. Seligmann-Lui, a treatise on cables (Constable & Co.), two lengthy serials, one on "Electrical Engineering" and the other on "Electric Heating and Lighting," which appeared in the "Builder," and he has translated Prof. Buchetti's work on "Engine Tests and Boiler Efficiencies."

He has communicated Papers to the Institution of Electrical Engineers, the Physical Society and the Royal Society. For five of his Papers to the Electrical Engineers he has received premiums, and six of his Papers have been published in the "Philosophical Magazine." To electrical engineers Dr. Russell's name is perhaps best known in connection with the grading of electric cables, a subject to which he has devoted a great deal of thought. He was the first to explain what was meant by the capacity of polycore cables, and in conjunction with Mr. G. F. C. Searle, F.R.S., devised an accurate definition of the capacity between two cores.

In 1901 he devised "Russell's test" for measuring the insulation resistance of a network of mains. This test is in daily use in many central stations. In 1903 he devised a rapid method of measuring the mean spherical candle-power of lamps, which has come into extensive use, and is embodied in the Russell-Léonard photometer. In 1906 he verified the suggestion made by Lord Kelvin in 1860 that at very high pressures the electric strength of air would be found to be constant. He has also found accurate formulæ for the self and mutual inductance of coils of various shapes, and verified them experimentally.

At the beginning of the present year he read a Paper to the Physical Society, giving for the first time the complete solution of the important problem of the "skin effect" in concentric mains which was first discussed by Maxwell. The solution was given in terms of certain new functions which he called the ber and bei functions. The computation of tables of these functions has been undertaken and is rapidly approaching completion. Kelvin's tables for ber and bei functions have also been re-computed. He has also this year, in conjunction with Mr. Arthur Wright, the well-known electrical engineer, been engaged with considerable success in perfecting methods for solving algebraical equations and doing other mathematical operations by electricity. Papers were read on this subject to the Physical Society, and the Arthur Wright device was shown at the Royal Society's Conversazione. Last June Dr. Russell read a Paper to the Royal Society in which he showed how the attractions or repulsions of electrified spherical conductors could easily be computed when they were close together.

He is a member of the Institution of Electrical Engineers, and has been for several years a member of the Council of the Physical Society. In 1908 the University of Glasgow conferred on him the degree of D.Sc.

INSPECTION AND INSURANCE OF ELECTRICAL AND OTHER MACHINERY.

The annual report for the year 1908 of Mr. M. Longridge, chief engineer to the British Engine, Boiler & Electrical Insurance Co., is of particular value to engineers in view of an important disquisition on the stresses in gas engine shafts, whilst the report also possesses its customary interest from the electrical engineer's point of view. It is divided, as usual, into the following sections: (1) Inspection and insurance of steam, oil and gas engines; (2) inspection and insurance of electrical machinery; (3) inspection and insurance of boilers and other vessels, and (4) boiler explosions and abstracts of the Board of Trade reports on boiler explosions received during 1908; whilst a note on the design of vertical single-acting air pumps is also included.

We notice from the first section of the report that the ratios of breakdowns of steam and gas engines have been approximately equal, viz., 1 in 9·4 and 1 in 9·1 respectively, compared with 1 in 11·7 and 1 in 11·1 in 1907, and 1 in 8·1 and 1 in 12·4 in 1906. In steam engines valves and valve gear are the main cause of breakdown, the proportion of such failures being 34·8 per cent. of the total. It would also appear that these parts are becoming increasingly liable to failure, since the percentage in the previous year was 28 per cent., and averaged 21 per cent. in the preceding 24 years. On the other hand, in the case of gas and oil engines, valves and valve gear are supposed to have given way in 31·3 per cent. of the total number of failures reported, compared with 43·3 per cent. in the previous year and 32·5 per cent. as the average of 24 years previous to 1907. An increase, however, is shown, in the case of gas and oil engines, in the percentage of failures of cylinders and cylinder ends, viz., 19·4 per cent., compared with 13·5 per cent. and 16·6 per cent. respectively. Probably of more importance is the increase in the percentage of gas engine shaft failures from 5 per cent. in the 24 years previous to 1907 and 4·7 per cent. in 1907 to 9·1 per cent. in 1908.

Mr. Longridge remarks that the continually increasing percentage of breakdowns of steam engines due to breakage of valves and valve gear, suggests that some improvement in designing and manufacturing these parts is desirable, and that more strength, and certainly more care in fitting and screwing nuts, screws, pins and cotters would reduce the number of failures. In view of the number of breakages of gas engine shafts in 1908 and of the variety of dimensions adopted by different makers, Mr. Longridge enters into the question and estimates the stresses upon such shafts more closely than is possible by the formulæ given in his annual report for 1906. He also suggests maximum stresses of 9,000 lb. per square inch for shafts with two bearings, and 8,000 lb. per square inch for shafts with three bearings.

The causes of the various breakdowns are roughly classified as follows: Accident and causes unascertained, steam engines 29 per cent., gas and oil engines 35 per cent.; old defects or deterioration by wear and tear, 15 per cent. and 20 per cent. respectively; weakness, bad design, workmanship or material, 31 per cent. and 18 per cent. respectively; negligence of owners or attendants, 25 per cent. and 27 per cent. respectively.

The customary descriptions of typical steam engine failures are given, but those of gas engines are limited to two cases, owing to the space devoted to the consideration of the strength of shafts mentioned above.

Turning now to the electrical branch of the company's business, a satisfactory increase is recorded in the number of insurances, but this is offset by an increase in the number of breakdowns and in the cost of repairing the damage done. The ratio of breakdowns among the various classes of machines was: Dynamos—direct current 1 in 13·7, alternating current 1 in 5·7; motors—direct current 1 in 9·2, alternating current 1 in 11·3; starters and controllers 1 in 24. The proportion in which the various parts of the machines caused or initiated the breakdowns are tabulated below, the corresponding figures for 1907 being given also:—

Part believed to have failed first.		Dynamos. 1907.	Dynamos. 1908.	Motors. 1907.	Motors. 1908.
Armatures and rotors	per cent.	35	30	38	36
Commutators and slip rings	,,	30	40	25	26
Magnet coils and stators	,,	7	11	14	16
Brush gear and terminals	,,	4	0	6	5
Shafts, spiders, cores, binders, pulleys and gear wheels	,,	20	11	9	9
Frames, pole-pieces, bearings, &c.	,,	4	8	8	8
		100	100	100	100

STARTING SWITCHES AND CONTROLLERS.

		1907.	1908.
Resistance coils	per cent.	60	52
Contacts and switch arms	,,	8	10
Automatic apparatus	,,	13	13
Frames, slabs, carriers for coils, springs, &c.	,,	19	25
		100	100

As motors form by far the largest proportion of the machines insured, the proportions in which the parts of direct and alternating-current motors caused or initiated breakdown in 1908 are tabulated separately, thus:—

Part believed to have failed first.		D.C. Motors.	A.C. Motors
Armatures or rotors	per cent.	38	21
Commutators or slip rings	,,	29	2
Magnet or stator coils	,,	11	53
Brush gear and terminals	,,	6	0
Shafts, spiders, cores, binders, pulleys, gear wheels, &c.	,,	9	6
Frames, pole pieces, bearings, &c.	,,	7	18
		100	100

The causes of the above breakdowns were probably as follows:—

		Dynamos. 1907.	Dynamos. 1908.	Motors. 1907.	Motors. 1908.	Starters. 1907.	Starters. 1908.
Accidental	per cent.	8	6	4	4	9	8
Dirt and neglect	,,	25	23	28	30	16	17
Age and deterioration	,,	23	25	23	20	27	25
Bad work or design	,,	21	20	18	11	8	9
Overloading	,,	0	0	1	1	5	2
Unascertained	,,	23	26	26	34	35	39
		100	100	100	100	100	100

We select from the report the following interesting and typical examples of breakdowns of electrical machinery during the year:—

(1) Two-pole semi-enclosed shunt-wound 2 H.P. motor, running at 1,300 revs. per min., with current at 250 volts, and coupled by gearing to a "nailing machine." One of the nails must have fallen into the casing, and been caught in the stray field and drawn in between the armature and one of the pole faces, short circuiting some of the armature conductors. Owing to the position of the damaged conductors the armature had to be entirely rewound. This and other cases illustrate the danger of leaving small pieces of iron or steel near dynamos or motors, especially those of open type, with stray fields unscreened by iron or steel casings.

(2) Direct-current 5 H.P. four pole motor, running at 700 revs. per min., with current at 220 volts. The armature shaft was carried in phosphor-bronze bearings, and lubricated by rings running in oil wells fitted with drain cocks, having handles cast with the plugs. The motor was coupled to the machine it drove by a belt, one edge of which passed very close to the drain cock of the bearing at the pulley end. For some reason the belt seemed to have run to one side of the pulley, caught the handle of the drain cock, and knocked it into the open position, with the result that the oil ran out of the oil well, lubrication ceased, and the bearing seized. The accidental opening of these drain cocks is by no means so rare an occurrence as might be supposed, and it does not seem unreasonable to suggest that they should be made in such a way as not to be liable to be opened by the chance touch of a jacket, a cleaning rag or a belt, if there be one near.

(3) Two-pole compound-wound open-type belt-driven direct-current dynamo, nine years old, giving 200 amperes at 100 volts when running at 700 revs. per min. The commutator "went to earth," the mica insulation between three of the bars was burnt, the conical clamping ring at the back of the commutator fused, and the solder holding the armature conductors to two of the commutator lugs melted. The cause was short-circuits between four of the commutator bars and the clamping ring at the end next the armature. The short-circuits were established by accumulations of carbon dust and oil behind the commutator lugs. The owners had been frequently advised of the importance of keeping this very vulnerable part of the commutator clean, and kept an air compressor to provide a strong blast for the purpose, but the presence of the oil rendered it ineffective. The passage of oil to the back ends of commutators is very difficult to prevent, and is most troublesome in its effects, as it cannot be removed. It does not take place when commutators are pressed on to their shafts, but no care in fitting seems able entirely to prevent it. When quills are held by feathers or screws the only satisfactory plan appears to be to caulk a copper ring beneath the shaft and the front end of the casting.

(4) Compound-wound bipolar belt-driven direct-current dynamo, 12 years old, giving 72 amperes at 150 volts when running at 1,000 revs. per min. The inspector found the shunt winding of one of the coils "earthed." When he removed the series winding to get at the fault he found the insulation of the shunt winding perished and worn away, especially at the bends round the corners of the metal former. The other coil was in a similar condition, and both had to be entirely re-wound. The deterioration was apparently due to nothing but the ordinary working heat and the slight movements produced by expansion and contraction.

(5) Three-phase alternating-current semi-enclosed motor, two years old, taking current at 440 volts and giving 15 H.P. at 800 revs. per min. The motor was placed in a chamber at the top of a tower, into which hot ashes slaked with water were lifted by an endless chain, driven by a belt. The chamber was full of dust and steam, and a very unsuitable domicile for an electrical machine. During the time the motor had been insured the company had urged the owner to move it, but without avail. It had worked all right; why should it not continue to work all right under the same conditions? There would be time enough to think about moving it when it did break down. This time came in 1908, when the insulation of the stator windings had become so rotted by sulphurous steam and impregnated with grit and dust that they became short-circuited. The fuse melted, and four of the stator coils were burnt, the top and bottom in one slot and the top in the two adjacent slots. The rotor suffered no visible damage. The breakdown was due to gradual deterioration of the insulation under the ordinary working conditions. Having demonstrated its need for a more suitable environment by breaking down, the motor was moved into a shelter, carried on brackets from the wall of the tower, where it had a chance of moderately fresh air and cleanliness.

(6) Four-pole shunt-wound 6 H.P. direct-current motor, running at 800 revs. per min., with current at 220 volts. Fuse, one No. 22 S.W.G. copper wire. Three of the commutator segments were short-circuited by copper dust and partly fused, and the insulation was burnt off three of the armature coils. The inspector who examined the motor found specks of copper embedded in the mica between most of the commutator bars and the edges of some of the bars burred over, and on inquiry ascertained that the owners of the machine had been turning the commutator in their own lathe, and had set it to work without taking care to clean the copper dust out of the mica between the bars or seeing that there was no bridging from bar to bar before replacing the armature in its bearings. The case is mentioned because it is typical. The breakdown was only one of many which might be avoided by the exercise of a little care. After commutators have been turned they should be carefully examined. The most risky places are the corners where the lugs spring from the bars.

(7) Completely enclosed four-pole shunt-wound 27 H.P. direct-current

motor, three years old, driving a fan at a speed varying from 875 to 970 revs. per min., with current at 460 volts. Each of the four brush holders contained one carbon brush, with V-shaped head, fixed in a corresponding slot through the end of the brush holder, and the foot of the brush resting on the surface of the commutator. The brush was prevented from coming out of its slot by a small set screw passing through the top of the brush holder and pressing on the flat top of the brush. On receipt of a message that something had gone wrong with the motor, the district inspector went to examine it. When the cover was taken off he found one of the brushes in the bottom of the motor casing, and the brush holder resting on the commutator and considerably worn down. The brush must have fallen out at an earlier date, and allowed the brush holder to drop on to the commutator, there being no stop on the spindle to prevent this. One of the commutators of another motor at the same works had been damaged in the same way a short time previously, and similar mishaps are of frequent occurrence when no provision is made for supporting the brush holder independent of the brush. In this case the holder itself was not satisfactory, otherwise it would not have allowed the brush to fall out in this way. The company has had least trouble, perhaps, with brush holders consisting of a plain box holding a rectangular block of carbon, with a flexible conductor attached, and a spring to keep the carbon up to the commutator surface.

(8) Four-pole shunt-wound semi-enclosed direct-current motor, seven years old, giving 12 H.P. at 1,000 revs. per min., with current at 250 volts. Fuse, one No. 20 S.W.G. copper wire. The motor drove a stentering machine by gearing. The fuse melted, and the owner sent for the inspector, who found the armature windings short-circuited and "earthed." The armature had to be stripped to get at the damaged coils. They were found to be six in number, and had all been in contact with the winding drums at the ends of the armature, the sharp unprotected edges of which had cut through the insulation. This case is typical of many others of the same kind. Surely common-sense should suggest that the edges of end plates and winding drums over which thinly-covered conductors pass should be well rounded, and that the conductors should be still further protected by strong presspahn or other insulating material. It is not possible to prevent entirely relative movement between the conductors and the core or winding drum, and it is certain that any movement, however slight, will enable a sharp metal edge to cut through the thin covering of an armature conductor. This relative motion is also responsible for another large class of accidents, the fracture of armature conductors at their junctions with the commutator arms. The usual methods of preventing the rotation of armature spiders and commutator quills, and still more of armature core plates threaded upon the shafts, by feathers, projecting screw heads and set-screws are not effective either because the bearing surfaces are insufficient, or because the fitting is not good enough. The best plan, when the diameter permits, undoubtedly is to build both armature and commutator upon the same casting.

Mr. Longridge remarks :—

The general impressions left upon the minds of those in charge of the electrical department are that a very large majority of the breakdowns are due to the deteriorating effect of oil, dust and damp on the materials used for insulating. Of these oil is the most injurious and most difficult to deal with. Better arrangements are needed to prevent oil throwing. If oil once gets out of a bearing it creeps along the shaft to the back of the commutator and on to the end windings, also on to the commutator insulation and brush gear, and mixing with copper, carbon or other dust, forms short-circuits, giving rise to carbonisation and "burning out." The next most fruitful cause of damage is probably imperfect fitting, keying, and locking of spiders and core plates, commutator bushes, and even pole pieces, leading to abrasion of insulation and "earthing." Careless winding and fitting of magnet coils is also sufficiently common to be noted. Lastly, many of the users of electrical machinery do not give it the attention it requires. They fix motors in places which are difficult of access, dusty or dirty, and leave them to work as best they may. If motor bearings were made like bicycle bearings, with balls running in vaseline, and if the armatures were regularly blown out, and the brushes attended to, the number of breakdowns would be far fewer than they are.

As many people seem to think that if a controller containing resistances in series with the armature of a motor will give certain variations of speed at full load the same controller will give the same variations at light load, Mr. Longridge goes at some length into the subject of speed control, taking, as an example, an actual installation. He shows that although in the case considered the controller was able to reduce the speed from 420 revs. per min. to 50 revs. per min., when taking the current required to give the full-load torque, it did not effect the same reductions with smaller currents, and with a current equivalent to only 6·45 per cent. of full load torque the speed control was only from 333 to 450 revs. per min. He also draws attention to the fact that all forms of speed control by resistance in series with the armature are wasteful. Control by resistance in the shunt circuit has, on the other hand, a high efficiency, and can be used with modern motors with interpoles for a speed variation of 1 to 6. But this efficiency is only obtainable at a high first cost. For as the effect of putting resistance in series with the shunt is to increase the speed by weakening the field, the motor must be large enough to give the torque required to overcome the resistance of the full load with the weakest field. Other arrangements are possible, however, and he points out that each case must be considered on its merits, having regard to first cost, working cost and graduation of speeds required.

ON CLARK AND WESTON STANDARD CELLS.*

BY H. L. BRONSON, PH.D., AND A. N. SHAW, B.A.

This Paper deals mainly with the accuracy and reproducibility of Clark and Weston cells, and it is hoped that it may throw further light on the value of the cell as one of the two legal electrical standards. The work has been very much facilitated by the courtesy of the Bureau of Standards at Washington, where one of the authors, at the suggestion of Dr. H. T. Barnes, spent some time in the summer vacation of 1908 in studying the construction of modern standard cells. At the invitation of Dr. F. A. Wolff we have been glad to co-operate actively with the Bureau in the work it has been doing along these lines.

I. *The Reproducibility of the Cells when Prepared according to the Specifications of Wolff and Waters.*—The mean of 15 Clark cells made in this way differed, a few weeks after their construction, from the mean of the reference cells of the Bureau of Standards by less than 14 microvolts. The average deviation of our cells from their own mean was not more than 13, while the maximum deviation was only 31 microvolts. In the case of the Weston cells the figures were similar, but showed somewhat better agreement in every case ; the difference between the mean of 13 cells and the mean of the reference cells at the Bureau of Standards being in this case 4 microvolts, the average deviation of the cells from their own mean being 8, and the maximum deviation being 22. Some of the Clark and Weston cells were made in Washington by one of the writers, and subsequently transported to Montreal. A means of direct comparison with the values of the cells at the Bureau of Standards was thus obtained. This comparison has recently been checked by a second interchange of cells. We have also had in our possession six Weston cells made at the National Physical Laboratory in London. One of these was damaged in transit ; the mean of the other five differed from the mean of our other cells by only 5 microvolts.

II. *The Effect of Introducing Slight Simplifications into the Preparation of Materials.*—About 25 cells were constructed in order to examine the effects of slight simplifications in their preparation. It was found that the ingredient of main importance is the mercurous sulphate, which must always be prepared with great care. When unpurified mercurous sulphate was used in a cell the average E.M.F. was found to be from 300 to 500 microvolts higher than that of the normal cell. The purification of the zinc and cadmium salts is not so important, and as the processes are somewhat tedious, especially in the case of cadmium sulphate, it is interesting to see what accuracy may be obtained with various samples of chemically pure commercial sulphates. It was found that no Clark cell made with this modification differed by more than 50 microvolts from the mean of our normal cells, while no Weston cell differed by more than 100 microvolts. Such cells are therefore sufficiently accurate for all practical work. The presence of basic oxide, oil, or small quantities of organic impurities was found to exert only a very small influence on the E.M.F.

III. *The Relative Value of Cells set up according to the Board of Trade Specifications and those set up according to the Specifications of Wolff and Waters.*—Ten Clark cells of the old "test-tube crystal" type were prepared from a number of different samples of chemically pure commercial materials, for the purpose of ascertaining how much they differed in voltage from those set up according to the modern specifications. The average E.M.F. of these cells during the first 75 days, neglecting the first day, was 0·31 millivolt higher than the mean of our normal cells. The average deviation of these cells from their own mean was considerable, about 0·06 millivolt, which suggests that there might be a possible variation of three or four in the last figure of the mean for different batches of 10 cells set up with different materials. It is therefore in good agreement with the value (0·00030 volt) given by Wolff and Waters.

IV. *The Ratio of the E.M.F. of the Weston Cell to that of the Clark.* The determination of this ratio, which had also been obtained at the Bureau of Standards, was made with the object of furnishing a further check on the reliability of the comparison between our cells and those of the Bureau, and to give added assurance that no errors

* Abstract of a Paper read before Section A of the British Association.

had been introduced by transportation. Five Clark cells were connected in series and placed in opposition to seven Westons similarly connected. The difference between the two sets was then measured on a Kelvin-Varley slide by the usual potentiometer method. The ratio obtained was 0·716953, which differs from the ratio 0·716958, determined by Wolff and Waters, by only seven parts in a million. This difference, small as it is, is entirely accounted for by the small differences, as ascertained by direct comparison between our cells and those made at the Bureau of Standards.

An account of several cells made with mercurous sulphate prepared at the Bureau of Standards and dried with alcohol, was also given in the Paper, while the results of a number of Weston cells of the normal type will be added to those mentioned in this abstract. Owing to large initial hysteresis their E.M.F. had not, up to the time of writing, assumed their final value.

THE ROTATION OF THE ELECTRIC ARC IN A RADIAL MAGNETIC FIELD.*

BY J. NICOL, B.A., B.SC.

Summary.—The speed of the electric arc across a transverse magnetic field is shown (1) to be independent of the arc length, (2) to be proportional to the magnetic field strength, and (3) to increase linearly with the current.

The experiments are similar to those made by Prof. Wilson and Mr. G. H. Martyn† with the electric discharge in a vacuum tube and were suggested by Prof. Wilson. The apparatus consisted of a vertical iron rod A (Fig. 1,) magnetised by two solenoids, B, at its ends, wound in opposite directions, so as to give a pole in the middle of the bar. With this arrangement the field round the middle of the bar is uniform and radial. The distance between the two solenoids was fixed by a quartz tube, C, which also served to protect the iron rod from the heat of the arc. The arc passed between two copper tubes, D, 2 cm. in diameter, held coaxial with the iron rod by a clamp made of wood and brass. The copper tubes were clamped in holes cut in two pieces of thick (5 mm.) sheet brass, E, fixed to the top and bottom of a block of hard wood, F. The required arc length was obtained by clamping the electrodes while they were pressed firmly against a gauge of sheet brass held between them. The base of the iron rod and the stand carrying the arc electrodes each rested on three screws in a hole slot and plane fixed to the table by paraffin wax. Thus the whole apparatus could be quickly taken down and set up again in the same position. This was necessary to enable the electrodes to be renewed after each experiment. The arc was in all cases started with the magnetic field already in action by momentarily bringing a piece of arc-lighting carbon in contact with the two electrodes.

Experiments were first made with carbon electrodes, but though the discharge could be started and would occasionally make a few revolutions it never lasted for more than one or two seconds. An iron-iron and an iron-mercury arc were tried with equally unsatisfactory results. Then a copper arc was used and with it all the experiments described in this Paper were made. The current for the arc was taken from the electric lighting supply at 200 volts, resistance being put in the circuit. Though the copper arc was much more stable than any of the others which had been tried, the discharge seldom lasted for longer than 30 seconds, and then only when brightly polished electrodes were used. After every second or third discharge, therefore, the apparatus was taken down and the electrodes replaced by fresh ones, while the old ones were repolished in a lathe with fine emery paper.

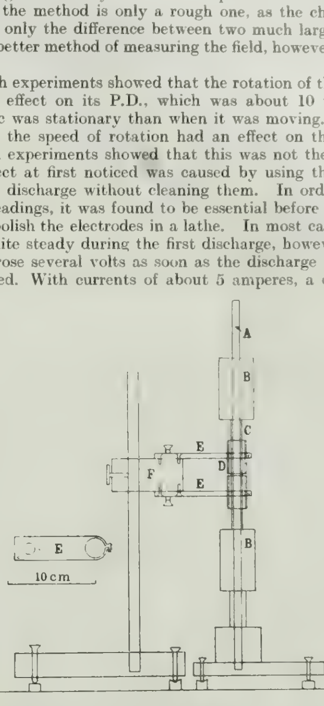
As the discharge only lasted for so short a period, a stroboscopic method of measuring the speed of rotation was out of the question, and in place of it a photographic one, involving the use of a rotating mirror, was employed. The mirror was fixed not quite normally on one end of the shaft of a small electric motor. When the motor was working, a point source viewed in the mirror appeared drawn out into a circle of light, and if the point source was intermittent this circle was broken into as many dots as the number of times the source became active during each revolution of the motor. The intermittent source was obtained by placing a vertical slit in front of the arc. This was illuminated by the arc once every time it revolved round the iron bar. The image of the slit in the rotating mirror was then photographed with an ordinary camera. To turn the mirror, a $\frac{1}{8}$ H.P. motor was run at about 250 revs. per min., and the camera exposure was about $\frac{1}{3}$ second.

If k_1 and k_2 are the velocities of the ions due to unit electric force, the rate at which the arc moves is given by the expression‡ $v = HXk_1k_2$, or $k_1k_2 = \frac{2\pi n}{H/r \, . \, X}$, where n is the number of revolutions the arc makes per second and H and X are the magnetic and electric forces and r the radius of the electrode. This relation is proved in the Paper.

The magnetising current was supplied from an 8-volt accumulator, and the actual values of the field (or rather of H/r, which is constant for a radial field) for different magnetising currents were found by the same method as that used by Wilson and Martin.

In order to obtain a value of the electric force in the arc, it was assumed that the change in the P.D. observed when the length of the arc was altered at constant current was equal to the product of the electric force and the change in length. This is equivalent to assuming that the potential-drops at the two electrodes are independent of the length of the arc. Probably this is not quite true, as lengthening the arc may affect the temperature of the electrodes. In any case the method is only a rough one, as the change in the P.D. used is only the difference between two much larger observed P.D.s. No better method of measuring the field, however, suggested itself.

Very rough experiments showed that the rotation of the arc had a considerable effect on its P.D., which was about 10 volts higher when the arc was stationary than when it was moving. At first it seemed that the speed of rotation had an effect on the P.D., but more careful experiments showed that this was not the case. The spurious effect at first noticed was caused by using the electrodes for a second discharge without cleaning them. In order to obtain consistent readings, it was found to be essential before each experiment to re-polish the electrodes in a lathe. In most cases the P.D. remained quite steady during the first discharge, however long this lasted, but rose several volts as soon as the discharge was stopped and re-started. With currents of about 5 amperes, a curious phenomenon was noticed. Soon after starting the discharge, the P.D. would rise steadily 4 or 5 volts and then fall again to its original value, remaining steady until the arc went out. This did not happen with larger or smaller values of the current.



The values of the P.D. obtained were multiplied by the arc current and the resulting product plotted against the current, as was done by Mrs. Ayrton in the case of the carbon arc. The curves obtained were not quite straight lines as they were in Mrs. Ayrton's experiments, but were very nearly so. Corresponding ordinates of the smooth curves were subtracted, and the differences $\delta(Vi)$ plotted against i. The points thus obtained lay with sufficient accuracy on a straight line giving $\delta(Vi) = 3{\cdot}75 + 5i$, $X = 1/0{\cdot}088(5 + 3{\cdot}75/i) = 57 + 42{\cdot}5/i$. The observations on which this formula is based are given in tables in the Paper.

Most of the experiments were made with arc lengths of 0·230 cm. or 0·272 cm. Arc lengths of 0·185 cm. and 0·360 cm. were also used. As far as the accuracy of the experiments extends, the arc length appears to have no influence on the speed of rotation. It was provisionally assumed that the speed of rotation was proportional to the magnetic field, and consequently to $(i_H - 0{\cdot}1)$. The mean values in the tables, obtained by dividing the number of rotations per second by $(i_H - 0{\cdot}1)$, were therefore plotted against the current, and the points lie approximately on the straight line $n/(i_H - 0{\cdot}1) = 4{\cdot}1i + 14{\cdot}2$, or substituting the values $H/r = 34{\cdot}9(i_H - 0{\cdot}1)$ and $2\pi rn = v$, $v = H(2{\cdot}55 + 0{\cdot}74i)$.

From the experiments the value k_1k_2, the product of the speeds of the ions carrying the current, is calculated. From this value, by assuming the negative ion to be a corpuscle and calculating its velocity, it is shown that the carriers of positive electricity have a mass of the same order as that of the hydrogen atom.

* Abstract of a Paper read before the Royal Society.
† "Roy. Soc. Proc.," A, Vol. LXXIX., 1907.
‡ Wilson and Martin, *loc. cit.*

THE EFFECT OF TENSION ON THERMAL AND ELECTRICAL CONDUCTIVITY.*

BY N. F. SMITH.

Summary.—The author first describes the apparatus used in the investigations. His results show that in every case the thermal conductivity of bars of iron, steel, copper, brass, &c., increased when a moderate tension was applied, whilst the electrical conductivity diminished.

Since it has been shown that the ratio of thermal and electrical conductivity is approximately constant for all metals, it is natural to expect that anything which produces a change in the one would cause a corresponding change in the other. The effect of tension on the electrical conductivity of wires has been measured by Cantone, Williams, Ercolini, Gray and others, and it has been shown that, in general, the resistance of such wires increases when under tension, that up to the elastic limit the increase in resistance is nearly proportional to the stretching force, that beyond this state the change is roughly proportional to the elongation. Bismuth shows a change in the opposite direction. So far as the writer knows, no measurements have been made upon the corresponding thermal problem. The present investigation was undertaken to determine what changes, if any, are produced in the thermal conductivity of metal bars when they are subjected to a stretching force, and to compare these changes with those which are produced in their electrical conductivity.

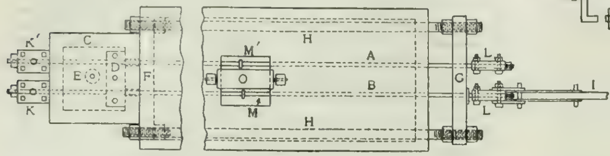


Fig. 1.

The method adopted for the thermal problem was substantially that of Wiedemann and Franz. Two bars, A and B, of the same size and material, and as nearly alike as possible in every respect, were heated at one end to a constant temperature. When the steady state was reached, a point was determined on B whose temperature was the same as that of a fixed point on A. B was then subjected to a stretching force while the condition of A remained unchanged. When the steady state was again reached a new point was determined on B having the same temperature as the fixed point on A. Assuming that the conductivity is proportional to the square of the length from the hot end to this point of constant temperature, we have a means of measuring the change produced by the force applied. Also the electrical resistance of a measured length of the bar B was compared with that of approximately the same length of bar A as each successive tension was applied to B. The method used was a modification of the Kelvin "double-bridge method" due to J. H. Reeves.

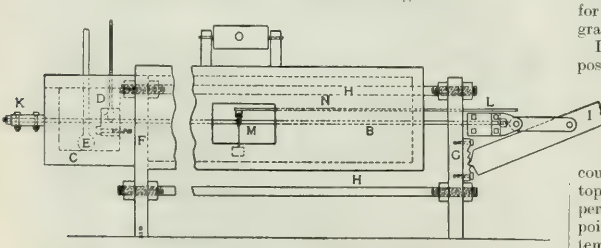


Fig. 2.

After many modifications, the apparatus finally used was constructed as shown in plan in Fig. 1 and in elevation in Fig. 2. Round bars were employed, $\frac{5}{16}$ in. diameter and about $4\frac{1}{2}$ ft. long. The bars A and B were mounted horizontally side by side about 3 in. apart. At the left-hand end they passed completely through a cast-iron box, C, each edge of which was 8 in., and whose sides were 1 in. thick. This rested on a tripod stand over a Bunsen burner. The box was provided with a cast-iron lid and was thickly wrapped in asbestos. On the inside of the box the bars were clamped between two heavy pieces of copper, D, one above the other, each 5 in. long, $1\frac{1}{2}$ in. wide and 1 in. thick. These were bored out to receive the bars and held together by bolts. The bars were carefully insulated from the box and from the copper clutch by thin sheets of mica. A hole in the centre of the copper clutch received the bulb of a thermometer whose stem projected through the cover of the box. The copper clutch was maintained at a constant temperature by a thermostat. This consisted of a mercury bulb, E, placed at the bottom of the box directly over the flame, having a capillary stem projecting above the cover. A wire inserted in the top of the stem touched the mercury when a certain temperature was reached. This closed an electric circuit and shut off the gas from the burner. As soon as the temperature commenced to fall the circuit was opened and the gas turned on and lighted by a small pilot light which burned continuously. Some difficulty was experienced in making the mercury bulb respond quickly enough to the changes of temperature. Finally the alloy used in making fuse wire was employed. This melted at the temperatures used, but did not vaporise, and secured intimate thermal connection between the bulb and the bottom of the iron box.

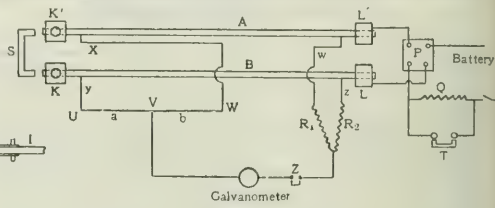


Fig. 3.

In order to apply tensions equal to the breaking strength of the bars it was necessary that they be mounted in an extremely rigid frame. This was constructed as follows: A cast-iron plate, F, was mounted upright on a table immediately in front of the iron box. A similar plate, G, was mounted parallel to the first and about 36 in. in front of it. The bars under observation passed through suitable holes in these plates, being insulated from them by fibre tubing. Four $\frac{3}{4}$ in. iron rods, H, connected the two plates. Two $\frac{3}{8}$ in. iron rods were screwed into the bottom of the plate F and made fast to the floor joists below. Two other rods $\frac{1}{2}$ in. diameter passed through F horizontally, then through a 12 in. brick wall of the building, and were made fast to a large iron plate on the opposite side. The stretching force was applied by means of a lever, I. A steel knife-edge was attached at right angles to the lever at its lower end. To the plate G was screwed another iron plate, J, insulated from G by sheets of mica. The plate J had several horizontal notches cut in it, in which the knife edge on the lever could rest, serving as a fulcrum. To hold the bar B from slipping and to afford a means of attachment to the lever, a friction clutch, KL, was provided for each end. A box for carrying weights hung from the end of the lever, and could be gradually lowered or raised by means of a jack screw.

In order that the bar A might be under conditions as nearly as possible identical with those of B, its two ends were provided with a similar pair of friction clutches and lock nuts. This was done in order that any changes in room temperature might produce the same effect upon the outer ends of the two bars. To protect the bars from air currents they were enclosed in a tight wooden box. The top of this box was hinged, and could be lifted to afford access to the bars, and glass windows in the top and side afforded mean sof observation. Observations of temperature were made by means of thermo-electric couples, two points, one on each bar, being determined which had the same temperature.

The arrangement of apparatus for the comparison of resistances is shown in Fig. 3. A number of storage cells could be connected with the two bars A and B through the commutator P. A resistance, Q (consisting of two incandescent lamps in parallel), was introduced into the circuit. This resistance could be completely cut out by inserting the copper connector T in its mercury cups. After trying various forms of movable contacts, the fine lead wires x, y, z, w were finally soldered directly to the bars. Great difficulty was experienced in eliminating the effects of thermo E.M.F.s developed at various contacts of dissimilar metals. For this reason the lead wires were, wherever possible, made of the same material as the bars to which they were attached. The other ends of x and y were joined to the terminals of a slide-wire bridge, whose resistance wire a, b was wound on a revolving cylinder, and the whole enclosed in a wooden box, so that the three junctions U, V, W should be at the same temperature. The free ends of z and w were joined to the terminals of two standard resistance boxes, R_1 and R_2. R_1 was kept

* Abstract from the "Physical Review."

fixed at 1,000 or 2,000 ohms, while R_2 was adjusted. Since it was found that small thermo E.M.F.s were developed by the pressure of an ordinary contact key, a key was constructed at Z consisting simply of a bent copper wire mounted in a piece of fibre on a spring, and bridging the gap between two mercury cups. Adjustments of the sliding contact V and of the resistance R_2 were made until the galvanometer showed no deflection whether the connector S was in the mercury cups or removed. When S was removed T was also removed, and a relatively small current employed. When S was inserted T was also inserted, and a current of from 10 to 20 amperes sent through the bars. In this way the resistance of the portion of B between y and z was compared with that of A between x and w. The direction of the current was then reversed by the commutator P and the measurements repeated.

Measurements were made on bars of iron, steel, copper, brass and a few on aluminium and zinc. Details of the experimental results are given in the Paper, and show that in every case the thermal conductivity of the bars increases when a moderate tension is applied. As the limit of elasticity is reached this increase approaches a maximum. As the tension exceeds this limit, the conductivity remains practically constant in the case of the more elastic metals, such as steel and brass, or begins to diminish in the case of the softer metals. After a bar has been stretched its conductivity does not immediately return to its former value. This is most noticeable in steel and brass. In the softer metals the return to the original value is more perfect. It is probable that steel and brass would regain their original conductivity if given sufficient time, but this has not been tested by experiment. The total change in the conductivity of steel may amount to 7 or 8 per cent., that of iron to 4 or 5 per cent., brass about 4 per cent., and copper 2 or 3 per cent. A few measurements made on aluminium showed an increase in thermal conductivity of about ½ per cent. under the maximum tension. Measurements were attempted upon bars of zinc, but these proved unsatisfactory. In every case the electrical resistance increased with increasing tension—that is, the conductivity diminished. These results are in substantial agreement with those obtained by other experimenters on the resistance of wires. Of course, the conditions of this experiment were not suited to a highly accurate determination of this effect. It is, however, of interest to note that the changes in the thermal conductivity produced by moderate tensions are opposite in direction to those in the electrical, and are of an order of magnitude about 10 times greater. Some rather rough experiments upon the effect of bending bars of iron and copper, so that a large permanent deformation was produced, seemed to show a marked decrease in thermal conductivity of from 5 to 8 per cent. This is to be expected from the behaviour of copper bars when stretched beyond their elastic limit.

THE EFFECT OF TORSION ON THERMAL AND ELECTRICAL CONDUCTIVITY.*

BY N. F. SMITH.

The experimental method was in all respects the same as in the previous investigation on the effect of tension.† The lever, by which tension was applied, was removed, however, and in its place was mounted a 12 in. cast-iron pulley carrying a divided circle, by means of which to measure the angle of twist. This pulley at its centre engaged the friction clutch attached to the outer end of the bar to be twisted, while the clutch at the other end of the bar was kept from turning by clamping between suitable iron plates. Weights attached to flexible wires wrapped around the pulley produced the twisting couple. The conditions were, of course, extremely unfavourable for an accurate comparison of electrical resistances, the total resistance of the bars compared being only a few ten-thousandths of an ohm.

Observations were made on two bars of soft steel, two of iron, two of copper and one of brass. The largest variation in electrical resistance was found in the bars of soft steel. In all the other materials employed this change was less than one part in two thousand, and was less than the experimental error. Hence no figures are recorded for the change in the electrical conductivity of iron, copper and brass. The curves and figures given show that in all cases the thermal conductivity is diminished by torsion; that the recovery is not complete when the torque is removed, even though no permanent twist has been produced; that the thermal conductivity tends to regain its original value after a period of rest; that the change is greatest in the case of steel where the torque applied is the greatest, and where, also, the change in electrical conductivity is most marked. The maximum change produced at any one time in the thermal conductivity of steel is from 3 to 5 per cent. The corresponding change in its electrical conductivity is from 0·1 to 0·2 per cent. The maximum changes produced in the thermal conductivity of iron, copper and brass are from 1 to 3 per cent., while the corresponding changes in their electrical conductivity are less than one-twentieth of 1 per cent.

It seems probable that a linear relation exists between the thermal conductivity and the angle of twist. As the strain in a bar approached the elastic limit the twist ceased to be uniformly distributed, but took place largely at one point, while the torsion in the rest of the bar may have actually diminished. An attempt was always made to increase the torsion just as long as the twist was uniformly distributed through the bar.

From these experiments, and those of the preceding Paper, it is apparent that any theory which fully explains the processes of thermal and electrical metallic conduction must account for a series of changes in thermal conductivity due to mechanical strains whose magnitude is far greater than that of the corresponding changes in electrical conductivity.

* Abstract from the "Physical Review."

† See p. 846 of the present issue.

PARLIAMENTARY INTELLIGENCE.

National Telephone Co.'s Employes.—In the House of Commons on Monday Mr. JOHN WARD asked the Postmaster-General whether his attention had been called to the dismissal of numbers of the established employés of the National Telephone Co. in Stoke-on-Trent district, on the ground that the company's undertaking was about to be transferred to the Post Office; and whether he could say how he intended to work the system acquired if the experienced men now working for the company were dismissed prior to such transference; or did he propose to re-engage the dismissed servants of the company for that purpose?

In reply, Mr. BUXTON said the numbers of the construction staff of the National Telephone Co. were constantly fluctuating. He was informed by the company that since the beginning of the year they had discharged eight men and one boy from their construction staff in the Potteries district owing to slackness of work. There appeared to be at the present time a considerably reduced demand for the extension of the telephone system, due partly to the fact that the system had made very rapid extensions of late years, and that there was, therefore, not the same opening for new construction, and, further, that the state of trade had of late seriously affected the demand for new telephone installations. As regards the Post Office system, there was also for the time being less work in connection with renewals, as the old plant had of late been largely superseded by new and more permanent plant. As regards trunk lines also, during the last few years lines had been added in anticipation of traffic, and there was at present less opportunity of extending them. There was thus, both on the part of the National Company as well as on the part of the Post Office, a somewhat diminished demand for construction work. He was glad to say, however, that, as already stated in the House, he had come to an arrangement with the National Company in regard to certain construction work, and was also in communication with them in regard to a proposed arrangement to enable them to continue to open new exchanges in their areas, in order that the work of construction should be continued without interruption between now and 1910.

Wireless Telegraphy in Shipping.—In the House of Commons on Thursday last week Mr. Seddon asked the President of the Board of Trade whether, in view of the national concern for news of the ss. "Waratah," he could promise an inquiry into the various systems of wireless telegraphy with a view to making an installation compulsory on all vessels carrying passengers, and at British and colonial ports.

In reply, Mr. CHURCHILL said the question of the installation of wireless telegraphy apparatus on passenger ships had been, and would continue to be, very carefully watched by the Board of Trade, but he did not think any useful purpose would be served by a special inquiry at the present moment.

Colinton Tramways Bill.—This bill, which authorises the construction of electric tramways in Colinton, Edinburgh, has been passed by the Examiner of Private Bills in the House of Commons. The capital of the company is to be £50,000 in £1 shares, with one thing borrowing powers.

Electricity in Mines.—In the House of Commons on Thursday last the Home Secretary (Mr. H. Gladstone) stated that he had had under consideration the report of the chief inspector and district inspector on the West Stanley mining disaster and other reports which had reached him from time to time in regard to the use of electricity in mines and the working of the special rules. Since the previous inquiry five years ago much further experience had been obtained, new points had arisen, and the special rules, the working of which had been carefully watched by his Department, had shown themselves in need of amendment on a number of points. He proposed, therefore, to appoint a small expert Committee to revise the rules. He would include in the inquiry the use of electrical machinery in mines, &c.

Marine Signalling.—On Monday, in the House of Commons, the Postmaster-General stated that Mr. Kelway's sound-beating system involved the use of wireless electric signals, and he was sorry to be com-

pelled some time ago, after consultation with the Admiralty, to refuse the grant of a licence to him for its installation at Dover or on the south or south east coast of England. The reason for the refusal was the risk involved in connection with the working of the system of interference with the naval and commercial wireless telegraphy, which was so largely carried on in those regions. A licence was, however, offered to Mr. Kelway for the trial of his system in some locality where that objection did not apply.

Telegraph (Arbitration) Bill.—This bill was read a third time in the House of Commons on Tuesday.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An engineering graduate is required to lecture and demonstrate on electrotechnics at Faraday House. Salary £250 per annum. Applications to the principal (Dr. Alexander Russell), Faraday House, Southampton-row, London, W.C., by Sept. 8. See an advertisement.

A pupil is wanted for a l.-t. three-wire station in South London area. See an advertisement.

A leading draughtsman is required, with a thorough knowledge of volume and pressure fans, capable of preparing schemes for the various uses to which fans can be applied, &c. See advertisement.

A competent instructor in electrical engineering is wanted, with good knowledge of general electrical engineering work. See an advertisement.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

The Council of the University College of Wales, Aberystwyth, require a demonstrator or assistant lecturer in the department of physics. Salary £150 per annum. Applications to the Registrar by Sept. 16.

Ilkeston Corporation require a manager for their tramways and electricity distribution department. Age 25 to 40. Commencing salary £200. Applications to Town Clerk by the morning of Sept. 6.

Mr. Thos. F. Wall, M.Sc., has been nominated for the vacant position of assistant lecturer and demonstrator in electrical engineering at the University of Birmingham.

EDUCATIONAL NOTICES.

King's College (University of London).—Two exhibitions of £25 each are offered for competition in the faculty of engineering in September. Applications to the Secretary, King's College, Strand, W.C.

University College of North Wales.—In the electrical engineering department of this college a systematic course of instruction is given in electrical measurement and practical electricity for students proposing to enter the profession of electrical engineer. The physics laboratory is well equipped. The course extends over two years. Prospectuses, &c., may be obtained from Mr. J. E. Lloyd, M.A., secretary and registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Glasgow and West of Scotland Technical College.—The session 1909-10 commences on Sept. 23 for the evening classes and Sept. 28 for the day classes. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, and the courses of study for the diploma usually extend over three sessions. Holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. There are new and well equipped laboratories in the departments of physics, chemistry, electrical engineering, mechanics, metallurgy, &c., and facilities for research are afforded. Calendar (price 1s. 4d.) and prospectus (free) can be obtained on application to the Secretary.

We have received a copy of the calendar for the 114th session (1909-1910), which contains full particulars of the courses of instruction, classes, fees, bursaries and scholarships, &c., at the Glasgow and West of Scotland Technical College. Among last year's awards we notice that the "Sir John Pender" gold medal and bursary in electrical engineering was given to Mr. Norman S. Sim. The physical, chemical and engineering laboratories are well equipped for practical work; and, in addition to the day courses, there are evening classes in all branches of engineering, chemistry, physics, naval architecture, &c.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

What is claimed to be the first classes in aeronautical engineering in this country will be held at this Institute during the forthcoming session. Mr. C. E. Larard will be the head of the new department, and the lecturer will be Mr. L. W. Blin Desbleds. The classes will commence on the 27th inst.

Hackney Technical Institute, London.—The next session commence on Sept. 20. There are evening lecture and laboratory courses in electrical engineering, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses may be obtained from the Principal of the Institute, Dalston-lane, London, N.E.

South-Western Polytechnic Institute, London.—A complete three years' course in electrical engineering is given at this Institute during the day and a four years' course in the evening. There are also courses of lectures and practical work in various electrical engineering subjects, including electrical design, alternating and polyphase currents, instruments and lamps, wiring and fitting, &c.

Battersea Polytechnic (London).—In the engineering departments of this polytechnic there are day courses which prepare for the engineering degree, B.Sc. London, polytechnic diploma in mechanical, electrical and civil engineering. The entrance examination commences on Sept. 21. There are also evening classes which prepare for the B.Sc. in engineering, the associateship examination of the Institution of Civil Engineering all mechanical engineering subjects, electrical, structional and automobile engineering, telegraphy and telephony, architecture and building, &c. Prospectuses from the Secretary, Battersea Park-road, S.W.

Borough Polytechnic Institute.—Complete courses of instruction in electrical and mechanical engineering, chemistry, &c., are given at this Institute. The head of the electrotechnics department is Dr. John Henderson, and the course of instruction in electrical engineering is spread over four years. There are also special courses for electric wiring work, construction and design of electrical appliances and workshop fittings, and also in advanced electricity and magnetism. The next session commences on 27th inst. Further particulars and detailed syllabus of each course are given in the prospectus, which can be obtained from the principal, Mr. C. T. Millis, Borough-road, London, S.E.

Aberdeen.—The Electricity committee recently considered the position created by the refusal of the Aberdeen Suburban Tramways Co. to abide by the award of the Board of Trade arbitrator (Mr. W. H. Patchell) in regard to the price to be paid by the Company for a supply of electricity from the Corporation.

Mr. Patchell was nominated by the Board of Trade on the application of the Council and the company, who had failed to come to an agreement, and the price fixed to be paid by the Company was a standing charge of £900 per annum, with ½d. per unit of electrical energy supplied, the period of supply to be five years.

The company allege that the reference to the arbiter was to fix a price for the current at so much per unit, and that as the arbiter had fixed the price upon the maximum demand system the award is ultra vires.

On the other hand, the Council contend that, while they do not admit that the decree is outside the reference, the company's agent acquiesced in the finding of the arbiter, and the company is now barred from taking exception to it.

On Tuesday the Electricity committee resolved to make a uniform charge of 3¾d. per unit for electric current for lighting, with the alternative to consumers of over 5,000 units per half-year, of being charged at the same rate as at present. Current for arc lamps is to be 2d. per unit; and a sliding scale for power consumers, ranging from 2½d. for the first 250 units to 7d. per unit for over 10,000 units per half-year, was agreed upon, as was also a flat rate of 1½d. per unit for heating and cooking.

The estimated income for the current year is £45,812, and the expenditure £44,929. After providing for interest and sinking fund £1,883 is to be carried to reserve.

The committee have considered an opinion by the town clerk on the question of the maintenance of a depreciation account, and it has been agreed to do away with the depreciation fund, and to fix the rate of interest on the sinking fund at 4 per cent.

Argentina.—The "Review of the River Plate" says the electric tramways in Tucuman will be inaugurated this month.

The Mayor of Santa Fé has been authorised to invite tenders for additional electric generating plant for the electricity works.

It is reported that negotiations are in progress for the amalgamation of the electric tramway companies at Montevideo.

The "Herald" (Buenos Ayres) says the general manager of the Anglo-Argentine Tramway Co. has submitted to Buenos Ayres Municipality the outline of a scheme for underground tramways, estimated to cost 50 million (paper) dollars.

Australasia.—The "Australian Mining Standard" says the local authorities of North, South and East Invercargill, Avenal and Gladstone, and the Awarua Riding of Southland county (N.Z.) are anxious to obtain an electric tramway service, and delegates from these councils recently decided to offer Sir Joseph Ward £1,100 for the Order in Council he now holds, and for plans, &c. A poll of ratepayers is to be taken on a proposal to borrow about £75,000 for constructing the tramways.

A poll of Launceston (Tasmania) ratepayers has resulted in a majority of 2,239 votes in favour of the construction of electric tramways by contract and the control of the system by the Corporation. The city engineer and city electrical engineer have been instructed to prepare plans.

The first of the electrically operated cranes, which it is the intention of the Victorian Railway Commissioners to supply to all the principal goods stations, was started at Ballarat on July 21.

A telephone line between Sydney and the Blue Mountains (N.S.W.), 750 miles in length, has been put into service and is giving satisfactory results.

Hawthorn (Victoria) City Council recently discussed a proposal to light the town electrically. A Government report on the subject stated that it would be necessary to get 700 private houses to take current to make the scheme pay, and the mayor said if it could be shown that the scheme would be financially sound at the end of six years they would go on with it. No decision was arrived at.

On the subject of the tenders received by Sydney Council for the supply of turbo-generators, and which were referred back, the city electrical engineer (Mr. H. R. Forbes Mackay) says the specifications approved by the Council restricted the speed of the sets to 750 revs. per min., but tenders for sets running at 1,000 and 1,500 revs. per min. were received. The A.E.G. tendered for 1,500 revs. per min. sets at £16,000 higher than that of the 750 revs. per min. sets recommended for acceptance. The lowest tender received for a 1,500 revs. per min. machine offered a turbine of the same type as that made by the A.E.G. but at very little more than half the cost. His inference was that the firm so tendering was unaware of the difficulties to be overcome in making such a machine. The ordering of 4,000 kw. turbo-generators to run at 1,000 or 1,500 revs. per min. would be an experiment that the Council had in his (Mr. Mackay's) opinion no right to make, and he would record his most emphatic protest against its being made.

Bacup-Rochdale Tramways.—On Wednesday Bacup Council appointed representatives to meet representatives of Rochdale Corporation, with power to arrange terms for leasing and working a suggested extension of the Whitworth tramways from Bacup boundary at Britannia to the centre of the town. Whitworth Council have obtained powers to construct tramways from the terminus of the Rochdale cars at Healey to Britannia, and Rochdale Corporation have already agreed to lease their line as far as Shawforth.

Bailieboro' (Ireland).—At a recent meeting of the Council it was reported that non-statutory electricity works had recently been opened at Drumshambo, and the L.G. Board had fixed the amount (3d. in the £) and limits of the charge for public lighting.

Belfast.—The Improvement committee recommend that High-street and Castle-place be illuminated by arc lamps.

Blackfriars Bridge.—The ceremony of opening the widened portion of Blackfriars Bridge will be performed by the Lord Mayor of London on 14th inst.

On the day of the opening the link between the L.C.C. tramways in Blackfriars-road and the Embankment will be completed. The widening was begun in February, 1907, and has cost over £200,000. The contractors (Sir W. Arrol & Co.) had until February next to complete the undertaking, and they will be entitled to a bonus of £20 for every day saved on the contract period, or over £3,000. Electric power was extensively used in connection with this work, cranes, rivetting machines and other machinery and tools having been driven electrically. Current was taken from the City of London Company, the maximum demand being nearly 300 H.P.

Bolivia.—Acting-Consul J. Watson says, in his report for 1908, that an overhead electric tramway is in course of construction in the city of La Paz. The line is 4 miles in length, and the plant and rolling stock come from the U.S.A.

Vice-Consul E. F. Moore (Sucre) says British and German imports were in former years about equal, and those from the United States half as much, but the figures given by the Government Statistical Department for 1907 show a marked increase of German and United States goods. The figures were for Germany £190,000, U.K. £170,000, U.S.A. £420,000. (The last sum includes an abnormal introduction of railway material by Speyer & Co. amounting to nearly £300,000.) One class of goods in which Great Britain was superseded by Germany is "electrical appliances."

The electric lighting installation was inaugurated at Sucre at the end of 1908. The standard price for lighting private houses is 3 bols 50c. (5s. 7d.) per 16 c.p. lamp per month. When 100 or more lights are ordered the price is 3s. 2d. per lamp. Electrical energy is generated by water power at a station on the river Cachimayo, 8 miles from Sucre. High-pressure current is transmitted by cables on poles, and is transformed at the boundary of the town.

Vice-Consul F. Ramsay Smith says many of the mines in the Oruro district now use electric power.

Brighouse.—The Electricity committee are now supplying electricity under the revised conditions. Current is taken in bulk from the Yorkshire Electric Power Co. For lighting the voltage is 230 and for power 460. The price is 5d. for lighting and from 4d. to 2d. for power.

Burslem.—An L.G. Board inquiry was recently held into the application of the Council to borrow £7,535 for the extension of the electricity works.

Burton-on-Trent.—An unopposed inquiry was held here last week into the application of the Council for sanction to borrow £4,000 for extensions of the electricity mains, house services, transformers, &c.

C.s. "Mackay Bennett."—The officers and crew of the cable steamer "Mackay Bennett" have recently had a singular experience while engaged in the work of laying for her owners, the Commercial Cable Co., the Newfoundland cable. During the course of the work it was found that an iceberg had grounded over the shore end of one of the cables which required repair, and it was necessary, in order to effect the necessary repair to the cable, to tow the iceberg out to sea. The berg was 160 ft. in length, and although 600 ft. of wire rope was circled round it the vessel failed to move the monster. The assistance of another vessel was obtained and efforts were made to blow up the berg; this was partially successful, as after a number of large pieces were broken off it toppled over, to the dismay of a number of men who were at work upon it. The berg was towed out and the "Mackay Bennett" ultimately succeeded in completing the repair.

Camborne-Redruth Tramway.—The report of the Board of Trade inspector (Col. Druitt) on the recent conference as to the proposed reconstruction of the Camborne and Redruth tramways has been issued.

With regard to the alleged default of the company as to the original construction of the line, Col. Druitt does not think the Board of Trade should take action, as the line was constructed nine years ago, and the local surveyors had full opportunities of seeing that the work was properly executed. To maintain the macadam margin outside the rails in good order the repairs should be executed in conjunction with the local road authority. The company should relay all the setts except where permanent repairs had recently been done, and improve the cross levels of the roadway in conjunction with the road authority as far as possible. They should renew all the old points and crossings, and improve the drainage, and also provide an improved method for working the points of the sidings leading to the mines and works.

Co-partnership.—We have received a copy of a reprint of an instructive Paper, recently read before the members of the Chartered Institute of Secretaries, by Mr. Russell Day, B.A., LL.M., on the important subject of Co-partnership. In the introductory part some interesting statistics relating to the organisation of labour, strikes, &c., are given, and this is followed by a brief sketch of the early history and development of bonus schemes, profit-sharing and co-partnership. The latter portion of the lecture gives particulars of the later developments and modern examples of profit-sharing schemes and co-partnership. The lecture deals with a very important subject, and all persons interested in the relations of capital and labour, and especially those anxious to secure industrial peace and freedom from strikes, should read the lecture, which is written throughout in a clear and lucid style. It is published at 6d. by the Chartered Institute of Secretaries, 65, London-wall, London, E.C.

Cotton Mill Driving in Brazil.—The Rio de Janeiro Tramway Light and Power Co. are now supplying electric power to the extent of 1,350 H.P. to the Cia Americana's, and 800 H.P. to the Fabrica Carioca's mills. The latter require 1,600 H.P. in all, and arrangements are being made to meet this demand.

Dunfermline.—The Fife Electric Power Co. have decided to put down a 2,000 H.P. turbine set at their Townhill works, and various extensions of the cables are also being made, including the extension of the overhead cable from the station into Lumphinnans and Lochgelly for the supply of power.

Electrical Exhibitions.—An exhibition of electric motors, fittings, cooking and heating apparatus, &c., which has been organised by the electricity supply department at the Town Hall, Accrington, was opened on Aug. 30.

Barnes Council have appointed a sub-committee to report as to the advisability of organising a local exhibition of electric motors, fittings, &c.

Electricity in Mining.—A recent issue of the "South African Mining Journal" contains a description of the plant in and about the Consolidated Gold Fields of South Africa's Simmer Deep and Jupiter mines.

It is stated that "the plant has the distinctive feature of being entirely driven by electricity, from the stamps right down to the last pumps in the extractor house." The 300 stamps are driven in lots of 10 by separate three-phase motors of about 50 H.P. each. The pulp, after passing over the amalgam tables, is pumped to 12 classifiers, and the underflow from these goes to four tube mills driven by separate 125 H.P. motors. Twelve conical sand separators are used, and the time occupied by the circuit of the sand from the mill to the dump is only about 6½ days, the usual time for sands treatment being nearly 10 days.

Erdington. The Board of Trade have sanctioned a further extension for two years for completing the lines authorised by the Erdington Tramways Act.

Euston-Watford Electric Railway.—Progress is being made with the construction of the Willesden and Harrow section of this line. When this portion has been completed it will be worked as a steam line until the completion of the entire railway. When the projected electric service has been established between London and Watford the main line will be relieved of local traffic, and it will then be possible to give a better service between Euston and stations north of Watford.

Fulham (London).—The electrical engineer (Mr. A. J. Fuller) has reported that, owing to the increasing demand for electricity for lighting and power, it will be necessary to put down additional boiler plant at the electricity works.

Mr. Fuller reports that, not withstanding the increasing use of metal filament lamps, the output still grows rapidly. The extension of the engine room plant can stand over until late in the autumn, but the boilers, if put in hand immediately, can be erected and connected up for running by November.

The Electricity committee have approved Mr. Fuller's report, and contracts for boilers and stokers have been conditionally let. Mr. Fuller is to carry out the work of supplying and fixing the motor for the underfeed stokers, excavating and building necessary foundations, supplying and fixing additional steam and other piping, &c., at an estimated cost of £935.

Greece.—M. Lamprynides has been appointed Director-General of Posts and Telegraphs.

Haslingden.—The Council have decided to dispense with the tangential suspension system, and ordinary mechanical ears are to be fixed on the overhead line within the borough.

Holland.—The Nederlandsche Buurtspoorweg Maatschappij, of Utrecht, have been granted a concession for the construction of an electric railway from Utrecht to Zeist, via Bilt.

Hospital Lighting.—King's Cross Hospital, Dundee, is to be wired.

India.—"Indian Engineering" states that the Gorakhpore workshops of the Bengal and N.W. Railway are being provided with new machinery for the repair of electrical plant.

The Electricity Bill was introduced at the first meeting of the Viceroy's Council on July 30.

The North-Western State Railway administration have recently been experimenting with phonopore telephones supplied by the new Phonopore Telephone Co. Conversations were carried on between Lahore and Multan (208 miles) and between Simla and Lahore (276 miles). The assistance of the Telegraph Department is being obtained to test the relative efficiency of copper and iron wire used in conjunction with phonopore instruments.

Italy. The Ministry of Public Works have issued favourable reports in connection with concessions for the construction and working of electric tramways from Trani to Corato and from Badia to Ripoli and Grassina.

Japan-British Exhibition, London, 1910.—Particulars are now available relating to the great exhibition which is to be held at Shepherds Bush, London, in 1910, under the auspices of the Imperial Japanese Government. The hon. president is His Royal Highness Prince Arthur of Connaught, and the president is the Duke of Norfolk. An influential list of vice-presidents and general committee contains the names of a vast number of leaders of industry, &c., in this country, and also of many notable public men. The exhibition is due to open on May 3, and will remain open until the end of October. The exhibits will be exclusively confined to the arts, manufactures and products of the Japanese and British Empires. It is pointed out that this is the first great exhibition of Japanese products ever held in Europe, and the importance of the event from the commercial side of the undertaking is emphasised. It is the desire of the promoters that the utmost shall be made by British manufacturers, &c., of the exhibition, and early application for space is requested, to the secretary, Exhibition Offices, Shepherd's Bush, London, W.

Leeds.—The Electricity committee have decided to obtain a small stock of electric cooking and heating appliances for the purpose of letting them out on hire.

Light Railways.—The Board of Trade have confirmed the Halesowen Light Railways (Transfer, &c.) Order, 1909, transferring to a company the Rural District Council's powers, &c., under their 1901 Order and the Extensions Order of 1902.

Littleborough.—At the last meeting of the Council the chairman (Councillor R. Hallett) stated that they had received several inquiries in regard to electricity supply.

Manchester.—The Electricity committee recommend the Council to apply for sanction to borrow £50,000 for extensions of the supply mains. The estimated annual charge in connection with the loan would be £3,121 and the estimated increased revenue is put at £7,260 per annum.

Marriage.—On Aug. 26 inst. Mr. Henry Medcalf Hobart, M.I.E.E., was married to Miss Edith Walpole, of Sydenham.

Presentations.—On his marriage Mr. Robert Elliot has been presented with a marble clock by Messrs. Crompton & Co.'s staff at the Arc Works, Chelmsford.

The staff of the Stafford electricity works have presented a Ruskin bowl to Mr. B. Reeder on his marriage.

Scottish Tramway Managers' Association.—On Friday last the Scottish tramway managers visited Rothesay. The company included Mr. R. S. Pilcher (Aberdeen), president, and Mr. Coutts (Paisley), secretary of the association.

The visitors were received by Mr. Archibald Robertson (manager) and Mr. H. H. Hill (resident engineer of Rothesay Tramway Co.) and were shown over the Pointhouse depot. Afterwards a Paper by Mr. P. Fisher (Dundee) on "Trackless Trolley Systems" was read, and a short discussion ensued. Subsequently the visitors drove to Rothesay and dined in the Bute Arms Hotel; and in the afternoon were conveyed in a special car to Ettrick Bay.

Spain.—H.B.M. Consul-General Roberts states that during 1908 the Compañia Barcelonesa de Electricidad (a German company) considerably extended their generating station and plant. The total H.P. is now 25,000, and the total capital invested about £800,000. The company supply about two-thirds of the energy for electric light and power in Barcelona, the remainder being supplied by a Spanish company.

Consul Medhurst (Corunna district) says the lighting of Corunna is effected by two companies, the Société d'éclairage de la Corogne et Vigo and the Sociedad Co-operativa Electrica, which both receive their power form the same source—a stream near Puentedeume, near Ferrol. Great competition formerly existed between the companies, but they have now come to a working arrangement. The lamps and fittings employed all come from Germany and are supplied by agencies in Madrid. The number of incandescent lamps required annually is about 55,000.

Vice-Consul Lovelace (Gijon) says the tramways at Gijon have been taken over by one of the Thomson-Houston companies and are being converted from horse to electric traction. It is proposed to lay an extension of the lines to Musel when the new Government road to that port is completed.

Vice-Consul Barcena y Andres states that although a portion of the track of the proposed electric tramway in the city of Vigo has been laid, the enterprise has fallen through, and there is no present prospect of the work being continued.

Theft.—Two young men (Geo. H. Withers and R. J. Brocklebank), who were charged on remand, before the Manchester magistrates on Aug. 26, with stealing Tantalum lamps from Messrs. Drake & Gorham, pleaded guilty and were sentenced to terms of one and two months' imprisonment respectively.

Toronto.—It is announced, in connection with the municipal scheme for the supply of electricity, that the distribution network will be completed by Nov. 15, when the Hydro-Electric Power Commission expects to deliver energy from Niagara Falls. The contracts for the remaining eight transformer stations in connection with the building of the Government power transmission line have been awarded by the Commission.

Transvaal Iron and Steel Industry.—The mining engineer of the Transvaal Government (Mr. Kotze) has prepared a further report on the proposal to establish the iron and steel industry in the Transvaal.

Mr. Kotze recommends the Government to consider the advisability of establishing a bounty system similar to that of Canada; and it also appears that there is a profitable and immediate field for the products of electrical furnaces which can turn out high-class steel with a comparatively small output per unit. It is recommended that the Government share the cost with the Central South African Railways on the £1 for £1 basis of establishing an electrical furnace.

U.S.A.—The report of Consul Laidlaw on the trade and commerce of the Portland (Oregon) district for 1908 states that large extensions of electric railways and the rebuilding of many of the older lines have been in progress. A report by the Oregon Conservation Commission puts the undeveloped power of the streams of Oregon State alone at 3,317,000 H.P., and the developed power at only 34,300 H.P. In connection with extensive irrigation works a diversion dam has been erected at Minedoka on the Snake river, and electrical plant is being erected at the dam to supply current to three pumping stations, each of which will lift the water 32 ft.

Victoria (British Columbia).—The British Columbia Electric Railway Co. and the Municipal Council have entered into an agreement which precludes the Council from installing a power plant in competition with that of the company without offering to purchase the company's plant at a price to be fixed by arbitration. The company agrees to reduce the cost of current for lighting and to instal a power plant at Indian River (about 50 miles from Victoria) at a cost of about $1,500,000. A similar arrangement exists at Vancouver.

Wireless Telegraph Notes.—The important new French wireless telegraph station in the Champ de Mars, Paris, is expected to be ready in October. This is a huge underground building, where provision has been made for a large staff of operators and officials, and will include a narrow gauge railway for purposes of transport. All power and lighting will be electrical. According to a correspondent of the "Morning Post" it is expected that the new station will have a radius of 5,000 miles, and will enable communication to be effected between Paris and San Francisco, U.S.A.

Mr. Viggo Gandil, representing the Poulsen interests in this country, has caused a communication to be made to the press intimating that an influential British company is in course of formation to operate the Poulsen wireless telegraph and telephone patents throughout the British Empire and along the principal ocean routes. It is stated that it is the intention of the company to establish a station in Canada (for which a licence has been granted by the Dominion Government), to work in conjunction with a station in Ireland which is nearly completed.

Discussion centres round the question as to whether all passenger-carrying vessels should be compelled to instal wireless telegraph equipments. It will be seen from our Parliamentary report that a question was put to the President of the Board of Trade this week on the subject. Several of the Continental Governments have the question under consideration. So far the principal objections come from shipowners, and underwriters who, although generally favourable to the idea, point out that the receipt of a call by a vessel at sea may involve her in danger and delay in answering the call.

The name of Eccles is closely associated with the subject of wireless telegraphy, and Eccles the wireless telegraph operator, who died at his post on board the ill-fated steamer "Ohio," which was wrecked off the coast of Alaska on Friday last week, will be remembered in the coming time as one of the heroes of the new industry. He was successful a moment or two before the ship foundered in setting up communication with two vessels which came to the assistance of the passengers and crew of his ill-fated ship. Immediately after he had succeeded in this task the "Ohio" foundered and Eccles was drowned. He was a native of Almonte, a small town near Ottawa, Canada.

The turbine steamer "Empress," which plys between Dover and Calais in the regular S.E. & C. Channel mail service, is the first vessel in that fleet to be equipped for wireless telegraphy. Marconi apparatus is installed on this vessel, as will be the case on all the South-Eastern and Chatham Co.'s boats, both on the Dover-Calais and Folkestone-Boulogne routes.

York.—The contractors for the construction of the local tramways (Messrs. Dick, Kerr & Co.) commenced work on the Fulford-road route on Tuesday.

Sports.—The fourth annual sports of the Robertson and Osram Social and Athletic Club took place at Shepherd's Bush on Saturday.

The Wilson Challenge Cup was again won by a G. E. C. London team, and a Marathon race by Mr. A. Bailey. Robertson Works beat Osram Works in a tug of war. Other interesting events were the girls' tug of war and lamp race. Mrs. C. Wilson presented the prizes, and Mr. C. Wilson, Mr. C. J. Robertson and Mr. E. G. Sheppard acted as judges.

Wigan Corporation Tramways Club had their annual sports on Wednesday.

Manchester defeated Salford in the final of the tug of war, and cycling was a leading feature. A local contemporary says V. Johnson and Ben Jones, *the* cyclists, were there, and the former, who hails from Birmingham, defeated the latter by 10 lengths in a two-lap pursuit race, and also won from scratch in an open lap cycle race, Jones being second.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—The accounts of the electricity department for the year ended July 31 show total income £45,791, compared with £45,372 in the previous year.

Working and general expenses were £19,622 (against £22,602), and gross profit was £26,168 (against £22,769). There was a surplus of £227 to be carried to reserve, after providing for interest, sinking fund, depreciation on buildings and plant (£9,657) and one fifth of cost of Aberdeen Corporation Electricity Act (£477). The amount standing to credit of reserve fund is £14,663. The units generated were 6,070,192 (compared with 6,106,941 in previous year) and the total quantity sold was 5,170,421 (5,104,036) units.

The report of the city electrical engineer (Mr. J. Alex. Bell) calls attention to the fact that the year has been unique in showing a decrease in the units generated, but, owing to economies in distribution, &c., the output shows a small increase. The smallness of the increase is partly due to depression in trade, but chiefly to the installation of metallic filament lamps. The new consumers connected are above the average for the last four years (exclusive of those taken over in the Cults district in 1908), but they do not balance the decrease of consumption caused by the change to metallic filament lamps. The estimated number of metallic filament lamps connected is 25,000. Mr. Bell expects that the effect of the change of lamps will be felt for at least another two years, but that the new lamps will eventually lead to a largely increased output. Arrangements have been made to give a supply to the Royal Lunatic Asylum, and the Admiralty's wireless telegraph station, which was recently opened, is taking current from the Corporation. A fall in the price of coal has brought coal costs down to a normal figure—viz. 0·3d. per unit sold.

Alterations in charges for current adopted by the Electricity committee are dealt with in another column.

Bath.—In reference to the abstract of the accounts of the electricity supply department for the year ended March 31, which appeared in our last issue (p. 809), the accountant of the department (Mr. C. A. Nethercot) points out that—

The statement that there was a deficit after payment of interest and capital charges of £1,661 is somewhat misleading, as it implies that there was a loss of that amount on that one year's working, whereas, as a matter of fact, the deficiency on the last year was only £384. 14s. 5d., the balance of £1,275. 17s. 3d. having been brought forward from previous years.

Nelson.—The accounts of the electricity department for the year ended March show capital expenditure £74,167 (increase £397).

Total revenue was £9,546, gross profit £4,561 (against £4,992 in previous year) and net profit £36 (£591). Units generated were 1,054,511 (1,026,068), supplied by meter for lighting 267,464 (263,544), by contract 21,989 (19,472), for motive power 65,188 (54,055), tramways 303,006 (295,669), light railways 231,926 (239,794). The maximum supply demanded was 745 kw. (735 kw.). 31,578 (30,176) equivalent 8 c.p. lamps are connected, and the motors connected have an aggregate horse-power of 302 (280).

The light railways department capital expenditure is £35,730 (increase £25). Traffic revenue was £6,591 (against £7,362)=8·33d. (8·63d.) per car-mile, and total revenue £6,604=8·34d. Current at 2d. per unit cost £1,933=2·44d. per car-mile, and total working and general expenses were £5,479=6·92d. Gross profit was £1,125 (£1,938), interest and sinking fund required £1,945 (£1,915), and the net result was a deficit of £820 (compared with £22 profit). The population served was 44,000. Passengers carried were 1,811,100 (against 2,060,712 in previous year), and 190,044 (204,746) car-miles were run; units used per car-mile 1·22 (1·17), and the average fare per passenger 0·92d.

The report of the electrical engineer and tramways manager (Mr. D. Helme) refers to the decrease of revenue for lighting, due to the more extended use of metal filament lamps and to depression of the staple trade of the town. Income for current supplied to the Council's own cars decreased about £80. There is a more general demand for power, which Mr. Helme expects to increase. If the report of the Brakes committee is acted upon to the full extent of their recommendations, the Board of Trade may (Mr. Helme thinks) compel the Corporation in the near future to use brake gear and appliances somewhat different from those at present in use.

St. Pancras London). The accounts of the electricity department for the year ended March, show capital expenditure £542,470, an increase of £18,450 compared with 1908.

The revenue was £75,359 (against £77,602), working expenses £42,470 (£43,295), gross profit £32,889 (£34,307), net profit £6,926 (£9,454). The reserve fund stands at £38,774. 9,067,403 (9,118,500) units were generated, 1,934,912 (1,946,958) supplied to public lamps, and 5,592,040 (5,670,051) to private consumers. The total maximum supply demanded was 4,268 kw. (4,141 kw.). The incandescent lamps connected or applied for are equivalent to 116,929 (109,916) 16 c.p., arc lamps 1,783 (1,573), motors 942 (770), and heating and cooking apparatus 2,108 (1,318).

TRADE NOTES AND NOTICES.

TENDERS INVITED.

GRIMSBY Corporation invite tenders for supply of paper-insulated lead-covered cables for two years. Specification and form of tender from the borough electrical engineer, Mr. W. A. Vignoles, to whom tenders are to be sent not later than first post Sept. 17. See also an advertisement.

The Lighting committee of DUBLIN Corporation invite tenders for supply of 750 a.c. meters (single-phase). Specification, terms and conditions and form of tender from the city electrical engineer (Mr. Mark Ruddle), Fleet-street, Dublin. Tenders to the Chairman of the Lighting committee, 3, Cork-hill, Dublin, by noon, Sept. 13. See also an advertisement.

LONDON County Council invite tenders for (1) the manufacture, delivery and erection in certain of the Council's substations of two 500 kw. and one 150 kw. motor generators, and (2) the manufacture, delivery and erection of h. and l.t. switchgear for Woolwich and other substations. Tenders, on forms to be obtained from Mr. G. L. Gomme, County Hall, Spring Gardens, S.W., by 11 a.m., Sept. 21.

LONDON County Council also invite tenders for the manufacture, delivery and laying of about 6½ miles of 0·075 sq. in. three core lead-covered h.t. cables, &c., and about 46 miles of single core lead-covered l.t. cables, telephone cables, &c.; manufacture (but not erection) of 50 tramway feeder pillars; laying about 16 miles of stoneware cable ducts, including necessary manholes, repaving, &c., and manufacture and delivery of 440,000 ducts of glazed stoneware for electric cables. Drawings, &c., at the County Hall, Spring Gardens, S.W. Tenders to the Clerk by 11 a.m. Sept. 14.

LONDON COUNTY COUNCIL also invite tenders for the partial reconstruction of the bridge carrying Lower-road, Deptford, over the East London Railway, and reconstruction and widening of the bridge carrying the same road over the Grand Surrey Canal. Tenders to the Clerk by 11 a.m., Sept. 14.

LONDON County Council also require tenders by 11 a.m., Sept. 21 for the manufacture, delivery and erection at Greenwich of steam, exhaust, feed and drain pipes, valves, water tanks, &c. Tender forms, &c., from the Clerk.

BRISTOL Education committee require tenders by noon, Sept. 21, for electrician's work at the new school at Alexandra Park, Fishponds, Bristol. Forms of tender, &c., from Messrs. Rodway & Dening, Gaunt House, Orchard-street, Bristol.

LEYTON Urban District Council invite tenders for wiring and electric light fittings for the extension of the public offices now in course of erection. Specification, conditions and form of tender may be obtained from the architect (Mr. Wm. Jacques, A.R.I.B.A.), 2, Fen-court, Fenchurch-street, London, E.C. Tenders must be delivered at the meeting of the Council, to be held at the Town Hall, Leyton, on Tuesday, Sept. 7, at 7 p.m.

LEYTON Urban Council also invite tenders for public lighting lanterns with clock switches for incandescent electric lamps. Tenders to the Clerk, Town Hall, Leyton, by 7 p.m. Sept. 7.

Tenders are wanted for the heating and electric lighting of a new high school for girls at WOLVERHAMPTON. Names of firms desiring to tender are to be sent by Sept. 9 to the Town Clerk, Wolverhampton.

The Deputy Postmaster-General, SYDNEY, N.S.W., wants tenders by 2:30 p.m. Jan. 12 for the supply and erection of a common battery switchboard at North Sydney telephone exchange, and for supply of apparatus for use on subscribers' premises. Specifications, &c., at the General Post Offices, Sydney, Melbourne, Brisbane and Adelaide, and can be had from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited for supply of 2,550 common battery telephones and protectors to the Postmaster-General's Department, NEW SOUTH WALES. Tender forms, &c., may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W.

Tenders will be received until Sept. 20 by the Société Nationale des Chemins de Fer Vicinaux, BRUSSELS, for supply of aerial electric equipment for the Anderlues-Lobbe section of the Carnières-Thuin light railway.

The Minister of the Interior, BUCHAREST, Hungary, requires tenders by Sept. 14 for supply of 1,400 Leclanché jars.

CORUMBA (Brazil) Municipality want tenders by Oct. 5 for the erection and equipment of electricity supply works.

TENDERS RECEIVED AND ACCEPTED.

Wigan Council have received the following tenders:—

Pipework and Economisers.

Tickle Bros. (*accepted*)	**£3,778**	Johnson Bros.	£4,182
Babcock & Wilcox	3,755	Stirling Boiler Co.	4,405
Stewarts & Lloyds	3,775	J. Musgrave & Sons	4,445
Crompton & Co. £4,000 and £3,816			

Coal Conveyor.

Ed. Bennis & Co. (*accepted*)	**£2,030**	Naylor Bros.	£2,600
Gilbert Little & Co.	2,114	Heenan & Froude	2,783
Strachan & Henshaw*	£1,790, £2,110 and £2,240	Babcock & Wilcox	2,905
Drake's Limited	2,120	Brit. Thomson-Houston Co.	3,050
Graham, Morton & Co.†	2,255	New Conveyor Co.	3,509
Cecil Bentham	2,450	West's Gas Improvement Co.	3,720
R. White & Sons	2,589	Edgar Allen & Co.	4,285

* No weighing machines. † No motors.

Mixed pressure turbine, with alternator at Wigan station and motor generators at Pemberton.

	Wigan.	Pemberton.
British Thomson-Houston Co. (Curtis turbine) (*accepted* for Wigan)	**£6,106**	£2,242
General Electric Co. (Belliss) (*accepted* for Pemberton)	6,719	**1,980 0**
Jas. Howden & Co. (Zöelly)	6,286	2,180 0
British Westinghouse Co. (Parsons)	6,882	2,027 0
J. Musgrave & Co. (Zöelly)	6,876	2,075 5
Crompton & Co. (Belliss)	7,077	2,142 0
Lancashire Dynamo & Motor Co. (Belliss)	7,491	2,561 0
Brush Co. (Parsons)	6,492	1,811 0
Phœnix Dynamo Mfg. Co. (Rateau)	6,628	1,910 0
Willans & Robinson (Parsons)	6,855	1,647 15

All the foregoing were for 1,000 kw. except the Brush Co., who offered a 750 kw.

Condensing Plant.

British Thomson-Houston Co. (*accepted*)	**£1,068**	General Electric Co.	£1,100
Jas. Howden & Co.	1,247	British Westinghouse Co.	1,400
		J. Musgrave & Co.	1,037

Switchboards.

British Thomson-Houston Co. (*accepted*)	**£2,470**	Johnson & Phillips	*£2,061
Crompton & Co.	2,499	Ferranti (Ltd.)	*2,198
Spagnoletti (Ltd.)	2,604	Siemens Bros.	*2,394
Dorman & Smith	2,632	Whipp & Bourne	†1,272
Elec. Construction Co.	2,654	Cowans (Ltd.)	†2,178
Switchgear Co.	2,678	Drake & Gorham	†800
General Electric Co.	2,797	Cox-Walkers	†833
Lancs. Dynamo & Motor Co.	3,076	Dick, Kerr & Co.	†2,788
B. Westinghouse Co.	*1,994	Union Electric Co.	†2,081
		Lahmeyer Electrical Co.	†2,095

* Not to specification. † Not fully quoted.

The acceptance of the tenders is subject to sanction of L.G. Board to proposed extensions.

Bolton Electricity committee have accepted the tender of J. Musgrave & Sons for an overhead travelling crane, and the Tramways committee have placed an order with G. R. Feather & Co. for patent point controllers.

Fulham (London) Electricity committee have conditionally accepted the tender of the Stirling Boiler Co. for the supply and erection of two boilers at £2,377, and that of the Underfeed Stoker Co. for two underfeed stokers at £556.

Salford Guardians have accepted the tender of the Hart Accumulator Co. for renewal and maintenance of the storage battery of 110 cells installed at Culcheth Cottage Homes.

Eccles Council have accepted the tender of Wm. Boby for water softening and purifying plant at £275.

The Bengal & Nagpur Railway Co. have ordered a storage battery of 100 cells from the Chloride Electrical Storage Co. for trial purposes.

The Oudh & Rohilkund State Railway administration have arranged to fit 16 additional four-wheel upper-class carriages with Stone's system of lighting and twin fans, at an estimated cost of R.45,000. Fourteen further carriages on the North Western State Railway are also being fitted with Stone's apparatus, at a cost of about R.41,000.

The contract for wiring and fitting St. Leonard's School Laboratory, St. Andrews, N.B., has been placed with Messrs. Maxwell (Dundee), Limited. A large edifice on the outskirts of the town, the building, when completed, will be quite an acquisition both educationally and structurally to St. Andrews.

The Postmaster-General's Department, Melbourne (Victoria), have accepted the tenders of Johnson & Phillips for steam-driven cable picking-up and paying-out machine at £803, dynamometer, including lead sleeves, £67, cable winch £47, two small grapnels, with shackles and swivels and chain, £7, two five-pronged grapnels, &c., £47, one bellmouth, with stays, &c., £13, and the British Insulated & Helsby Cables for 10,000 copper binders at 4s. 1d. per 100 and 10 tons h.d. copper wire at £73 per ton.

The Postmaster-General's Department, Brisbane (Queensland), have accepted the tender of the Western Electric Co. for 24 strips of fuses at £7. 9s. 8d. per strip and 12 strips of heat coils and carbon arresters at £13. 17s. 3d. per strip.

Woodeson Water-tube Boiler.—The Woodeson patent water-tube boiler, as manufactured by Messrs. Clarke, Chapman & Co., Gateshead-on-Tyne, is recognised by steam users as a most economical and efficient steam generator, and one that is applicable for all usages and purposes. Some very large and important orders for these boilers have recently been placed with Messrs. Clarke, Chapman & Co., among the most recent being:—

Three large boilers for Bury Corporation, one large boiler for the Admiralty, four large boilers for the new coke oven plant for Messrs. Strakers & Love (making the sixth repeat order from this firm), a large boiler for the Yorkshire Electric Power Co. (repeat order due to the success of a similar boiler installed by the company in the early part of this year), a further repeat order for two large boilers for the power station in Naples (third repeat order), also important orders for large boilers for South Africa and Japan. The firm are daily receiving inquiries for these boilers from the most important steam users in the world.

Water Purifying Plant.—A contract for a large water purifying plant for H.M. Dockyard (North), Devonport, has been placed with the Harris Patent Feed Water Filter (Ltd.), of London and Newcastle-on-Tyne.

The contract includes all structural ironwork for supporting the plant over the boilers in the boiler house, and all the pipes and valves conveying the water to and from the apparatus. The plant is of the Harris Co.'s latest design, and is arranged to treat 7,000 gallons of condensed steam per hour, and guaranteed to remove absolutely every trace of oil therefrom.

Agents Wanted.—Chinnery Signs (Ltd.), 23, Old-street, London, E.C., makers of illuminated and other signs, advertise that they wish to appoint provincial agents.

Patents Development.—The Proprietors of patent No. 226 of 1904 relating to "Improvements in electrical conductors for illuminating purposes such as lamp pencils or filaments," desire to sell the patent or to grant licences. Inquiries to Messrs. Hyde & Heide, 3, Broad-street Buildings, Liverpool-street, E.C.

The proprietors of patent No. 19,979/1904, for "Improvements in magnetic wheels or electromagnetic motors," desire to enter into arrangements by way of licence and otherwise for exploiting the same. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

The owners of patents No. 23,501/1899, relating to "Improvements in vacuum tube lighting," and No. 12,582/1902, relating to "An improved system of electric lighting," wish to negotiate for the granting of licences. Applications to Messrs. Lloyd Wise & Co., 46, Lincoln's-inn-fields, London, W.C.

Useful Tables.—We have received from Mr. S. N. Brayshaw, of Manchester, three varnished cards, which we shall doubtless find useful in our work. One of these is entitled "Millimetre Equivalents," and gives the value in inches for each millimetre between 1 and 100 mm. and then for every 100 mm. up to 900 mm. The second card gives the decimal equivalent of fractions of an inch between one-sixty-fourth and sixty-three sixty-fourths inclusive, advancing by sixty-fourths. The third gives a useful comparison of the Centigrade and Fahrenheit scales. Mr. Brayshaw will be pleased to supply these cards free of charge to anyone who would find them useful either for works, office or drawing office use. We feel sure there will be a great run on them.

Spiral Self-centring Chuck.—Mr. Charles Taylor, of Birmingham, announces that he is now making this chuck with four jaws as well as with three jaws, and in two styles, namely, for ordinary lift work and also for bar work.

The Ediswan "Metfil", Lamp.—We reproduce herewith a striking advertisement of the Royal Ediswan "Metfil" lamp, which recently appeared on the front of a London daily paper. It is obvious that every interested person who reads such a bold announcement will feel compelled to go to the electrician from whom he purchases his electrical supplies in order to know more about these lamps. The advertisement will, therefore, directly benefit the contractors and retail traders.

Railway Enterprise.—Our leading railways are doing a great deal in the way of compiling and issuing literature of an instructive and interesting character, regarding the show places on their various systems, and amongst the railways which have made a conspicuous feature of this work is the Great Central Railway Publicity Department. Messrs. T. M. Middleton & Co., of Essex-street, Strand, London, are the publishers of a book which has been prepared by Mr. T. W. D. Smith, manager of the Publicity Department of the Great Central Railway, under the title "America's Motherland." The book gives a concise description of many of the many "beauty spots" and places of interest on this Company's route, especially for American visitors to this country. There are a large number of places on the Great Central of note and interest, which justify the compilation of a book of this kind, and we are sure that American visitors will appreciate the work that Mr. Smith has done so well for them in putting together much information in small compass, and in a form that is easily accessible. Many of the illustrations are of special interest to our American cousins. The published price is 1s., or 25 cents. Mr. Smith is to be congratulated on the careful selection he has made of the mass of material at his disposal, and also in the selection of his illustrations.

"The Metal Industry."—This is the title of a new paper, issued by the proprietors of "Cassier's Magazine," and which will be devoted exclusively to the non-ferrous metal trades. The paper will be published at 6d. per copy, from the offices, 33, Bedford-street, London, W.C.

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer. We would add that the portrait is mounted so as to be conformable as to size with "The Electrician" series of steel plate portraits, and is well suited for framing with the series.

CATALOGUES, &c.

Siemens' Selective Call for Telegraph Stations. This apparatus makes it possible, on a telegraph line with many stations, to call up any individual station by means of a bell signal, without disturbing all the other stations. The apparatus is claimed to be particularly adapted to telegraph lines where, owing to special working conditions, the operators are obliged to attend to other duties, and are, therefore, not able always to give their instruments close attention. The advantages of this selective call are the following: (1) No alterations are necessary to the existing apparatus; (2) the selective call being merely an accessory, the working of the tele-

graph is independent of the working of the selective call, which is operated by means of the existing Morse key; (3) the instrument is absolutely reliable; and (4) a call bell can be fixed at any convenient distance from the apparatus. The call is automatically restored by the ordinary telegraph working. This apparatus is described in a pamphlet recently issued by Messrs. Siemens Bros. & Co.

LOW-TENSION SWITCHGEAR.—We have received from the Union Electric Co. an advance copy of a new catalogue dealing with low-tension switchgear. In this catalogue are illustrated and described knife switches fitted with an auxiliary brake arrangement, and suitable for use on circuits whose pressures do not exceed 600 volts. These switches are made in a number of capacities up to a maximum of 1,000 amperes. Similar switches with laminated brush contacts and auxiliary copper and carbon sparking tips are made for circuits whose pressures do not exceed 600 volts and for capacities up to 6,000 amperes. Porcelain handle switch fuses and switches in cast-iron cases are also described. In this connection we may call special attention to the distribution boards in cast-iron boxes, which are dealt with at the end of the catalogue. These are of substantial design, and are provided with glazed fronts, so that the whole is open to easy inspection. Special care is also taken to prevent any contact between poles of opposite polarity. The positive and negative poles are, in fact, fixed on separate battens, and can be easily removed when required. A porcelain fillet divides the two poles.

LAMINATED LEATHER BELTS.—Messrs. James Hendry & Co., 252, Main-street, Bridgeton, Glasgow, have sent us a catalogue dealing with the Hendry patent laminated leather belting. The method of manufacture and the various advantages claimed for this system are fully dealt with. The particulars given are instructive, and will serve to make the merits of Messrs. Hendry's goods even better known than at present.

ARON MAXIMUM DEMAND INDICATOR.—The Aron Electricity Meter (Ltd.) forward a pamphlet dealing with this indicator, which, it is claimed, is universally adaptable and equally suitable for all systems of electric supply. It is essentially a mechanical device, and therefore requires no further electrical connections. It is claimed for it that its accuracy is equal to that of the Aron meter, and follows the same straight line law.

"JANDUS" ARC LAMPS.—The beginning of the arc lamp season is celebrated by the Jandus Arc Lamp & Electric Co. by the issue of an artistic brochure dealing with their lamps.

"SANTONI" LAMPS.—The Globe Electric Co., who now deal in the Santoni lamps, have ready a pamphlet on the subject.

ELECTRICAL ACCESSORIES.—Messrs. A. J. Wright (Ltd.), of Leyton, have ready a small catalogue in which various accessories for electrical installation work are illustrated. These include batteries, bells, rosettes and pushes of various kinds, telephones, distribution and fuse boards, metal filament lamps and electric fans.

SILENT GEAR.—Messrs. W. F. Dixon & Co., of Manchester, have issued a new circular, in which both Buffalo raw hide and waterproof paper gears are dealt with.

BANKRUPTCIES, LIQUIDATIONS, &c.

Meetings of the creditors and shareholders of the Ozonisation Syndicate (Ltd.) were recently held, Mr. Warley, O.R., presiding. The filed accounts showed a deficiency of £879 as regards shareholders. The company was registered in 1907 with a capital of £500 in £1 shares, to acquire certain patents relating to the manufacture of aluminium, and to an electrical process of purification. In the absence of a quorum the meeting of creditors was adjourned.

A meeting will be held at Duchy Chambers, Clarence-street, Manchester, on Oct. 4 to receive an account of the winding up of Generators Ltd. (In vol. liq.)

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

BOWERS & BARR (LTD.) (104,680.)—Reg. Aug. 23, capital £2,000 in £1 shares, to take over the business of electrical engineers carried on as Bowers & Barr, at Great Yarmouth. Private company.

BULLIVANT'S SOUTH AFRICAN CO. (LTD.) (104,728.)—Reg. Aug. 26, capital £5,000 in £1 shares, to carry on in South Africa and elsewhere the business of dealers in wire rope and netting, wire tramways, mining and hauling plant, telegraph cables, &c. Private company. First directors, W. P. Bullivant, F. A. Bullivant, P. J. Bullivant and B. S. Bullivant. Reg. office, 72, Mark-lane, London, E.C.

E. M. F. (LTD.) (104,693.)—Reg. Aug. 24, capital £20,000 in £1 shares, to carry on the business of electricians, mechanical and electrical engineers, suppliers of electricity, &c. Private company. First directors, J. M. Bein, A. J. Grose and O. H. Bishop.

ETNA LIGHTING & HEATING CO. (LTD.) (104,579.)—Reg. August 16, capital £1,000 in £1 shares, to adopt agreements (1) with J. Warry and G. N. Arculus, and (2) with H. R. Prosser for the acquisition of certain patents, tools, &c., and to carry on the business of electric and gas fittings manufacturers, lighting and heating engineers, &c. First directors are L. W. Goold and H. R. Prosser.

INTERNATIONAL ELECTRIC TRANSPORT & ENTERPRISE CO. OF ALSACE-LORRAINE (LTD.) (104,668.)—Reg. August 21, capital £200,000 in 195,000 preferred shares of £1 each and 100,000 deferred shares of 1s. each, to undertake and develop electric carriage and other enterprises in Alsace-Lorraine and elsewhere, and to carry on the business of constructors of electric tramways and railways, motor vehicles, carriers of passengers and goods, &c. First directors, C. Simon and A. Sautier (Guebwiller, Alsace), and A. F. Argles. Reg. office, 3, East India-avenue, E.C.

MORTGAGES AND CHARGES.

KENT ELECTRIC POWER SYND. (LTD.)—Debentures for £1,038, dated Aug. 5, 1909, charged on company's undertaking and property, present and future, including uncalled capital. Holders, Kent Electric Power Co. Memoranda of satisfaction (*a*) in full on Nov. 8, 1905, of charge dated Feb. 14, 1905, securing £4,275, (*b*) to the extent of £1,300 on July 24, 1908, of charge dated May 26, 1905, securing £1,850, and (*c*) in full on Aug. 13, 1906, of charge dated July 3, 1905, securing £750, also notified on Aug. 21, 1909.

"Z" ELECTRIC LAMP MFG. CO. (LTD.)—Charge under Land Transfer Acts, dated Aug. 11, 1909, to secure £25,000, charged on freehold land and buildings at Southfields, S.W. Holders, J. G. B. Stone and J. Venning.

CITY NOTES.

MEMORANDA (Sept. 2).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{7}{8}$d. per oz. Consols $84\frac{1}{2}$—$84\frac{5}{8}$ for money and $84\frac{9}{16}$—$84\frac{11}{16}$ for account. Consols Pay Day, Oct. 1; Stock and Shares Continuation Days, Sept. 8 and 27; Ticket Days, Sept. 9 and 28; Pay Days, Sept. 10 and 29; Mining Shares Carry Over Days, Sept. 7 and 24.

PRICES OF METALS (London).—*Copper*, cash, $59\frac{1}{8}$; three months $60\frac{1}{16}$. *Lead*, English, 13; foreign, cash, $12\frac{5}{8}$; three months, $12\frac{1}{2}$. *Spelter*, cash, $22\frac{1}{2}$. *Tin*, English, 135—137; foreign, cash, $137\frac{3}{8}$; three months, $138\frac{3}{8}$. *Iron*, Cleveland, cash, 51/4, and three months, 52/1. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the five weeks ended July 30 were 904,731, compared with 724,011 units in the corresponding five weeks of 1908.

CLAUD HAMILTON (LTD.)—At the recent meeting a dividend at the rate of 6 per cent. per annum on the ordinary shares was declared.

COMPANIES STRUCK OFF THE REGISTER.—The Borough Mills Power Co., the Doherty Iron Castings Process and the London-Provincial Electrical Co. were struck off the Register of Joint Stock Companies on August 27.

DOULTON & CO. (LTD.)—The directors announce that they are advised that the trading for the past six months does not warrant the declaration of an interim dividend on the preference shares.

DUMBARTON BURGH & COUNTY TRAMWAYS CO.—The profit for the year ended July 31, after providing for interest, was £6,192, to which has to be added the amount brought forward, making £7,520. After providing for preference dividend the balance is £3,020, which is carried forward.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—A dividend is announced of 2s. per share on the ordinary shares.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have granted a quotation to £150,000 5 per cent. second mortgage debentures of the *Bombay Electric Supply & Tramways Co.* (in lieu of the scrip now quoted).

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—The report for the half-year ended June 30 states that the net revenue from investments and rents (after deducting general expenses and interest) amounted to £62,879. 10s.; the net income from the operation of the power house was £40,659. 10s. 11d., but the interest on £775,000 $4\frac{1}{2}$ per cent. power house debentures was £17,437. 10s., leaving a surplus from the power house of £23,222. 0s. 11d., or a total of £86,101. 10s. 11d. After meeting interest on the 5 per cent. prior lien bonds, $4\frac{1}{2}$ per cent. bonds, &c., which aggregated £102,341. 15s. 9d., there was a deficiency of £16,240. 4s. 10d. To cover this deficit Messrs. Speyer have purchased from the company (in accordance with the agreement of April 7, 1908) £10,700 $4\frac{1}{2}$ per cent. bonds of 1933 and £16,050 6 per cent. income bonds for £16,050. The income from investments for the six months shows an increase of £22,065. 9s. 9d., or about 40 per cent., over that in the previous half-year. A summary of the traffics of the associated railway companies accompanies the report.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 25	1,568	− 152	12	19,336	− 653
Airdrie	,, 20	226	+ 2	33	7,163	− 113
Anglo-Argentine	,, 26	37,522	+ 3,396	34	1,322,219	+ 80,090
Ayr Corporation	,, 28	416	+ 15	15	6,229	− 210
Baker St. & Waterloo Ry.	,, 28	2,655	+ 10	8	23,230	+ 875
Barnsley	,, 20	210	− 21	33	5,541	− 290
Barrow	,, 20	271	− 26	33	7,641	− 586
Bath Electric Trams, Ltd.	,, 25	859	+ 87	34	26,358	+ 1,181
Birmingham Corporation	,, 28	6,234	+ 172	22	141,693	+ 3,727
Birmingham & Mid.	,, 13	813	+ 51	32	26,953	+ 321
Blackburn Corporation	,, 25	1,0[illegible]	− 55	22	21,991	− 920
Blackpool and Fleetwood	,, 28	1,551	+ 365	...	...	...
Bolton Corporation	,, 20	2,333	+ 83	22	51,853	− 707
Bombay	July 29	R31,979	+ R5,017	29	R1,126,617	+ R68,913
Bournemouth Corporation.	Aug. 25	2,211	− 71	21	38,179	+ 48
Bradford Corporation	,, 28	4,763	+ 176	21	107,482	+ 2,114
Brighton Corporation	,, 28	1,292	+ 132	22	23,205	+ 937
Bristol Trams & Carriage	,, 27	5,742	+ 826	14	83,629	+ 3,1[illegible]9
Burnley Corporation	,, 28	1,270	+ 113	22	28,366	− 73
Burton Corporation	,, 29	232	− 1	22	5,943	− 148
Bury Corporation	,, 20	1,116	+ 13	†22	26,034	− 593
Calcutta Tramways Co.	,, 28	R18,520	+ R2,620	8	R398,149	+ R26,518
Camborne-Redruth	,, 23	136	− 1	35	4,286	− 131
Cardiff Corporation	,, 28	2,295	+ 72	22	49,548	+ 438
Cavehill	,, 20	134	+ 4	33	2,954	− 150
Central London Railway	,, 28	4,549	− 2,031	8	39,504	− 16,030
Charing C., Euston & H'stead	,, 28	3,365	+ 505	8	29,210	+ 3,810
Chatham & Dist. Lt. Rys.	,, 26	920	+ 55	37	27,700	+ 1,539
City & South London Rly.	,, 29	2,838	+ 43	8	24,351	+ 1,302
City of Birmingham	,, 20	2,710	+ 127	33	92,529	+ 868
Colchester Corporation	,, 25	234	+ 16	8	1,631	− 842
Cork Electric Trams Co.	,, 26	505	+ 25	8	14,978	− 786
Croydon Corporation	,, 27	1,649	+ 422	‖21	33,355	+ 1,210
Devonport & Dist. Trams	,, 20	384	− 116	33	12,214	− 2,962
Dover Corporation	,, 28	370	+ 93	22	4,980	− 381
Dublin & Lucan Railway	,, 27	181	+ 31	5	1,395	+ 40
Dublin United	,, 27	6,848	+ 413	‖3	50,805	+ 1,335
Dudley-Stourbridge	,, 20	963	+ 27	33	27,014	− 752
Dundee Corporation	,, 25	1,217	+ 18	†15	17,530	− 558
East Ham Council	,, 25	938	+ 179	§21	22,141	+ 3,001
Exeter Corporation	,, 27	375	+ 4	22	7,831	+ 570
Gateshead & Dist. Trams	,, 20	1,030	+ 43	33	32,891	− 267
Glasgow Corporation	,, 23	16,842	− 67	‡13	213,551	− 3,868
Glossop Trams	...	...	...	...	...	...
Gravesend—Northfleet	,, 20	250	+ 6	33	6,882	− 163
Great Northern & City Rly.	,, 23	1,209	+ 19	8	9,837	− 3
Gt. Northern, Piccadilly, &c.	,, 23	4,450	+ 110	8	39,015	+ 865
Greenock & Port Glasgow	,, 20	684	+ 43	33	18,062	+ 410
Hartlepool Tramways	,, 20	295	− 3	33	7,741	− 207
Hastings Elec. Trams Co.	,, 26	1,445	− 67	8	11,301	− 373
Hong Kong	,, 23	$3,306	+ $644	...	...	...
Huddersfield Corpn.	,, 23	1,679	+ 152	21	36,294	+ 923
Hull Corporation	,, 23	2,571	+ 214	21	54,383	+ 1,433
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 25	147	+ 3	22	2,905	− 200
Ipswich Corporation	,, 28	514	+ 59	22	9,302	+ 113
Isle of Thanet Co.	,, 23	1,699	+ 151	§33	26,762	+ 97
Jarrow	,, 20	131	+ 15	33	3,903	+ 355
Keighley Corporation	,, 23	167	+ 1	21	3,728	+ 93
Kidderminster & District	,, 20	119	+ 11	33	3,624	− 224
Kilmarnock Corporation	,, 28	145	− 1	15	2,338	− 81
Lanarkshire Trams Co.	,, 26	1,441	+ 120	31	43,361	− 863
Lancashire United	,, 25	1,313	− 270	34	45,273	− 529
Leamington	,, 20	201	− 3	33	5,768	+ 170
Leeds Corporation	,, 23	6,849	+ 336	22	149,539	+ 2,391
Leicester Corporation	,, 23	2,154	+ 90	8	18,299	− 193
Leith Corporation	,, 28	625	+ 111	15	9,892	+ 1,193
Lincoln Corporation	,, 28	134	...	22	2,759	+ 102
Liverpool Corporation	,, 21	11,012	+ 184	‖32	356,558	− 2,532
Liverpool Overhead Rly.	,, 20	1,423	+ 25	‡9	13,403	+ 44
Llandudno & Colwyn Bay Ry	...	...	...	...	...	...
London County Council	,, 14	37,585	+ 2,795	§19	719,401	+ 24,437
London United	,, 23	6,882	+ 286	‖19	209,783	− 20,681
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	,, 28	205	+ 16	21	4,146	− 236
Manchester Corporation	,, 28	14,793	+ 340	22	328,233	− 3,463
Mersey Railway	,, 28	1,842	+ 42	8	15,252	+ 551
Merthyr	,, 20	209	+ 1	33	7,034	+ 86
Metropolitan Dist. Railway	,, 28	8,569	+ 216	8	75,124	+ 5,476
Metropolitan Elec. Trams	,, 20	6,905	+ 450	33	203 195	+ 15,461
Middleton	,, 20	454	− 31	33	11,271	− 913
Nelson Corporation	,, 23	148	+ 10	§21	3,076	− 92
Newcastle-on-Tyne Corp.	,, 28	3,729	+ 17	21	84,527	− 1,100
Newport (Mon.)	,, 28	641	+ 23	22	14,781	− 309
Northampton Corporation	,, 27	490	+ 17	§22	10,799	+ 267
Oldham, Ashton & Hyde	,, 20	534	− 130	33	18,479	− 1,273
Oldham Corporation	,, 29	1 935	− 180	23	42,823	− 3,123
Perth (N.B.) Corporation	,, 25	189	+ 7	14	2,477	− 13
Perth (W.A.) Elec. Trams	,, 27	1,390	+ 83	34	47,901	+ 110
Peterborough	,, 20	155	+ 16	33	3,903	− 323
Portsmouth Corporation	...	...	...	..	...	...
Potteries	,, 20	1 670	+ 41	33	58,233	− 1,378
Preston Corporation	,, 25	738	− 2	8	6,185	− 47
Rotherham Corporation	,, 26	694	− 36	21	12,694	− 581
Rothesay	,, 20	653	+ 1	33	7,518	− 200
Salford Corporation	,, 30	4,463	+ 43	‡22	101,165	− 3,517
Sheerness	,, 20	76	− 3	33	1,682	− 234
Sheffield Corporation	,, 29	5,537	+ 160	§23	125,157	− 1,421
Singapore Trams	,, 23	$3,790	− $11	...	...	...
South Metropolitan	,, 20	1,023	+ 65	33	26,314	− 524
South Staffs	,, 20	852	− 9	33	27,627	− 1,419
Southend Corporation	,, 25	815	+ 71	21	12,802	+ 2,003
Southport Tramways	,, 20	362	− 73	33	9,700	− 332
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Sunderland Corporation	,, 20	1,118	− 93	22	25,914	− 1,003
Sunderland District	,, 20	448	− 54	43	19,812	− 863
Swansea Trams	,, 20	1,116	+ 22	33	31,758	+ 496
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 20	62	+ 15	33	1,344	− 61
Tynemouth and District	,, 20	461	+ 70	33	[illegible]	+ [illegible]
Tyneside Trams Co.	,, 20	432	+ 5	8	3,823	+ 203
Wallasey District Council	,, 28	976	− 13	§21	21,010	+ 135
Walsall Corpn.	,, 23	507	+ 12	34	17,451	+ 1,161
Warrington Corpn.	,, 25	373	+ 11	21	8,150	+ 56
West Ham Corporation	,, 19	2,392	+ 193	20	48,457	+ 2,830
Weston-super-Mare	,, 20	463	− 22	33	5,097	+ 194
Wolverhampton Co.	,, 20	455	+ 6	33	13,842	− 1,295
Wolverhampton Corpn.	,, 25	763	− 30	8	6,716	− 268
Worcester	,, 20	342	+ 11	33	9,235	− 79
Wrexham	,, 20	112	− 3	33	3,222	− 146
Yorkshire W.R. Trams	,, 29	1,250	+ 49	35	41,505	...
Yorkshire Woollen District.	,, 20	1,022	+ 50	33	29,884	− 418

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed., Sept. 1.	Rate % Yielded. (£ s. d.)	Dividend Due.	Business Week to Sept. 1. Highest.	Business Week to Sept. 1. Lowest.
		ELECTRICITY SUPPLY.					
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9½ –9¾	6 3 0	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾ –10	4 [illegible] 0	Feb, Aug	9	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 –10½	5 14 0	Feb, Aug	10½	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 –103	4 7 6	Jan, July	[illegible]	101
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½ –4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 –96	4 16 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7½ –8	6 12 0	March....	7½	..
5	3/6	Do. 7 per Cent. Pref.	7¾ –8	4 8 0	Mar, Sept	..	—
St.	4%	Central Elec Sup. Co. 4% Guar. Db. Stock	97 –100	4 0 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 –4½	5 16 6	Feb, Aug	4½	—
5	2/3	Do. 4½ per Cent. Pref.	4½ –4¾	4 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb Stock (red.)	96 –99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99½ –101½	4 [illegible] 6	..	99¾	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾ –4¼	5 2 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3¾ –4¼	4 9 3	March ..	3[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	10[illegible] –103	4 7 9	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord.	10½ –1[illegible]	5 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	1[illegible] –12¾	4 11 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 –124	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 –103	4 7 6	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1¾ –2¼	—	April, Oct	..	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 –3½	3 11 0	April, Oct	3¼	..
10	4/0	County of London Elec. Supply Ord.	7⅞ –8⅛	6 3 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½ –11	5 9 0	Mar, Sept	10[illegible]	1[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	104 –107	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 –103	4 7 6	May, Nov	—	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅞ –5⅛	5 9 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 –100	4 10 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7½ –7¾	5 11 6	April, Oct	—	..
5	4/0	Kensington & Knightsbridge Ord.	6¾ –6⅞	5 16 6	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅛ –6⅜	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 –98	4 2 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 –101	3 19 0	April, Oct	9[illegible]	..
St.	4½%	Kent Elec. Power Co.	85 –89	5 1 0	Jan, July	8[illegible]	87½
3	1/9⅜	London Electric Supply Ord.	1⅞ –2¼	3 6 8	Mar, Sept	..	..
5	3/0	†Do. 6 per Cent. Pref.	5 –5¼	5 14 0	Mar, Sept	5[illegible]	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 –97	4 2 6	Jan, July	95½	95
5	2/6	Metropolitan Electric Sup. Ord.	4½ –4⅝	5 19 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ –5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 –108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ –85½	4 0 6	Jan, July	84	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	96 –98	4 12 0	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4⅞ –5⅛	4 0 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	85 –87	5 4 5	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4½ –4⅝	2 14 0	Feb, Aug	4½	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4½ –5	5 0 0	Feb, Aug	4[illegible]	4½
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 –99	4 1 8	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 –101	4 19 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 –91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	11¾ –12¼	5 14 0	March ..	—	—
5	4/6	Oxford Electric Ord.	5 –5⅜	5 8 0	March ..	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 –98	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8¾ –9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 –7½	4 13 4	Feb, Aug	—	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 –85	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord.	[illegible]	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2¾ –3	6 16 0	April	..	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 –103	4 17 0	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	—
1	0/3⅜	Do. 7 per Cent. Cum. Pref.	1⅛ –1¼	5 12 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	102 –105	4 6 0	April, Oct	—	—
5	2/6	Urban Electric Supply Ord.	¾ –1	—	April, Oct	¾	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1½ –2	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	77 –81	5 11 6	April, Oct	..	—
5	5/0	Westminster Elec. Sup. Ord.	8⅝ –9⅛	5 8 0	Mar, Sept	[illegible]	9½
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 –5⅛	4 4 0	Jan, July	5[illegible]	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	99 –101	3 19 0	Jan, July	100½	99½
1	..	Bath Elec. Trams Pref. Ord.	¼ –⅜	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 –91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	88 –91	4 19 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8 –8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8 –8½	4 14 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100 –101	3 19 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	[illegible]	—	June, Dec	..	..
10	8/0	Do. 6 per Cent. Cum. Pref.	2 –2½	12 0 0	Feb, Aug	2⅜	2¼
St.	5%	Do. 5 per Cent. Perpetual Debs.	85 –88	5 13 0	April, Oct	85¼	85
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 –67	6 14 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	63 –64	4 14 0	Feb, Aug	63	62½
St.	4%	Do. 4 per Cent. Pref. Stock	84 –86	4 13 0	Feb, Aug	8[illegible]	84½
St.	2½%	Do. Deferred Stock	43 –45	5 11 0	Feb	.	..
100	4%	Do. 4 per Cent. Debs.	101 –103	3 18 0	Jan, July	10[illegible]	102½
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	92 –94	4 6 0	Jan, July	9[illegible]	93
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ –5¼	4 10 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 –101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	31½ –32½	4 12 0	Feb, Aug	32¼	31½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	108 –110	4 11 0	Feb, Aug	..	..
St.	5%	Do. (1896)	104 –107	4 15 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100 –103	5 2 6	Feb, Aug	10[illegible]	1[illegible]
St.	5%	Do. (1903)	93 –96	5 4 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	103 –102	3 18 0	May, Nov	10[illegible]	..
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾ –13¼	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ –1	..	Feb, Aug	..	..
10	..	G. Northern, Picc. & Brompton 4% G.P.	8 –8½	—	Feb, Aug	.	—
St.	4%	Do. 4 per Cent. Deb. Stock	91 –93	4 3 6	Jan, July	9[illegible]	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¾ –2	..	Mar, Sept	[illegible]	—
St.	4½%	Do. 4½ Db. St.	76 –81	5 11 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 –4½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	6 –6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80 –82	5 10 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ –1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58 –63	6 7 0	Jan, July	..	—
10	5/6	†Lanarkshire Tramways	9¾ –10	5 15 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ –90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	..	—
10	5%	Do. 5 per Cent. Pref.	5 –5	8 6 8	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82 –84	4 15 8	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2¼ –2½	..	Jan, July	2½	2[illegible]
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 –70	5 14 0	Jan, July	65	..
St.	—	Mersey Con. Ord. Stock	1 –2	—	Feb, Aug.	..	..
1	10⅜	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April.. .	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 1 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 –97	4 12 9	Jan, July	..	..
St.	1%	Metropolitan Railway Consolidated	39½ –39	1 5 8	Feb, Aug	39½	3[illegible]
St.	2¾%	Do. Surplus Lands Stocks	65 –67	4 5 6	Feb, Aug	66	65⅜
St.	3½%	Do. 3½ per Cent. Preference	88 –90	3 17 9	Feb, Aug	8[illegible]	89
St	3½%	Do. 3½ per Cent. "A" Preference	85 –87	4 0 6	Feb, Aug	.	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 –85	4 1 0	Feb, Aug	85	85
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 –94	3 14 6	Jan, July	93½	92½

In calculating the yield allowance has been made for accrued interest but *not* for redemption.

* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., Sept. 1.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Sept. 1. Highest.	Lowest.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	92	..
St.	..	Metropolitan District Railway Ord.	16½—16¾	—	Feb, Aug	17⅛	16¾
St.	..	Do. Extension Pref. (5 per Cent.)	49 —51	..	Feb, Aug	50	48½
St.	3½	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	65 —67	5 3 0	Feb, Aug	67	66½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	76½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	—
St.	3½	Do. Guar. Stock 4 per Cent.	94 —97	4 2 6	Mar, Sept	94½	94½
St.	6	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9	Jan, July	..	..
St.	4	Do. 4 per Cent. Ditto	94 —96	4 4 0	Jan, July	95½	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—⅞	6 11 0	Feb, Aug	..	—
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5%1stMt.Db	81 —85	5 18 0	Jan, July	81½	—
..	..	UndergdE.Rys.Lon.6% In.bds.with coup.3	37 —39	..	June, Dec	37½	37
..	5	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103⅜	..
—	4½	Do. 4½% Bonds with coup. 3	89 —91	4 19 0	..	89¾	88½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
St.	..	Anchor Cable Co. 4½% Deb. Stock	102 —104	—	..	102½	102½
1	..	Aron Electricity Meter Ord.	¼—½	..	..	..	..
1	1/4½	Do. 6% Cum. Pf.	⅞—⅝	6 17 0	April, Oct	—	..
1	2/4½	Babcock & Wilcox Ord.	4⅛—4⅞	4 14 9	April, Oct	4⅛	4½
1	0/7½	Do. Pref.	1⅛—1¼	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	7⅛—7⅜	6 7 0	July, Feb	7⅛	7⅛
5	3/0	Do. 6 per Cent. Pref.	6⅛—6⅜	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	..
St.	4½%	†British Thoms'n-Houst'n 4½% 1st Mt.Db.	89 —94	4 16 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅜—⅝	—	Feb, Aug	½	—
100	1%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	98	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock‡	38 —42	9 10 0	Jan, July	..	..
St.	4½%	†Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	41 —46	9 18 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	11⅛—11⅝	5 17 9	Jan, July	10⅞	10⅝
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 7 0	Jan, July	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	2 —2¼	5 18 0	May, Nov	2⅛	2⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 —108	4 3 8	Feb, Aug	—	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅝—1⅞	6 11 9	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/7	Consolidated Electrical Co.	⅞—1	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1 —1⅛	8 18 0	April, Oct	1 1/16	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	15/16—1	6 0 0	April, Oct	..	..
5	8/0	*Crompton & Co. (Nos. 1 to 85,000)	⅝—1⅛	13 7 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	90 —93	5 7 6	Jan, July	..	—
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1 3/16	7 12 0	Sept	1 5/32	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	1	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	68 —73	5 9 6	June, Dec	69⅛	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅛—5/16	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 6 0	Jan, July	..	—
2	..	Electric Construction Co.	7/16—11/16	..	Jan, July	..	—
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1 3/16—1 7/16	9 16 0	July	..	..
St.	4	Do. 4 per Cent. Perp. 1st Mort. Debs.	65—69	5 16 0	Jan, July	..	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71—77	6 10 0	...	..	...
10	5/0	General Electric (1900) 5% Cum. Pref.	7¾—8¼	6 1 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	5/0	†Henley's Telegraph Works Ord.	12½—13½	5 15 6	Feb, Aug	13 1/16	12½
5	2/3	†Do. 4½ per Cent. Pref.	5⅛—5⅜	4 2 0	Feb, Aug	..	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14¾—15¼	6 9 0	Feb, Aug	14 13/16	..
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—10¾	..	..	10 11/16	..
100	4%	Do. 4 per Cent. Debs. (red.)	100 —102	3 19 0	April, Oct	100½	—
1	..	National Elec. Construction Co.	⅜—⅝	..	April......	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	5/16—½	..	Nov	½	7/16
1	..	Do. 6 per Cent. Cum. Pref.	11/16—13/16	..	May, Nov	¾	¾
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	82 —86	5 4 0	Jan, July	83	..
1	..	Simplex Conduits Ord.	1½	—	—	..	—
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	..	..
12	12/0	Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	35½	34⅝
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	—	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2¼—2 9/32	4 8 0	—	2 9/32	2 7/32
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛ 1¼	4 0 0	—	1 7/32	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	110 —113	4 8 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red	101½—103½	3 17 6	June, Dec	103	—
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 18 0	..	107	106
10	8%	J. G. White & Co. 6% Cm. Pref.	9½—10½	8 6 0	..	10	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	8 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅞—3⅛	9 12 0	Apr, Oct	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3⅛	—	June, Dec	..	..
100	5%	Do 5 per Cent. Debs. (red.)	95 —96	5 4 0	June, Dec	..	..
St.	15/0	Anglo-American	60½—62½	5 3 6	F,My,Ag,N	60½	..
St.	30/0	Do. Preferred	103¾—104¾	5 15 0	F,My,Ag,N	104½	103½
St.	8/0	Do. Deferred	21 —21½	1 18 0	F,My,Ag,N	21⅛	20½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	91	90
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	—
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	2⅞—3⅛	5 18 0	April, Oct	2¾	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅝—8⅞	5 12 9	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100% 102%	4 8 3	Jan, July	..	..
20	5/0	Direct United States Cable	13 —13½	6 6 0	Ja,Ap,Jy,O	13⅛	12 15/16
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	129 —132	5 6 0	Ja,My,JyO	129¾	129
St.	17/6	Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,JyO	86	84¾
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	105	..
St.	4/6	Eastern Extension	11¾—12¼	5 14 0	Ja,Ap,Jy,O	12 1/16	11 7/16
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	102	..
25	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	3 18 0	May, Nov	101⅛	100½
10	7/0	G.N. (of Copenhagen), with Coupon 77	26 —27	6 13 6	Jan, July	26	—
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 —101	4 9 0	June, Dec	100	..
..	12/6	Indo-European Telegraph	61½—63½	5 16 9	May, Nov	63	61½
100	$1	Mackay Companies Common	82 —86	4 13 0	Ja,Ap,Jy,O	—	..
100	$1	Do. Preference	74 —78	5 2 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	1 3/16—1 5/16	..	April....	1¼	—
1	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	100 —102	3 18 0	June, Dec	1⅛	—
2½	1/3	West Coast of America	1⅛ —1⅜	4 12 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
1	..	West India & Panama	½—⅝	..	May, Nov	½	..
10	6/0	Do. 6 per Cent. 1st Pref	8 —8½	7 1 0	May, Nov	8¼	..
10	5/0	Do 6%, 2nd Pref.	8 —9	6 13 6	May, Nov	—	—
100	5%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	13½—13¾	5 2 0	Mr,Jn,O,D	13⅝	13 9/16
St.	4%	Do. 4 per Cent. Deb Stock (red.)	103 —105	3 16 0	June, Dec	103½	..
—	4	Western Union Telegh. $1 000 4% Bonds	97 —99	4 1 0	..	..	..

Share	Last Dividend	Name	Price Wed., Sept. 1	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Sept. 1. Highest.
		TELEPHONES.				
100	2⅜	Amer. Telephn. & Telegh. Cap. St.	145 —147	5 8 6	..	111½
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	96 —98	4 2 0	Jan, July	—
St	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103½—105½	4 16 0	Mar, Sept	..
5	8/0	Chili Telephone	8 —8⅜	4 15 6	August ..	..
1	0/7½	Monte Video Telephone Ord.	13/16—15/16	6 8 0	Nov	..
1	0/6	Do. 5 per Cent. Pref.	¾—⅞	5 14 3	May, Nov	..
St.	6%	National Co. Pref. Stock	106 —107½	6 11 6	Feb, Aug	107½
St.	6%	Do. Def. Stock	122½—124½	4 15 6	Feb, Aug	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—10⅜	5 9 0	Feb, Aug	10⅜
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10⅜—10⅞	5 9 0	Feb, Aug	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 5/16—5 11/16	4 8 0	Feb, Aug	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	98½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	101
1	1/0	Oriental	1⅜—1⅝	5 6 9	April, Oct	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	April, Oct	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	86⅝
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk. (red.)	100½—102½	4 8 6	Jan, July	..
5	5/0	United River Plate	6 13/16—7 3/16	5 11 0	July	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼ —5⅝	4 9 0	June, Dec	..
St	4½%	Do 4½ Deb. St. Red.	104 —106	4 5 6	Jan, July	105
		FINANCIAL INVESTMENT, &c.				
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..
10	5/6	Globe Telegraph & Trust	10½—10¾	6 7 0	SpDcMrJu	10 9/16
10	3/0	Do. 6 per Cent. Pref.	13¾—14¼	4 4 0	SpDcMrJu	14⅛
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.				
£	—	Anglo-Argentine 5% Cum. 1st Prof.	4⅝—4⅞	5 2 8	April, Oct	4 5/16
£	—	Do. 5% Cum. 2nd Pref.	4 1/16—4 1/16	5 7 0	Jan, July	4⅛
St.	4%	Do. 4% Deb. Stock	92¾—93¼	4 6 0	June, Dec	92⅝
St	..	Do. 4½% Deb. Stock	97½—98½	..	..	98
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	—
1	3/6	Brisbane Electric Trams. Invest. Ord.	6¾—7	4 6 0	May	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	..
St.	8%	British Columbia El.Ry.Df. Ord.	152 —157	5 2 0	Mar, Sept	155½
St.	6%	Do. Pref. Ord. Stock	123 —127	4 14 6	May, Nov	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	109 —112	4 9 0	Jan, July	110
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	—
St.	4½%	Do. 4½% Perp. Con. Deb. St.	103 —105	4 1 0	—	101½
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	..
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	92 —96	6 5 0	Feb, Aug	93
5	2/0	Calcutta Tramways (1 to 137,610)	4 7/16—4 11/16	4 2 0	Mar, Sept	4½
100	2/6	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	99½
St.	..	Cape Electric Tram Shares	¼—½	..	..	⅜
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 13/16—6 1/16	4 4 0	F,My,A,N	6⅛
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	91 —94	5 6 6	Feb, Aug	—
1	..	Kalgoorlie Elec. Trams Sh.	1/32—3/32	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	91 —94	5 6 0	Jan, July	92½
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 12 0	Jan, July	68½
5	1/0	Lisbon Elec. Trams. Ord.	1 1/32—1 3/32	4 4 9	July	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1 3/16	5 1 0	Jan, July	—
St.	6%	Do. 5 per Cent. Reg. Mort. Debs	98 —102	4 18 0	Jan, July	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 3 0	Feb, Aug	—
100	$1½	Mexico Trams Co. Com. St.	128 —131	3 16 6	..	130
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98½	5 5 0	..	97½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	103
1	0/6	Perth Elec. Trams Ord.	⅝—⅞	8 0 0	May	..
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	—
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5¾—6¼	5 4 8	..	—
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	92 — 94	..	..	91½
..	5%	Do. 30 yr. Gold Bnds.	93½—95½	5 4 0	..	94½
100	5%	Do. 50 yr. Mt. Bnds	85½—86½	5 16 6	..	80
—	$1½	Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —150	6 6 9	..	148½
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	..
100	4½%	†Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.				
5	8/0	†Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅞—5⅛	5 17 6	Mar, Sept	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9⅝—9⅞	6 1 6	..	—
St.	4½%	Do 4½ per Cent. Deb. Stk. (red.)	93½—95½	4 13 6	Jan, July	..
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	93⅝—95⅝	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	6 —6½	6 8 0	April, Oct	6¼
100	$1¾	Canadian Gen. Elec. Co. Com. St.	122 —127	5 13 0	..	124½
100	$3½	Do. 7% Cm. Pf. Stock	119 —121	5 14 6	..	119½
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..
500	5%	†Elect. Development Co of Ontario	84 — 86	5 16 6	..	—
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	—
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—
10s	1¼%	Kalgoorlie Elec. Power & Ltg. Ord.	¼—½	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	¾—⅞	6 18 8	April, Oct	¾
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83 —85½	6 10 0	..	84½
St.	$1	Mexican Lt & Power Co. Com. St.	71 —75	5 19 0	—	74
500	5%	Do. 5% 1st Mort. Gold Bnds.	86 —88	5 14 0	..	87½
100	$1	Montreal Lt. Ht. & Power Co. Cap. St.	127 —131	4 15 0	F,My,A,N	..
1	1/7½	River Plate Electricity Co. Ord.	1 5/16—1 7/16	5 11 0	April	..
1	1 2⅝	Do. 6 per Cent. non-Cum. Pref	1 1/32—1 3/32	5 1 6	May	..
St.	5%	Do. 5 per Cent. Deb. Stock	103 —108	4 14 0	Jan, July	103
5	8/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅝—5⅞	5 6 6	April, Oct	..
5	8/0	Do. 2nd Pref.	5⅞— 6	5 0 0	—	..
100	$1	Shawinigan, Water & Power Co. Ca	98 —100	4 0 0	—	99½
..	5%	Do. 5 per Cent. Bds.	105 —107½	4 13 6	Jan, July	106
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	98 —99	4 11 0	—	..
St.	4½%	Toronto Power Co. 4½% Db. St.	99½—100½	4 9 6	..	99
..	6d.	Victoria Falls Power Co. Pref.	13/16—15/16	5 14 0	Jan, July	..
1	—	Do. 15/- paid	9/16—11/16	..	..	..

* In calculating the yields allowance has been made for accrued interest but *not* for redemption. † Ex dividend ‡ The London Stock Exchange Committee have declined to quote

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NOTES.

Wireless Telegraphy.

FROM a statement made by the Postmaster-General in the House of Commons on Tuesday it would appear that the State is about to become the possessor of certain of the Marconi wireless telegraph stations situated on the coasts of the British Isles. There had previously been statements published that the deal was already an accomplished fact, but Mr. BUXTON stated that the negotiations were, to a certain extent, contingent on the success of somewhat similar negotiations with Lloyds, which, also, were not complete. In view of the existence of the Radio-Telegraphic Convention of 1906, it may be assumed that there will be no hitch in this attempt of the Government to secure these stations; it is desirable that enterprises of this nature should become the property of the State at the earliest possible moment consistent with proper development and efficiency and with the utmost fairness to those who have initiated them. Now that communication between the shore and ships at sea has passed beyond the experimental stage it is essential to place it under State control, along with the ordinary land telegraphs. It should, however, be borne in mind that the principle of Government monopoly must be applied with considerable care in order that private enterprise may be in no way discouraged. The contention that individuals should reap the reward of their early efforts is obviously only a just one, and we feel assured that the Marconi interests will be equitably arranged.

Electricity on Board Ship.

AT the present time there is a widespread popular belief that in the immediate future everything will be "worked" electrically; but although we believe that the developments in the application of electrical energy during the next few years are likely to be at least as momentous as in the past we can scarcely subscribe to the above impression. Many likely fields for electrical enterprise, among which may be mentioned the use of electrical power on mercantile vessels, have, however, until recently remained practically untouched. For many years the sole application of electrical energy to such boats was for lighting, but the description which we published a year or two ago of the electrical installation on the s.s. "Mauretania" showed that the claims of electricity were becoming more recognised. Much remains to be done in this direction, and in the Paper read by Mr. J. McLAREN before the Institute of Marine Engineers at the meeting on "Engineering Day" at the Imperial International Exhibition, the author showed what great economies can be effected by adopting electrical appliances in marine work. From the abstract of the Paper, which we give elsewhere in this issue, it will be seen that he also favours a suction-gas plant in combination with a three-phase alternator for providing the electricity supply. Mr. McLAREN bases his opinion on fuel economy, but in view of the results so far achieved with this type of plant we cannot support the author in his belief that suction-gas plant will cause, in the near future, a revolution in the ideas of sea-going engineers.

ALTHOUGH the driving of auxiliary machinery on board ship provides considerable scope for electrical enterprise, it is of less importance compared with the developments likely to result from the adoption of electrical power for main marine propulsion. This latter subject is now receiving much attention by electrical engineers, and the figures which are put forward by advocates of the electrical drive certainly seem to show that considerable economy in fuel can be obtained, a possible saving of no less than 31 per cent. in steam consumption for a ship of the size of the "Lusitania" being suggested by Mr. W. P. DURTNALL at a meeting of the London Association of

Foreman Engineers and Draughtsmen on Saturday last. Much remains to be done, however, before marine engineers as a body are convinced of the advantages claimed for electric propulsion, and we hope, therefore, that the results obtained from the experimental installations at present in hand will bear out the estimates which have been put forward, since a much desired fillip would thereby be given to the electrical industry.

Newcastle Corporation Tramways.

In the course of his annual report the general manager, Mr. Ernest Hatton, of the Newcastle Corporation tramways, makes some remarks of considerable interest. He points out how necessary it is for an undertaking like that over which he presides to possess a substantial "reserve and renewals fund," in addition to the execution of "repairs and maintenance" out of revenue. As the undertaking advances in age so does the amount expended under this latter head increase, and it is by no means easy to augment the revenue in proportion. Mr. Hatton goes so far as to maintain that if the reserve fund, which now amounts to £63,000, had been devoted to the reduction of rates, the Committee would now find itself in the position of being unable to contribute to the rates for the year just finished and within measurable distance of calling upon them to assist the undertaking.

He further calls attention to the difficulty of increasing the revenue by the simple process of raising the fares, and points out that nothing less than a 50 per cent. increase of the minimum fare of a penny is practicable owing to the coinage difficulty. The problem is entirely different for a gas or electricity supply undertaking which [illegible] has to raise the price by a small percentage, a c[illegible]ich is clearly impossible for a tramway. Mr. Hatton suggests that the minimum fare should be $1\frac{1}{2}$d. with discounts for taking quantities of tickets; but if the tramway system serves a very poor district such a change might have serious effects. It might even be maintained by local politicians that the rich were being benefited at the expense of the poor. At all events, it is to be hoped that the Newcastle Committee will not support the demand for a new coin, value 1·2d., which was recently put forward by a tramway shareholder.

Illuminating Engineering Society.—We are informed that Prof. S. P. Thompson, D.Sc., has consented to become the first president of this society.

The India Rubber Co.—We have made inquiries concerning the rumours which were current early in the week concerning the probability of the India Rubber, Gutta Percha & Telegraph Works Co. removing from their present Silvertown works at West Ham. There is no intention on the part of the company to remove from West Ham, but a site is being sought for the extension of the factories, and a Midland centre may be selected. There are about 3,000 employés at the Silvertown works, which have an area of $16\frac{1}{2}$ acres and a river frontage of 860 ft. It is satisfactory to know that the business of the company demands an extension of the works premises.

Cable Interruptions.	Date of Interruption.
Tangier—Cadiz	May 19, 1909
Tourane—Amoy	June 17, 1909
Assab—Perim	July 8, 1909
Gibraltar—Tangier	Aug. 7, 1909
Dakar—Conakry	Aug. 19, 1909
Balik Papan—Kwandang	Sept. 2, 1909

Central Technical College.—We are informed that Mr. T. Mather, F.R.S., has been appointed professor of electrical engineering in this college in succession to the late Prof. Ayrton. Mr. G. W. O. Howe, M.Sc., has been appointed assistant professor.

University of Birmingham.—It is announced that the Council of this University has decided, on the recommendation of the Senate, to confer for the first time a certain number of honorary degrees on distinguished persons in connection with the recent Royal visit. These degrees will be conferred on Wednesday, October 20. The proposed names include: Sir William Crookes, F.R.S., Mr. Maurice P. Fitzmaurice, C.M.G., Sir Archibald Geikie, P.R.S., Sir Alex. Kennedy, F.R.S., Sir Joseph Larmor, F.R.S., Sir William Ramsay, F.R.S., Lord Rayleigh, F.R.S., Prof. Ernest Rutherford, F.R.S., Prof. S. P. Thompson, F.R.S., Sir J. J. Thomson, F.R.S., and Dr. W. A. Tilden, F.R.S.

The "Electron."—We must congratulate the Editor of the "Electron" on the exceedingly healthy appearance of the August number, and on the high standard which is noticeable in the articles, which include the following: "Driving Arrangements for Full Gauge Electric Locomotives," by Mr. Hayden, and "The Starting Torque of Three-Phase Motors," by Dr. Kloss. A further article deals with the development of "Siemens," in which the works at Nurnberg and Charlottenberg are described. Mr. Saxton deals with "Modern Machine Tools," and the activities of the Institute are adequately recorded. The "Electron" appears to have come very well through the "silly season."

Extension of Electric Traction on the New York Central & Hudson River Railroad.—According to the "Electrical Review and Western Electrician" steadily and surely the electrical zone of the New York Central & Hudson River Railroad is reaching out toward Fishkill Landing. So steadily is the extension of the zone going on that to reach these villages is now but a step. Croton, about 25 miles south, is already in the zone, and Peekskill, Cold Spring and Fishkill Landing will be included when the next step northward is taken. Recently the big power plant at Glenwood, near Peekskill, was put in operation. This plant gives the New York Central a power house which will supply power sufficient to run the cars from New York to Croton-on-Hudson. A similar plant is to be erected either at Fishkill Landing or Poughkeepsie. Level crossings are to be abolished within the zone.

Lightning Conductors on Ely Cathedral.—Lightning conductors were first fitted to Ely Cathedral about the year 1859 to the specification of Sir William Snow Harris, F.R.S., Advisor on Lightning Conductors to the Crown, but doubts were entertained as to whether these were still in an efficient condition. Mr. Alfred Hands, author of "Lightning and the Churches," was therefore instructed by the Dean and Chapter to make tests and report as to the advisability of adopting more modern methods. Snow Harris's conductors, formed of short copper tubes screwed together, proved to be so defective that it has been found necessary to instal an entirely new system of copper tapes. This comprises two conductors on the western tower with branches from the flagstaff and four turrets, two from the towers over St. Catherine's Chapel and four from the eastern or Lantern tower, as well as from the nave, choir, transepts and Lady chapel. The system has been arranged so as to be scarcely noticeable, and does not detract from the appearance of the cathedral.

An Electric Motor with Mixed Windings.—A motor of this kind, made by the Aarhus Dynamo- und Elektromotorfabrik of Aarhus, Denmark, is described in a recent number of "Helios." It is arranged for starting at full load without resistances and its direction of rotation can be reversed without difficulty. This result is obtained by fitting every second pole core of the magnet frame with a series winding, the other poles on the frame being provided with a winding which is in parallel with the armature. These two exciting windings are so arranged that the series windings oppose the shunt windings, shunt coil opposing series coil. The relation of the two windings can be so adjusted that the speed of the motor will vary according to the load in a definite manner. For

instance, the motor can be designed to run at the same speed at any load or to run at higher speeds when the load is reduced. A motor of this kind is said to be specially suitable for working cranes, hoists, &c., in fact, all machinery which is continually started, stopped and reversed.

Municipal Tramways Association.—The annual conference of this association will be held in London from September 22nd to 24th inclusive. The first meeting will take place at 11 a.m. on Wednesday, September 22nd, in the Council Chamber at the County Hall, Spring-gardens, when Mr. A. L. C. Fell will deliver his presidential address, and a Paper on "Medical Examination of Tramway Employés" will be read by Mr. A. W. Chapman. At the afternoon meeting a Paper on "The Central Repair Depot of the London County Council Tramways" will be read by Mr. W. E. Ireland. On this day members of the association will be entertained to luncheon at the Trocadero by the London County Council, while the association dinner will be held in the evening at the Garden Club of the Imperial International Exhibition. At the meeting on Thursday Papers will be read on "Some Comparisons of Continental and British Methods of operating Tramways," by Mr. A. R. Fearnley, and on "Current Consumption" by Mr. R. S. Pilcher. Members will be entertained to luncheon by the Highways committee of the London County Council, and in the afternoon a visit will be paid to the Central repair depot and Greenwich generating station of the Council. A reception by the Lord Mayor will be held at the Mansion House in the evening. The annual general meeting of the association will be held on Friday morning, and in the afternoon Windsor will be visited. A demonstration of railless electric traction will be given at the Hendon depot of the Metropolitan Electric Tramways on Saturday morning.

Gold Mirrors for Searchlights.—The recent R.A.C. tests (*see* "THE ELECTRICIAN, Aug. 27, 1907) on motor car headlights have brought prominently before both motorists and the public generally the importance of road illumination from the point of view of the motorist and of other users of the road. It has always been taken for granted that the whiter and the more powerful the light, the more perfect the illumination obtained. This, however, is by no means the case, for the rays of low refrangibility—*i.e.*, the red and yellow rays, are far less absorbed by the atmosphere than the violet rays. Again, the red colour exhibited by the sun at its setting is due to the fact that the violet rays are largely absorbed by the greater thickness of atmosphere which must be penetrated by the sun's rays. To achieve these results a long series of experiments have been made with glass mirrors coated with gold instead of the usual silver deposit. The resulting beam of light is practically devoid of the blue and violet rays of the spectrum, being composed of red, yellow and green rays only. At the same time its range or penetrative power is not reduced by the elimination of the violet rays while the dazzling effect is greatly decreased. We understand that these gold mirrors are being supplied to the principal lamp makers by the Reflector Syndicate (Ltd.), of 82, Victoria-street, Westminster, S.W., who hold the patents for the process.

The Post Office and Wireless Telegraphy.—"The Times" of Tuesday announced that an agreement between the Postmaster-General and Marconi's Wireless Telegraph Co., for the transference of six working shore stations in the United Kingdom from the company to the Post Office, had been completed. The stations concerned are those at Liverpool, the Lizard, Crookhaven, Rosslare, Caister and Niton.

The Post Office also propose to take over the North Foreland station, hitherto under the joint control of the company and Lloyd's, and it is presumed that it will re-open two stations which the company had abandoned—those at Withernsea and Holyhead. These shore stations exist for communication between the shore and passing ships, but the agreement also gives the Post Office the right to use for 14 year the Marconi system for the transmission of telegrams from the mainland to islands in the waters of the United Kingdom. It is believed that this provision in the agreement will make it unnecessary to lay cables to many islands to which it would otherwise have been necessary to extend them sooner or later, and in this respect a considerable saving will be effected. So far as passing ships and the adjacent islands are concerned, the Post Office will incorporate wireless telegraphy in the State system. The Marconi Company will be released from its contract with Lloyd's, which the Post Office practically adopts. There are about 230 ships carrying the Marconi apparatus, and messages despatched from and received by those ships will continue to be under the company's control, as will the trans-Atlantic messages and messages between ships and lighthouses and lightships; and (it is stated) the company will be encouraged, if it chooses, to introduce wireless telegraphy between large towns in the United Kingdom. The company will provide operators for the shore stations until the Post Office has organised its own staff.

It will be seen from our parliamentary columns that this announcement is premature.

Electrification of Canadian Main Lines.—The following interesting paragraph on the above subject appears in a recent issue of the "Electrical World": "Hitherto the proposals to electrify main lines in Canada have been limited chiefly to the western sections of the Dominion where large water-powers are abundant. Mr. C. A. Steeves, Consul at Moncton, now reports that the electrification of the Grand Trunk Pacific, or National Trans-continental Railway, from the St. Lawrence River to Moncton, is under the serious consideration of the railway company, the Dominion Government and the New Brunswick cabinet. Electrical engineers who have given the subject consideration declare the conditions to be entirely favourable. The distance between the St. Lawrence and Moncton is about 460 miles, and for a considerable part of the distance the line passes through dense forests of spruce and fir in Lower Quebec and northern New Brunswick, as well as through the rich farming country along the Upper St. John Valley. What has given impulse to the new plan is that at Grand Falls on the St. John river, 170 miles from the St. Lawrence and 160 miles from Moncton, is found water-power sufficient to develop energy enough for the working of the whole road. At this point the river has a natural fall of about 130 ft. and a flow that electrical experts estimate will be sufficient to furnish from 100,000 H.P. to 125,000 H.P. continuously by the provision of comparatively inexpensive means of storage and conservation. As the requirements of the road are estimated at not more than 40,000 H.P., there is every reason to believe that the supply will be more than equal to the needs."

A New Electric Signalling System.—According to the "Railway Gazette," on the Toronto & York Radial Railway, a Canadian urban line about 10 miles in length, there has been in use, for about six months, a train despatching and block signalling apparatus of unusual interest. Two principal functions are performed in this system. The train despatcher gives the motorman "proceed" and "stop" signals by means of electric lights in the motor cab, a signal being given at the entrance to each block section, and at each station the cars automatically record their passage over a short section of third rail by means of an electromagnet, which perforates a paper that is unwound by clockwork in the train despatcher's cabin. The despatcher has thus a graphic record of the position of all the cars constantly before him, not only when they enter a block section, but all the time that the car is in that section, and until it begins to report itself in another section, as apparatus set in motion by the electromagnets is kept in operation so long as the car is in that section. There is a separate wire from the despatcher's office to each station and it is by the circuit closers for these wires that the despatcher actuates the cab signals in the cars. The clockwork mechanism, in addition to unwinding the record sheet, which runs out over a drum, regulates by a circuit-breaker the time intervals between each perforation. The third rail conductors previously referred to are about 30 ft. in length, one being provided for each siding and running line, whilst "distant" rails are installed at intervals of about 1,000 ft. each way from the sidings. The motorman's cab contains a battery, a green and red electric light and a relay, the armature of the last-named constituting the switch by which either the red or green lamp is illuminated according to whether the signal is on or off. A bell is in parallel with the red light. The cabins are in addition provided with a telephone, by which the motorman can communicate directly with the despatcher whenever the car is on one of the third rail sections. The traffic on this railway is heavy on Saturdays, Sundays and holidays, when a 15 minute service is operated, and out of a total of 82,564 cab-signal indications given during June last, only four failures were recorded.

THE EXTENDED USES OF ELECTRICITY ON BOARD SHIP.*

BY J. McLAREN.

Summary.—The author considers a suction gas plant and alternator for supplying the electrical energy for operating the auxiliaries on board ship, and shows the great saving which can be effected by such an installation, compared with the usual donkey boiler with its long lengths of steam piping.

The application of electricity on board ship for driving auxiliary machinery has made rapid headway of late years. The time has now arrived for engineers to consider the most economical means of applying electric power for ship work, as at present there is great scope for such. My proposal is to drive all the auxiliary machinery by the use of electric motors, which will include all cargo winches and hoists, capstans and ventilating machinery, &c., and also to use electricity for the heating of cabins and passages and for cooking. In the engine department to drive all pumping, refrigerating, lifting machinery and fans by the use of electric motors, and, of course, to use electricity for lighting the ship throughout.

The efficiency of the steam auxiliary plant at present in use is about 25 per cent. Owing to the great length of present-day ships and the large increase of auxiliary machinery, the steam has greater distances to travel, with very high loss by radiation. The back pressure of the exhaust steam travelling away to the engine room to get to the condenser is very considerable. Many ship designers and engineers are a very long way out in their estimate of the power required for driving the winches, due to the great losses met with in working the auxiliary machinery not being properly recognised and allowed for.

A suction gas installation is one of the cheapest and most efficient forms of power known at the present day which is suitable for commercial purposes. I am also convinced that it is admirably suitable for auxiliary purposes on board ship used in conjunction with electricity. I will not say that it would be cheaper in the first cost, horse-power for horse-power, but for equal powers the working of the plant would show a very considerable reduction in working costs, and in a very short time it would more than pay for any increased capital outlay.

In the system which I propose, all these losses, or at least the greater part of them, would be obviated. A moderate estimate of the efficiency of a plant, such as I propose to describe, is 80 per cent.; this figure compared with the efficiency figure for the steam plant, which is, as I mentioned before, a maximum of 25 per cent., gives a difference in favour of the suction gas electrical plant of no less than 55 per cent. You will see at once that in a large ship the monetary saving would be very considerable, and it is this side of the question which, of course, appeals to shipowners and is causing them to be keenly alive to anything bearing on the question.

My objection to the continuous-current motor, which is at present largely used for ship's work, is, that it is my object to eliminate all rubbing surfaces, such as brushes and commutators, from the exposed motors, which are well known to be a source of trouble and expense. This can only be got over by the use of alternating current for driving the motors.

I propose to divide the Paper into three heads, viz., the producer, the gas engine, and the alternator, and briefly describe what I consider to be the most suitable form of each for the purpose of installing on board ship for driving the auxiliary machinery, taking a 300 H.P. unit for consideration. I believe that in the near future the introduction of suction gas plant will cause a revolution in the ideas of sea-going engineers.

Producer.—The gas generator is usually made of steel plates, to allow for expansion and contraction, lined with fireclay bricks or other suitable material. The ashpit and firegrate are preferably made of cast iron, which, although being a little heavier, wears much better than a steel plate would do, and is more able to withstand corrosion. On top of the generator and embodied in the design is an arrangement for raising the steam required for making the gas. The approximate weight of the producer plant for 300 H.P. would be 19 tons, and the space occupied about 14 ft. by 10 ft. 6 in. by 16 ft.

Gas Engine.—The type of gas engine I would suggest as being the most suitable one for our purpose would be a vertical multiple-cylinder single-acting type, operating on the Otto or four-cycle principle. The cylinders should be arranged so that there is ample space for water cooling; the water jackets should have large ports so that any scale deposited by the salt water used for cooling purposes can be easily and quickly removed. The type of engine adopted should be such that none of the moving parts require water cooling. The valve gear should be as simple as possible and so arranged that the parts can be easily got at. The mixture regulating handles, starting valves, ignition timing, speed regulation, should be mounted together on the crank-case of the engine so that all can be controlled by one man from the floor level. The engine would be started by compressed air through a special starting valve. The usual method of ignition for gas engines of this type and size is by high-tension electricity, but for marine purposes I think that low-tension magneto-ignition would be much preferable, especially in view of the fact that the plant would be working in all temperatures and climates. The speed of the engine should be about 200 revs. per min. to suit the alternator. A good governor should be fitted. The modern gas engine governor is very effective, which is one of the advantages of the gas engine.

Alternator.—In my last Paper on this subject I suggested that a pressure of 2,000 volts might with advantage be used on large ships and transformed at the point of use to 250 volts for operating the machinery. This voltage was objected to in the subsequent discussion on account of possible danger. In a moderate-sized vessel I now suggest that alternating current should be generated at 250 volts and carried direct to the machinery. The generator should be built upon the flywheel of the gas engine and generate three-phase current at 250 volts at a frequency of, say, 50 cycles. The armature of the generator should be of the stationary type with revolving field magnets built up on the rim of the gas-engine flywheel. A small direct-current dynamo, the "exciter," should be coupled direct to the armature shaft. The armature should be star connected. In selecting the type of alternator, care should be taken to see that the wave form of the currents is sinusoidal.

Distribution.—The switchboard should be placed in the gas-engine room and would be divided into two distinct sections, one for the power circuits and one for the lighting circuits. From each power panel would be lead an armoured three-core cable to each distributing centre. From this point smaller mains would be taken off to the motors.

Motors.—For the smaller motors I propose to use "squirrel-cage" induction motors. For the more powerful motors it might perhaps be necessary to use rotors wound somewhat similarly to the stators and slip rings, so that resistances could be inserted for starting purposes; but even motors so fitted are vastly superior to continuous-current motors as now used with commutators.

There is no doubt that if it were possible to use the simple squirrel-cage induction motor, we should have a most ideal condition of affairs, and if its natural and inherent faults could be overcome, its use on shipboard for driving machinery for all purposes would inevitably follow. It has not only the acme of simplicity, but also great mechanical strength; whilst the absence of commutators means there is no sparking limit to allow for, therefore it can stand the roughest of use, and it has the greatest output per unit of weight, compared with a direct-current machine, and without sacrifice of efficiency. It is a well-known fact that a squirrel-cage polyphase induction motor will run on a given load, quite cool, when compared with direct-current motors of the same weight. This is partly due to the large section which can be given to the conductors, and also to the laminated character of the iron, which facilitates ventilation. A further (and what may prove eventually very valuable) feature in connection with the squirrel-cage induction motor is the fact that, should the rotor by any outside means be driven above the synchronous speed of its revolving magnetic field, the machine immediately becomes an asynchronous polyphase generator, and will return current to the supply mains. Thus, should such a motor be driving a crane, the lowering of a heavy load into the ship will not only steady the lowering of the load but a valuable portion of the energy represented by the falling weight could be returned to the mains, and possibly utilised for supplying other motors on the ship, reducing the load on the main engine and generator.

For driving cranes, winches, hydraulic pumps working against head, refrigerating machinery, and in many other cases on shipboard, great turning effect or starting torque is absolutely necessary. The squirrel-cage induction motor has very little starting torque when supplied in the ordinary way, therefore before it is used with real satisfaction for general purposes on ships it is very evident that some means must be produced so that the frequency of the supply current to the motor at starting can be reduced and gradually brought up to that required to run same at full speed.

It is also of immense importance to have very reliable means of speed variation for such motors as will be used on cargo boats, &c., and means must be procured that the speed of the motor can be varied with economy. The only way to vary the speed of the simple

* Abstract of a Paper read before the Institute of Marine Engineers on Saturday last at the meeting in the Imperial International Exhibition, Shepherd's Bush, W.

induction squirrel-cage motor is by varying the frequency of the supply current to same, and up to now there have been no efficient means available for so doing, and the general application of this motor is thus limited to driving machines that require very little starting torque, and where no speed variation is required.

There is a system of speed variation applied to induction motors without the use of slip rings or auto-transformers, just put on the market by Mr. Durtnall, which, in my opinion, will be the way to employ the above very simple and most desirable motor for auxiliary driving on ships. Mr. Durtnall's system* may meet all the requirements which will be demanded, and by means of the generation of variable frequency current will overcome the defect of bad starting against load, and also will secure the variation of speed that will be required, in the simplest and most efficient way. I have had occasion to study this question very closely, and, as far as I can see, it is sound mechanical and electrical engineering, and its simplicity will appeal to the progressive marine engineer.

In an actual case which Mr. Durtnall has in hand—the design of the plant for operating the machinery for a large dredger now being built, in which it is proposed to use as the prime mover a 200 B.H.P. Diesel engine, running at 300 revs. per min., this to run at constant speed irrespective of the speed or direction of rotation of the squirrel-cage induction motors, which are to be direct coupled to the bucket chain, main winch, rotary pumps, ladder winch, revolving screen and belt conveyer. These will be driven at variable speed, as desired, through special controllers situated at the motors, in which way reversing of the machine at any speed can take place. The voltage is to be 350 (between phases); the frequency will be 10, 20, 30, 40, 50 and 60 periods per second, so that (with, say, 3 per cent. slip) the eight-pole motors to be used will run at 146, 290, 437, 582, 730 and 874 revs. per min.

The generator in this instance will consist of six small machines, mechanically coupled together in line and on one base-plate. They will consist of four-pole machines: the first machine will be a synchronous three-phase alternating-current generator, this will give the 10-period current, and the field will be separately excited either from the continuous-current lighting circuit or from a small exciter that can be driven by, and mounted on, the end of the prime-mover crankshaft; the other machines will be five transformer generators. The primary of the first transformer will be excited by means of the 10-period current, and this primary being mounted on the same shaft as the 10-period generator, and being of the same polarity, the frequency of the current in the secondary of the transformer (which is a stator) will be 20, and 20-period current is tapped off at slip rings. In the next transformer the 20-period current is taken to the primary stator, and it is so connected that the magnetic flux revolves in the opposite direction in the air-gap; the consequence is that the frequency in the revolving secondary is raised to 30 periods. Tappings are taken by means of slip-rings from the windings of the revolving secondary to provide 30-period current; and this 30-period current also forms the exciting current for the mechanically driven primary of the third transformer, and similarly for the other machines. The whole combination is a very efficient machine as a generator of variable frequency polyphase current for power transmission. It will be noticed that each machine is mechanically driven, and supplies its part of the total work done. It is interesting to note what will take place in the event of stopping a motor that, say, is running at the top speed. Assume such a motor is connected with the 60-period current, and that the machine and heavy moving masses are running at high speed. We turn the controller to the 50-period position; the machine does not drop in speed so quickly as the change of connections is made, so that momentarily the squirrel-cage rotor is running above the synchronous speed of the 50-period magnetic flux in its stator, and the heavy moving mass of not only the rotor of the motor but also the machine that it may be driving is very quickly brought down in speed by this means. This process is carried down to the 10-period point, so that the return of mechanical energy is a very considerable item in very large work and should meet with considerable success.

The distribution of the electrical energy is to be carried out by means of bare copper bars, led to a trunk set of mains running the distance each side of the engine room where the motors will work, where tappings are to be taken off by means of suitable cables to the controller, or frequency selector as it can also be termed.

Lighting.—For lighting the ship the lighting section of the switchboard would be divided into three panels, one for each phase, and advantage can be taken of the star-connected generator, previously mentioned, for reducing the voltage (250 per phase) for lighting purposes.

Heating.—I think that you all agree with me that the heating of the ship by steam is very unsatisfactory. Steam has to travel through long lengths of small bore pipes to get to the radiators, and by the time it reaches them it has lost anything from 50 per cent. of its heat. On the other hand, electricity can be transmitted any distance with a loss of about 2 per cent., thus leaving about 98 per cent. to be expended in heating the radiators. Again, electrical radiators can be more efficiently placed than steam raidators and better controlled.

Cooking.—With regard to cooking by electricity it has been found by actual experience that it is far more cleanly, economical and easier to apply than coal. Applied on board ship, coal and ashes could be banished from the galley altogether, and as this is usually anything but a commodious space, it would be a great advantage as well as cleaner.

Another advantage in connection with an electrical installation is that there is no trouble from freezing.

Refrigerator.—All refrigerating machinery could be very well operated by electric motors. They would of course require to have a large range of speed, somewhere about 40 to 120 revs. per min. It would enable the refrigerator to be installed in the most suitable place without regard to the means of getting steam to it with resulting economy.

Efficiency.—I propose to take the actual tests taken on a 750 B.H.P. suction gas engine of the type I have described and compare it with a high-class Corliss steam engine working with condenser and economiser. In the case of the steam engine the coal consumption under test conditions was 2 lb. of coal per brake-horse-power-hour at the flywheel. The total amount of heat supplied to the boiler from the coal which appears as useful work is 11·2 per cent. and the mechanical efficiency of the engine is not far out, I think, at 85 per cent.

Dealing now with the gas engine, it has been found in a test of the engine mentioned above that it is possible to obtain 1 B.H.P.-hour for an expenditure of 8,500 B.T.U. from the coal fed into the gas producer. We assume that the coal for the producer has the same calorific value as the coal for the steam engine, that is, 13,650 B.T.U. per pound of coal. Taking the producer efficiency at 80 per cent., from each pound of coal fed into the producer we get 10,900 B.T.U., which appears as gas available for use in the engine; we must, however, take from this figure 9 per cent., which from a number of tests represents the stand-by losses of the producer, leaving 10,000 B.T.U. really available. We therefore get the quantity of coal for 1 B.H.P.-hour as 0·85 lb. Therefore the fuel costs of the gas engine will not in any case exceed one-half those of the steam engine. There is no reason whatever why the figures for the gas engine could not be maintained if used for the purpose of driving an alternator for supplying current for the auxiliaries on board ship. And whereas the losses due to the distribution of the current, &c., would not amount to more than, say, 20 per cent. for the electrical plant, the losses due to distribution of steam to the auxiliaries would be, on the most favourable conditions, a minimum of 75 per cent. I think that these figures should convince everyone that the system I have described has a great future before it for auxiliary work on board ship.

The weight and space occupied for the different systems is next considered. Owing to the above great saving in distribution and in coal consumption per brake-horse-power-hour the actual bunker space required with a producer would be only one-quarter of the space required for the donkey boiler. Again, a table of weights given in the Paper shows that a 300 H.P. producer weighs approximately 19 tons and occupies 14 ft. by 10 ft. 6 in. by 16 ft., whilst the gas engine weighs 30 tons and occupies 16 ft. by 9 ft., and is 12 ft. high; thus the total weight of combined producer and engine is 49 tons.

The cost of upkeep of a producer plant of course varies somewhat, but from my experience it should not exceed more than £10 to £11 per annum in a well-designed and constructed plant of 300 B.H.P. The water required by the producer varies from 1½ to 2 gallons per brake-horse-power-hour. Again, figures given in the Paper show the enormous difference in stand-by losses in favour of the producer, compared with a steam boiler.

In a previous Paper read by Mr. E. Shackleton before the Institute he gives some very interesting figures relating to the coal consumption required for loading or discharging cargo by steam: for a 200 H.P. plant the fuel consumption of the average steam winch may probably be put at 5 lb. per horse-power per hour. Comparing this figure with the coal consumption of the electrical winch driven from the suction gas alternator and allowing distribution losses of even 25 per cent., we get a coal consumption of 1·06 lb. of coal per brake-horse-power-hour on our electrically driven winch, as compared with 5 lb. of coal for the steam-driven winch.

Included in the Paper are the actual test figures taken on a Hornsby Stockport suction gas engine of 200 B.H.P., showing cost of working, including capital expenditure and maintenance, &c. The cost per

* Described in THE ELECTRICIAN, March 19, 1909, p. 887.

[illegible] the 200 H.P. engine was 49d., or ¼d. per brake-horse-power-hour.

The author next quotes from an article in "Cassier's Magazine" on the gas engine experiments in the "Rattler." The old boilers and steam engines have been removed and a single set of vertical Beardmore Chaplain suction gas engine and producer installed in their place. The engine is 500 B.H.P., five cylinder, single acting; bore 20 in., stroke 24 in., 120 revs. per min. The five cylinders are independent of each other. The vessel has run up to date over 1,800 miles at an average speed of 8 to 9 knots per hour. As regards weight and space, the gas producer saves from 25 to 30 per cent. of the corresponding item of a steam outfit, but it is in the cost of labour and fuel that one of the chief benefits is to be found. The "Rattler" as a steam vessel had 13 stokers and four engineers, now as a gas ship she has three engineers and four helpers. The producer only requires a few minutes' attention every two hours. It was found that starting from all cold took 30 minutes. Consumption of fuel compared with the steam plant was 50 per cent. less for the gas plant.

Reference is next made to tests on the electrical equipment at the Powell Duffryn Aberdare Collieries, the cost per unit coming out at 0·365d. In conclusion, the author mentions that the maintenance and depreciation in sea-going installations would not be at all heavy, say, 10 per cent. for depreciation and 2 per cent. for maintenance. So we get 12½ per cent. as an annual charge on the capital outlay of the installation.

CORONA PHENOMENA IN AIR AND OIL AND THEIR RELATION TO TRANSFORMER DESIGN.*

BY W. S. MOODY AND G. FACCIOLI.

Several experimenters have investigated the phenomena of corona and published very complete results of their investigations, which, however, have been confined almost entirely to the conditions found in transmission lines. The experiments recently made by the authors were not undertaken with any idea to add to the available information applicable to transmission lines, but rather with reference to apparatus, and especially static transformers. In transmission lines we have the simplest form of a condenser to consider in studying the corona effects. In apparatus, the forms of condenser that must be considered are evidently very much more complex, because of the relatively shorter length of the dielectric, the irregular shapes of the condenser surfaces and the combination of solid, liquid and gaseous dielectrics.

The first series of tests were made on apparatus consisting of a cylindrical conductor parallel to a plate, and it is shown for a maximum permissible stress in air at atmospheric pressure of 100,000 volts per square inch that the voltage at which corona will appear on a cylindrical conductor is given by

$$E = \frac{100,000}{0{\cdot}434}\,\rho \log_{10}\frac{2D}{\rho} = 230,000\,\rho \log_{10}\frac{2D}{\rho},$$

or, using the effective value,

$$E_{\text{eff.}} = 160,000\rho \log_{10}\frac{2D}{\rho},$$

this being true for a sine wave where D is the distance apart of the centre of the conductor and the plate.

Applying this formula to distances D = 9 in., 12 in. and 18 in. for diameters of conductors of ⅛ in., ¼ in., ⅜ in. and ½ in. the following table of voltages necessary to establish corona under different conditions is obtained:—

D	Diameter of conductor.			
	0·125 in.	0·25 in.	0·375 in.	0·50 in.
9 in.	24,600	43,200	59,400	74,400
12 in.	25,800	45,600	63,C00	79,200
18 in.	27,600	49,20C	68,400	86,400

This formula does not take into consideration the temperature, barometric pressure and the vapour product. To check the results of this formula experimentally the apparatus outlined in Fig. 1 was used. A rod 45 in. long was suspended by small bare copper wires AC and BD from pieces of treated wood hanging from the ceiling. A large earthed iron plate 69 in. long and 27 in. wide was fixed at a distance, D, from the rod. The points C and D were connected by bare copper wire. Connection was made by a wire M from the terminal of a transformer whose other terminal was earthed. The volts were read across the secondary of a transformer which was excited by a 60-cycle sine-wave generator. The capacity of the transformer was 100 kw., and by properly grouping the secondary coils, different ratios of transformation were obtainable.

The results given below are the average readings taken repeatedly over a period of two months; the readings taken at different times under the same conditions agreeing remarkably well. The variations of temperature and barometric pressure were very small, the average temperature being 23°C., and the average barometric pressure 28·9 in.

It must be noted at this point that corona appears on the conductor very abruptly; furthermore, the luminous phenomenon is accompanied by the well-known characteristic noise, so that there is little chance for errors of observation.

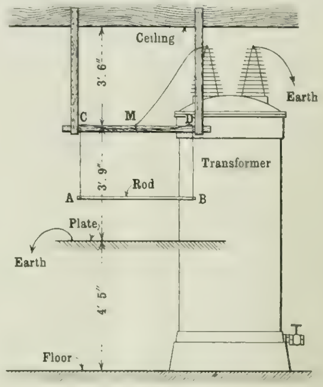

FIG. 1.

Fig. 2 gives the voltages at which corona appears on the centre of the rod in the apparatus illustrated in Fig. 1. The curve obtained from the tests is in all cases fairly parallel to the calculated theoretical curve, and the test values may be represented by the formula

$$E = 160,000\rho \log_{10}\frac{2D}{\rho} + f$$

where f is a constant, whose value is 12,000 volts.

Prof. Ryan has given a formula to determine the conditions necessary for corona between two parallel cylindrical conductors. The maximum value of the voltage at which corona appears, according to this formula is

$$E_{\text{max.}} = \frac{17{\cdot}94b}{459{\cdot}2+t}\,350,000\,(\rho + 0{\cdot}07)\,\log_{10}\frac{s}{\rho}$$

where b is the barometric pressure in inches, t is the temperature in degrees Fahrenheit, ρ is the radius of the conductors and s the distance between the conductors.

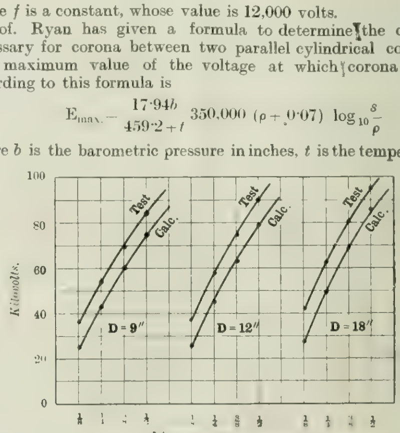

FIG. 2.

To apply this formula to the above case, $E_{\text{max.}}$ must be divided by 2 to obtain the voltage between one of the conductors and the neutral plane. The correction factor for pressure and temperature is 0·97, and using the effective value of the voltage we finally arrive at

$$E_{\text{eff}} = 120,000\,(\rho + 0{\cdot}07)\,\log_{10}\frac{2D}{\rho}$$

This formula is supposed to apply only to conductors ¼ in. in

* Abstract of a Paper read before the American Institute of Electrical Engineers.

diameter and upward. The corona voltages, according to Ryan's formula, are then –

D	Diameter of conductor.		
	0·25 in.	0·375 in.	0·50 in.
9 in.	50,500	61,200	71,500
12 in.	53,500	65,000	76,500
18 in.	57,700	70,300	83,000

Comparing these results obtained by Prof. Ryan's formula with the results obtained experimentally, it will be seen that for the rod 0·25 in. in diameter the calculated results are higher than the test values. For the 0·375 in. rod the calculated results are still high, but nearer to test values, while for the 0·50 in. rod the calculated results are lower than the test values.

The authors then go on to describe some tests made by them with the plate mentioned above, this plate being used as one electrode and earthed. For this purpose it was necessary to know the voltage wave-form as the corona depends on the maximum rather than the average effective voltage shown by the voltmeter. An unsuccessful attempt was made to use a spark-gap in parallel with the test apparatus, as a voltmeter. Oscillograms, however, showed that the tests were carried out with voltages of practically a sine wave form.

Another important point was the condition of the surface of the conductor. The surface must be smooth and free from metallic spots, while spots of insulating material also lead to annoyance and must be eliminated. In order to obtain consistent results great care was therefore, taken to work with clean uniform surfaces, but the effect of insulation on the conductor appeared so peculiar that an investigation of this matter was made with very interesting results.

If the potential is raised above 78,500 volts, the brushes at the edge of a rubber tube slipped over the rod increase in length and volume until they span the whole distance between the rod and the plate. Increasing the potential still further, the colour of the brushes changes from blue to purple, and finally the spark jumps

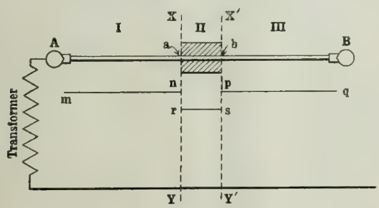

Fig. 3.

from the rod to the plate through the mass of one of the brushes. If no insulation were on the rod the breakdown would have occurred at one of the ends of the rod, but the presence of the rubber tube has changed the conditions and has brought the weakest point of the system to the edge of the insulation. This phenomenon obtained with a piece of rubber tube can be reproduced by using any kind of insulating material on the surface of the rod. A thin coat of paraffin on the rod will produce the phenomenon as well as a glass or mica tube, a knot of varnished cambric tape, a rubber cork, a disc of sulphur, or the like.

An explanation of these results is simple, if the disturbances in the field of electric forces, which take place on the introduction of the insulating material around the centre of the rod AB, are investigated in the following way: Imagine the system of conductors and insulations in Fig. 3 divided up into three contiguous condensers, I., II., III. Attempt to draw one of the equipotential surfaces of the system and it will be seen that in condensers I. and III. the sections of the equipotential surfaces are represented by the lines *mn* and *pq* at the same distance from AB. But in the condenser II., which has a material of high specific inductive capacity near the rod, the trace of the equipotential surface will be lower than *mn* and *pq*, say *rs*. In the vertical planes XY and X′Y′, the conditions of the field are very peculiar, inasmuch as the voltage of each point along these lines, considered as a part of condenser I., is different from the voltage of the same point considered as a part of condenser II. The result, we believe, therefore, shows the existence of a transverse stress along the lines XY and X′Y′, which causes the appearance of the brushes and the final breakdown. If this is correct we should be able to stop the formation of brushes in *ab* by equalising the potential along the planes *nr* and *ps* by metallic surfaces. If we slip on either side of the insulation two metallic discs having diameters as large, or larger, than the insulation, we should expect that we would eliminate the brushes *ab*. Tests show this to be the result. Two tinfoil discs 2 in. in diameter were put on the rod. The edges of the insulation were then entirely free from brush discharge and the condenser broke down at one of the spheres at 144,000 volts.

It is to be noted that although the metallic discs were nearer to the plate than the ends of the rod, still these ends remained the weakest point of the apparatus. If the same reasoning is applied and the equipotential surfaces of the condenser considered it would be thought that the introduction of these discs on the rod would have the effect of relieving the stress from a certain length of the rod on each side of the discs. The test proves that this assumption is correct.

A rod, 0·25 in. in diameter and 45 in. long, parallel to an earthed plate, and 12 in. away from it, begins to glow at 57,000 volts. If tinfoil is wrapped in the centre of the rod, making a little cylinder 3 in. long and 1 in. in diameter, corona will appear in the middle of the two sections of the rod at 62,300 volts. If the tinfoil cylinder is shifted on the rod so that the two sections are of different lengths, then the middle of the longer section glows at a lower voltage than the middle of the shorter section. The same thing occurs if two cylinders are placed equidistant from each end.

An interesting point was brought out in further study of this phenomena by variously dividing up the rod with one or two tinfoil discs.

For it takes an increasing voltage to establish corona the shorter the length of the rod. In other words, corona is not a fixed quantity for a given voltage and diameter of rod, unless the length of the rod is great and the diameter uniform. In order to demonstrate this

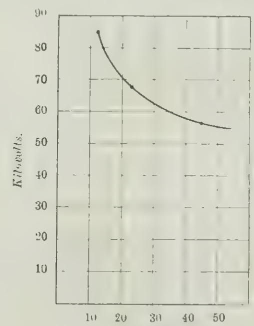

Fig. 4.

point thoroughly, three rods ¼ in. in diameter were experimented with. The rods were of different length, all the other conditions of the test being identical. The arrangement was the one represented in Fig. 1 and the distance between the rod and the earthed plate was 12 in. The results of the test are shown in Fig. 4.

The values differ from the corresponding values given above, but the conditions of the test are somewhat different in the two cases, and the "suspension" of the rod might influence the results.

The results obtained when the voltage in the apparatus shown in Fig. 1 is gradually raised are as follows: At 57,000 volts the rod was dark; at 58,000 volts the centre of the rod glowed.

Theoretically, as soon as the critical voltage is reached corona should appear over the whole length of the rod, assuming the intensity of the field is constant and the equipotential surfaces in the immediate neighbourhood of the rod are cylinders practically concentric with it. This test shows, however, that the intensity of the field is not uniform throughout the length of the rod. At 58,000 volts the length of the glowing portion of the rod is 15 in., exactly in the centre. At 80,000 volts its length becomes 33·5 in. The system breaks down at 113,000 volts from one end of the rod; although even at this voltage the portion of the rod near the suspension wires remains dark. If the bridging wire is eliminated and the high potential lead brought to *c*, the suspension wire is connected to the rod only, and it is then found that at 54,000 volts the rod was dark, at 55,000 volts corona was 15 in. long in the centre, at 60,000 volts corona was 22 in. long in the centre, at 80,000 volts corona was 33 in. long in the centre, at 100,000 volts corona was 35 in. long in the centre, at 112,000 volts the system breaks down from one of the ends to the plate.

If the copper wire BD is removed the following results are obtained: At 50,000 volts the rod is dark, at 51,000 volts, the portion of the

rod near B, or near the silk tape suspension, glows for the length of 21 in. measured from B. Increasing the voltage causes the corona to approach more and more to the point A. At 66,000 volts the corona is 33 in. long. At 80,000 volts it is 41 in. long; at 90,000 volts 41 in. long, and at 105,000 volts still 41 in. long, while at 112,000 volts a spark jumps from A to the plate.

The ends of the rod do not affect the character of the phenomena. Fig. 5 gives curves showing the voltages and corresponding lengths of corona in the cases mentioned above. The dimensions and position of the earthed plate do not affect the position or spreading of the carona. The voltage at which the corona starts is naturally different, though its general appearance is the same as before. In conclusion, the corona voltage is affected by many conditions which can hardly be shown in a formula. The tests to check the law

$$\rho' \log \frac{2D'}{\rho'} = \rho'' \log \frac{2D''}{\rho''}$$

proved to be erratic, as might be expected, but in general they show that a small rod at a comparatively great distance from the plate requires a higher voltage than a large rod at a correspondingly small distance from the plate. However, on account of the great difference in distances, it is almost impossible to reproduce exactly the same conditions of test in both cases, and the behaviour of the electric field is so sensitive that we should not be surprised at the apparent inconsistency between theory and test.

The second type of condenser on which experiments were performed consisted of different rods 45 in. long, suspended at both ends by copper wires, which were placed in the centre of a metallic disc. The dimensions of the ring were 10 in. inside diameter, 20 in. outside diameter and 2 in. long. The disc and the portion of the rod covered by it constituted condenser, and the effective voltage at which corona will appear on the inside conductor was in volts

$$E_{eff} = 160{,}000\,\rho \log_{10}\frac{\rho'}{\rho}$$

If we apply this formula for $\rho' = 5$ in. and for diameters of rods $\frac{1}{8}$ in., $\frac{1}{4}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in., we have:—

Radius of conductor.	Corona voltage.
0·0625 in.	19,000
0·125 „	32,000
0·187 „	42,600
0·250 „	52,000

In attempting to check these calculations the metallic cylinder was earthed and the rod connected to one of the terminals of the testing transformer, whose other terminal was also earthed. The rod was 45 in. long and the cylinder 2 in. long, the latter being located in the centre of the rod. The following results were obtained:—

Radius of conductor.	Corona voltage.
0·0625 in.	26,500
0·125 „	40,500
0·187 „	52,000
0·250 „	62,000

The tested values are again higher than the calculated values, but their difference is not constant. The discrepancies between tests and theories are undoubtedly explained by the fact that the formula applies to cylinders of indefinite length, whereas one cylinder in this case was very short and consequently the disturbing influences of the ends of the cylinder were proportionately very great.

Just how the length of the outside ring influences the results can be easily seen from the further tests made with apparatus consisting of metallic tubes of different lengths, which were inserted and supported by the cylinder previously used. It appears that the voltage increases with the diameter of the rod, and that the longer the cylinder the lower is the corona voltage, which shows a more uniformly distributed field in the centre of the apparatus; that is, the longer the cylinder the nearer we approach the theoretical results. On the other hand, if the length of the rod is decreased, the voltage at which corona appears is increased.

We obtain identical results if, instead of using shorter rods, we shift the suspension wires nearer together. As in the other type of condenser, the protecting influence of the suspension wires, which relieves the stress for a considerable length on the surface of the rod is apparent. We should expect also to find that the cross-section of the ring has a pronounced influence on the results. If we take a pipe, 1 in. in diameter, bend it in a ring 10 in. in diameter, pass through its centre rods 45 in. long and of varying diameters, it is found that the corona voltage increases considerably with the radius.

It should be borne in mind, however, that we have not only changed the cross-section of the ring, but we have also decreased its length, the pipe used being only 1 in. in diameter. The results of all these tests show that conditions existing in the field between the ring and the rod are very different from those assumed in the theory. The lines of force have commonly been thought of as perpendicular to the surfaces of the outside cylinder and uniformily distributed along its length. Evidently this cannot be the case when the length of the cylinder is short. The density of the field is a maximum in the central part of the rod and decreases in intensity towards the ends. This can be clearly shown by observing the fact that when the rod is excited from both ends the middle begins to glow at very much lower voltage than is required to distribute this glow upon the entire length of the rod. In fact, with the proper combination of apparatus, the voltage applied can be quite accurately determined by the length of the rod that glows.

A number of experiments are then described to show that the voltage at which corona appears in apparatus of limited dimensions not only depends on the dimensions of the apparatus itself and the mutual action of the different parts, but is also a complex function of several quantities and conditions. Therefore, the formula which takes into consideration only the principal dimensions of the condenser between which the electric stress exists could not give correct results.

Before closing, we wish to say a few words with reference to corona as it exists under oil. We have often heard it said that the use of oil eliminates corona, but such is not the case in our opinion. There are some distinct differences in the manifestation of corona in air and in oil, but, so far as our present rather limited experimentation goes, we believe there is no essential difference in this manifestation in the two materials. If we submerge two needles

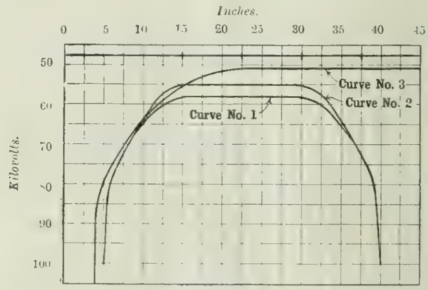

Fig. 5.

12 in. apart in oil, and raise the difference of potential between them, there is no noticeable glow given off up to 100,000 volts, but with 1,000 volts more, the glowing is very perceptible in the shape of a small steady brush, noiseless and green in colour. We have here, then, not only a corona, but the same characteristic that is found in air corona; namely, that a very slight difference exists between the voltage at which there is no corona and that at which it appears. If we raise the potential still further, the brushes increase in size and eventually touch each other and soon after cause a disruption of the oil. If the needles, instead of being 12 in. apart, are only 6 in. apart, the corona will be established at about 78,000 volts; if the needles are 3 in. apart, the corona will start at about 72,000 volts. If before breakdown takes place we decrease the difference of potential between the needles, the corona will disappear at the same voltage at which it started. Furthermore, the oil that is in the gap is set in violent motion, which is maintained so long as a stress exists. Analogous results can be obtained by using the needle opposed to the plate; that is, at a certain voltage the point will emit a steady luminous brush, which is similar to the brushes obtained in air.

With our present knowledge, the comparison of values between corona voltage in air and under oil is very difficult and unsatisfactory. Under oil it is only with wires of small diameter that the corona voltage is sufficiently abrupt and constant to be measured consistently, while in air it is the small wires with which it is difficult to get consistent results. Such small wires in air depart markedly from the law that expresses the corona phenomenon on larger wires. The larger wires under oil, as we have said, give very unsteady, and therefore unsatisfactory, results.

Conclusions.—Commercial transformers are now being extensively built to use for voltages where these complex laws of the corona must be generally, if not exactly, known, if their design is to be correctly

worked out. Of course, it has been generally appreciated for some years that corona discharges must be avoided, even more in transformers than on the transmission line to which they are connected. When in transformer design only the simple law of the diameter of the conductor and the corresponding corona voltage are considered, and the effect of such factors as the length of the conductor, changes in its diameter and the solid insulation necessary on parts of the conductor are neglected; then these experiments show that it is not surprising that designs, apparently similar, have given very different results in service.

THE OPERATION OF ALTERNATORS IN PARALLEL.

BY JOSEPH W. ANSON.

The writer proposes in the following article to detail the experience gained, during some $2\frac{1}{2}$ years, whilst controlling large alternating-current units running in parallel.

Although the question of running large direct-current generators in parallel is one of great importance, and an equal amount of attention and care is required in order to maintain a steady and continuous supply of energy, it must be acknowledged that there is not the scope for the application of a scientific training in running direct-current generators in parallel, that there is in running alternating-current generators in parallel, especially when the alternators are driven by large reciprocating engines.

Synchronising.—In large power stations, where the load at given and regular times increases very rapidly, ample time should be allowed for starting up new machines; and the signal to run up a fresh machine requiring, say, 10 minutes to be brought up to synchronous speed, should be given when the load on the existing machine or machines is about 75 per cent. of the full load capacity, otherwise difficulty may be experienced in synchronising owing to the speed of the running plant, or plants rising and falling considerably, as their overload limit is approached from time to time.

The writer well remembers a case early one morning in which it took 23 minutes to synchronise a large set into parallel with another set which had been running all night. No doubt the time was left a little too late, and this, together with the fact that the high-pressure admission valves were working a little erratically on the incoming machine, caused the trouble. By the time the new machine was actually in parallel, the load was well up to 5,000 kw. on the one plant, and the field current on this machine, needless to say, was certainly somewhat over the full-load field current. This sort of practice is very nerve straining, and may be easily avoided by allowing ample time for synchronising.

The question of synchronising is of great importance in large stations, and must be treated under two headings :—

1. Synchronising with electrically operated oil switches.
2. Synchronising with hand-operated oil switches.

There is no doubt that using hand-operated oil switches, a good phase may be obtained with the needle of the synchroscope revolving fairly fast, whereas to attempt to synchronise a generator with electrically operated oil switches, with the synchroscope needle revolving at the same speed would be disastrous; the reason being that when hand-operated switches are used the closing is practically instantaneous; and when electrically operated switches are used a certain time is required to operate the controller, and also for the oil switchgear to work. The time required for a motor-operated oil switch to close is much in excess of the time required for a solenoid-operated oil switch to close. It is very difficult to take a quickly moving phase with electrically operated switches; in fact, the synchroscope needle must be moving very slowly indeed, and the operating controller should be closed when the moving needle is very steady, and just a little time before it covers the painted pointer on the dial, which indicates that the machines are in phase.

It is, however, always advisable to synchronise with a moving synchroscope needle, as it is far more trustworthy than synchronising with the needle completely at a stop in the right position. Although the plants are quite in phase during this time, it is possible for the needle to be 90 deg. out of phase by the time the controller is operated and the switch has closed, whereas, with a slowly and steadily moving pointer one can see at once what position the needle is going to take up.

Methods of Ensuring Steady Running in Parallel.—There is undoubtedly a great tendency to run plants two or three revolutions over the designed speed, and this is one of the greatest causes of unsteady running in parallel, especially with engines having Corliss or drop-valve gears, which run most steadily and quietly at the correct speed. The reason for this tendency to run fast is due to the inductive nature of the loads now dealt with in this country. In order to obtain the full output of power from a machine, at the correct voltage of supply, running on an inductive load it becomes necessary to do one of two things :—

1. Increase the field current to an excessive amount.
2. Increase the speed of the engine.

The first method is the one to employ to ensure good steady running, but it is probable that the second method is more often used in practice. There is far too much hesitation on the part of operators in increasing the field current 30 or 40 per cent. of the full-load field current, but it must be done to overcome the demagnetising effect of the excessive currents flowing in the stator coils, due to the low power factor of the system.

Another advantage of increasing the field current in order to maintain the voltage of an alternator, on a heavy and inductive load, is that there is nothing which conduces more to steady running than to run with a good stiff field.

Generators Running on Loads with a False Power Factor.—It is interesting to take the case of an engine driven alternator supplying the night load on a system, where it is necessary for a number of large induction motors to run lightly loaded. When the power factor meters on the various feeder panels range between 0·3 and 0·5, with perhaps one or two meters reading unity for sub-stations with synchronous machinery, it would be expected that if a reading was taken on the generator power factor meter, the result would be a power factor of about 0·6 or 0·65, after making allowance for the synchronous plant; instead of that it is quite probable that the generator power factor meter will be reading 0·9 or 0·92, and the operator on the switchboard congratulates himself on the good power factor of his generator. If, however, one examines the engine tachometer it is at once seen that the plant is running under false conditions, probably 5 per cent. too fast, and with a very light field current; hence the good power factor showing on the generator instrument. These conditions just stated are the worst for withstanding a sudden short-circuit or earth on the system. The correct way to run a plant of this type on a light but inductive load, is to slow the engine down until it is running at the designed speed, at the same time increasing the field until the machine is maintaining the correct voltage at correct speed. The generator power factor meter will then be registering the correct power factor of the system.

Parallel Running on Light Load.—Another interesting point in connection with parallel running is the difficulty of operating two large machines in parallel on light load with any degree of steadiness. It certainly does not require as much skill to control alternating-current generators on heavy load, as on light load. On heavy load all steam admission valves on the engines will have large openings to steam, and the cut off will be very sharp and definite; whereas, on light load the period of admission will be very small—in fact, it is quite possible for the governors of the engines to be set in such a way that a valve at one end of the cylinder may miss being opened at all for one revolution.

These effects cause uneven turning moments on the shaft, and consequently the parallel running is unsteady. The above facts refer, of course, to engines having automatic expansion gear with the full steam pressure up against the high pressure

admission valves on all loads, and not to engines on which the governing is effected by throttling the steam.

An inductive load indirectly affects parallel running on light loads as well, for it may be necessary to run two machines in parallel, not because the actual load is too much for one machine, but because the line current necessary for that load at a low power factor is far in excess of the full load current of one generator. It therefore becomes necessary for the current to drop down to the full load current of one generator before a machine can be shut down, quite irrespective of the load in kilowatts on the system.

To give an instance, it is quite possible that two generators, each capable of supplying 4,250 kw., may have to run in parallel for half an hour on a load dropping down from 5,000 kw. to 3,000 kw. before it is possible to take one machine out, owing to the excessive line current required for the latter output at a low power factor; and with two machines of this size it is difficult to share the load between them without any surging taking place. It is quite apparent that any surging may be stopped at once by reducing the steam pressure on the engine which is shortly to be taken out, thus obtaining a more definite opening of the valves for a given load; but with care and attention it is possible to run both machines on the governor, thus ensuring the greatest economy in steam consumption.

Again, the question of speed is of great importance, and when running large generators in parallel on light load, the revolutions should be kept well down, even a shade under correct speed, say 1 per cent. rather than over, and when the load is falling off, the wattmeters should be watched carefully, so that every time the load eases down definitely the engine speed can be kept constant either by switchboard governor control, or by hand. The machines should be kept well in hand, and never be allowed to speed up in any way owing to load coming off, otherwise surging may be set up which might be difficult to stop. The field current is also of the greatest importance when running in parallel on light load; with the speed kept low as advocated above, just sufficient field should be kept on the machine to maintain the exact line voltage.

In fact, practical experience shows that in order to run two machines steadily on light load, they must be so cut down that they can only just do the load that is required at the time—that is to say, if the load suddenly increased, say 500 kw. or 600 kw., the volts might drop 4 or 5 per cent. This, of course, would be immaterial as long as there was no danger to the continuity of supply, due to surging between the generators.

Should two generators get out of control and commence to surge badly, one machine should be put on the stop valve at once, otherwise the interchange of heavy currents will inevitably reduce the line voltage. If the surging can be definitely traced to the faulty action of any valve or mechanism on the engine, the engine-room staff should remedy the defect immediately, or change over the machines.

It is interesting to note that even when severe surging is taking place between generators running in parallel, the effect on the running of the converting machines in the sub-stations is practically negligible. Although the needles of the ammeters and kilowattmeters on the generator instrument panels may be most unsteady, the meters on the feeder instrument panels will be reading quite normally. This note specially refers to sub-stations having asynchronous machinery.

When large generators are run over their correct speed for any reason, there is far more danger of their emergency governors operating should a large amount of load be removed for any cause, than there would be if the machines were running at their correct speed.

When turbo-alternators are run in parallel with engine-driven alternators, it is quite essential to run the engines at the correct speed, otherwise, if the engines are running slightly fast, say three or four revolutions, in order to synchronise, the turbo-alternators would have to be speeded up excessively, the amount depending on the ratio of the number of poles of the two types of machines, and the number of revolutions per minute that the engines were running over speed.

ELECTRICAL POWER GENERATION AND DISTRIBUTION AT THE COLLIERIES OF THE LOCHGELLY IRON & COAL CO., FIFE.*

BY JOHN PAUL.

Introduction.—On the coal-field of the Lochgelly Iron & Coal Co. there are 10 pits, distributed over an area of about 16 sq. miles, and raising an aggregate of 1,250,000 tons of coal per annum. Until the end of last year, electricity supply for both power and lighting was provided throughout this area by numerous isolated continuous-current plants of low and medium pressure. The more modern consisted of Belliss & Morcom high-speed vertical engines direct-coupled to generators, and the remainder of slow-speed horizontal engines connected to generators by belt drives, these latter including several small combinations, supplying current at 200 volts for lighting the pit-heads.

Early in 1907 the increase in demand for electric drives of all kinds made it imperative for the company to consider the question of increasing the supply of electrical energy to several of the pits, and incidentally to weigh the relative advantages of providing extensions to the existing scattered plants and the alternative of generating in bulk at high pressure at a convenient centre and distributing to the several consuming points. As a result of consultation with Messrs. James E. Sayers & Caldwell, of Glasgow, the choice fell upon the latter alternative. It was decided to instal, to begin with, plant sufficient to deal with five of the pits and the workshops, but to design the lay-out with a view to the ultimate inclusion of the whole field in the scheme. The general lay-out of the scheme is shown in Fig. 1.

A schedule of the motors immediately to be provided for having been drawn, and the incidence of load and the diversity factor having been taken into account, a load diagram (reproduced in Fig. 2) was deduced, which showed that between the hours of 6 p.m. and 6 a.m. the estimated maximum load was 613 B.H.P., and during the remainder of the 24 hours 761 B.H.P., or about 450 kw. and 550 kw. respectively. It was therefore decided to provide in the first instance two generating units of about 450 kw. capacity each, and arrange accommodation in the power house, in addition, for a third similar unit and a 1,000 kw. exhaust or mixed-pressure turbo-generator, and also so to design and arrange the first portion of the equipment that no part would require modification if extensions were made.

The question of immediately utilising the exhaust steam from the winding and other engines at the Nellie pit, for generating electricity, was carefully considered, and the position of the power house was arranged with a view to this development. Examination of the relative advantages of turbines and reciprocating engines for the size of units required resulted in favour of the last named, both as regards cost per kilowatt capacity and steam consumption per kilowatt output, the quotations and guaranteed steam consumption appearing to be in favour of reciprocating sets for units of 1,000 kw. capacity downwards.

Condensing plant was included in the proposals, to ensure good feed water and to reduce capital expenditure on boilers and engines. The recovery of the condensed steam for feed purposes being of great importance, owing to the indifferent character of the available supply of water at the Nellie pit, choice was restricted to the surface and evaporative types of condensers, the latter type being chosen. The adoption of any other type of condenser would have involved circulating arrangements of at least four times the capacity of the little set now in use for this duty, and, in addition, would have entailed the provision of cooling towers or ponds.

For steam raising, boilers of the water-tube type were advocated. Superheating and high velocity of steam in the main were also put forward as ensuring important economies, and of especial value in this particular instance, as the boilers had to be nearly 200 ft. distant from the nearest generating unit. This rather excessive distance was inevitable, owing to the necessity of selecting a site convenient for the future collection of steam for the proposed exhaust turbo-generator and, on the other hand, the necessity, for economic reasons, of placing the new boilers in line with the existing Lancashire boilers.

In the spring of 1907 specifications were prepared and competitive offers obtained for the necessary works. The more important contracts were entered into shortly afterwards, and at the beginning of 1909 the power house, transmission line and transformer sub-station were put to work, and the change over from the old direct-current drives to the new three-phase system was begun. The nature and scope of the scheme having been indicated, a brief description of the completed works will now be given.

* Abstract of a Paper read before the Mining Institute of Scotland.

Boilers.—There are four Babcock & Wilcox boilers, set in two batteries. Each boiler contains 2,531 sq. ft. of heating surface and is constructed for a maximum working pressure of 200 lb. per square inch. Each boiler is fitted with the new type of chain-grate mechanical stoker. The grate is self-clinkering, and allows of smokeless combustion, while at the same time hand firing can be easily resorted to in case of need. The links of the grate are closely spaced in order to reduce riddling to a minimum, and the whole of the grates are driven by a small steam engine. The expected maximum evaporation per hour from and at 212°F., with wet dross and gum, is about 10,000 lb. per boiler. The boilers are fitted with superheaters of the integral type, each having 428 sq. ft. of heating surface, designed to add 100°F. to the temperature of the steam.

Feed Pumps.—Of these there are three, of single direct-acting type, designed to operate with superheated steam. Any two of these pumps are more than capable of supplying the whole of the feed water required.

Steam Alternators.—There are two Belliss & Morcom triple-expansion engines, direct-coupled to two Bruce Peebles three-phase alternators with a frequency of 50, having exciters on the same shaft.

As accessories to this plant, there are two oil separators inserted between the engines and the condensers; two automatic relief valves, fitted as bye-passes to the atmosphere; a three-throw Edwards air-pump, driven through gearing by a three-phase motor; a small force pump (driven from the air-pump shaft), delivering the water passed by the air pump to the inlet chamber of a Harris-Anderson feed-water purifier; and a small pump, also driven from the air-pump shaft, for draining the two oil separators. The centrifugal pump motor set for maintaining a film of water over the condenser tubes is of about 3 H.P. capacity.

Power House Switchgear (Fig. 3).—The high-tension portion consists of four generator panels and six feeder panels, only two of the former and four of the latter being at present fully equipped. The feeder panels in use supply: (1) The transformer for the Nellie pit, (2) the transformer for the power-house motors, (3) the overhead line supplying the Mary and Newton pits and (4) the overhead line supplying the workshops, Jenny Grey pits and the Dundonald colliery.

There are, in addition, two panels dealing with low-tension three-phase current from the power-house transformer. One of

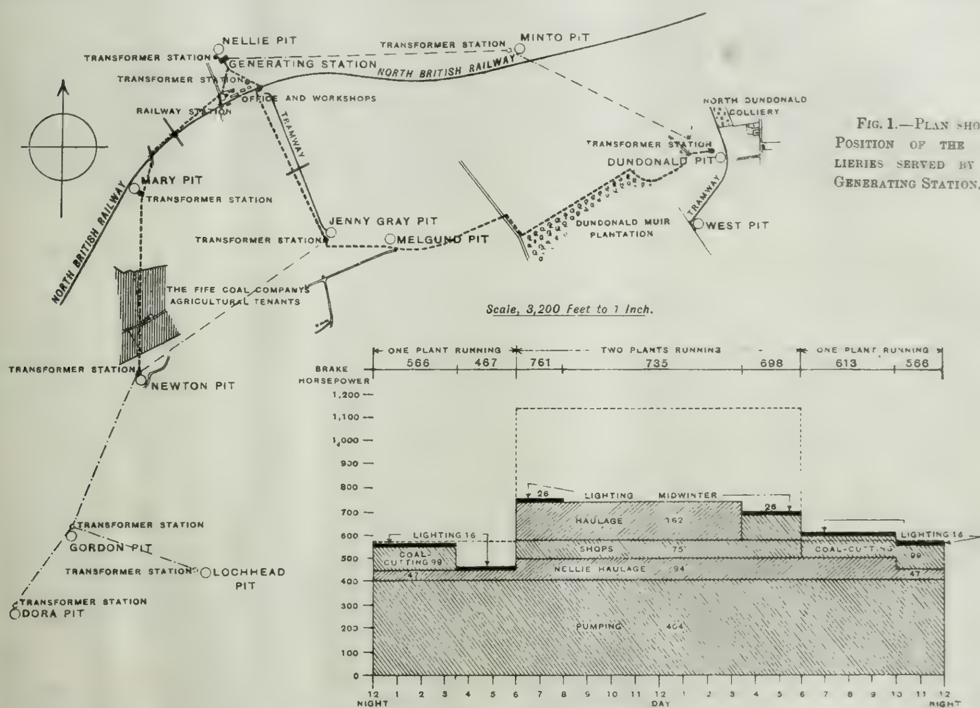

Fig. 1.—Plan showing Position of the Collieries served by the Generating Station.

Fig. 2.—Diagram showing the Load over 24 Hours for Estimated Immediate Requirements of Nellie, Mary, Jennie Gray and Newton Pits, and the Workshops

The combined sets are each designed for a continuous output of 420 kw. on a 0·8 power factor (and for 25 per cent. overload for periods of two hours at clear intervals of six hours) at 3,000 to 3,300 volts when running at 375 revs. per min., either exhausting into a condenser with a vacuum of 26 in. or into the atmosphere. The engines are fitted with the makers' well-known system of forced lubrication and are supplied with steam at from 160 lb. to 180 lb. per square inch, and at a temperature of 470°F. to 500°F.

Oil-settling, filtering and storage tanks are arranged in the basement, by means of which the oil from any crank chamber may be drawn off and a fresh supply pumped in. New oil is run by gravity into the storage part of this apparatus from a point outside the station.

Evaporative Condenser.—This condenser consists of 336 corrugated pipes built up into 14 coils of 24 pipes each, and to operate it 10,000 gallons of water per hour have to be circulated, of which 800 gallons are evaporated; the remainder falls back into the tank, and is used over again, the wastage being made up by a supply to the tank. The temperature of the water in the tank may rise to 115°F. without any reduction in vacuum.

these controls a 50 kw. motor-generator supplying continuous current at 200 volts for the lighting of the power house, Nellie pit-head and the offices and shops, and the other the air pump, condenser and centrifugal-pump motors. There is also a continuous-current panel controlling the 200-volt lighting supply from the motor-generator already mentioned.

All but the measuring and indicating instruments and the handles of the oil switches are contained in screened cubicles in a switchboard recess, which is in turn guarded by Boswick gates with locking arrangements, conforming to the Home Office requirements, no "live" metal or connections being on the front of the three-phase panels.

Fixed to the sides of the brick piers within which the main panels are accommodated are the synchronising 'bus-bar voltmeter and earth-detecting panels. On each of the equipped generator panels are mounted a three-pole oil switch having automatic reverse power trip gear, arranged to disconnect a faulty machine from the 'bus bars, an indicating wattmeter, an ammeter and the necessary plug connections for the operation of synchronising. In front of each of

these panels is an exciter pillar comprising a rheostat handle for varying the exciting current of the generators, an ammeter, a voltmeter and an exciter field switch. On each of the feeder panels are mounted a three-pole oil switch having automatic overload and out-of-balance trip gear, arranged to disconnect a feeder in the event of a predetermined overload, or in the event of any line or lines of the circuit becoming earthed, an indicating wattmeter, an ammeter and a kilowatt-hour or integrating wattmeter, to measure the units of electrical energy supplied to the individual circuits. On each of the low-tension three-phase panels are mounted a three-pole oil-switch, as on the high-tension feeder panels, an ammeter and one voltmeter common to both panels. There are no fuses on any of the three-phase panels. On the 200-volt continuous-current lighting panel is mounted a main switch and three circuit knife switches, a pair

FIG. 3.—VIEW OF SWITCHBOARDS AND TRANSFORMERS FOR NELLIE PIT AND POWER HOUSE MOTORS.

of main and three pairs of circuit fuses, a voltmeter, three ammeters, and a field rheostat for voltage control. The whole supporting structure is of iron, the sides and tops of the cubicles are of slate and the panels themselves are of marble.

Motor-generator for Lighting.—This set has already been referred to. In addition to this source of illumination, the switchboard is provided with lamps supplied by a small static transformer as a safeguard. The inside of the power house is lined with glazed bricks and has a gantry running the whole length, from which a 10-ton traveller serves the whole area.

High-tension Distributing System.—This consists of overhead lines from the power station to the Mary and Newton pits to the

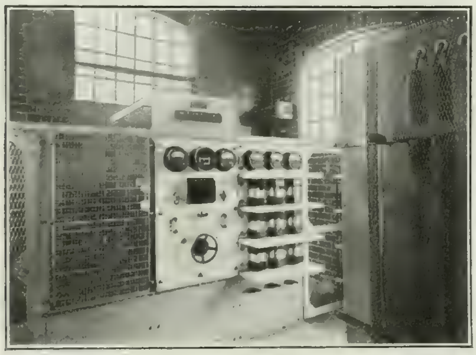

FIG. 4.—LOW-TENSION SIDE OF TRANSFORMER.

south-west, to the workshops and the Jenny Grey pits to the south-east, and sundry lengths of lead-covered and armoured paper cables under the North British Railway track and from the power house to the adjacent terminal pole. Fig. 1 gives an idea of the extent of this portion of the work, the heavy dotted line indicating the two lines now in operation, the dotted line from the Jenny Grey pit to the Dundonald colliery, the extension not yet at work, and the chain-dotted lines the sanguine hope of the consultants, which may or may not be realised. The point, however, of the interconnected network, completed as shown by these chain-dotted lines, is that in conjunction with the special arrangement of isolating switches in the several transformer stations, any section of line, excepting that from the Newton pit to the south, could be made dead (for repairs or other purposes) without interfering with the supply. This, of course, is an important consideration. The earthing guards have been arranged for operation with the supply from either direction, in view of this linking up.

All cables and apparatus in connection with the overhead lines are

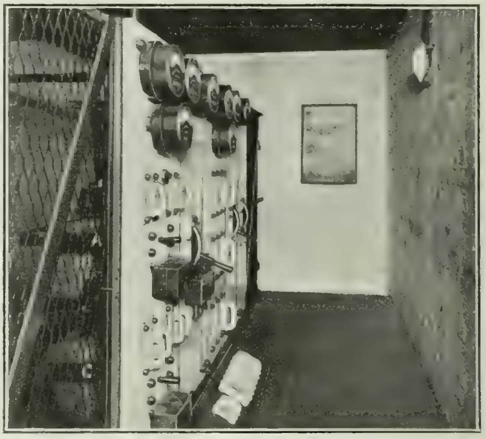

FIG. 5. VIEW OF ONE OF THE INBYE SWITCHBOARDS.

protected from the effects of lightning, and excessive pressures from other causes, by spark-gaps; and public roads and positions in the vicinity of the pits are guarded by adequate cradling.

Transformer Stations.—Each transformer station is designed to contain two 200 kw. transformers (0·8 power factor) and the necessary switchgear, but at present they have only half of their equipment. The transformers are oil-cooled, and are wound to transform three-phase current from 3,000, 3,150 and 3,300 volts to 525 volts, the several ratios being arranged for compensation for varying line losses at the different consuming points dependent upon distance from the power station. The full-load efficiency of these transformers on test was about 97 per cent. The switchgear for the transformer chambers is of the Ferranti type, and comprises a high and a low-tension panel for each transformer, with automatic oil switches, indicating instruments, and an integrating wattmeter to

FIG. 6.—VIEW OF PART OF THE OVERHEAD LINE.

measure the units of electrical energy supplied. The switchgear is designed to cut out automatically a faulty transformer, and is generally in line with the apparatus in the power house, which has already been described. On the high-tension side, space has been left for a high-tension feeder panel, in case it is desired to take high-tension circuits down the shafts. On the low-tension side, there are three circuits, each of 200 kw. capacity, for transmission of current at 525 volts for shaft cables or other purposes.

A good general idea of the design and arrangement of these transformer chambers and their contents may be obtained from Figs. 4 and 5.

Shaft and Inbye Cables.—These are of three-core bitumen, in-

sulated and filled, and double armoured with galvanised-steel wires. They are supported in the shafts at intervals of 40 ft. to 50 ft. by cleats of special design, and suspended inbye by hempen slings. Electrical continuity of the armouring throughout each network is effected by substantial armour-clamping rings, and the whole efficiently connected to the best earth obtainable on the several systems.

Inbye Switchboards.—These are of very substantial construction and are designed for underground conditions. Arrangements are also provided on each board by means of auto-transformers for the supply of current to 50 lamps. Fig. 5 gives a front view of one of these boards in position.

Sub-circuit Fuseboards.—These are of heavy mining type with porcelain barrel fuses, and have all connections on the front of the slate panels. They are enclosed in cast-iron cases with armour anchor rings, and the lids, of braced iron plate, are hinged and secured by wing nuts.

Motors.—These have been supplied for haulage, pump and fan drives, and include both the slip-ring and squirrel-cage types, with control panels and starting switchgear suitable to the particular requirements of each drive. Coal-cutters have been supplied by two Motherwell firms. The pits at present outside the area of the three-phase supply are the Minto and the Raith group, the latter comprising the Dora, Gordon and Lochhead pits. The Minto pit is provided for by two steam dynamos of 100 kw. capacity, and one of 250 kw., generating continuous current at 500 volts. The Raith

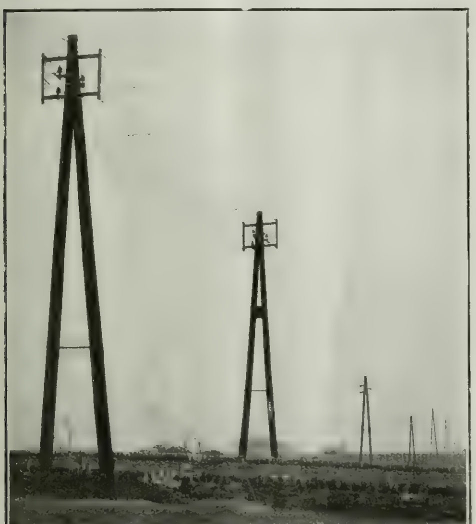

Fig. 7.—View of Overhead Line, showing Cradling over Roadway.

group is supplied by two combinations of 100 kw. capacity, which are exact duplicates of the first-named sets at the Minto pit. These are located at the Dora pit, and serve the Gordon and the Lochhead pits in addition by overhead transmission lines. All these pits have small 200-volt generators for lighting purposes.

As to the outlay, it may be taken that the generating costs, based on the load diagram produced, plus the capital charges, namely, interest on capital and sinking fund to redeem the capital in 20 years, will enable the company by the equipment described to deliver electrical energy at any point in the coalfield for something less than 0·3d. per Board of Trade unit; and that with an increased load the cost per unit will be even cheaper, owing to the fact that much of the capital expenditure already incurred really belongs to these possible and probable extensions.

Owing to the courtesy of the consulting engineers, Messrs. J. E. Sayers and Caldwell, we are able to supplement the description of the distribution system given by the author of the Paper with the following particulars:—

A general idea of the lay-out of the overhead transmission system can be obtained from Fig. 1 above, whilst Fig. 6 is a typical view of one of the overhead lines. The poles were specified to be best selected red fir, and to be loaded with at least 10 lb. of creosote to the cubic foot. The spans vary between 100 ft. and 120 ft., whilst the cradled spans in no case exceed 100 ft. Fig. 7 shows a view of the cradling over a roadway, and Fig. 8 illustrates the details of a pole fitted with a cradle.

In regard to earthing, all poles are connected by an earth line, strained up by means of turnbuckles, such line consisting of either six No. 12 or nineteen No. 16 gauge galvanised steel strands on a hemp core. At intervals of about 400 yds. coke pits are provided adjacent to the poles, into each of which pits is carried an earth wire of No. 3 S.W.G. copper. These earth wires are electrically connected to the aerial earth line and the whole of the metal fittings and stays of the pole, and project 6 in. above the pole roofs, not more than one wire being secured under any one bolt head or nut. The coke pits are about 4 ft. deep by 3 ft. square, and are constructed as follows: A 12 in. layer of small coke is laid at the bottom of the pit, on which is staggered a 20 ft. continuation of the copper earth wire, and over this is laid a further 12 in. of small coke, the whole being thoroughly saturated with water. The remaining poles are provided with No. 4 S.W.G. galvanised iron earth wires, stapled round the underground portion of the pole and spirally on the under end

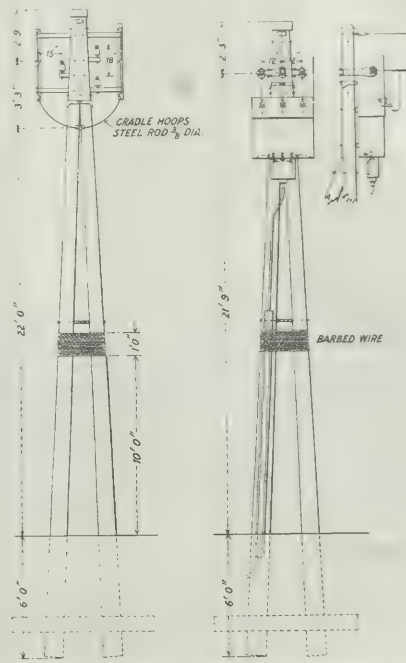

Fig. 8.—Types of Poles and Protecting Cradles used for Lochgelly Power Scheme.

thereof. Stay wires consist in all case of seven No. 8 S.W.G. strands of galvanised iron.

The insulators employed are of the triple shed type, and of brown glaze porcelain, a rubber disc being interposed between the top of the spindle and the porcelain. Each insulator before erection was subjected to a flash test of 30,000 volts, and also to a pressure test of 10,000 volts for 48 hours, the latter test being applied immediately after the insulators had been immersed for 48 hours in water.

The terminal poles from which the underground cables run to the power station, and also those at the far ends of the transmission lines, are provided with lightning and excess pressure dischargers. Four dischargers are fixed at each point, connected so that there are two in series between any two lines, and the equivalent of 1½ in. series between any line and earth. Choke coils are inserted between each underground cable and the points of connection of the dischargers. The dischargers and choke coils are contained in a hinged galvanised iron case, secured upon steel channels to the terminal pole as shown in Fig. 8. From the bottom of the case depends an iron plate supporting the trifurcating box.

The copper conductors for each overhead line consists of strands of hard drawn copper laid on a hemp core. The whole of the lines after erection successfully withstood the application of 7,000 volts pressure alternating, 50 cycles, between any two lines and between any line and earth for 30 minutes.

THE WIDENING OF BLACKFRIARS BRIDGE.

To those whose daily work requires that they should come into the City, especially to the western end, from the southern suburbs, it has been very evident for some time that extensive engineering works have been in progress at Blackfriars Bridge. These engineering works, although designed to alleviate the traffic over that bridge and to provide further facilities in the way of trams from the Middlesex to the Surrey side of London, have temporarily at least caused a good deal of congestion and delay generally to both foot and wheeled traffic.

The desire of the London County Council to provide suitable connections between the northern and southern sections of their tramways required that the tram lines should be laid across Blackfriars Bridge. The existing bridge at the time the proposal was made was too narrow to allow of this to be done with safety, and without causing the other wheel traffic to become too congested, this bridge being one of the principal connections between the north and south of London. It was, therefore, decided that the bridge should be increased in width by about 30 ft. The late Sir Benjamin Baker was appointed consulting engineer, and advised that the outer ribs of the four spans of the existing bridge should be used again, but that the rib in the north span would not be strong enough to carry the weight of the curved approach. It was at first proposed that the outer rib of each span should be taken down, put to one side, and finally re-erected in the new position. This was, however, found to be impossible, and the ribs were actually moved bodily to their new position 30 ft. westward, an arrangement which has saved both time and cost. Two large systems of latticed girders were constructed to cover the widest span, and were bolted at either end to

FIG. 1.—VIEW OF TRAMWAY TRACK ON BLACKFRIARS BRIDGE.

bogies running on special tracks along the extended piers, which arrangement formed a large travelling crane. The ribs to be moved were supported by seven hangers from cross girders, which were arranged to take the weight on the 3 in. screws provided with large nuts. By means of this arrangement, and also by the help of hydraulic jacks, the nuts on the hangers were tightened simultaneously, and the rib raised about 1 in. clear of the old supports. Temporary girders were employed to steady the movement of the rib, and were bolted to its underside, the other ends being slung in stirrups from the old ribs of the bridge. A screw rack on each girder, which was worked by hand when the signal was given, pushed these girders westward. The bogies of the traveller were moved 1½ in. at a time, and the uniform movement of the girders prevented any oscillation or irregular movement of the rib. These arrangements worked so well that the full 30 ft. travel was effected within from three to four hours. The eight temporary girders were then used as a staging for building the three new ribs completing the span. Each traveller was moved in three portions to the new span and then connected again. One traveller did the whole of the moving of these outer ribs, and when one rib had been moved it was lowered to the correct level and the space between the ends and the new skewbacks filled in with molten lead. In order to keep the thrust on the new piers balanced all the face ribs had to be moved before the new ribs were built up.

The above indicates briefly what may be termed the civil engineering, and, of course, in this case, the most important portion of the work; but in carrying it out we are pleased to hear that the contractors used electric power for driving the various machine tools, and that their enterprise in this direction was attended with signal success. All the cranes were electrically driven, and the fact that the mains for the City of London Electric Supply Co. already crossed the bridge was taken advantage of, the current being supplied from them. It was found that the saving effected by the use of these methods was very great, and the convenience was at the same time very much appreciated. Electrically driven air compressors, driven by 35 H.P. motors, were used for sinking the caisson used in the widening process. Two of these compressors were put down at the Blackfriars end of the bridge, one being of the high-pressure type, which subsequently supplied compressed air to the pneumatic tools at 110 lb. pressure. For the caisson work a pressure of only 25 lb. was necessary. On the staging at the bridge ends and on the piers seven 10 ton electrically driven derricks were erected. The motors for driving these derricks were supplied with current at 420 volts.

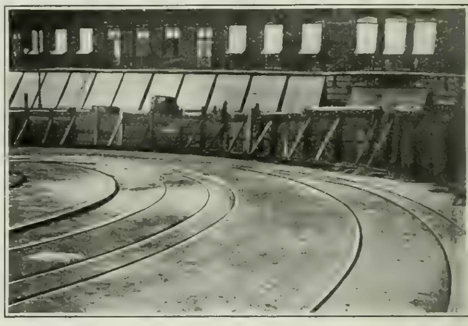

FIG. 2.—VIEW OF THE CURVE FROM BLACKFRIARS BRIDGE TO THE EMBANKMENT.

Two 15 ton cranes equipped with 40 H.P. motors and a 7 ton crane fitted with 30 H.P. motor were also used in this work. The tools in the workshop at the north end of the bridge were electrically driven, and this method, we are pleased to hear, was found to be of great value in expediting the completion of the contract. Another use to which electricity was put was for raising the material from the foundations, a 10 H.P. motor being used for this purpose. The maximum lift was from 40 ft. to 50 ft. and the load about 10 cwt. The general contractors for the work of widening this bridge were Messrs. Sir William Arrol & Co., Glasgow.

An interesting piece of work in connection with the L.C.C. tramways has also become possible by widening this bridge. Messrs. Dick, Kerr & Co. have been contractors for the tramway work, a general view of which can be seen in Fig. 1. The track has been laid

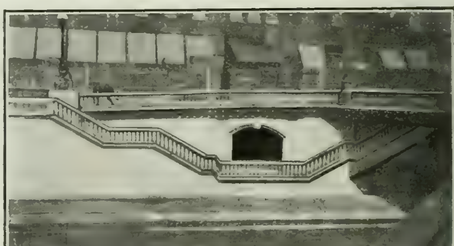

FIG. 3.—ENTRANCE TO THE NEW SUBWAY.

down on the standard conduit system adopted by the L.C.C. on bridges, and, as stated above, forms a very useful connecting link between the northern and southern portions of the tramway system. The curve from the Embankment on to the bridge is very steep and sloping, as will be seen from the photograph in Fig. 2, and we should imagine that very careful driving will be necessary to negotiate this part of the line safely. The configuration of the roadway generally does not allow of an easy approach to be made, and we feel certain that every care has been taken in the construction of this very difficult line. It will be noticed that, as in the case of Westminster Bridge and the Embankment, the track has been placed at one side of the road and adjacent to the pavement.

In connection with the widening of the bridge another interesting piece of work has been done. Both workers in and visitors to the City know that there scarcely exists a more awkward crossing

than that at the City end of Blackfriars Bridge. Nervous passengers will now be able to avoid this crossing by using the subway which has been constructed from near Blackfriars Station to the other side of Bridge-street. The entrance to the subway can be seen in Fig. 3.

The whole of the work has been carried out under the general direction of Mr. Basil Mott, the consulting engineer, the resident engineer being Mr. D. Anderson.

ON THE SELF-DEMAGNETISING FACTOR OF BAR MAGNETS.*

BY SILVANUS P. THOMPSON, D.SC., F.R.S., AND E. W. MOSS.

On the Significance and Definition of the Self-demagnetising Factor.—Between any two magnet poles, whether they are regarded as points or as regions over which there is a surface distribution of magnetism, there are magnetic forces. In the space between any two point poles the intensity of the magnetic field that is due to these poles, at any point in the line joining them, is expressed by the equation :

$$\mathbf{H}_x = \frac{m_1}{(a+x)^2} + \frac{m_2}{(a-x)^2};$$

where the respective strengths of poles are m_1 and $-m_2$, a the half of the distance between them, and x the distance of the point in question from the mid-point between them. The value of this expression in no way depends on the material in the space between the poles, whether non-magnetic or magnetic, or actually magnetised in any manner.

If m_1 and $-m_2$ are numerically equal, the expression becomes

$$\mathbf{H}_x = 2m \frac{a^2 + x^2}{(a^2 - x^2)^2}.$$

At the mid-point, under the same condition, the intensity has the minimum value of $\mathbf{H}_{\min.} = 2m \div a^2$.

If the space between the two point poles be regarded as occupied by a thin, cylindrical, uniformly magnetised steel magnet the ends of which constitute the point poles in question, then these equations will be the expressions for a self-produced magnetic field acting in a direction which opposes the actual magnetism of the magnet, and tending to demagnetise it. Each portion of the filiform magnet will be acted upon by a demagnetising field, strongest towards the poles, weakest at the middle. The supposed uniform magnetisation of the magnet will, of course, be unstable. If it were produced, even for a moment, there would at once be a retrocession of a portion of the magnetisation from the ends, with a new distribution of the polarity. On the supposition that the middle part of the rod retains still its full flux, the retrocession of the pole would shorten the effective length of the magnet, diminishing the magnetic moment, but increasing any self-demagnetising internal action. This tendency to produce a retrocession of the pole may operate to different degrees according to whether the bar consist of soft iron or hard tungsten steel. In either case the retreat of the pole can be only incomplete; because, if we suppose the pole to have actually retreated by any given amount —for example 1 cm.—the end piece of that length will now be subjected to the magnetising action of the rest of the bar, and will be re-magnetised up to a certain point, namely, such that the reaction of the magnetism of this piece is equal to the magnetising action of the whole of the rest of the bar, less the demagnetising reaction of the bar as a whole. The inevitable result is a distributed pole. It cannot remain concentrated at one point, on the end; it must re-distribute itself along the bar with a distribution determined by the conditions of equilibrium at every point.

Also the middle piece of the bar will not be exempt from influence; it, too, must diminish its inherent magnetism, because even in weak fields the magnetism of the hardest steel is subject to cyclical changes, and because any retrocession of the poles is, *pro tanto*, productive of an increase in the self-demagnetising force at the middle. Only in cases where this self-demagnetising force at the middle is less than that which suffices to produce an irreversible change in the magnetism of the steel—that is, only in cases where the bar is very long in proportion to its cross-section—can the action at the middle be regarded as negligible.

It is clear then, in general, that for every bar-magnet there will be a self-demagnetising action the value of which, at the middle of the bar, depends, for a given intensity of magnetisation, on the length of the bar relatively to its cross-section, on the permeability of its parts, and on the distribution of its surface magnetism. Owing to the circumstance that with every kind of steel the permeability is neither constant nor stands in any simple or even single-valued relation to the flux-density, any calculation of the actual polar distribution for rods or bars is exceedingly complicated and indeed impracticable.

As is well-known, the one and only form of magnet that is practicable for calculation is that of the ellipsoid, the properties of which are that for any and every value of the permeability, and when placed in any uniform field, the surface magnetism is so distributed that the magnetic force which this distribution of polarity exerts in the interior is uniform at every point within. Hence the internal demagnetising force everywhere within is constant; the resultant field at every point of the interior (if the structure is homogeneous and isotropic) is also constant, and the internal flux-density cannot but be uniform.

Du Bois and others have determined by experiment the demagnetising actions of cylindrical rods of various dimensions, and have compared them with ellipsoids of revolution of similar dimensional proportions.

In the case of ellipsoids, it is natural to compare the value of the intensity of the self-demagnetising force with the value of the internal magnetisation $\mathbf{I}$, because both of these are uniform throughout the interior. But because both $\mathbf{H}_d$ and $\mathbf{I}$ are for an ellipsoid of given ellipticity proportional to one another, it was quite natural to regard the quotient of the former by the latter—that is to say, the amount of self-demagnetising force per unit of intrinsic magnetisation—as a sort of natural coefficient, and to recognise it as a self-demagnetising factor. Du Bois (following Maxwell) assigns to it the symbol N. Denoting the dimension ratio of axial length l to equatorial diameter d by the symbol $\mathfrak{m} = l \div d$ (in Du Bois' notation), then $\mathfrak{m}^2$N varies from 25·49 when $\mathfrak{m} = 10$, to 80 when $\mathfrak{m} = 1{,}000$. (*See* Du Bois, "The Magnetic Circuit," p. 41.)

But, if we now compare the case of the ellipsoid with that of the cylindrical bar, we find that the matter is not so simple. For with the bar, as stated above, $\mathbf{H}_d$ is by no means uniform throughout the interior, neither is $\mathbf{I}$. But the nett value of $\mathbf{H}_d$ for the entire bar can be easily determined by comparing the **B-H** curve of the bar (found by experiment) with the **B-H** curve of a ring (or infinitely long rod) of the same iron, and taking the difference of the values of $\mathbf{H}$ for some assigned value of $\mathbf{B}$. On the other hand, values of $\mathbf{I}$ can be found by experiment. The ratio $\mathbf{H}_d \div \mathbf{I}$ so deduced may still be called the self-demagnetising factor, and values found for rods of different dimension ratios.

All previous writers have defined the term dimension ratio as applied to a bar as the ratio between its length l and the diameter d of its circular section. But it is preferable to define it in terms of the ratio which is borne by the length to the square root of the area of section. The ratio $l \div \sqrt{A}$ we accordingly propose to denote by the symbol λ. For any given bar we have the relation $\lambda = \mathfrak{m} \times 1{\cdot}128$.

Experimental Determination of the Self-demagnetising Factor.—To clear up, if possible, the discrepancies in the values for N found by various observers a research was undertaken in the laboratory at the Technical College, Finsbury. The bars used were cut from two long rods of best Swedish iron carefully annealed, and for comparison a ring was forged from the same material. To each and all of the rods the same diameter was given, namely, 1·128 cm., in order that each might have a cross-section of precisely 1 sq. cm. After being turned down to approximate size they were annealed, and then finally turned to the precise size required.

The magnetising coil used to magnetise the rods was a long coil wound on a brass tube 91·4 cm. in length and 4·75 cm. in external diameter. It was carefully overwound with 5,800 turns of wire of No. 20 S.W.G., in seven layers. With this coil a very uniform field over a length of 60 cm. could be produced of any desired intensity up to $\mathbf{H} = 255$. The longest specimen of iron was only 40 cm.

The ballistic method was used for determining the magnetisation of the bars. On the middle of each bar was wound an exploring coil of 10 turns of very fine wire, the breadth of each such coil not exceeding 0·25 cm. **B-H** curves were determined for both rods and rings for fields varying from 20 to 255. Let the field due to self-demagnetisation at the mid-point of any bar, for any given flux-density $\mathbf{B}$, be called $\mathbf{H}_d$. Let the total impressed field due to the magnetising coil be called $\mathbf{H}$, and let the impressed field required in the ring to produce the same given value of $\mathbf{B}$ be called $\mathbf{H}_r$. Then

$$\mathbf{H}_d = \mathbf{H} - \mathbf{H}_r.$$

Then since, by definition, the self-demagnetising factor N has the value

$$N = \mathbf{H}_d \div \mathbf{I},$$

and

$$\mathbf{I} = \frac{\mathbf{B} - \mathbf{H}}{4\pi},$$

we get

$$N = \frac{4\pi \mathbf{H}_d}{\mathbf{B} - \mathbf{H}}.$$

* Abstract of a Paper read before the Physical Society. This Paper was referred to briefly in our issue of March 12, 1909.

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Rods with the dimension ratios of from 35·6 to 2·66 gave curves which were sensibly straight lines up to **B** = 12,000, or as high as the curves could be carried. The value **B** = 10,000 was chosen for the calculation of the self-demagnetising force and deduction of the self-demagnetising factor, except for the very short rods in which lesser values of **B** were alone available. Fig. 1 gives as the final result the curve exhibiting the values of the self-demagnetising factors found, for rods of different lengths, the corresponding values found by Du Bois and by Riborg Mann being added for comparison. It will be seen (1) that our values are throughout lower than those found by either of these experimenters; (2) that we have carried the determinations down to shorter rods than those examined by either of them; (3) that the discrepancies between their results and ours are smaller as the dimension ratios are larger.

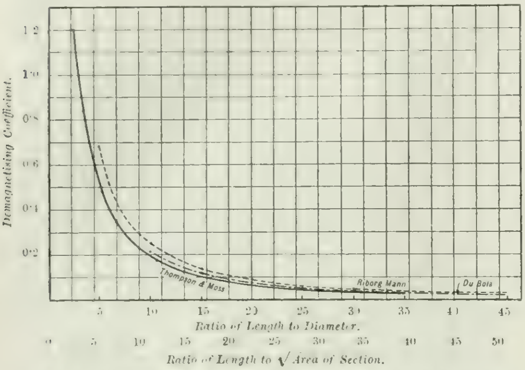

FIG. 1.—COEFFICIENTS OF DEMAGNETISATION FOR BARS OF CIRCULAR SECTION.

The fact that our values are throughout lower than those of Du Bois and Riborg Mann is doubtless due to the circumstance that they used a magnetometric method, whilst we have returned to the ballistic method of Ewing. The values of **I** which they employ are the mean values deduced from the magnetic moment, and are presumably mean values throughout the length of the bar, whilst our values of **I** are the values deduced from the action of an exploring coil wound round the equator of each bar, and presumably measure the maximum value of **I**. As the self-demagnetising action of a bar depends on neither the mean value nor the maximum value of **I**, as we have

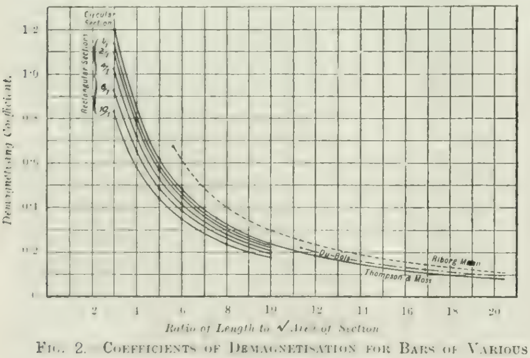

FIG. 2. COEFFICIENTS OF DEMAGNETISATION FOR BARS OF VARIOUS LENGTHS AND FORMS OF SECTION.

seen, but on a mean that is impossible to calculate unless the actual surface distribution of the magnetism is known, it appears to us preferable to take the value of **I** that can be ascertained with precision at the place where the self-demagnetising force has its minimum, namely the centre of the bar.

One point of criticism on Riborg Mann's results may be permitted us. To give us confidence in our results, we have throughout used substantial bars of 1·128 cm. in diameter, and have raised the lengths. Riborg Mann used a single cylinder of iron 11·850 cm. in length, originally of a diameter 1·526 cm., therefore of a dimension ratio of 7·76. This he turned down successively to smaller and smaller diameters until he reached a diameter of 0·237 cm., giving a dimension ratio of 50. How he contrived to turn so thin a wire is remarkable. It would have a sectional area of only 0·0561 sq. cm. Further, while his cylinder was 11·850 cm. in length, his magnetising coil was only 30 cm. long and 4 cm. in diameter. The ends of his rod were therefore at points only 2¼ diameters distant from open ends of the coil, where, therefore, the value of the field would differ by some 2½ per cent. from the value of the uniform field at the middle of the coil.

We are not aware that any previous investigator has determined the self-demagnetising factor for square bars or flat bars of rectangular section such as are often used in magnetic work.

A priori we should expect the self-demagnetising factors to be less than for bars of equal section of circular form and equal length; since the greater perimeter of the rectangular forms is magnetically equivalent to giving to the end parts a polar expansion, reducing the reluctance of the air paths of the external magnetic flux, and so bettering the magnetic circuit. And such has proved to be the case.

The experiments were made in exactly the same manner as those for the bars of circular section, 35 rectangular rods being used. The final results are summed up by plotting the several demagnetising factors as functions of λ, the ratio of the length to the square-root of the area of section (Fig. 2.)

For equal values of the ratio of l to $\sqrt{A}$, it was found in general that the self-demagnetising factor, for bars having a sectional ratio of 2 to 1, was about 93 per cent. of that for bars of square section; while for flat bars, having a sectional ratio of 10 to 1, the value of the self-demagnetising factor went down to about 75 per cent. of that for bars of square section.

THE COLLISION ON THE METROPOLITAN RAILWAY.

The report of Lt.-Col. E. Druitt to the Board of Trade in connection with the inquiry into the causes of the collision, which occurred on August 5th between two passenger trains at Moorgate-street on the Metropolitan Railway, has been issued. It will be remembered that a passenger train ex Neasden was standing at the up platform at Moorgate-street when it was run into from the rear by a passenger train ex Hammersmith, three passengers being slightly injured. The damage to rolling stock was slight, and there was none to the permanent way. The collision occurred at 6:16 p.m. After setting out the evidence taken at the inquiry the report states that there is no doubt from the evidence but that the up home signal was "off" for the second train, though it should have been "on," as the first of the two trains was still in the section just ahead. The system of signalling in use is known as the Johnson all-electric automatic and semi-automatic power signalling system. It has been recently installed by the McKenzie, Holland & Westinghouse Power Signal Co., and it is still in their hands for maintenance. It was brought into use at Moorgate-street on July 4th last, though it has been in operation at Praed-street Junction since July 26, 1908. The following description of the system is given:—

At certain interlocking stations between Praed-street Junction and Aldgate—*i.e.*, Edgware-road, Baker-street, Farringdon-street, Aldersgate-street, Moorgate-street and Bishopsgate-street—where the points are not required to be very frequently worked, the existing manual frames have been retained, circuit-breakers being fitted to the signal levers for the purpose of controlling the main line signals. When the traffic is to run on the up and down main lines the signal levers governing such movements are pulled over. The signals then become automatic, going to danger by virtue of the track circuit after the passage of each train, and come to the clear position only after the train has left the section they control, and of course put the next signal to danger. Train stops have been fitted to every signal controlling passenger movements on the main lines, and in addition to this repeaters have been fixed at the railway company's request to certain stop signals. These repeaters exhibit a yellow light when the signal they repeat is at danger, and a green light when it is clear. The signals in the open stations and in some of the cuttings are of the semaphore type, operated by Johnson's patent oil machines, but the signals in the tunnels are of the lamp type, and each of these is fitted with two Fresnal lenses, one red and the other green, or, for repeaters, yellow and green as the case may be. The lamps in these signals burn alternately in accordance with the control of the signal, the lamp relay in same being so arranged that it is impossible for both a red and green light in a signal to be alight at the same time.

The points and signals at Praed-street Junction are worked by electric current at a potential of 120 volts, and those at Aldgate will be worked at the same potential. The points at the former location are worked by

the Johnson's patent oil point machine, which transforms the rotary motion of the point motors to the necessary reciprocal motion. The machine consists of a small two-gear oil pump driven by an electric motor, which pumps oil on to either side of a vane in the direction of rotation of the motor. The vane is mechanically connected to the point gear, and a bye-pass around the pump is so arranged that should the pressure against the vane be excessive the valves are automatically opened, allowing free circulation of the oil. This relieves the motor of the excess load that would result should the points become blocked owing to any mechanical obstruction, and the disadvantages connected with mechanical and electrical clutches are thereby entirely eliminated, saving the delays which would otherwise be caused by blown fuses or burnt-out motors.

The mechanism operating the semaphore signals is very similar to the point machine just described. The oil pump and resulting piston movement pulls the signal off. Oil pressure is applied to one side of the piston only, and when the signal is cleared it remains in the safety position by the retention of the oil in the cylinder by an electrically controlled valve. When the lever in the cabin is put normal, or the track circuit becomes de-energised by the presence of a train in the section, this valve opens owing to the de-energisation of the magnet controlling it. The signal returns to danger by gravity, and the oil is discharged into the pump reservoir.

The locking frames at Praed-street Junction and Aldgate are fitted with continuous point indication, the signal circuits being closed only when the point indication is received. A small banner is also provided to show the position of the points. The signal contacts are held closed only as long as the point indication circuit is maintained. Should, however, the position of the points become altered the indication circuit would be interrupted, resulting in the signal being put to danger if "off" or remaining at danger if "on." The point levers could thus safely be thrown quickly in the sequence required by the mechanical locking and the signal lever reversed. Signals cannot go to the clear position until all the contacts in the signal circuit have been closed.

The cabins at Praed-street Junction and Aldgate and all the intermediate interlocking cabins mentioned above have been provided with illuminated diagrams which show the condition of the track circuits approaching and in their jurisdiction. When a track circuit is unoccupied the portion of the diagram repeating same is illuminated, and when occupied a dark patch is shown in place of the illumination. A failure of current will thus give the indication of "Train on line" rather than "Line clear." The track circuit equipment, with its attendant polarised relays, &c., is identical with that installed on the District Railway and certain Tube railways.

Lt.-Col. Druitt in his report goes on to say :—

At the time of the collision the levers in Moorgate-street signal box were pulled over, and the signals were working automatically. There was a man on duty in the signal box, but his duties were simply to record the times of the trains passing, and to work the points leading to the up bay line should a train be required to be run into that line. On this occasion, had the signalman on duty noticed the second train entering the section between Moorgate-street outer home and home signals, he could not have put the home signal to danger by putting back the lever in the frame, as the track circuit was already de-energised by the presence of the first train in the section just ahead of the home signal, and the movement of the lever has only the same effect. All he could have done would have been to hold out a red flag, which would in all probability not have been seen by the motorman.

After the collision the oil machine which worked the signal rod was examined by the chief engineer of the power company, who is of opinion that the probable cause of the signal remaining in the clear position was an accumulation of sediment in the oil, which caused the release valve to stick, and so prevented the signal going to danger when the magnet controlling the release valve was de-energised by the track circuit being interrupted by the presence of the first train in this section. This release valve is to be re-designed, and all the signals actuated in a similar manner, 18 or 19 in number, will have new valves fitted to the oil machine. In the meanwhile all these signals are being watched to see that they go to danger after the passage of a train, and they will be watched until the contemplated alteration in the pattern of valve has been effected, and found by practical working to be satisfactory.

TELEGRAPHY IN THE UNITED STATES.

The statistics for the telegraph industry of the United States, taken as a part of the third census of the electrical industries of the United States, for 1907, will shortly be issued in bulletin form. There are many tables, much explanatory comment, and a number of illustrations. Conspicuous among the facts exhibited are the stupendous single-wire mileage of the commercial telephone and telegraph systems, the millions of messages annually carried over the wires, the almost incredible growth of the telephone system as compared with the telegraph, the large capitalisation of the companies concerned, and the enormous sums expended by them ; and the difficult development of the wireless system. The first table relates to the telegraph systems and is a summary, by classes. The total number of systems is given as 1,813, of which 25 are commercial land line and ocean cable, six wireless, and 625 railroad telegraph systems, the remainder not being involved in the topics treated of herein. The 25 commercial land line and ocean cable systems operated 1,577,961 miles of single wire, employed an average of 28,034 persons, paid £3,561,650 in salaries and wages, expended £8,375,922 earned, £10,316,773, and sent 103,794,076 messages. The 625 railroad telegraph systems operated 860,342 miles of single wire, employed an average of 68,197 telegraph operators and dispatchers, expended £7,448,495, sent 264,512,816 messages, of which 5,923,483 were of a commercial nature, the income for which is reported by the commercial systems.

Another table shows that there was a grand total of 15,072,220 miles of single wire in the telegraph and telephone service. Of this, the telephone systems controlled 12,999,369 miles, of which there were on pole or roof lines 5,092,223, in overhead cables 2,917,114, in subways or conduits 4,969,302, and in submarine cables 20,730 miles. Of the grand total stated, the telegraph systems, exclusive of Government telegraph systems, used 2,072,851 miles, of which there were on pole or roof lines 1,958,336 miles, in overhead cables 41,886, in subways or conduits 65,247, and in submarine cables 7,382 miles. These figures emphasise the economic importance of the telegraph and the telephone.

A comparative summary deals with the telephone and commercial telegraph systems, not including railroad lines and the wireless, giving the grand total as 22,996 companies, of which there are 22,971 telephone systems, which include 17,702 independent farmer or rural lines, and 25 commercial telegraph systems, not including the wireless. The grand total of single-wire mileage was 14,570,142, of which the telephone systems controlled 12,999,369 miles, which include 486,294 miles of wire on independent farmer or rural lines, while the telegraph systems used 1,570,773 miles, exclusive of 7,188 miles of leased wire.

The grand total of ocean cable was 46,301 nautical miles, all controlled by the commercial telegraph systems.

There were six commercial wireless telegraph systems, having 122 tower stations in 1907, situated at most of the large ports on the Atlantic and Pacific oceans, the Gulf of Mexico, the Great Lakes, and in Hawaii. Wireless messages to the number of 163,617 were sent between these ports in 1907. These six companies had an authorised capitalisation in the form of stock with a par value of £7,890,000, of which £6,545,248 was the value of outstanding stock. The year's income was £24,430, and the expenses £33,956, of which £17,514 was expended in the salaries and wages of 182 employes.

It is pointed out that the Federal Government has realised the value of wireless telegraphy, and the Bureau of Equipment in the Navy Department, at the end of the fiscal year 1907, had installed wireless telegraph apparatus on 73 naval vessels and at 44 shore stations. During that period the shore stations sent 26,933 messages, containing 541,919 words, and received 34,073 messages, amounting to 675,607 words. Cape Cod, Mass., led all stations in this respect, sending 2,673 messages, and Cavite, in the Philippine Islands, came next, sending 2,025 messages. Of the number of stations receiving messages, Dry Tortugas, Fla., had 2,703 ; Newport, R.I., 2,701 ; Mare Island, Cal., 2,334 ; Cape Cod, Mass., 2,304 ; Norfolk, Va., 2,171 ; and Cavite, P.I., 2,013. The shore stations are open to the public for messages, and these are also received from or put on the telephone or telegraph land lines.

The Electrical Propulsion of Ships.—At a meeting of the London Association of Foreman Engineers and Draughtsmen on Saturday last Mr. W. P. Durtnall read a Paper on this subject. The author took, as an example, the "Lusitania," and showed that by adopting the electrical drive a saving in steam of no less than 31 per cent. could be obtained, his figures being based on the test figures published in connection with the trials of that vessel—viz., 12·77 lb. per shaft horsepower-hour, and a steam consumption of 11 lb. per kilowatt hour for the five 10,480 kw. turbo-alternators which he would propose to instal, whilst two 8,188 H.P. induction motors, having an efficiency of 93 per cent., would be used on each propeller shaft. In addition to the above saving in fuel he estimated an equivalent reduction in boilers, stokers, pumps, fans, bunkers, &c. Further, the author stated that quotations he had obtained from manufacturing firms showed that the total weight of the machinery was, if anything, slightly in favour of the electrically driven ship. Mr. Durtnall also referred to the use of internal combustion engines for marine purposes, and mentioned that in the near future he hoped to to able to publish some tests on a 500 H.P. vessel to be equipped with the "Paragon" system of electric propulsion in combination with suction gas plant.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fortieth issue of the Supplement will be published (Gratis) with the number of "THE ELECTRICIAN" for Sept. 17.

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THE "THEROL" ELECTRIC WATER HEATER.

The introduction of the "Therol" electric water heater by Messrs. Spagnoletti is of more than usual interest, as it involves the new idea of heat storage in electric heating. One of the difficulties hitherto has been the fact that if water is to be heated rapidly a comparatively large current is necessary. In the "Therol" heater this difficulty is overcome by storing the heat in a block of iron which is cast round a spiral tube and carefully lagged. Thus, if only a small amount of power, say 200 watts, is used continuously for heating the iron, the heat produced is stored until hot water is required. When that is the case, the cold water is drawn through the spiral, and as this, through prolonged heating, may be at a much higher temperature than that of boiling water, hot water is at once obtained, and may be drawn continuously until the temperature of the iron block is so far reduced that it cannot supply heat quickly enough to maintain the temperature of the water at what the householder may regard as "hot."

It will, of course, be obvious that the total energy required for heating a given quantity of water is not less than by the older methods. Indeed, it may be somewhat greater, due to radiation losses. But whereas the "geysers" so far produced—whether heated electrically or by gas is immaterial—cannot give a quick flow of really hot water

unless the current or gas supplied to them is considerable, the "Therol" heater is able to supply a comparatively large quantity of really hot water owing to the reserve of heat energy which it contains. Moreover, this result is obtained with a small current, the power required for a heater giving 25 gallons per day being only 200 watts. The fact remains, however, that the total energy required must be the same, and that the consumer will have to pay for the same number of units as hitherto, though his maximum demand will be reduced. Further, the heater must be rather carefully proportioned to the requirements of the consumer.

But this reduction in the maximum demand, and consequently the improved load factor, is an important achievement, and upon this Messrs. Spagnoletti have based a scheme which should prove attractive to the central station engineer. A heater of the kind described has a 100 per cent. load factor, and therefore should be supplied with electricity at a cheap rate; but under ordinary conditions this could not be done except on a special circuit, and this would introduce one of the standing difficulties at present in the way of a cheap supply. Messrs. Spagnoletti propose to overcome this trouble by proportioning the heater to the other electrical needs of the house. Thus, if the heater is so connected up that it is automatically cut out of circuit when light is required, then the load can be maintained more or less constant. If a heater is made with, say, 10 coils, and these are connected so that they can be switched out as desired, then if electrical energy is required for any other purpose at any time, a certain number of coils are switched out and the required fan, griller or lamps, as the case may be, are switched on in their place. For the supply of hot water recourse is had to the heat stored in the iron, and the load on the supply mains is maintained constant.

It must be remembered that very cheap energy is essential for the electric heating of water to be commercial. For an electric method to compete with heating by coal in an average house a price as low as even ½d. per unit would be too high unless there were some other advantage to be gained. But if, as outlined above, light can be worked in with heating to give a really high load factor, the cost of lighting (to the consumer) may be reduced to so low a figure that it is economical to spend more on heating water than would otherwise be the case.

The question remains, Is the scheme quite feasible? And the answer to such a question is not altogether easy. To begin with, popular fad and fancy have a bearing on the matter, and one never knows quite where popular prejudice may come in. Then much depends on the station engineer. If he does not trouble to encourage such a scheme it will not thrive, because a cheap tariff is essential to its existence. Further, it may not be altogether easy to adjust the lighting and other requirements of a consumer to those of his water supply. We do not know what relation there is between the two, and this would have to be determined. We think it will be allowed that 25 gallons per day is a very small allowance, except, perhaps, for a small flat. If too small a heater is put in, a 100 per cent. load factor will not be obtained; on the other hand, if the heater is too large, there will be waste of heat, and the capital outlay may also be a deterrent. Further, unless a consumer wants more hot water in summer than in winter he will be wasting energy if the full load is maintained. If, for example, the consumer goes in for heating his house electrically to some extent, a 100 per cent. load factor can scarcely be expected, and it will fall off very much in the summer.

Nevertheless, we think there is no question that the "Therol" heater is a move in the right direction. We are sure that its progress will be watched with much interest by the station engineer, and we trust that this interest will take the practical form of arranging suitable tariffs.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electricity: Present and Future. By LUCIEN POINCARÉ. Translated by JASPER KEMMIS. (London: Sisley's Ltd.) Pp. viii.-308. 7s. 6d. net.

The author in his preface mentions that he does not propose to tread beaten paths, or to write a book suitable only for experts, nor yet for beginners in their first stage. His purpose is rather to address himself "to that intelligent class, so widespread nowadays, which takes a genuine interest in the advance of modern science, and to place before it as accurate a picture as possible of the existing condition of electricity." Later on the author mentions that he desires to draw attention to the steps traversed in the path of progress by the physicist, and by which the latter has been brought face to face with so many difficult problems.

The book starts with a purely physical consideration of magnetism and the induction of the electric current, which are discussed in two chapters. The author then, in the five following chapters, passes on to technical applications. The account that is given, more particularly in the physical part, is interesting, though here and there the reader may, perhaps, disagree with the author. Thus, the "field in iron" is spoken of where it is usual to speak of the "induction." The year 1891 is mentioned as the beginning of alternating currents. In this country, at all events, we should be inclined to say that alternating currents were in vigorous use before that time, though, doubtless, long transmissions date from the Lauffen experiments in 1891. Later on in the book the statement is made that alternating currents were only rarely used 15 years ago, and again that towards 1897 a change of opinion arose in favour of alternating currents for transmission. In speaking of different methods of charging accumulators the unusual statement is made that the constant potential system is more rational than charging with constant current and lengthens the life of the plates.

Generally speaking, the translation appears to have been well done, but at times one is inclined to think that the translator has not fully appreciated the meaning of the author. To those who object to them, the split infinitives will prove annoying. Also several names, whether due to the original or the translation it is impossible to say, are incorrectly spelt. For example, Fresnal, Swyngedaun, Birkland and Claudius; and one is a little surprised at the present day to read of *Herr* Steinmetz. We presume that Mrs. Ayrton is intended when referring to researches on electric arcs, and not the late Prof. Ayrton.

After reading through the book one is a little puzzled to understand for whom it has been written, notwithstanding the author's preface. The work is interesting, more particularly in the purely physical part, and this part may prove useful; but when we come to the technical part there seems to be very little use in talking in a general way about the theory of polyphase motors and such like matters. No diagrams are given and there is no mathematical treatment. Consequently, for the elementary student, this part of the book is not of any value. On the other hand, for the engineer who knows anything about such matters, very little, if anything, is gained by reading these pages.

From the title we expected some interesting speculations in regard to the future of electricity, theoretical and applied. This part of the subject, however, is not touched upon until the last chapter of the book, and as this chapter only consists of about five pages, there is not much object in bringing the "future of electricity" into the title of the book.

Die Elektrischen Eigenschaften und die Bedeutung des Selens fur die Elektrotechnik. By Dr. CHR. RIES. (Berlin: "Der Mechaniker.") Pp. 92. M.3.

The various modifications of selenium, with their crystalline forms and chemical and photoelectric properties are well set forth in this useful little book. The selenium cells hitherto constructed are divided into two classes, in one of which the current flows in a direction normal to the light rays, while it is parallel to them in the other. The former type includes the Siemens, Bidwell, Ruhmer, Bell, Mercadier, Liesegung, and Righi patterns, while the cells devised by Fritt, Uljanin, Sabine (electrolytic), and Righi's wire-net cell belong to the second type. The author deals effectively with the temperature-coefficient of the conductivity, the photoelectric after-effect and inertia, and the variation of the photoelectric sensitiveness with the intensity and colour of the light. The various theories hitherto propounded are all dismissed as unsatisfactory, and no new theory is put forward. When that is done next, it will no doubt start with the question of ionisation, and link up the phenomena with the effect of light on zinc or sodium. A valuable part of the book is the collection of some 200 references to the literature, including Berzelius' original discovery (1817) and Smith's announcement of the change of resistance with illumination (1873), discovered, it is well to remember, at the Valentia Island cable station during some insulation experiments. Of technical applications we find references to photometry, automatic day and night actions, phototelephony, and the transmission of pictures and sight by wire. The transmission of drawings is well illustrated by some of Korn's remarkable work. A little-known application relates to the photometry of total solar eclipses. By means of a selenium cell, it has been found possible to register the occurrence of totality to within 0·001 sec., and to deduce valuable conclusions with regard to the path of the moon. The addition of 0·1 per cent. of silver, which acts as a catalyser, increases the speed of reaction and enables us to go down to over 2,000 pulses per second. The book is a timely and useful production.

E. E. F.

Die Kraftfelder. By Prof. V. BJERKNES. Part XXVIII. of "Die Wissenschaft. Brunswick: Fr. Vieweg & Sohn.) Pp. xvi. 173. M.7.

Of the various attempts at formulating a mechanical theory of electrical phenomena, those involving the conception of an incompressible fluid are, on the whole, the most promising. If they serve no other purpose, they give us, at all events, several suggestive analogies which enable us to visualise the internal happenings accountable for some apparent actions at a distance. Euler and Kelvin worked out some analogies in which the motion of the incompressible fluid is steady. The present author's father, C. A. Bjerknes, obtained some remarkable results by dealing with vibratory motions, which, he found, simulated electric and magnetic attractions and repulsions. In the present work both these sets of analogies are deduced in a simple and elegant manner, the necessary vector algebra being prefaced in a special chapter, which adopts the notations of Heaviside and Gibbs. The experimental treatment of these problems is still in its infancy, but the author gives a number of simple experiments which corroborate the theoretical results, qualitatively at least. Among these, the experiments showing the kinetic impulsion ("kinetischer Auftrieb") are of special interest, as showing that any liquid in a state of acceleration is a "field of force" with respect to bodies of different density immersed in it. If the body has a density less than the liquid, it is urged forward through the liquid in the direction of the acceleration. But should not the word "Antrieb" have been substituted for "Auftrieb"? The latter means an upward force, such as figures in the principle of Archimedes, whereas an "Antrieb" would be a force urging the body in any direction. The author devotes a final chapter to fields of force in media possessing gyrostatic properties. It is only such media which can have a reaction to torsion free from deformation. They are necessary to a complete theory of light. But, unfortunately, we have no physical examples of such media. Speaking generally, indeed, it can hardly be said that the last 10 years have brought us perceptibly nearer a mechanical interpretation of electrical phenomena. In hydrodynamics, the signs come out uniformly opposite to the signs of the electromagnetic forces. But the present work is valuable as a full statement of what has so far been accomplished in this fascinating research.

E. E. F.

"ENGINEERING DAY" AT THE IMPERIAL INTERNATIONAL EXHIBITION.

Last Saturday marked a somewhat unusual event in the world of engineering, namely, a gathering at the Imperial International Exhibition, Shepherd's Bush, London, of representative members of the various branches of the engineering profession. Considerable interest had been aroused amongst engineers from the time when the suggestion to hold an "Engineering Day" was first brought forward, and it is to be regretted that the weather on Saturday last was so unpropitious. Nevertheless, judging from the large number of visitors who throughout the afternoon faced the elements and inspected the various engineering features of the Exhibition, many technical societies were well represented, and there is no doubt that the congress was a great success, as may be partly gathered from the fact that the attendance at the banquet in the evening numbered about 250.

The proceedings opened in the Congress Hall of the Exhibition at about 2:45 p.m., when Mr. Alph Steiger delivered a lecture on "Water Power and Turbines," Mr. W. B. Bryan presiding. The lecturer instanced the installations at Loch Leven and of the North Wales Power Company as proving the inaccuracy of the statement frequently heard that we have no facilities for employing water power in this country. As a matter of fact the United Kingdom possessed no less than 1,000,000 B.H.P. in the way of natural water power, and this could be developed at a total capital cost of from £30,000,000 to £40,000,000, or, say, £40 per brake horse power. He agreed that this was a large expenditure, but the possibilities of thereby bringing about great economies in several industries justified the capital outlay, and there would be, he had no doubt, little difficulty in laying down many water power installations. As an instance of the importance of such developments, he mentioned the iron and steel industry. The product of the electric furnace was greatly superior to that obtained by other methods, and from this point of view alone, if we were to compete successfully with other countries, it was important to develop what water power we possessed. Canals, foundations and the pipe line accounted for the greater part of the capital outlay, and these parts of the equipment only required a very small outlay for depreciation as compared with that necessary in the case of machinery. As illustrating the economy in running costs, he estimated that the cost per unit for a water power plant would be only one-third that of a steam plant, assuming a 12-hour working day. The lecturer then proceeded to describe the Pelton wheel, which is specially adapted for high falls, and gives excellent results with falls of from 100 ft. to 3,000 ft.; and as any diameter of wheel can be employed, owing to the water only being applied at certain points on the circumference, the Pelton wheel proves very convenient from the point of view of choice of speed. In Switzerland Pelton wheels have been constructed and installed in sizes up to 7,000 H.P. or 8,000 H.P., instances of such installations being mentioned by the lecturer. In this country, however, our water power is distributed in the form of a number of small falls.

Papers presented to the Institute of Marine Engineers were the next items on the programme. These consisted of one by Mr. J. McLaren on "The Extended Uses of Electricity on Board Ship," and "The Treatment of Marine Boilers on Long Voyages," by Mr. H. Ruck Keen, the chairman during the reading of both Papers being Sir Fortescue Flannery. The Paper by Mr. McLaren was of great interest to electrical engineers, the author advocating the driving of all auxiliary machinery on board ship by electric motors, and also the employment of electricity for heating and cooking purposes. An abstract of this Paper will be found on page 860 of the present issue. The second Paper was, of course, mainly of interest to marine engineers.

During the interval for tea the Lord Mayor of London, Sir George Wyatt Truscott, who had taken great interest in the arrangements, held a reception on the terrace of the Imperial Tower. Attention was, however, again soon concentrated in the Congress Hall, Mr. P. R. Allen's name being in the programme for a lecture on "Large Gas Engines," on which subject he is, of course, well qualified to speak. Mr. Dugald Clerk presided and made a few introductory remarks, which were listened to with interest. The secretary of the joint organising committee then read Mr. Allen's lecture, which was illustrated by a large number of lantern slides. Further reference to this lecture will be made in our next issue.

The audience in the Congress Hall showed great appreciation of the next lecture, which was by Mr. T. R. Ablett, director of the Royal Drawing Society. The subject was "Snap-Shot Drawing for Engineers and Architects," and the lecturer was introduced by Sir John Cockburn, who presided. Mr. Ablett drew attention to the importance of developing the power of being able to sketch the general appearance of a scene or object from memory, and the examples of work done by his pupils of ages from 3 to 14 years were certainly marvellous. In this connection he showed how important it was to train the pupils to be unbiased observers. The lecturer showed the importance to engineers of being able to sketch from memory the general outlines of a piece of machinery, and he drew attention to the fact that when an object can be drawn well, it usually means that its construction is well understood. The last lecture was on "The Simplest Perspective Drawing of Machinery," and was by Mr. C. A. Ablett, the chairman being Mr. J. P. Maginnis.

Throughout the afternoon parties of visitors were conducted, at intervals of a quarter of an hour, to inspect the construction and operating mechanism of the various side-shows of the Exhibition, and also various power plants and the substation in connection with the electrical power supply. These installations have been described in our columns on previous occasions, and further reference is unnecessary; but we may mention that much interest was taken by the visitors, amongst whom were many ladies, in the various plants. Demonstrations and exhibits in the Machinery Hall also attracted considerable attention.

At the conclusion of the last lecture mentioned above the members adjourned to the Garden Club Banqueting Hall, where the programme for the day was brought to a very successful conclusion by a banquet, at which, as mentioned before, the company numbered about 250. After the customary loyal toasts, the Hon. A. Stanley, M.P., who presided, proposed the toast of "Engineering," mentioning that the present year had witnessed the most interesting engineering developments of the present age. He considered that there was not the slightest doubt the British engineer was holding his own in every part of the world. The toast was seconded by Mr. W. Worby Beaumont, and supported by Mr. F. S. Courtney and Mr. J. W. Orde. Other toasts were "Mining and Metallurgy," "Architecture and Building," and "The Press."

There seemed to be a general desire that an annual gathering of kindred engineering societies should take place, and the success—both technical and social—of the present congress should prove very gratifying to the organising committee.

THE DISTRIBUTION OF DIELECTRIC STRESS IN THREE-PHASE CABLES.*

BY PROF. W. M. THORNTON, D.SC., D.ENG., AND O. J. WILLIAMS, B.SC.

(*Concluded from page 834.*)

The following diagrams (Fig. 4) were prepared by projecting the photographs upon large sheets of drawing paper and sketching in the lines by hand. The curves were then inked in, and occasional missing lines interpolated. The diagrams were then traced, and the tracings reduced by photography to the given figures.

Although great care was taken in preparing the waxed plates and in adjusting the flow, it is too much to hope that the diagrams represent the electrical state exactly everywhere, especially where a line is on the point of changing its end from one conductor to another. It will be seen by a comparison of Figs. 4 and 6 that in general, where the change over takes place, the stress in the dielectric differs greatly within a small distance on one conductor or the other.

The case represented is that of a high-tension cable with wrapping and filling of the same dielectric constant. It corresponds most nearly in practice with the extra high-pressure cable for 6,600 volts;

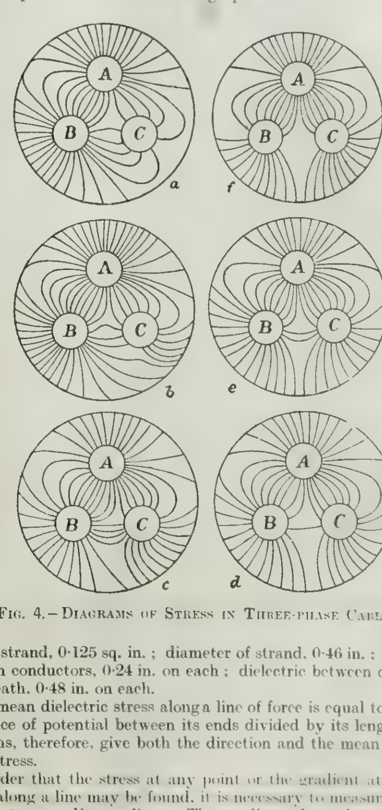

FIG. 4.—DIAGRAMS OF STRESS IN THREE-PHASE CABLES.

area of strand, 0·125 sq. in.; diameter of strand, 0·46 in.; dielectric between conductors, 0·24 in. on each; dielectric between conductor and sheath, 0·48 in. on each.

The mean dielectric stress along a line of force is equal to the total difference of potential between its ends divided by its length. The diagrams, therefore, give both the direction and the mean intensity of the stress.

In order that the stress at any point or the gradient at different points along a line may be found, it is necessary to measure the distance between adjacent lines. The gradient along the centre line MN in Fig. 5 is inversely proportional to the distances *a*, *b*, *c*, *d*, and to find the exact stress at any point along it the average stress must first be found—that is, V_{MN}/L denoted by w in the diagram; at *cd*, for example, the stress per inch $\frac{S}{cd}w$ where S is the mean space of the lines apart. As in all cases where circular conductors are used, the stress is greatest at the circumference of the conductor.

The figures *a* to *f*, Fig. 4, show how the stress changes during the cycle. The following Tables I. to VI. give the mean stress along lines starting at equal distances apart around each conductor. The zero of the angular measurements was in each case the line joining the centre of the conductor to the centre of the cable. The angles were measured left-handed from this.

* Paper read before the British Association at Winnipeg.

Table I.

Angle.		A.			B.			C.	
		−4,660			+4,660			Nil	
		L.	v.		L.	v.		L.	v.
0	B	0·565	16,500	A	0·548	17,000	...	0·511	9,100
10	B	0·692	13,450	A	0·495	18,800	B	0·511	9,100
20	B	0·847	11,000	A	0·475	19,600	B	0·511	9,100
30	C	0·500	9,500	A	0·473	19,700	B	517	9,000
40	C	0·552	8,400	A	0·485	19,200	B	536	8,700
50	C	0·665	7,000	A	0·512	18,200	B	561	8,300
60	C	0·847	5,500	A	0·582	16,000	B	612	7,600
70	S	1·04	4,450	A	0·734	12,700	B	716	6,500
80	S	1·04	4,450	A	0·932	10,000	B	832	5,600
90	S	0·93	5,000	A	1·330	7,000	B	877	5,300
100	S	0·692	6,750	S	0·776	6,000	B	970	4,800
110	S	0·621	7,500	S	0·707	6,600	B	1·081	4,300
120	S	0·586	8,000	S	0·666	7,000	B	1·165	4,000
130	S	0·53	8,800	S	0·613	7,600	B	1·26	3,700
140	S	0·496	9,400	S	0·582	8,000	B	1·33	3,500
150	S	0·475	9,800	S	0·555	8,400	B	1·45	3,200
160	S	0·471	9,900	S	0·530	8,800	B	1·55	3,000
170	S	0·466	10,000	S	0·586	9,600	B	1·63	2,850
180	S	0·466	10,000	S	0·486	9,600	...	...	...
190	S	0·485	9,600	S	0·49	9,500	A	1·55	3,000
200	S	0·507	9,200	S	0·496	9,400	A	1·50	3,100
210	S	0·53	8,800	S	0·512	9,100	A	1·37	3,400
220	S	0·575	8,100	S	0·532	8,750	A	1·26	3,700
230	S	0·617	7,550	S	0·569	8,200	A	1·15	4,050
240	S	0·665	7,000	S	0·614	7,600	A	1·034	4,500
250	S	0·764	6,100	S	0·666	7,000	A	0·950	4,900
260	S	0·818	5,700	S	0·832	5,600	A	0·847	5,500
270	B	1·33	7,000	C	1·08	4,300	A	0·776	6,000
280	B	0·912	10,200	C	1·33	3,500	A	0·716	6,500
290	B	0·688	13,550	C	1·45	3,200	A	0·621	7,500
300	B	0·561	16,600	C	1·33	3,500	A	0·575	8,100
310	B	0·50	18,600	C	1·035	4,500	A	0·561	8,300
320	B	0·48	19,450	C	0·666	7,000	A	0·541	8,600
330	B	0·47	20,000	C	0·536	8,700	A	0·536	8,700
340	B	0·48	19,450	C	0·44	10,600	A	0·536	8,700
350	B	0·492	18,900	A	0·745	12,500	A	0·517	9,000

$V_{AB}=9,320$, $V_{AC}=4,660$, $V_{BC}=4,660$.
$V_{AS}=4,660$, $V_{BS}=4,660$, $V_{CS}=0$.

Table II.

Angle.		A.			B.			C.	
		−4,828			+4,278			+550	
		L.	v.		L.	v.		L.	v.
0	B	0·612	14,900	A	0·53	17,200	A	0·537	10,000
10	C	0·476	11,300	A	0·474	19,200	A	0·585	9,200
20	C	0·489	11,000	A	0·472	19,300	A	0·618	8,700
30	C	0·497	10,800	A	0·472	19,300	B	0·472	7,900
40	C	0·549	9,800	A	0·474	19,200	B	0·472	7,900
50	C	0·70	7,700	A	0·490	18,600	B	0·478	7,800
60	C	1·12	4,800	A	0·527	17,300	B	0·485	7,700
70	S	1·15	4,200	A	0·570	16,000	B	0·533	7,000
80	S	0·976	4,900	A	0·696	13,100	B	0·583	6,400
90	S	0·805	6,000	A	0·94	9,700	B	0·622	6,000
100	S	0·69	7,000	A	1·26	7,200	B	0·69	5,400
110	S	0·644	7,500	S	0·714	6,000	B	1·24	3,000
120	S	0·604	8,000	S	0·68	6,300	S	0·393	1,400
130	S	0·561	8,600	S	0·603	7,100	S	0·50	1,100
140	S	0·530	9,100	S	0·516	8,300	S	0·55	1,000
150	S	0·514	9,400	S	0·496	8,800	S	0·612	900
160	S	0·498	9,700	S	0·474	9,030	S	0·688	800
170	S	0·478	10,100	S	0·472	9,080	S	0·688	800
180	S	0·478	10,100	S	0·472	9,080	S	0·688	800
190	S	0·493	9,800	S	0·474	9,030	S	0·688	800
200	S	0·503	9,600	S	0·476	9,000	S	0·688	800
210	S	0·514	9,400	S	0·484	8,850	A	0·598	900
220	S	0·537	9,000	S	0·498	8,600	A	0·538	1,000
230	S	0·575	8,400	S	0·510	8,400	A	1·25	4,300
240	S	0·628	7,700	S	0·535	8,000	A	1·07	5,000
250	S	0·70	6,900	S	0·612	7,000	A	0·945	5,700
260	S	0·847	5,700	S	0·750	5,700	A	0·83	6,500
270	B	1·57	5,800	S	0·950	4,500	A	0·648	7,100
280	B	1·01	9,000	S	1·22	3,500	A	672	8,000
290	B	0·74	12,300	S	1·29	3,300	A	612	8,800
300	B	0·62	14,700	C	0·83	4,500	A	549	9,800
310	B	0·503	18,100	C	0·533	7,000	A	512	10,500
320	B	0·467	19,500	A	0·910	10,000	A	0·494	10,900
330	B	0·455	20,000	A	0·868	10,500	A	0·472	11,400
340	B	0·467	19,500	A	0·735	12,400	A	0·489	11,000
350	B	0·490	18,600	A	0·723	12,600	A	0·507	10,600

$V_{AB}=9,106$, $V_{AC}=5,378$, $V_{BC}=3,728$.
$V_{AS}=4,828$, $V_{BS}=4,278$, $V_{CS}=550$.

Table III.

Angle.		A.			B.			C.	
		−5,047.			+3,943.			+1,104.	
		L.	v.		L.	v.		L.	v.
0	B	0·666	13,500	A	0·697	12,900	A	0·56	11,000
10	B	0·692	13,000	A	0·576	15,600	A	0·662	9,300
20	C	0·55	11,200	A	0·480	18,700	B	0·50	5,700
30	C	0·488	12,600	A	0·473	19,000	B	0·48	5,900
40	C	0·534	11,500	A	0·477	18,800	B	0·517	5,500
50	C	0·641	9,600	A	0·505	17,800	B	0·615	4,400
60	C	1·02	6,000	A	0·562	16,000	B	0·73	3,900
70	C	1·23	5,100	A	0·642	14,000	B	0·812	3,500
80	S	1·0	5,100	A	0·749	12,000	S	0·69	1,600
90	S	0·87	5,800	A	0·900	10,000	S	0·65	1,700
100	S	0·72	7,000	A	1·20	7,500	S	0·65	1,700
110	S	0·640	7,900	S	0·73	5,400	S	0·65	1,700
120	S	0·574	8,800	S	0·692	5,700	S	0·614	1,800
130	S	0·549	9,200	S	0·580	6,800	S	0·552	2,000
140	S	0·513	9,850	S	0·519	7,600	S	0·502	2,200
150	S	0·495	10,200	S	0·493	8,000	S	0·48	2,300
160	S	0·481	10,500	S	0·487	8,100	S	0·48	2,300
170	S	0·472	10,700	S	0·487	8,100	S	0·48	2,300
180	S	0·481	10,500	S	0·487	8,100	S	0·502	2,200
190	S	0·495	10,200	S	0·506	7,800	S	0·552	2,000
200	S	0·504	10,000	S	0·526	7,500	S	0·602	1,830
210	S	0·532	9,500	S	0·556	7,100	S	1·65	1,700
220	S	0·561	9,000	S	0·580	6,800	A	1·54	4,000
230	S	0·609	8,300	S	0·616	6,400	A	1·25	4,900
240	S	0·674	7,500	S	0·668	6,000	A	1·12	5,500
250	S	0·72	7,000	S	0·730	5,400	A	0·99	6,200
260	S	0·732	6,900	S	0·822	4,800	A	0·88	7,000
270	B	1·2	7,500	S	0·963	4,100	A	0·82	7,500
280	B	0·873	10,300	S	1·04	3,800	A	0·74	8,300
290	B	0·670	13,400	S	1·06	3,700	A	0·654	9,400
300	B	0·572	15,700	C	0·748	3,800	A	0·56	11,000
310	B	0·523	17,200	C	0·710	4,000	A	0·50	12,300
320	B	0·488	18,400	C	0·580	4,900	A	0·485	12,700
330	B	0·480	18,700	A	1·47	6,100	A	0·48	12,800
340	B	0·50	18,000	A	0·856	10,500	A	0·485	12,700
350	B	0·573	15,700	A	0·676	13,300	A	0·516	11,900

$V_{AB}=8,990$, $V_{AC}=6,151$, $V_{BC}=2,839$.
$V_{AS}=5,047$, $V_{BS}=3,943$, $V_{CS}=1,104$.

Table IV.

Angle.		A.			B.			C.	
		−5,207.			+3,565.			+1,642.	
		L.	v.		L.	v.		L.	v.
0	B	0·627	14,000	A	0·605	14,500	A	0·535	12,800
10	C	0·49	14,000	A	0·504	17,400	A	0·586	...
20	C	0·48	14,250	A	0·48	18,250	A	0·685	10,000
30	C	0·476	14,400	A	0·48	18,250	A	0·90	7,600
40	C	0·504	13,600	A	0·501	17,500	B	0·506	3,800
50	C	0·596	11,500	A	0·542	16,200	B	0·62	3,100
60	C	0·737	9,300	A	0·589	14,900	S	0·747	2,200
70	C	0·966	7,100	A	0·67	13,100	S	0·781	2,100
80	C	1·37	5,000	A	0·77	11,400	S	0·715	2,300
90	C	1·71	4,000	A	0·964	9,100	S	0·657	2,500
100	S	1·0	5,200	A	1·25	7,000	S	0·609	2,700
110	S	0·744	7,000	S	0·714	5,000	S	0·587	2,800
120	S	0·628	8,300	S	0·66	5,400	S	0·548	3,000
130	S	0·548	9,500	S	0·594	6,000	S	0·53	3,100
140	S	0·52	10,200	S	0·532	6,700	S	0·514	3,200
150	S	0·483	10,800	S	0·51	7,000	S	0·50	3,300
160	S	0·474	11,000	S	0·495	7,200	S	0·50	3,300
170	S	0·470	11,100	S	0·488	7,300	S	...	3,200
180	S	0·470	11,100	S	0·475	7,500	S	0·53	3,100
190	S	0·470	11,100	S	0·488	7,300	S	0·548	3,000
200	S	0·470	11,100	S	0·502	7,100	S	0·548	3,000
210	S	0·491	10,600	S	0·51	7,000	S	0·53	3,100
220	S	0·520	10,000	S	0·524	6,800	A	1·85	3,700
230	S	0·566	9,200	S	0·575	6,200	A	1·49	4,600
240	S	0·643	8,100	S	0·625	5,700	A	1·25	5,500
250	S	0·745	7,000	S	0·70	5,100	A	1·09	6,300
260	S	0·869	6,000	S	0·76	4,700	A	0·98	7,000
270	B	1·25	7,000	S	0·85	4,200	A	0·835	8,200
280	B	0·976	9,000	S	0·892	4,000	A	0·745	9,200
290	B	0·798	11,000	S	0·94	3,800	A	0·658	10,400
300	B	0·645	13,600	S	0·964	3,700	A	0·596	11,500
310	B	0·626	14,000	C	0·534	3,600	A	0·535	12,800
320	B	0·552	15,900	C	0·481	4,000	A	0·497	13,800
330	B	0·472	18,600	C	0·47	4,100	A	0·483	14,200
340	B	0·487	18,000	A	0·9	9,700	A	0·489	14,000
350	B	0·548	16,000	A	0·655	13,400	A	0·511	13,400

$V_{AB}=8,772$, $V_{AC}=6,849$, $V_{BC}=1,923$.
$V_{AS}=5,207$, $V_{BS}=3,565$, $V_{CS}=1,642$.

Table V.

Angle.	A			B.			C.		
	−5,350			+3,161			+2,189		
		L.	v.		L.	v.		L.	v.
0	B, C	0·728	11,700	A	0·549	15,500	A	0·538	14,000
10	C	0·644	11,700	A	0.504	16,900	A	0·58	13,000
20	C	0·493	15,300	A	0·495	17,200	A	0·672	11,200
30	C	0 483	15,600	A	0·50	17,000	B	0·55	1,770
40	C	0·50	15,100	A	0·529	16,100	B	0·65	1,450
50	C	0·524	14,400	A	0·568	15,000	S	0·466	4,700
60	C	0·628	12,000	A	0·63	13,500	S	0·706	3,100
70	C	0 828	9,100	A	0·74	11,500	S	0·84	2,600
80	C	1·21	6,200	A	0·915	9,300	S	0·84	2,600
90	C	1·25	6,000	A	1·21	8,000	S	0·783	2,800
100	S	0·80	6,700	A	1·71	5,000	S	0·884	3,200
110	S	0·734	7,300	S	0·77	4,100	S	0·576	3,800
120	S	0·621	8,600	S	0·702	4,500	S	0·534	4,100
130	S	0·535	10,000	S	0·62	5,100	S	0·498	4,400
140	S	0·486	11,000	S	0·554	5,700	S	0·486	4,500
150	S	0·482	11,100	S	0·518	6,100	S	0·476	4,600
160	S	0·479	11,600	S	0·486	6,500	S	0·474	4,620
170	S	0·475	11,200	S	0·472	6,700	S	0·472	4,640
180	S	0·472	11,200	S	0·472	6,700	S	0·472	4,640
190	S	0·475	11,200	S	0·486	6,500	S	0·476	4,600
200	S	0·479	11,600	S	0·50	6,300	S	0·510	4,300
210	S	0·482	11,100	S	0·526	6,000	S	0·548	4,000
220	S	0·52	10,300	S	0·563	5,600	S	0·625	3,500
230	S	0·558	9,600	S	0·618	5,100	S	0·73	3,000
240	S	0·63	8,500	S	0·644	4,900	S	0·811	2,700
250	S	0·704	7,600	S	0·716	4,400	S	0·925	2,370
260	S	0·776	6,900	S	0·79	4,000	A	1·50	5,000
270	B	1·29	6,600	S	0·875	3,600	A	1·27	6,000
280	B	1·06	8,000	S	0·955	3,300	A	1·09	6,900
290	B	0·728	11,700	S	1·01	3,100	A	0·83	9,100
300	B	0·596	13,300	S	0·955	3,300	A	0·685	11,000
310	B	0·571	14,900	S	0·91	3,500	A	0·598	12,600
320	B	0·50	17,000	C	0·65	1,450	A	0·550	13,700
330	B	0·478	17,800	C	0·55	1,770	A	0·520	14,500
340	B	0·497	17,100	A	0·80	10,650	A	0·506	14,900
350	B	0·608	14,000	A	0·64	13,300	A	0·512	14,750

V_{AB} = 8,511, V_{AC} 7,539, V_{BC} −972.
V_{AS} = 5,350, V_{BS} 3,161, V_{CS} = 2,189.

Table VI.

Angle.	A.			B.			C.		
	−5,380			+2,690			+2,690		
		L.	v.		L.	v.		L.	v.
0	C	0·727	11,100	A	0·524	15,400	A	0·524	13,400
10	C	0·607	13,300	A	0·502	16,100	A	0·557	14,500
20	C	0·514	15,700	A	0·480	16,800	A	0·62	13,000
30	C	0·480	16,800	A	0·480	16,800	...	...	...
40	C	0·483	16,700	A	0·495	16,300	...	...	...
50	C	0·524	15,400	A	0·546	14,800	...	...	...
60	C	0·673	12,000	A	0·630	12,800	...	...	...
70	C	0·807	10,000	A	0·754	10,700	...	...	...
80	C	1·02	7,900	A	0·923	8,750	S	0·77	3,500
90	C	1·15	7,000	A	1·15	7,000	S	0·718	3,750
100	S	0·84	6,400	S	0·90	2,990	S	0·672	4,000
110	S	0·77	7,000	S	0·868	3,100	S	0·625	4,300
120	S	0·708	7,600	S	0·718	3,750	S	0·585	4,600
130	S	0·656	8,200	S	0·64	4,200	S	0·56	4,800
140	S	0·612	8,800	S	0·578	4,650	S	0·538	5,000
150	S	0·573	9,400	S	0·538	5,000	S	0·518	5,200
160	S	0·538	10,000	S	0·508	5,300	S	0·498	5,400
170	S	0·508	10,600	S	0·493	5,400	S	0·489	5,500
180	S	0·480	11,200	S	0·489	5,500	S	0·489	5,500
190	S	0·508	10,600	S	0·489	5,500	S	0·498	5,400
200	S	0·538	10,000	S	0·498	5,400	S	0·508	5,300
210	S	0·573	9,400	S	0·518	5,200	S	0·538	5,000
220	S	0·612	8,800	S	0·538	5,000	S	0·578	4,650
230	S	0·656	8,200	S	0·56	4,800	S	0·64	4,200
240	S	0·708	7,600	S	0·585	4,600	S	0·718	3,750
250	S	0·77	7,000	S	0·625	4,300	A	0·868	3,100
260	S	0·84	6,400	S	0·672	4,000	A	0·90	2,990
270	B	1·15	7,000	S	0·718	3,750	A	1·15	7,000
280	B	1·02	7,900	S	0·77	3,500	A	0·923	8,750
290	B	0·807	10,000	...	...	...	A	0·754	10,700
300	B	0·673	12,000	...	...	...	A	0·630	12,800
310	B	0·524	15,400	...	...	...	A	0·546	14,800
320	B	0·483	16,700	...	...	...	A	0·495	16,300
330	B	0·480	16,800	...	...	...	A	0·480	16,800
340	B	0·514	15,700	A	0·62	13,000	A	0·480	16,800
350	B	0·607	13,300	A	0·557	14,500	A	0·502	16,100

V_{AB} = 8,070, V_{AC} 8,070, V_{BS} 0.
V_{AS} 5,380, V_{BS} = 2,690, V_{CS} 2,690.

The maximum voltage above zero in each phase was 5,380. The voltages at the top of each group of readings in the tables are those above zero. The P.D. between any two conductors is found by adding these algebraically. For example, in the first set, V_{AB} = 9,320. V_{AC} = −4,660. V_{BC} + 4,660. The voltages to the sheath V_{AS} = −4,660, V_{BS} + 4,660, V_{CS} 0.

The letter in each row indicates that conductor upon which a line, starting from the conductor at the head of the column, terminates.

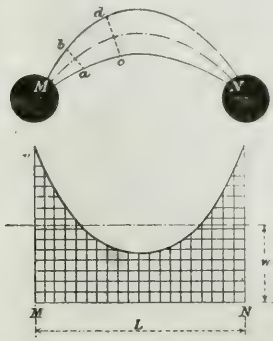

FIG. 5.—CHANGE OF INTENSITY OF STRESS ALONG A LINE OF FORCE.

The length L are those of the actual lines of force in the cable in inches, and the voltage v is the mean gradient in volts per inch along the line starting at the given angular position. For example, at 0 deg. A, Table I., the line goes to B, the total drop of volts along it is 9,320, its length being 0·565 in., the gradient is 16,500 volts per inch. From the tables the mean gradient at any angle can be read off at any point in the cycle, the exact stress at a point between the conductors can then be found, if desired, by measuring the space between adjacent lines, as previously shown in Fig. 5.

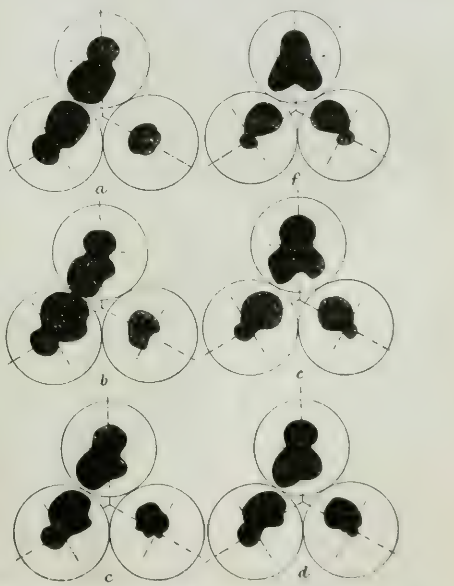

FIG. 6.—POLAR DIAGRAMS OF INTENSITY OF STRESS FROM FIG. 4.

The lengths L given in the tables were obtained by measuring the enlarged photographs and finding the corresponding mean gradient, then drawing the polar curves of Fig. 6. The boundary of these curves is a mean line through the points. Having drawn a fair curve, the gradients v were scaled off and the corresponding

lengths L found. In the tables given below every alternative row of measurements has been omitted.

The dielectric surrounding each conductor carries a stress which, on the whole, rises and falls in a sine wave if the applied voltage is sinuous. The nature of the alternation and the way in which the centre line of intensity of stress in the cable swings round is readily seen by the polar diagrams of Fig. 6 corresponding respectively to the diagrams of Fig. 4 and drawn from Tables I. to VI.

The radius vector of the curve around each conductor is the mean stress along the line, starting from the surface of the conductor in that direction. The feature of these polar curves is the very sharp manner in which the mutual action of the charges on conductors and sheath is developed around the surface of the conductors, suggesting harmonic disturbance there—at least, in the interpolar space. This is more fully illustrated by drawing curves of change of intensity of stress at various angles during the period, as in Fig. 7. In the first diagram of Fig. 4 the conductors A and B are at equal potentials above and below zero, and C is at zero. As the pressure on C rises the stress in the medium rapidly increases in the neighbourhood of the line joining the centres of A and C, and, to a less extent, of B and C; and by a transition which is readily followed in the diagram the stress between A and B falls, whilst that between A and C rises, until it is equal to the former. During a period these states occur, so far as the conductor A is concerned, in the order *a, b, c, d, e, f*, followed by *e, d, c, b, a*, but with the diagrams reversed. Thus, if we have tracings representing the first six states, at intervals 0, 6, 12, 18, 24, 30 deg. (of phase C), the distribution of the field at 36, 42, 48, 54, 60 is found by taking the tracings for 24, 18, 12, 6 and 0 and turning each front to back. Both the order and the diagrams are reversed. At the end of this set the conductor C will be in exactly the same state as A was at the start, and the sequence is repeated for C and then for B, making 60 diagrams for the complete period. It will be noticed that although the pressure in the phases, measured

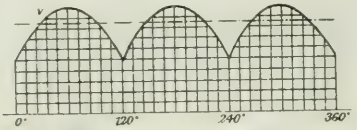

Fig. 7.—Triple Frequency Variation of Intensity of Stress between Conductors.

from zero, reaches a maximum in the order A, B, C, as in Fig. 3, the position of maximum stress revolves in the direction opposite to this. Thus, in the first diagram it is greatest between A and B, after 30 deg. of phase it is equal from A to B and C, after 30 deg. more the maximum stress in the dielectric is between A and C, so that the position of maximum intensity of stress, irrespective of its direction, rotates backwards at twice the frequency of the circuit.

The stress between a conductor and the sheath is a rectified wave at the supply frequency. Elsewhere the reaction between the charges induces a pulsation of higher frequency. For example, taking the position of 30 deg. on the conductor A—that is the line joining the centres of conductors A and C—the variation of mean intensity of stress along a line of force starting at this point is as follows:—

Mean Stress in Kilovolts per inch.

Phase	0	6	12	18	24	30	36	42	48	54	60
Kilovolts	9·5	10·8	12·6	14·4	15·6	16·8	17·8	18·6	18·7	20	20
Phase	66	72	78	84	90	96	102	108	114	120	—
Kilovolts	19·7	19	18·2	17	16·8	14·5	14·2	12·8	11·4	8·1	—

These are the pressures scaled from the diagrams and are plotted in Fig. 7. There are three maximum and three minimum conditions of stress in one alternation, giving in effect a triple frequency harmonic with a disturbance of higher frequency. The same is found with smaller amplitude at 60 deg. and other points.

In order to use the section to the best advantage, the dielectric should carry a stress as nearly as possible the same everywhere, not, of course, at every instant, but averaged over the cycle. It is possible to do this in single-phase cables by suitably grading the insulating material, so that the dielectric constant decreases outwards from the conductor.

It is impossible to arrange this everywhere in three-phase cables, but by the use of "clover-leaf" sections for the conductors the stress may be made much more uniform than in the case of circular sections.

The efficiency of a cable, so far as its manufacture is concerned, may be expressed as the maximum kilovolt-amperes which it will carry per pound weight of insulation per yard run. Since the stress by which electrical energy is transmitted along a cable is in the insulation, and not in the copper, the most efficient cable is that in which the mean volts per inch per square inch of section of insulation is greatest. Without going into the intensity of stress as fully as in the cable with circular conductors, the nature of the change in the form of the field in a clover-leaf section during the common part of a period was examined in the same way as before. The diagrams of Fig. 8 show the greater economy of section, apart from questions of manufacture in the "clover-leaf," as compared with the circular conductor. These were taken from the inked-in enlargement without this being retraced. The polar curves for the clover-leaf case would, however, show more sudden changes at the corners of the conductors.

Under most conditions of working the copper loss is much greater than that from dielectric hysteresis, and the heat so produced expands the conductor and insulation equally in all directions, but the dielectric loss in a lightly-loaded cable is not equally distributed over the section. Assuming that it varies as the square of the voltage gradient at any point, curves of heating might be drawn by squaring

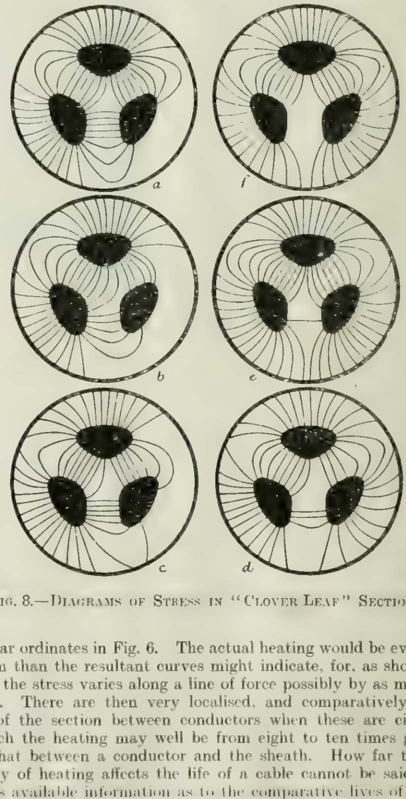

Fig. 8.—Diagrams of Stress in "Clover Leaf" Section.

the polar ordinates in Fig. 6. The actual heating would be even less uniform than the resultant curves might indicate, for, as shown by Fig. 5, the stress varies along a line of force possibly by as much as 3 to 1. There are then very localised, and comparatively small parts of the section between conductors when these are circular, in which the heating may well be from eight to ten times greater than that between a conductor and the sheath. How far this inequality of heating affects the life of a cable cannot be said until there is available information as to the comparative lives of cables with circular and other forms of conductors, but otherwise under the same conditions.

What may be more important is that the ageing of the insulation will certainly be very unequal; and, so far as the tendency to powdering is concerned, the life of the insulation is that of the small part immediately between the conductors.

So far as dielectric heating is concerned, the load factor of a cable is usually high, and the effects of inequality of its dielectric heating may, for all practical purposes, be entirely masked by the copper heat. All that can be done in our present meagre knowledge of dielectric changes is to indicate the magnitude of the stress from point to point in the insulation, to provide a working basis for future theory.

CORRESPONDENCE.

ANTENNÆ.

TO THE EDITOR OF THE ELECTRICIAN.

Sir : In your issue of July 23 I notice an article by Mr. G. W. Pickard, entitled "Antennæ." In this article, in speaking of the Stone direction-finder, he says that in this direction-finder two antennæ are used, separated by a half wave length of the radiation from a distant station. This, he points out, renders the arrangement impracticable for commercial use, because of the limitation to a definite wave length. He further states that the system will give the bearings of a distant station to 5 or 10 deg. of arc. As each of these statements is incorrect, and therefore misleading, I take the liberty of pointing out that there is nothing to warrant Mr. Pickard in the belief that there is any limitation to a definite wave length in the direction-finder in question.

In the second place I wish to state that I have been in charge of the only official tests of this direction-finder. In these tests the apparatus was installed on board the United States Naval Auxiliary "Lebanon," Capt. Merithew commanding, and in the hands of Lieutenant Commander S. S. Robison, U.S.N., and Lieutenant J. Hyland, U.S.N., neither of whom had ever used or ever seen an apparatus of this type before; the direction-finder gave the cross bearings of two stations distant approximately 14 miles from the vessel, with an error of less than the minimum value assigned by Mr. Pickard. Later in the same day these officers determined the bearing from the "Lebanon" of a station distant 27 miles, with an equal degree of precision. Observations have been made by assistants under my orders on this and other ships of the U.S. Navy in which the error was likewise below the minimum value set by Mr. Pickard. Further, I wish to say that in only one special case was any attempt made to use a wave length equal to twice the distance between the masts, whereas in general the wave lengths were those normal to the ship and shore stations.

Under these conditions I scarcely need to point out that the apparatus in the hands of the master of a ship, accustomed to using it, would give even closer results than those noted above, so that there is no reason to doubt that the apparatus will yield, in the hands of a skilled operator, bearings as close, or even closer, than a helmsman can steer.—I am, &c.,

Ernest R. Cram,

Boston, Mass., Aug. 26. Stone Telegraph and Telephone Co.

ELECTRICAL PROPULSION OF STEAM SHIPS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir : As an important organ of the electrical manufacturing trades, I desire to draw your attention to a letter in "The Times Engineering Supplement" of to-day's date, signed by a leading member of the electrical engineering profession, in which he complains of "extravagant claims for electrical power transmission for the above important purpose," and makes various other uncalled-for remarks in connection with the matter.

I write as one who has made a very close study of this most important matter, in co operation with some of the leading naval architects and marine engineers in this country and abroad, and as one who has endeavoured to enlighten marine engineers as to the "truthful" position, by drawing their attention to the great possibilities of co-operation with electrical engineers, by the opening up of another field of operation for efficient means of generation and transmission of power, which, if taken up, will make a tremendous increase in the business of electrical plant manufacture and should be thoroughly investigated by the leading plant manufacturers of this branch of engineering. If they will so investigate the subject I shall be most happy to lay before any members the system as advocated by the writer of the letter above referred to and the system which I have designed for the purpose. They are at liberty to judge the merits for themselves and form their own conclusions as to which system is capable of fulfilling the claims that have been made, and I should esteem it a favour if such conclusions were published for the guidance of others.—I am, &c.,

William P. Durtnall,

Bush-lane, London, E.C., Sept. 8.

THE "THEROL" ELECTRIC WATER HEATER.

There are two problems which, among others, are at the present time exercising the minds of those connected with the electrical industry. And though the solution of these problems will undoubtedly be confined to a particular class of engineers, though different in each case, the solution of one will affect the other, for they are to a great extent mutually interdependent. These two problems are: How to increase the day load on the mains of a central station, which question worries the supply engineer, and how to design an efficient and domestically-usable electric water heater, which worries the electrical manufacturer. If the manufacturer can achieve the latter feat the way towards establishing an excellent day load is at once opened, for it will not be denied that perhaps the most essential household commodity is hot water—a commodity to obtain which, it may be mentioned, leads to more waste of fuel than any other operation.

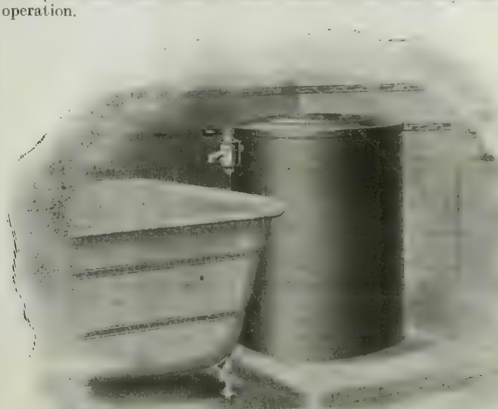

Fig. 1. "Therol" Electric Water Heater.

Messrs. Spagnoletti (Ltd.), of London, have recently put forward an apparatus known as the "Therol" water heater, for which they claim certain distinct advantages. It may, perhaps, be as well first to explain its essential features, and then to point out how it may help towards a solution of the other problem mentioned above.

A general view of the apparatus is shown in Fig. 1 and a section of the heater in Fig. 2. In its simplest form the apparatus consists of a block of iron cast round a coil of pipe. This block is embedded in and covered with a layer of magnesia lagging some 2 in. thick. The top of the block is hollowed out into a cylindrical form, and in this hollow is placed the heating element, consisting of four coils of iron wire insulated with mica. The block of iron is then continuously heated by electricity, and water is, when required, passed through the pipe and heated. Further economy is effected by introducing between the lagging and the outer cover a small reservoir, which is in turn protected by lagging from the outermost surface of the heater, and which serves for raising slightly the temperature of the incoming water before it is introduced to the heater proper.

Since the coil of pipe through which the water passes must have sufficient surface for heating the water when the block is comparatively cool, it follows that when the block is very hot the water will be converted into steam. It is necessary, therefore, to mix the issuing steam with water, and thus reduce it to a suitable temperature. There being no satisfactory valve for the purpose, a special one, shown in section in Fig. 3, has been designed, by the use of which it is claimed a mixture of the steam and water can be completely effected, and the temperature of this mixture adjusted at will. As will be seen by reference to the drawing, pipes are brought

up from the main and from the hot water chamber to this mixer, where, by placing the tap in the appropriate position, either cold, tepid or hot water can be obtained.

From this description it will be seen that the heater is simple in construction, entirely self-contained and requires little alteration of any existing pipework when it is installed. Hot water is always

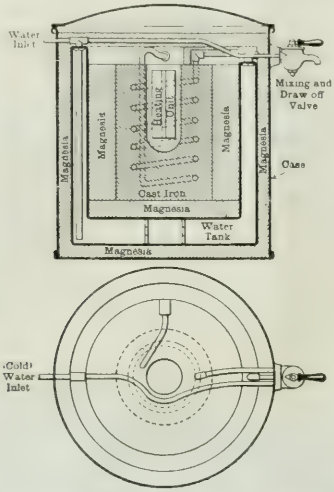

FIG. 2.—PLAN AND SECTION OF "THEROL" ELECTRIC HEATER.

available, and by suitably adjusting the tap may be drawn off at any desired temperature. There are no noxious gas or products of combustion, and no flue or chimney is required.

While this apparatus appears to have solved the problem of electrically heating water without demanding a large current, it is still more interesting from the fact that its design has been carried out with a view to developing central station business, and that in rather a novel way. Messrs. Spagnoletti have joined the ranks of rate-

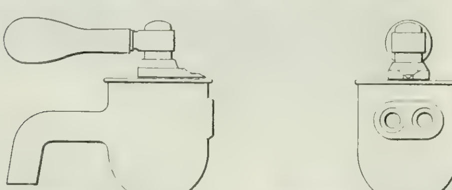

FIG. 3.—DETAILS OF MIXING VALVE AND TAP.

evolvers, and suggest that a householder should be charged on a sort of rateable value basis. For instance, a man decides that he has a load of, say, 200 watts; he is accordingly charged for this amount, and can then use 200 watts for 24 hours a day. He would then instal a 200 watt "Therol" heater and keep it continually in circuit, thus making available a certain quantity of hot water for his domestic uses. When he wanted to use the current for other purposes he would switch his lights or cooker on in the ordinary way, and by means of a simple switching arrangement a proportionate amount of the heater elements would be automatically cut out, thus retaining the total load at 200 watts. A lump sum per quarter would be paid for the use of the electricity supply, so that maximum demand systems and other brain-wracking ideas would become a thing of the past. The domestic hot water supply would, further, become the determining factor in deciding what size of heater, and hence the other electrical details of the house, should be employed.

This 100 per cent. load factor would undoubtedly have a beneficial effect on the central station problem, and would allow such consumers to be supplied at a very low cost per unit. Further, should it be necessary, it would give rise to no great hardship to cut out the heater during "peak" hours, for enough heat would be retained by the lagging to ensure an adequate water supply.

Returning once more to the heater proper, it may be pointed out that the size of the heater refers to the quantity of water it will raise

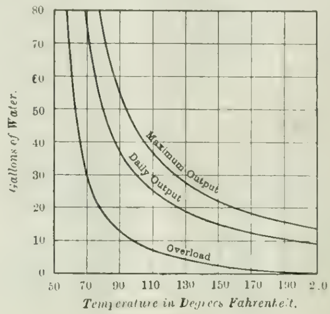

FIG. 4.

through 60°F. every 24 hours. Thus, a 25 gallon heater will raise this amount of water from 50°F. to 110°F.—*i.e.*, to the temperature of a very hot bath—while if only warm water is required a very much larger quantity may be obtained. In every case the amount of water available may be drawn off all at once, or in smaller quantities at any time during the 24 hours.

Fig. 4 shows the quantity of water that may be drawn from a 25 gallon electric heater at any temperature. The initial temperature of the water is assumed to be 50°F., and it will be seen that the average daily output is 25 gallons at 110°F., or a little over 9 gallons of boiling water. Similarly, every other point on the middle curve gives the quantity of water available at the corresponding temperature every day. The lower curve gives the overload capacity of the heater, or the quantity of water at any temperature that may still be obtained even after that given by the middle curve has been drawn off, though, of course, if this overload is drawn on the quantity available next day will be less than that given by the middle curve.

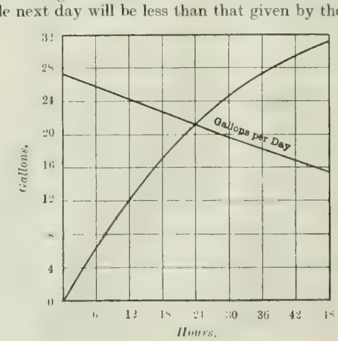

FIG. 5.

The upper curve gives the maximum quantity of water available at any temperature—that is to say, the quantity that may be obtained from the heater if less than that given by the middle curve has been taken on previous days. Such calculation on the part of the householder regarding his water supply may not, however, be pleasant to his generally unscientific mind, and it would probably be better for him to instal a heater of capacity somewhat in excess of his usual demands, so as to be on the safe side should emergency arise.

In Fig. 5 is shown the variation with time of the available quantity of hot water in the 25 gallon "Therol" heater. It will be seen that if the heater is exhausted the heat starts storing up again at the rate of more than a gallon per hour, while after sufficient heat is stored to give 25 gallons it only stores up at the rate of about ½ gallon an hour, and finally becomes stationary at the maximum of 37 gallons. The other curve gives the quantity of hot water per day that may be obtained if drawn off in equal amounts at regular intervals. Thus, if the water were allowed to run all day in a small stream the total quantity obtainable would be 27 gallons, if it were drawn off every eight hours 25 gallons, and if drawn off all at once 21 gallons per day, while if the water were only drawn off once in every two days there would be 31 gallons obtainable, or only 15½ gallons per day. The heater from which these curves were taken, being designed for household use, where it would seldom be allowed to rest for more than eight hours, is called the 25 gallon size. It should be noted that these curves are drawn with a 200 watt heater, and that if a larger heater were used and switched off for such a time each day that the average quantity of hot water remained the same, then both the rate at which heat is stored up and the maximum quantity that can be stored up will be much greater.

We may be allowed to congratulate Messrs. Spagnoletti on having produced a piece of apparatuus which should go far towards solving the problem of heating water by electricity. We shall watch its development and practical operation with interest.

SIEMENS SELECTIVE CALL FOR TELEGRAPH STATIONS.

It is often useful in telegraph working to be able to call up any distant station, up to a certain number, without ringing up all the intermediate stations. A possible method of effecting this is by the employment of a selective call system such as is manufactured by Messrs. Siemens Bros. & Co., and which is described in the following article :—

This apparatus is so arranged that it will not respond to ordinary Morse signals. In order to operate it, the circuit must be closed for at least three to four seconds ; after that, short current impulses are given, corresponding in number to the number of the station required ; finally the circuit is closed again for about 10 seconds. The last operation causes the bell to ring at the selected station. The current impulses which are then given, being ordinary Morse signals, restore all the selective calls on the line to their normal condition.

In the design of the apparatus, the following objects have been kept in view : (1) That the selective call can be added to any existing telegraph system practically without any alterations being required. (2) That the selective call can work in a local circuit and is, in consequence, independent of variations of line current, whilst the impulses in the line and the other telegraph apparatus are not influenced by the insertion of the apparatus. (3) That the call may be given by manipulating the existing Morse key in the usual manner.

The apparatus (Fig. 1) consists of a retarding relay T (*see* Fig. 2) and an electromagnetic counter, S, which is fitted with a revolving drum. The drum carries contact segments arranged to correspond with the call number of the respective stations, and these segments

Fig. 1.—General View of Siemens Selective Call.

are electrically connected with the call bell. The whole is mounted on a circular metal base and enclosed in a brass case with dial and glass face. The dial is marked with the usual Morse code letters and signs and the call number appears through a small window in the centre. The effective operation of the retarding relay is secured by the use of a dash-pot fitted with a piston of compressed graphite. This device lubricates itself automatically and requires no attention, whilst it is impossible for the piston to jam.

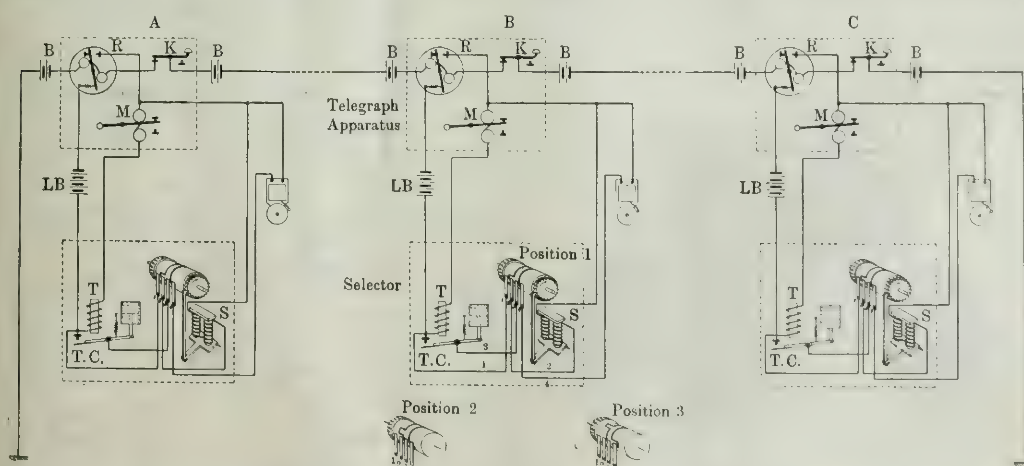

Fig. 2.—Diagram of Morse Telegraph Line with several Sections for Closed Circuit Working, showing Method of Working of Siemens Selective Call.

The diagram (Fig. 2) shows clearly the method of working the selective call, and represents a Morse telegraph line provided with several stations with relays for closed circuit working. For instance, suppose station A wishes to call station B with the number 6. Station A depresses the key K for three to four seconds and then makes five short contacts and one long one, whereupon the bell at station B is

thrown in by the selective call and rings so long as the key is depressed. The usual Morse signals, which follow, replace the selective call to its normal position.

The instruments operate in the following manner: The first long depression of the key K causes the line relays R at all the stations to be cut out and their armatures to throw in the retarding relays T. which are in a local circuit. These slowly attract their armatures and, after about three seconds, close the main contact TC. This causes the electromagnet of the counter in each instrument to receive a current impulse through the springs 2 and 3, the drum is

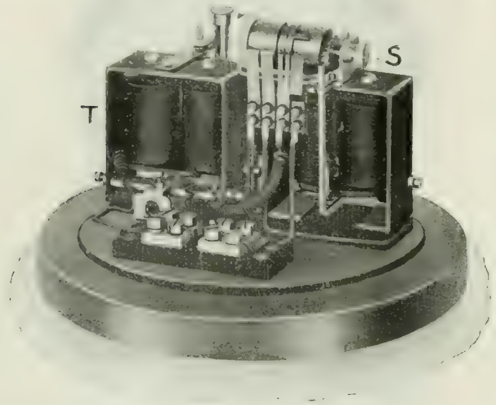

Fig. 3.—Siemens Selective Call with cover off, showing Retarding Relay and Electromagnetic Counter.

revolved by means of the toothed wheel to the extent of one tooth, and the springs 1 and 2 are brought into contact over a segment on the drum. This position causes all further current impulses (in this case there are five) corresponding to the five short depressions of the key on the part of the calling station A, to go not only through the retarding relay T, but also simultaneously through the electromagnet S, owing to the closing of the contact TC. The retarding relays do not close their contacts TC under the short current impulses, but the electromagnets are operated and the drums are revolved by the current impulses to the extent of five teeth. The segments on each drum are now so arranged that the springs 3 and 4 are connected

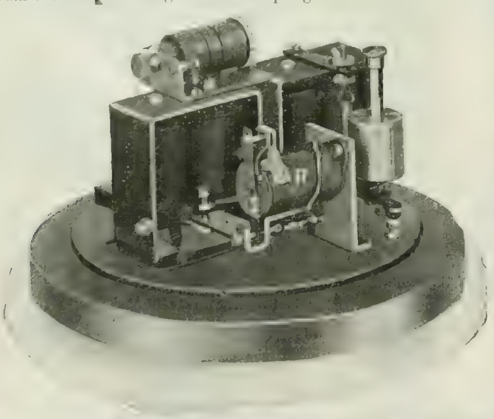

Fig. 4.—Siemens Selective Call with cover off, showing Line Relay and Dash-pot for Retarding Device.

over a particular position of the drum corresponding to the call number of the respective stations, and close the bell circuit through the contact TC. In the case of the selected station 6, the special position of the springs 3 and 4 is arrived at by the six current-impulses, and after a period of about three seconds the bell commences to ring through the retarding contact TC. The bell circuit is interrupted at all the other stations. The station which is called gives the acknowledgment signal in the usual manner, and the telegraphic messages between the two stations can then pass. The Morse signals which are now given restore all the selective calls to their normal positions. The call bell, which can also, if necessary, be made for continuous ringing, is not mounted direct on the selective call, but can be fixed in any position, for instance, outside a signal box.

A 6-volt battery of large cells is necessary for working these selectors, but the apparatus will work without readjustment even if the voltage drops as low as 3·5 volts. This source of current serves as a local battery as well, if the Morse apparatus is worked by a relay. The best form of battery for the purpose is made up of four Siemens-Obach dry cells, each having an E.M.F. of 1·5 volts.

In connection with local Morse working, the selector is placed in the local circuit of the line relay. For direct working Morse, sounder or needle instruments, the apparatus is provided with a small relay, R, of 100 ohms resistance, which is connected to the line, the selector being in the local circuit of the relay.

The maximum number of stations which can be controlled by this system is at present 18, and the adjustment to a smaller number of stations is effected in a very simple manner.

OPPOSITION TO GRANT OF PATENT.

An inquiry is to be held by the Comptroller of Patents into the opposition of Messrs. Siemens Bros. & Co. to the grant of a patent to Messrs. Willoughby Statham Smith and Wm. Puddicombe Granville, in accordance with specification dated Feb. 26, 1909, and filed March 2, 1909, which has become merged with and known by the number of a provisional specification No. 27,470 of 1908. The final specification (numbered 4,376 of 1909) states that "the object of the invention is to provide an improved inductance coil suitable for use in telephone cables and the like."

The notice of opposition by Messrs. Siemens Bros. & Co. (filed Aug. 21, 1909) states that their opposition is on the grounds:—

1. That the invention has been claimed in the complete specification of British Letters Patent No. 25,306, applied for on Nov. 9, 1906, by ourselves jointly with Wm. Dieselhorst for "Improvements in Electric Cables," of which patent we are the registered proprietors and which patent is of prior date of the patent the grant of which is opposed.

2. That the nature of the invention or the manner in which it is to be performed is not sufficiently or fairly described in the complete specification.

PARLIAMENTARY INTELLIGENCE.

The Post Office and Wireless Telegraphy.—In the House of Commons on Tuesday the Postmaster-General (Mr. S. Buxton) stated that the statement in the "Times" of the 7th inst. was not supplied by the Post Office. The statement was premature, as the arrangements were not yet completed. The negotiations were, moreover, to a certain extent contingent on the success of somewhat similar negotiations with Lloyd's, which also were not yet completed. When the arrangements were finally completed he proposed to make a statement on the subject to the House.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A designer is wanted, with experience in the design of electric motors and also good college and workshop training. See advertisement.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

Applications are invited for the position of chief lecturer in chemistry in the Manchester Municipal School of Technology. Salary £350 per annum. Applications to the Dean of the Faculty of Technology, Mr. J. H. Reynolds, by Sept. 11.

The Council of the University College of Wales, Aberystwyth, require a demonstrator or assistant lecturer in the department of physics. Salary £150 per annum. Applications to the Registrar by Sept. 16.

A senior chemistry master is required for the City of London School. Salary £300, increasing to £450. Application forms from Mr. A. J. Austin, at the school, Victoria Embankment, E.C. Applications by Oct. 16.

Mr. D. Fisher, son of Mr. P. Fisher, general manager of the Dundee Corporation tramways, has been appointed manager of the Dundee, Broughty Ferry & District Tramway Co., in succession to Mr.

J. H. Shepherd, who has been entrusted with the management of the Dunfermline & West of Fife Tramways. Mr. Fisher, who will enter upon his new duties on Oct. 1, has been over 10 years in the service of Dundee Council.

Major C. G. Burnaby, R.E., has been appointed chief instructor at the School of Electric Lighting, Plymouth, in place of Major Caulfield, R.E., who has completed his period of service in the appointment.

Bournemouth Council have appointed Mr. W. Webster, of Burton, instructor to the motormen.

Sydney City Council have approved the appointment of Mr. E. J. Cochrane, of Ballarat, as chief assistant in the electricity department at £500, rising to £600 per annum.

EDUCATIONAL NOTICES.

University of London.—An Appointments Board has been constituted to assist graduates and students of this University in obtaining appointments, and to co-ordinate and supplement the work done by the schools and institutions of the University with this object. The board wish to assist graduates to find employment and to assist employers to find, in the University ranks, suitable men for vacancies.

King's College (University of London).—The session 1909-1910 commences on Oct. 6. Prospectuses, &c., relating to the courses of instruction in the Faculty of Engineering and Applied Science and Division of Architecture may be obtained from the Secretary, Kings College, Strand, W.C. Evening classes are held in electrical and mechanical engineering, drawing, mathematics, physics, &c.

Two exhibitions of £25 each are offered for competition in the faculty of engineering in September. Applications to the Secretary.

University of Bristol.—The session 1909-1910 commences on Oct. 1. There are full courses of instruction in the faculties of arts, science and engineering, and facilities are afforded for research and post-graduate work in all important branches of science and engineering. Prospectuses, &c., from the Registrar.

University College of North Wales.—In the electrical engineering department of this college a systematic course of instruction is given in electrical measurement and practical electricity for students proposing to enter the profession of electrical engineer. The physics laboratory is well equipped. The course extends over two years. Prospectuses, &c., may be obtained from Mr. J. E. Lloyd, M.A., secretary and registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909–1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Merchant Venturers' Technical College.—The engineering departments of this college will, from the beginning of next session, include the faculty of engineering of the University of Bristol. The college has already special departments for electrical engineering (under Prof. Robertson) and motor car engineering (under Prof. Morgan), but the departments of civil, mechanical and mining engineering have hitherto been amalgamated, and they have been in charge of the vice-principal, Prof. Munro. The engineering staff will now be strengthened by the inclusion of those who have hitherto been engaged in teaching engineering at University College, Bristol, and a separate department of civil engineering will be inaugurated and placed in charge of Prof. Ferrier. Not only will this mean improved facilities for students in civil engineering, but it will also strengthen the departments of mechanical and mining engineering, which will remain in charge of Prof. Munro. As regards equipment, the Merchant Venturers' Technical College is already provided, in its new building, with the latest apparatus and machinery, and with laboratories and workshops constructed on the most modern principles. To this has lately been added the best of the machinery and apparatus formerly used in the engineering departments of University College. [A description of the new building appeared in THE ELECTRICIAN for July 30 and Aug. 6, 1909.]

We have received a copy of the calendar of this college for the 1909–10 session which gives full particulars of the courses of instruction, fees, &c. It is published at 6d.

Sir John Cass Technical Institute, London.—The new session commences on 23rd inst. There are classes in general physics and mathematics as a preparation for the final B.Sc. examination of London University, and special courses of general physics and electricity and magnetism for the honours B.Sc. on "Conduction in Gases" and "Radio-activity" and on the "Differential and Integral Calculus for Science Students." There are also evening classes in chemistry, metallurgy, physics and mathematics designed to meet the requirements of those engaged in the chemical, metallurgical and electrical industries, &c., and facilities are afforded for special and advanced practical work in well-equipped laboratories. Particulars from the Principal, Sir John Cass Institute, Jewry street, E.C.

Glasgow and West of Scotland Technical College.—The session 1909-10 commences on Sept. 23 for the evening classes and Sept. 28 for the day classes. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, and the courses of study for the diploma usually extend over three sessions. Holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. There are new and well equipped laboratories in the departments of physics, chemistry, electrical engineering, mechanics, metallurgy, &c., and facilities for research are afforded. Calendar (price 1s. 4d.) and prospectus (free) can be obtained on application to the Secretary.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars at the Institute, Clerkenwell, London, E.C., or of the Principal, Dr. R. Mullineux Walmsley.

The evening technical courses in all branches of electrical and mechanical engineering will commence on Monday, Sept. 27. The laboratories are well equipped for both alternate (single and polyphase) and continuous-current work, and for all kinds of electrical testing. Particulars as to fees, &c., can be obtained at the Institute or on application to the principal, Dr. R. Mullineux Walmsley.

The new building, which was in course of erection at this time last year, has since been finished and is now available for the extending work of the institute. It provides a much-needed enlargement of the mechanical engineering workshop and of the mechanical laboratory, besides two entirely new power laboratories. This increased accommodation will materially assist the work of the mechanical engineering department as established as well as the new departure in the direction of aeronautical engineering which is being made in the coming session. The extension also provides a new class-room capable of accommodating 280 students and 13 other class-rooms of various sizes. Besides the new classes in aeronautical engineering, there will be in the electrical engineering department a new class on the testing of electrical plant, conducted by Dr. C. V. Drysdale, in place of the advanced class on electrical instruments, which will not be held this session. There will also be a new class on electrical engineering quantities and estimates, conducted by Mr. E. Kilburn Scott. In the telephony and telegraphy section the pioneer class on submarine cable work, started last session, now takes its place among the regular classes of the institute's work, and the class on radio-telegraphy and telephony, conducted by Dr. J. Erskine Murray, will be continued. There will also be special classes for the members of the postal telegraph service adapted to the departmental requirements. In technical optics the classes have been somewhat modified to meet the requirements of the new syllabus of the Spectacle Makers Company, a syllabus which in many respects follows the lines which have been a feature of the work of this institute for some years. Technical chemistry day courses in electrochemistry now take their place in the regular work of the institute. These courses extend over three years, and give thorough training in the subject, similar to that which is given in heavy electrical engineering in the engineering day courses. In this department a class on metal colouring is also announced.

Enrolments for the evening classes commence on Monday next, and details of the syllabuses and the equipment, as well as the special developments for the 1909-10 session, are given in the "Announcements" of the institute, which has just been published.

Hackney Technical Institute, London.—The next session commence on Sept. 20. There are evening lecture and laboratory courses in electrical engineering, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses may be obtained from the Principal of the Institute, Dalston-lane, London, N.E.

Battersea Polytechnic (London).—In the engineering departments of this polytechnic there are day courses which prepare for the engineering degree, B.Sc. London, polytechnic diploma in mechanical, electrical and civil engineering. The entrance examination commences on Sept. 21. There are also evening classes which prepare for the B.Sc. in engineering, the associateship examination of the Institution of Civil Engineering all mechanical engineering subjects, electrical, structional and automobile engineering, telegraphy and telephony, architecture and building, &c. Prospectuses from the Secretary, Battersea Park-road, S.W.

Goldsmith's College (University of London).—The new session commences on Monday, 20th inst. Enrolling begins on 13th inst. There

are complete courses of instruction in electrical, mechanical and constructional engineering. Students are also prepared for the B.Sc. in Engineering of the University of London, and for the examinations of the Institution of Civil Engineers, the Board of Education, and the City and Guilds of London Institute. The head of the Engineering Department is Mr. W. J. Lineham, B.Sc., M.I.C.E., M.I.E.E. Further particulars from the Warden of the College.

New Technical College.—The new South of Scotland Central Technical College, Galashiels, was opened on Saturday by Lord Reay. The cost of the erection and equipment of the college has been about £22,000, and a special effort will be made to give complete instruction in all textile subjects.

Aberdeen.—The electricity supply department have opened showrooms (at 244, Union-street) for the display of electric lighting fittings, lamps, motors, cooking and heating apparatus, &c.

The Churches committee have agreed to put in an electric light installation in St. Clement's parish church at a cost of £64. 15s., and to put in metal filament lamps in the church and the Sessions House.

The Council have adopted the following revised scale of charges for supply of electric current :–

Lighting : Flat rate of 3½d. per unit, minimum of 15s. per hafl-year ; or alternatively, for consumers using 5,000 units or over per half-year, 5½d. per unit for the first hour daily of the maximum demand and 1½d. per unit for all subsequent supply. *Public lighting* (by arc lamps) : 2d. per unit. *Power* : A sliding scale, from 2½d. to ¾d. per unit, according to consumption, minimum charge 10s. her half-year. *Heating and cooking* : 1½d. per unit. *Traction* (for Corporation tramways) : 1·1271d. per unit, subject to adjustment.

Acton.—A special meeting of the Council was held last week to consider various questions in regard to the electricity department, and particularly as to the proposed revision of the scale of charges for electricity supply for lighting and power.

It was resolved that the price of current for lighting be increased from June 30 to 7d. per unit to consumers on free wiring installations, and 6d. per unit to all other consumers, and that the offer of the Metropolitan Electric Supply Co. (of Nov. 3, 1908), as to the supply of electricity, &c., be accepted.

It was also decided by 4 votes to 3 that from Oct. 1 next shopkeepers be charged on a flat rate of 5d. per unit ; and the electrical engineer (Mr. J. M. Blair) was requested to prepare a report as to the method of charging for current for power and heating.

Amble.—A proposal to erect electricity supply works was recently referred to the ratepayers, and the result of the poll has now been declared as follows : For the scheme 251 ; against 129. About 120 papers were returned with the questions unanswered. It has now been decided to engage an electrical engineer to examine and report upon the scheme, and a second vote of the ratepayers will then be taken.

Appreciation of Long Service.—An interesting ceremony took place at the works of Messrs. Ruston, Proctor & Co., Lincoln, on Saturday last, when Mr. Liens, who has completed 50 years in the service of the firm, was presented with the gold medal, which has been established by Messrs. Ruston, Proctor & Co. as a reward for long service. Four thousand work-people assembled to witness the presentation, which is likely to be repeated shortly, as two other employés are approaching the length of service which entitles them to the medal.

Australasia.—In his recent presidential address to the Electrical Association of Victoria, Mr. H. R. Harper, city electrical engineer of Melbourne, said :—

In years to come, when population had been attracted to Australia, heavy electrical manufacturing might become possible, but he was afraid it would not be in his time. It was a matter for congratulation that the Federal Legislature had lately appreciated that fact and had removed the heavy import duties which had been hampering industry. The legislators had seen that it was their duty to facilitate the importation of highly specialised power-house plant which was necessary to obtain cheap supply of power.

Mr. Harper said there had been issued 21 Orders in Council granting electricity supply powers to municipalities outside Melbourne, and in some cases to private enterprises, in Victoria. Some of the towns concerned had populations not exceeding 1,000, and on that basis there were yet about 44 towns likely in the near future to require supplies. The capital expenditure on all the supply undertakings in Victoria, comprising those in Melbourne and including tramways, was about £1,600,000, and the total capacity of their plants was about 16,000 kw., of which about 11,000 kw. was in Melbourne. Their gross revenue was about £250,000 per annum. Melbourne had not attained that extent of development in regard to the use of electricity that had been reached in the old country. In many districts in the Melbourne area no public supply was yet available, although statutory powers had been obtained for some of these. For instance, Orders in Council had been granted for Hawthorn, Williamstown, Port Melbourne and Brighton, but, so far, no supply was available. Factories in Melbourne using electric power in 1902 numbered 118, and the horse-power taken was 759, compared with 488 factories and 3,701 H.P. in 1907. The prospects of electric lighting might be considered very satisfactory.

The report of the city electrical engineer (Mr. H. Forbes Mackay) to Sydney Electric Light committee, advising the committee not to accept a tender for supply of 1,000 kw. sets running at 1,500 revs. per min., was considered recently by the committee. The chairman (Ald. Cocks) hoped the committee would not depart from Mr. Forbes Mackay's report, but an amendment that fresh tenders be invited was carried.

Geelong (Victoria) Council have accepted a modified scheme of tramways. Only the Geelong West and Newtown routes are now to be laid.

Two 400 H.P. Crossley gas engines and electric generators are being installed at the No. 5 shaft of the Waihi Gold Mining Co. (N.Z.) and the current will be transmitted to No. 4 shaft to drive two three-throw ram pumps to lift 1,500 gallons of water per minute from the 1,000 ft. level.

Belfast.—The Tramways committee have decided to substitute side for central poles in order to comply with a request of the City Commissioner of Police.

Bentley (Doncaster).—An L.G. Board inquiry was held on Friday into the sewerage scheme for Bentley Colliery model village (Rostall), &c. The engineers (Messrs. D. Balfour & Son, of Newcastle-on-Tyne and London) explained the scheme. The sewage will be conveyed to a pumping station, where, after screening, it will be discharged into two separate tanks, from which it will be pumped by centrifugal pumps worked by electric motors all in duplicate. The pumps will be placed in an underground chamber adjacent to the storage tanks, worked by a spindle from the motors in the motor house to be built above ground. The motors will be automatically started and stopped by floats. Each pump will be capable of delivering 30,000 gallons per hour of sewage at the existing sewage disposal works, where it will be treated in liquefying tanks and continuous filters, with final treatment over land.

Birmingham.—A new tramway service between Trafalgar-road, Moseley, and High-street, via Bradford-street and Digbeth, was inaugurated on Monday.

Bolton.—The Electricity committee have decided to convert an overhead travelling crane for electric working at a cost of £620, which is to be borne by the revenue of the electricity department.

Considerable discussion arose on this question at the Council meeting, as some members contended that the cost should be placed to capital account. The chairman of the Electricity committee (Ald. Berry), however, explained that they had no powers to borrow for specific purposes, and it was probable that the L.G. Board would refuse to sanction a loan for the whole amount. In order to avoid delay it had been decided to meet the cost out of revenue.

Bray (Ireland).—On Tuesday the Council adopted a report of the Electric Light committee which recommended :—

(*a*) That the L.G. Board be applied to for sanction to a loan of £1,000, particulars of which were submitted at the recent inquiry ; (*b*) that sanction be asked to substitute a Diesel oil engine for the gas plant originally proposed ; and (*c*) that the engineer (Mr. Sowter) be instructed to prepare specifications for one 50 B.H.P. Diesel oil engine and h. and l.-t. disconnecting boxes, and that tenders be invited for same.

Bristol.—The new schools at Alexandra Park, Fishponds, are to be wired.

Burslem.—The Education committee have decided to wire the Middleport schools,

Cumberland.—Various inaccurate statements have appeared as to the negotiations, which are taking place between the Electrical Co. and the promoters of the Cumberland Electricity and Power Gas Act, in regard to the transfer of the powers and the erection of electricity supply works. We are informed by Messrs. Barr, Nelson & Co., of Leeds, that the facts are as follows :—

The Cumberland Power Synd. promoted the Cumberland Electricity and Power Gas Act, and accordingly has a claim, in the nature of a lien, for the costs incurred in obtaining the act. The Parliamentary Co. has, however, not yet taken steps for the raising of its capital, and there have been certain negotiations with the Electrical Co., but it is impossible to sell an act of Parliament or an undertaking thereby authorised. If the negotiations are carried through it will mean that the Electrical Co. will take up the capital of the Power Co. out of which the syndicate will be paid the promotion costs, and the Electrical Co. will be the shareholders in the Power Co., and thus control it. If they erect a generating station it will, no doubt, be on the site of the works near Workington, as this was one of the scheduled sites to the act.

Clevedon (Somerset).—The Lighting committee have arranged to obtain a report upon the proposal to adopt electricity for street lighting.

Electrical Exhibitions.—Hampstead (London) Council are organising an exhibition of domestic electrical appliances at the public baths, Finchley-road, N., during the first week in October.

The public will be admitted free of charge to the exhibition, which will last four days. A special feature will be made of heating and cooking apparatus, electric motors, electric lamps and fittings, &c. One of the baths will be reserved for special cooking demonstrations, ironing displays, &c. Another interesting exhibit will be the model kitchen, where modern labour-saving electrical domestic appliances will be seen in operation.

Progress is being made with the arrangements for holding an exhibition of electric fittings, motors, domestic appliances, &c., at the Pitfield-street Baths, SHOREDITCH, next month.

The greater portion of the available space in the large first and second class halls has been disposed of to prominent firms. Among the exhibits will be up-to-date forms of heating and cooking apparatus. The borough electrical engineer (Mr. C. Newton Russell) is sole manager of this exhibition, which the boroughs of Hackney and Stepney are co-operating with Shoreditch in organising.

Electricity in Mines.—The Agenda of the Council meeting of the Durham Miners' Association on Saturday contained a resolution to the effect that electrical machinery and cables should be taken out of mines, as they were considered a source of great danger. The resolution was withdrawn on an explanation that a Select committee had been appointed by the Government to consider the question, and also that the owners were willing to arrange a meeting on the subject.

Evesham.—Stratford-on-Avon Electricity Supply Co. have notified the Council of their intention to apply for a provisional electric lighting order.

Falkirk.—The tramway route to Laurieston was opened for traffic on Friday last. The line is about 1½ miles in length. The contractors for the permanent way were Messrs. Alex. Stark & Sons, and for the overhead equipment the British Insulated and Helsby Cables.

Farnworth (Lancs.)—The new extensions of the Council's electricity works and the new destructor works were recently inaugurated.

The inaugural ceremony was performed by Mr. J. Green, chairman of the Electricity and Destructor Works committee, and after an inspection of the works the electrical engineer (Mr. Leach) set in motion the new machinery.

Mr. GREEN said the electricity works extensions were a sound financial scheme. They could purchase current at a cheaper rate than they could generate it. They had to bear in mind the short period of loans now granted by the L.G. Board, whereas a private company need not allocate such heavy repayments. He thought that, taking into consideration the size of the plant, their record was amongst the best in the British Isles.

Mr. C. D. TAITE, manager of the Lancashire Electric Power Co., said that day's ceremony marked a new era in the history of the company he represented. Their original intention was to supply electricity in bulk to local authorities in Lancashire, but very great difficulty was found in persuading local authorities that it was to their advantage to make use of the company's power. The result was that other consumers had to be obtained, and most of their power was now used by manufacturers and not by local authorities. Farnworth Council was the first in Lancashire, owning their own generating station, to carry out extensions by means of a supply from the company, and it would be generally admitted that the policy adopted was a very enlightened one. Their example was being followed in other parts of the country by a number of local authorities.

Mr. LEACH briefly expressed his gratitude for the kind remarks made about himself. He had been ably assisted by his staff, especially by Mr. Hutchinson.

Grimsby.—The Highways committee have approved the plans of the proposed electric tramway between Grimsby and the new deep-water dock at Immingham. The line is to be constructed and worked by the G.N. Railway Co.

Hackney (London).—Owing to the increasing demand for electricity for power and lighting in the Hackney Wick district, it is proposed to lay a new feeder, with certain distributing cables, at an estimated cost of £3,650.

Haslemere.—The Hindhead and District Electric Lighting Co. propose to supply electric current for lighting in this district at 2s. 6d. per quarter per lamp, provided there are four lamps in each house connected, and that the owner or occupier agrees to pay for at least three years, whether the house be occupied or not.

Hove.—In consequence of ill-health, the resident electrical engineer (Mr. G. M. Harris) has tendered his resignation.

Ilkeston.—The question of the resignation of the electrical engineer and tramways manager (Mr. Gilbert) was raised at the Council meeting on Tuesday.

Mr. W. RICHARDS, in moving the confirmation of the minutes of the Tramways committee, complained strongly of the manner in which the committee had been treated by the Council. When the committee desired to consult the Council with regard to the recent dispute with the tramway employés they did not expect that the matter would be taken completely out of their hands. The dismissed men having been reinstated, there was nothing else for the tramways manager (Mr. Gilbert) to do but resign, which he did accordingly. He hoped the new manager they would appoint—he did not know if the Tramways committee would be entrusted with or be capable to make the appointment—would have neither uncles nor other relations to consider in carrying out his duties.

India.—"Indian Engineering" says the Madras Government have directed that, in future, joint applications by consumers and electricity supply undertakers for the approval of the Government to supplies of electrical energy at pressures exceeding 250 volts should be submitted through the Electrical Inspector, instead of direct to the Government. This innovation is intended to avoid delay.

The appointment of Mr. T. Roberts, telegraph superintendent to the Madras & Southern Mahratta Railway Co., is to be extended for 12 months, until Oct. 10, 1910. The company have also a telegraph engineer (Mr. H. H. L. Prendergast) at Arkonam.

A contract has been placed for the electric lighting of Pondicherry town and pier.

The "Indian and Eastern Engineer" says the Lucknow Cantonments Electric Traction Licence, 1907, has been revoked as from Aug. 24.

Work has been commenced on the Simla hydro-electric scheme, under the supervision of Mr. J. R. Wilson, executive engineer of the Public Works Department.

The Lahmeyer Electrical Co., whose representative in India is Mr. H. R. Speyer, are equipping the power house of the Tata Iron & Steel Co.

The Punjab Electrical Distribution Synd. is going into liquidation, and the question of the future electric lighting of Lahore and Amritsar is under consideration.

Italy.—Mr. R. S. Macbean, M.V.O. (British Consul at Palermo), states that two hydro-electric stations are in course of construction on the Cassibile (south of Syracuse), and on the Alcantara (near Taormina). It is intended to link the two stations and supply power to the whole of the east coast of Sicily, from Messina to Syracuse, and ultimately to Ragusa. The requirements are estimated at 10,000 H.P. Another project for supplying a similar area with electric power in Sicily is also under consideration, the station in this case to be on the river Sunato.

L.C.C. Tramways.—Electric cars are now running from Holborn to Park-street, Regent's Park, via King's Cross and Crowndale-road, and the route to Hampstead Heath by way of Great College-street, Kentish Town-road and Prince of Wales's-road, was inspected by Col. Yorke on Wednesday and will probably be opened to-day (Friday). The lines to Hampstead via Chalk Farm-road, and to Highgate through Kentish Town and Junction-road, are in course of construction, and a contract has just been let for the Swain's-lane section.

Longton.—The salary of the manager of the gas and electricity works (Mr. W. Langford) has been increased to £550 per annum.

Mansfield.—The Council have received sanction to a loan of £500 for additional plant at the electricity works.

Metal Filament Lamps.—As doubts had been cast upon the accuracy of the figures recently published by the city electrical engineer of Bristol (Mr. H. Faraday Proctor), as to the economy of metal filament lamps, Mr. S. L. Pearce, the city electrical engineer at Manchester has issued figures in regard to half-a-dozen consumers, taken at random from the books of Manchester Corporation electricity department:—

	Cost in 1907.	Cost in 1908.
Large warehouse, Portland-street	£607	£320
Public Institution, Princess-street	330	224
Shop, Victoria-street	19	11
Shop, Stretford-road (tobacconist)	14	8
Shop, Stretford-road (hosier)	17	10
Warehouse, Mosley-street	20	9

Mexico.—Mr. P. G. Holms (British Vice-Consul) states that the interests of Senor M. C. Gallardo and the Cia de Tranvias, Luz y Fuerza de Guadalajara have been amalgamated, and a Berlin firm have undertaken to advance £750,000 for constructing hydro-electric power works on the Santiago river. The old plant is already supplying 10,000 H.P., but new turbines are being installed to give an additional 8,400 H.P., which will be largely used in the mines in the Hostotipaquillo district.

Motor Exhibition.—The eighth International Motor Exhibition of the Society of Motor Manufacturers and Traders will be held at Olympia, from Nov. 12 to 20 inclusive. The whole of the space available has been allotted to about 300 British and foreign exhibitors.

Municipal Wiring in Sheffield.—At Wednesday's meeting of the City Council, Councillor Neal moved—

That it be an instruction to any committee of the Council (including the Education committee) requiring work doing by an electrician not to apply for or accept any tender for such work, but that the same be entrusted to the electric supply department of the Corporation, which department is hereby instructed to execute such work at the actual net cost thereof, with an addition of 5 per cent. to cover standing charges.

Councillor NEAL thought that the Council, as a body of business men, ought to accept his proposal. Recently the Education committee received tenders for certain electrical work which varied from £93 to £350. It was not possible that contractors desirous of doing the same work according to the same specification could vary so much in amount. The Council occupied an anomalous position; they had their own electric light department. Why could they not do their own work? They would not find Messrs. Vickers, Sons & Maxim asking for tenders from other firms for armour plates. There was now a great danger of them ceasing to regard the Corporation as a unit. His proposal was that they should do their own work. After allowing for cost of material and labour, he would place 5 per cent. down for management and other expenses. It was a bad advertisement for their department

that they should ask other people to contract for work they could do themselves. They would, by such a means, eliminate any possibility of getting scamped work, and would keep their contracts in their own hands.

Councillor NOWILL thought the figure for management expenses should be 7½ to 10 per cent.

Councillor CROWTHER pointed out that large drapery firms in the city, who did electrical work as a side line, had not invited tenders from outside firms when they wanted their own premises fitted up. The great discrepancies in the amounts of the various tenders showed that some of the tenderers had not understood what was required. It was in the interests of the ratepayers that, having that Corporation department, work for the Corporation should be done by it.

Ald. MARSH, while admitting that the electric light department was a somewhat weak child originally, did not think that it required protection now. The other day it tendered for work at the Victoria Nursing Home, and, its tender being the lowest, it got the work. That showed that the department was just as capable of tendering cheaply as any other concern, and he thought it ought to be continued on that basis. If Corporation undertakings were to be worth anything they ought not to fear the competition of outsiders. If work was done by a private firm it was checked by an unbiassed inspector, who saw that it was properly done, whereas if he were inspecting on behalf of the Electric Light committee he would be much more liable to pass inferior work.

Councillor APPLEYARD said if they took away competition they took away the life and soul of business. If the electric light department was allowed to do the work of any other department without any price or limit being placed upon it, a spirit of laxity would be engendered, and there would not be sufficient control to keep down the cost of production.

Councillor MARSDEN said he recently asked the electric light department for a tender, but it was not only very slow in sending its estimate, but that estimate was twice as high as a private firm's.

Councillor CARTER opposed the resolution. The Electric Light committee had a monopoly of the supply of electricity, and he did not think the other department ought to exist at all.

Sir WILLIAM CLEGG also opposed and said the work for which the committee had statutory powers was the supply of electricity, and the fittings department was subordinate. He was strongly in favour of municipalisation, within certain well-defined lines, but it was not right for the Corporation to interfere unduly with private manufacturers. A ratepayer manufacturing electrical fittings had as much right to tender for Corporation work as the Corporation itself. The Corporation risked the ratepayers' money, and if, in addition to that, they were going to debar those ratepayers who were in that line of business from properly competing with them, they were unfairly handicapping them. As to executing the work at actual cost, it would be very difficult to arrive at the figures. And who was to check those figures? They had to trust their officials, and when an official was working up his department so as to show a profit there was a tendency—however much he might try to prevent it—to put before the committee the best case and the best figures, whether they really worked out at that or not.

Ald. GAINSFORD believed that frequent competition from outside traders was necessary in order to keep the Corporation departments in thorough order. If they were to remove that check they would be going in a wrong direction.

Other speakers having expressed their views, Councillor NEAL replied, and the motion was rejected by a substantial majority.

Newcastle-on-Tyne.—The report of the general manager of the tramways (Mr. E. Hatton) for the year ended March 31 has been issued.

In regard to power supply a considerable saving had been effected. In 1908-9 the units generated were 9,864,969, and the coal consumed was 15,742 tons. The average saving in tonnage during the past four years had been 2,417 tons per annum, an average saving of £937. 9s. 2d. per annum. The total units used for purposes other than traction were 1,746,260 for lighting streets and buildings, compared with 1,743,417, and the traction units were 8,118,719, compared with 8,265,170, or 1·892 units per car-mile (against 1·873), the car-miles having been 4,289,997, against 4,411,745. 44,439,282 passengers were carried, against 46,203,164. The consumption of coal was 3·57 lb. per unit, compared with 3·54 lb. The gross receipts were £209,540. 19s. 10d., compared with £217,080. 18s. 5d. The traffic expenses were £56,912. 18s. 2d., against £58,583. 4s. 11d; and the general expenses £21,291. 11s. 5d., against £17,609. 2s. 7d. General repairs and maintenance cost £27,924. 2s. 3d., against £22, 570. 6s. 1d., and power expenses were £14,947. 3s. 6d., against £16,615. 18s. 2d. Working costs (exclusive of public street lighting) were £121,075. 15s 4d., against £115,378. 11s. 9d. The assessment for the ensuing half-year has been reduced from £34,746 to £30,789, but Mr. Hatton advises the committee to make a further appeal against this. The expenditure on the maintenance of cars shows an increase, and it is unlikely that this item can be reduced, as the cars become older from year to year. Providing the revenues of the undertaking do not quickly begin to show an improvement, it may become necessary to withdraw some of the concessions already granted. It may even in the future become necessary to have a minimum fare of 1½d., and to sell tickets in batches, but with a discount to the regular daily travellers, and so place the tramways undertaking on the same footing as a gas undertaking, with its revenue on a more flexible and controllable basis. The gross capital expenditure (inclusive of public lighting) has been £1,183,346. The traffic revenue was £203,302, compared with £211,085 in the previous year. Operating costs (including lighting) were £122,609, against £116,852. The gross profit, before providing for sinking fund or depreciation, was £86,931, against £100,229. The sinking fund took £36,252, against £34,878; and £1,551 was given in relief of rates, and the surplus was £7,558, compared with £19,478.

Northampton.—Electricity supply mains are to be laid in several additional streets.

Pacific Cable Board.—The report and accounts of the Board for the year ended March 31 have been issued this week.

Traffic receipts were £114,825. 15s. 1d. (less the Atlantic companies' charge for conveying date and time, and for delivering duplicate copies in London and other large centres in the United Kingdom, £3,763), making £111,062 net. Adding interest on deposits (£61), amount received for services rendered by the "Iris" (£1,339) and refund tolls and dues (£629), the net total was £113,093.

Expenditure included head office (salaries and expenses, canvassing, engineers' fees and royalties, and cost of remitting money home), £5,956; cable stations (salaries and expenses), £40,738; ships' salaries and expenses, £17,164; provident fund, £1,576; renewal account, £31,000; leaving excess of receipts over expenditure £16,657, which was available for reduction of the amount (£77,544) contributed annually for interest and sinking fund on the capital advanced by the National Commissioners. The amount payable by the Governments associated in the enterprise is therefore £60,888, against £62,362 for the previous year. Compared with the contribution made by the Board towards the redemption fund in 1908, this amount shows an increase of £1,474.

The total receipts during the past year exceeded those of the previous year by £2,933. Miscellaneous receipts amounted to £2,031, compared with £522, so that the actual increase on account of traffic was £1,425. The year's expenditure shows an increase of £1,458, due to normal increase under the incremental scheme of salaries and to the fact that within the past year practically all the staff engaged by the Board at the outset for service abroad became entitled to "long leave" and the cost of return passages to domicile. The preliminary forecast of revenue and expenditure for the year ending March 31, 1910, is as follows:—

Receipts.—Traffic revenue, £113,000. *Expenditure.*—Renewal fund £30,000, working expenses £69,955, showing an excess of £13,045.

The renewal fund stood at £192,595 on March 31 last. The balance of cash at that date to credit of this account was £18,791, and this has since been invested. Credit is given to the renewal fund for all interest earned by investments on this account, and as the annual interest now amounts to £7,000, while the appropriation from the revenue for this purpose has recently been £31,000 (for the coming year it will be £30,000), the present growth of the fund is at the rate of £37,000 a year. In addition to this cash reserve, there is in hand cable, &c., of the value of £18,945. During the past year serious interruptions of the Canadian landline service occurred on many occasions, and the Board's interests were adversely affected thereby. For several months some delay was caused almost daily to the Board's Australian traffic owing to the faulty condition of the Southport–Sydney line. The line between Doubtless Bay and Auckland, placed at the disposal of the Board by the New Zealand Government, was maintained in good condition throughout the year. Experiments with improved methods of increasing the duplex speed of the Bamfield–Fanning section of the system met with great success, and this cable, laid with the anticipation that the speed would not, in actual practice, exceed 65 letters a minute, is now daily working at the speed of 90 to 97 letters a minute. As the traffic-carrying capacity of the entire route is ruled by the results attainable on this section, this increased speed, which has been attained without risk of damage to the cable, greatly improves the revenue-earning capabilities of the Board's system. Throughout the year the cable was worked without interruption, and no repairs were necessary. The buildings, electrical apparatus and plant at all stations have been maintained in good order. Last year 238,088 ordinary messages, 8,310 Government messages and 3,192 Press messages were sent over the cables, and this year the figures were 232,304 ordinary, 9,086 Government and 2,532 Press messages, the total messages in each year being 249,590 and 243,922 respectively. The number of words transmitted in 1908-9 was 2,739,544, against 2,736,002 in 1907-8.

Patent Amendment.—The "Z" Electric Lamp Synd. (Ltd.), Orient House, New Broad-street, London, E.C., seek leave to amend specification of letters patent No. 20,223/1907 for "Improvements relating to the manufacture of filaments for electric incandescent lamps." Particulars of proposed amendment are given in the "Illustrated Official Journal" (Patents) of the 1st inst., and notice of opposition must be given within one calendar month from that date.

Rosyth Works Power Station.—Messrs. Easton Gibb & Son have arranged to erect a private electric power station for the supply of electricity for light and power throughout the entire works at Rosyth naval base. Gas-driven plant will be employed, and the National Gas Engine Co. have secured an order for four gas engines and suction gas plants with a maximum output of 1,100 B.H.P. The plant will be run day and night. Current will be supplied at 500 to 550

Sir CHARLES TILSTON BRIGHT.

It will interest our readers to know that we have some reproductions on sale at 1s. each, of the portrait of the late Sir Charles Bright (when knighted at the age of 26). This forms the frontispiece to the recently-issued abridged biography of the distinguished engineer. We would add that the portrait is mounted so as to be conformable as to size with "The Electrician" series of steel plate portraits, and is well suited for framing with the series.

volts to the various motors spread over the extensive area, the work to be done including quarrying, stone crushing, concrete mixing, the driving of machine shops and sawmills, pumping, &c. The suction gas plants are to use gas coke for fuel, costing about 10s. per ton, and it is estimated that electricity will be obtained at an inclusive cost of ⅜d. per unit.

Russia.—The "Bulletin Commercial" (Brussels) states that Kharkov Municipal Council have applied for powers to borrow £633,000, of which £100,000 is required for electric tramway construction and £50,000 for electricity supply works.

Sheffield.—Electricity supply mains are to be laid in four additional thoroughfares at a cost of £380.

South Africa.—The "South African Mining Journal" states that tenders are to be invited by Johannesburg Council for supply of the following plant (of the estimated value of £57,000) for their electricity supply works:—

Four boilers, each to produce 14,000 lb. of steam per hour, four mechanical stokers, economisers, chimney and flues, steam, exhaust and circulating piping, two cooling towers, cooling pond, two feed pumps and house, one borehole and pump, removing six boilers, steam pipes, &c., and steam engines.

The "British and South African Export Gazette" says Johannesburg Chamber of Trade have secured an extension of time for tendering for South African Government and municipal contracts.

At the end of the last financial year there was only one electric and one oil-driven main-winding hoist in Transvaal gold mines out of 432, the remaining 430 being steam driven. Recently there has been an important development of engineering opinion on this subject, and the advocates of electric winding plant are likely to see their views widely adopted, as the tendency towards the substitution of electricity is unmistakable.

Prof. Klingenberg has brought before the Transvaal Power Schemes Commission the subject of the application of electricity to agriculture. It is pointed out that with no consumers existing between the Zambesi and the Rand, the gigantic Victoria Falls power scheme is practically in abeyance, but it might be proceeded with if a satisfactory plan were devised for tapping the transmission line at a sufficient number of points to supply agricultural districts.

Roodepoort United Main Reef Gold Mining Co. (Ltd.) is in the market for a large number of motors.

Stretford.—The Electricity committee have been unable to agree with Manchester Corporation as to the charge for current for tramway traffic. The Corporation offered a supply at 1d. per unit, subject to an adjustment in respect of the price of coal, the arrangement to remain in force until March 31, 1912; but this is not acceptable, and the Board of Trade have been asked to appoint an arbitrator to settle the price to be paid.

Sweden.—Vice-Consul Westerberg (Lulea) says surveys and experimental works in connection with the electrification of the railway from Kiruna to the Norwegian frontier are being conducted. Power is to be taken from large waterfalls adjacent to the route.

Vice-Consul Forsell (Skelleftea) says Skelleftea Council are under contract to supply electric power to the Ytterstfors Travaru Aktiebolag and to the Ohrvikens Aktiebolag (two sulphite mills) to the extent of 1,725 kw. and 600 kw. respectively per annum. These works are 31 miles and 27 miles respectively from the generating station. The total capacity of the station is 3,000 kw. The town owns waterfalls sufficient to provide a further 3,000 kw., and there is a project under consideration to utilise this.

Vice-Consul Burchardt (Hernösand) reports that a huge electric power station has been built by the Graningeverkens Aktiebolag at Forsse, where the water power of the falls of the river Faxalfken is utilised to the extent of 6,000 H.P. Part of the current is transmitted (at 40,000 volts) about 35 miles to pulp mills at Kramfors, Frano and Svano. The millowners pay £4 per horse-power per year.

Swinton and Pendlebury.—The Council are recommended to appoint an electrical engineer as manager of the electricity supply department at £150 per annum. The undertaking has hitherto been managed by the Lancashire Electric Power Co., who supply energy in bulk.

Tavistock.—As the Council have received notice from a company of intention to apply for a provisional electric lighting order, the question of a municipal application is being discussed.

Telephone on Monte Rosa.—The Italian Government have erected a telephone service on Monte Rosa. The lines cross from Colle d'Olen (9,587 ft.) across to the Gnifetti Shelter (11,862 ft.), to the Regina Margherita Observatory at the top of Gnifetti Peak, a total height of 14,820 ft.

The Electrical Engineer as an Athlete.—Mr. H. L. Ross is electrical engineer to the owners of the "Daily Mail," whose interesting exhibit is a conspicuous feature of the White City, Shepherd's Bush, London. Mr. Ross is also a member of the Carmelite Athletic Club, and in this relation was one of the 32 starters for the walk from London to Brighton on Saturday last. The distance between start and finish was 51¾ miles, which Mr. Ross accomplished in 8 hr. 11 min. 14 sec., the fastest time on record by more than 7 minutes.

Usworth (Co. Durham).—The Parish Council have decided to adopt public electric lighting, and overhead mains will be employed.

Warrington. The gas lamps around the Town Hall are to be adopted for electric lighting.

Wireless Telegraph Notes.—According to "The Times Engineering Supplement" the New Palace Hotel in Shanghai was completed a week or two ago, and one of the chief features was an apparatus for wireless telegraphy which was installed on the roof of the hotel, in order to communicate by way of Wusung with incoming vessels. This apparatus has been found to work extremely well, but the Chinese Government entered a protest against its employment, as it was asserted that wireless telegraphy had been declared a State monopoly in China. It would seem that recent experiments have convinced the Chinese of the vast importance of this system of telegraphy in a country of such immense extent as China, and of its superiority to the present system. The inland wires are now chiefly laid along the banks of the main rivers, and serious interruptions are caused by the frequent floods, which wash away the telegraph poles, while in certain districts the telegraph lines have to be guarded by troops. A wireless system would thus give great safety in working, which is probably the reason for the decision to keep the system as a State monopoly.

It is announced that the Government of Bombay have decided to instal a wireless telegraph station at Bombay, the range to be limited to 300 miles seaward. The Government Telegraph Department is to erect and work the installation, and the first communications are expected to be ready by Oct. 22.

Wolverhampton.—The new high school for girls is to be wired.

Workhouse Lighting.—On the advice of Mr. John Christie, the Brighton Guardians have decided to substitute metal filament lamps (of 50 c.p.), and Nernst lamps (25/30 c.p. each) for the present carbon filament lamps at the workhouse.

Worthing.—The L.G. Board have sanctioned the borrowing of £3,550, out of £3,900 applied for by the Corporation, viz., £2,300 for feeder and distributor cables, and £1,250 for house services. The Board suggest, however, that the cost of meters (£337) should be met out of revenue. The Council have decided to adopt this course in future, but have requested the Board to sanction in its entirety the amount applied for in the present case.

York.—The horse-drawn tramcars have been taken off the streets and 'buses have been substituted in order to facilitate the work of converting the lines to electric traction.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 100,000 porcelain insulators to the Postmaster-General's Department, VICTORIA. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-st., London, S.W.

SPECIAL NOTICE.

NOW READY.—Vol. LXII. of "THE ELECTRICIAN" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

Tenders are invited for the supply to the Postmaster-General's Department, New South Wales, of a common battery switchboard for the NORTH SYDNEY telephone exchange. Tender form, specifications, &c., may be obtained from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 2,550 common battery telephones and protectors to the Postmaster-General's Department, NEW SOUTH WALES. Tender forms, &c., may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W.

LONDON County Council invite tenders for (1) the manufacture, delivery and erection in certain of the Council's substations of two 500 kw. and one 150 kw. motor generators, and (2) the manufacture, delivery and erection of h. and l.t. switchgear for Woolwich and other substations. Tenders, on forms to be obtained from Mr. G. L. Gomme, County Hall, Spring Gardens, S.W., by 11 a.m., Sept. 21.

LONDON County Council also invite tenders for the manufacture, delivery and laying of about 6½ miles of 0·075 sq. in. three core lead-covered h.t. cables, &c., and about 46 miles of single core lead-covered l.t. cables, telephone cables, &c.; manufacture (but not erection) of 50 tramway feeder pillars; laying about 16 miles of stoneware cable ducts, including necessary manholes, repaving, &c., and manufacture and delivery of 440,000 ducts of glazed stoneware for electric cables. Drawings, &c., at the County Hall, Spring Gardens, S.W. Tenders to the Clerk by 11 a.m. Sept. 14.

LONDON COUNTY COUNCIL also invite tenders for the partial reconstruction of the bridge carrying Lower-road, Deptford, over the East London Railway, and reconstruction and widening of the bridge carrying the same road over the Grand Surrey Canal. Tenders to the Clerk by 11 a.m., Sept. 14.

LONDON County Council also require tenders by 11 a.m., Sept. 21 for the manufacture, delivery and erection at Greenwich of steam, exhaust, feed and drain pipes, valves, water tanks, &c. Tender forms, &c., from the Clerk.

The Lighting committee of DUBLIN Corporation invite tenders for supply of 750 a.c. meters (single-phase). Specification, terms and conditions and form of tender from the city electrical engineer (Mr. Mark Ruddle), Fleet-street, Dublin. Tenders to the Chairman of the Lighting committee, 3, Cork-hill, Dublin, by noon, Sept. 13.

GRIMSBY Corporation invite tenders for supply of paper-insulated lead-covered cables for two years. Specification and form of tender from the borough electrical engineer, Mr. W. A. Vignoles, to whom tenders are to be sent not later than first post Sept. 17.

BRISTOL Education committee require tenders by noon, Sept. 21, for electrician's work at the new school at Alexandra Park, Fishponds, Bristol. Forms of tender, &c., from Messrs. Rodway & Dening, Gaunt House, Orchard-street, Bristol.

OULTON BROAD (Suffolk) Council are prepared to receive applications from companies or individuals who will undertake the carrying out of the Council's electric lighting order. Particulars from Mr. C. G. Taylor, Victoria-chambers, Lowestoft.

MANCHESTER Tramways committee want tenders by 10 a.m., Sept. 21, for supply of steel girder tramway rails. Specifications from Mr. J. M. M'Elroy, 55, Piccadilly, Manchester.

FULHAM (London) Council require tenders by noon, Sept. 22, for supply of 150 electricity meters. Forms of tender, &c., from the Borough Electrical Engineer, Townmead-road, Fulham, S.W.

Tenders will be received until Sept. 20 by the Société Nationale des Chemins de Fer Vicinaux, BRUSSELS, for supply of aerial electric equipment for the Anderlues–Lobbe section of the Carmères–Thuin light railway.

The Minister of the Interior, BUCHAREST, Hungary, requires tenders by Sept. 14 for supply of 1,400 Leclanché jars.

CORUMBA (Brazil) Municipality want tenders by Oct. 5 for the erection and equipment of electricity supply works.

CAPE TOWN Municipality want tenders by Sept. 29 for supply of about 2,500 dry cells during the year commencing July 1 next.

The Servian State Railways Department want tenders by Sept. 14 with deposit of £320) for supply of the following material for a new mining installation at SEONE: Coal extracting apparatus, three centrifugal pumps, four electric conductors and five sets of signalling apparatus. A responsible agent in Servia is necessary, and specifications can be seen at the State Railways Department, Belgrade

The Turkish Government want tenders for the installation and working of a telephone system in CONSTANTINOPLE and the vicinity. An agent on the spot is practically essential. Tenders to the Minister of Finance, Constantinople, by Oct. 14.

TENDERS RECEIVED AND ACCEPTED.

Bradford Electricity committee recommend for acceptance the following tenders in connection with the electric light and power plant at the Technical College :—

Crosthwaite Fire Bar Synd., cooling tower, £168; Cole, Marchent & Morley, low-speed engine, surface condenser and jet condenser, £1,200; Campbell Gas Engine Co., gas engine with suction gas plant, starter, &c., £1,100; Tudor Accumulator Co., battery of 220 cells, £332. 10s.; Siemens Bros. Dynamo Works, motor-generator, £171; Phœnix Dynamo Mfg. Co., high-speed set, low-speed set, booster and balancer, and gas set, £600; Thwaite Bros., high-speed engine, £260; T. Green & Sons, economiser, £104; Holdsworth & Sons, Lancashire boiler, £368.

Wishaw Corporation received the following tenders for supply and erection of a three-wire d.c. switchboard :—

Ferranti, Ltd. (*accepted*)	**£150**	Siemens Dynamo Works	‘172
G. Hill & Co.	229	Dorman & Smith	168
Balchin, Schulz & Co.	215	Universal Elec. Mfg. Co.	163
W. McGeoch & Co.	205	Brit. Thomson-Houston Co.	160
Kelvin & James White	203	Elec. Construction Co.	160
General Electric Co.	180	Evered & Co.	158
Brit. Westinghouse Co.	179	Spagnoletti (Ltd.)	157
Crompton & Co.	176	Whipp & Bourne	154
J. Cartwright	175	Johnson & Phillips	*153
Veritys Limited	173	G. Braulik	*151

* Incomplete.

Brighton Guardians have accepted the tender of the Post Office for :—(*a*) Providing and maintaining an extended exchange system between the parochial offices, the workhouse and the Warren Farm Schools for an annual rental of £77. 12s.; (*b*) providing and maintaining a private installation at the workhouse for £37. 0s. 9d. per year, for five years.

An order has been placed by Messrs. Easton Gibb & Son (contractors for the Rosyth Naval Works) with the National Gas Engine Co. for supply and erection of four gas engines and suction gas plant, with a maximum output of 1,100 B.H.P.

York Tramways committee have accepted the tender of the British Thomson-Houston Co. for supply of 18 tramcars, at £10,914. 4s.

W. T. Henley's Telegraph Works Co. have orders for 3,000 ft. of three-core cable for the Village Deep (South Africa) Mines, and also an order for cables for Bantjes Consolidated Mines.

Dick, Kerr & Co. have obtained orders for mill motors of 400 H.P., 240 H.P., and 165 H.P. in connection with the electrification of the Rand Mines (Ltd.)

The Electrical Apparatus Co. has been allotted the Admiralty contract for all enclosed fuses from 35 to 60 amperes inclusive, up to Dec. 31, 1911.

Swansea Education committee have accepted the tender of Mills, English & Co. for electric light fittings, &c., for the Technical College extensions at £375.

Pooley & Austen have an order for street lamp fittings for electric lighting at Cape Town.

Mansfield Council have accepted the tender of Babcock & Wilcox for water softening plant at £220.

Rochdale Council have accepted the tender of the Lorain Steel Co. for tramway points and crossings at £422.

Brighton Guardians have placed an order with the Electrical Co. for supply of 500 F type Nernst lamps at 1s. 7½d. each (£40. 12s. 6d.)

Geelong (Victoria) Harbour Trust have placed contracts with Siemens Bros. Dynamo Works for switchboard, balancer and cables, and with Johns & Waygood for overhead travelling crane for power house.

Melbourne (Victoria) Corporation have accepted the tenders of the British Thomson-Houston Co. for supply of 69,750 incandescent lamps, £1,329; W. T. Henley's Telegraph Works Co. for 7,810 yd. of insulated copper cables £552; British Insulated and Helsby Cables for 13½ miles h.d. copper cable £409, and W. Hallenson & Co. for 1,500 kw. d.c. dynamo and engine £9,881.

The Postmaster-General's Department, New South Wales, have accepted the tender of the Western Electric Co. for supply and erection at William-street, Sydney, of branching metallic multiple magneto switchboard with meters at £4,179. 10s.

BUSINESS NOTICES.

By licence from the Board of Trade, the New Brotherton Tube Co. (Ltd.), of Excelsior Works, Commercial-road, Wolverhampton, have altered the style of the firm to that of *Brotherton Tubes & Conduits (Ltd.)*, which name has been duly registered with the Registrar of Joint Stock Companies.

In future the address of the Underground Electric Railways Co. of London, and the Baker-street and Waterloo, the Great Northern, Piccadilly & Brompton, and the Charing Cross, Euston and Hampstead Railway Co.s will be at St. James' Park Station-buildings, Broadway, Westminster, S.W. The telegraphic address is "Underneath, London"; and the Telephone No. 5820 Gerrard (9 lines).

Patents Development.—The proprietors of the following patents wish to enter into negotiations with firms in Great Britain for the sale of same or for the grant of licences to manufacture under royalty:—

No. 23,429/1901, relating to "Electric locomotives." Applications to Messrs. Hyde & Heide, 3, Broad-street Buildings, Liverpool-street, London, E.C.

No. 18,408/1906, for "Improvements in electric insulators for high-tension conductors," and No. 18,125/1905, for "Improvements in electric motor control systems." Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton Buildings, Chancery-lane, London, W.C.

No. 739/1909, for "Apparatus for continuously indicating the horse-power being transmitted by marine propeller shafts and the like." Applications to Mr. W. McBretney, 44, Portland-street, Lancaster.

A.E.G.-Zeitung.—In the Sept. number Dr. Bloch continues his article on "Electricity in Domestic Dwellings." Other articles deal with "The Deterioration of Tubes in Surface Condensers," and "The Work of the Victoria Falls and Transvaal Power Co." The petrol-electric car made by the A.E.G. for the Prussian State Railways is also described, as well as an interesting lorry recently put on the market.

"Victoria" Turbo Pumps.—Messrs. Willans & Robinson, who have recently taken up the manufacture of centrifugal pumps, for dealing both with high and low lifts, have at present some 12 pumps under construction. A series of tests has recently been completed on one of these pumps, which has shown that the high efficiency estimated by the designer (Mr. Jens Orten Böving) has been fully realised in practice. The pumps in question are of a particularly simple design, and are being built with a view to requiring the minimum amount of attention in working. In view of the large number of high lift sinking pumps imported into this country, there would seem ample room for a well-built reliable British made pump.

CATALOGUES, &c.

USEFUL TABLES.—The Langdon-Davies Motor Co. have ready a small brochure containing a number of useful tables. Comparison is made in these between watts, horse-power, force de cheval and kilogramme-metres. These tables will be of considerable use to engineers. The booklet also contains details of the standard ratings of Landon-Davies continuous and alternating-current motors, the latter being designed for two and three-phase, as well as for single-phase circuits.

KALKOS TINNED TUBE WIRING SYSTEM.—It will not be denied that the well-known "Kalkos" tinned tube wiring system offers a cheap and easy method of filling houses and factories with the blessings of electric light and power. The various details of this system are, of course, by this time well known to our readers, as it has now been on the market for about two years. We are pleased to hear that from small beginnings "Kalkos" has rapidly found favour with consulting engineers and architects, and we can recommend any of our readers who are interested in the subject, either actively or otherwise, to apply to the Sun Electrical Co. for a copy of their latest catalogue. This contains details of the very large number of fittings and appliances which have been designed to render the system more complete and still wider in its applications. The prices of these fittings have been considerably reduced.

DOUBLE-ACTING AIR PUMPS. The Midland Engineering Co. issue a pamphlet dealing with their "Zylba" double-acting air pump, which contains no foot or bucket valves. It is claimed for this class of pump that it is most suitable for high-speed work and for maintaining sufficient vacuum with a minimum of driving power and cost of upkeep. Station engineers will be interested in the pamphlet.

"HYLO" TURN-DOWN LAMPS.—Wm. Geipel & Co. have issued two illustrated leaflets dealing with this subject.

A MATCHLESS LIGHT. Messrs. J. & H. Grevener have issued an advertising folder intended to give publicity to their well-known "Arcoflame" lamps.

MODERN SWITCHBOARDS.—A handsome brochure dealing with this subject has come to hand from the Union Electric Co., giving a number of illustrations showing apparatus recently manufactured by the company. We would advise those of our readers who desire to have a record of the present position of switchboard work generally to write the Union Company for a copy of this artistic booklet.

HIGH-SPEED ELECTRIC MOTORS FOR LARGE OUTPUTS.—The greatly increased use of centrifugal pumps in this country has called for a reliable high-speed motor. To solve the problem thus set has been part of the work of the Lahmeyer Electrical Co., and a description which we have just received of the company's latest type of high-speed motor, in which the windings are specially insulated in accordance with mining regulations, seems to show that these conditions have been successfully fulfilled. Motors fitted with vertical shafts are supplied for all outputs and voltages in commercial use, and these motors are said to be specially suitable for modern shaft-sinking pumps.

"CONTA" LAMP.—The Regina Bogenlampen-fabrik, of Cologne, have prepared a well-arranged catalogue dealing with their new universal and interchangeable arc lamp which, it is claimed, is suitable for use on any system of supply. It is further claimed that this lamp is at least twice as durable as any other lamp offered to the trade, and contains a number of other special advantages. We cannot in the space at present at our disposal deal with the details of this lamp at any great length, but we hope to do this in an early issue. A price list of the other lamps made by this firm, along with the accessories pertaining to the same, is also to hand.

WIDE-SPAN OVERHEAD TRAVELLING CRANE.—An interesting piece of equipment, from the crane engineers' point of view, is illustrated and described on a sort of enlarged postcard recently received from Messrs. S. H. Heywood & Co., Reddish. The span of this crane is 83 ft. 6 in. and the working load 4 tons when it was tested with a central load of 6 tons 2 cwt., the deflection of the girders under this load being $\frac{5}{16}$ in. Three motors were fitted, all of the series-wound type, and capable of running sparklessly in either direction with a fixed brush position. When tested, the load of 6 tons 2 cwt. was hoisted 20 ft. in 56 sec. The speed of the cross traverse was 125 ft. in 1 min., and the travelling speed 255 ft. in 1 min.

ELECTRICAL MEDICAL APPLIANCES.—Under certain conditions electricity can be very successfully applied in medical work. It has, in fact, been fashionable for some time to use electro-medical apparatus, we fear in some cases, whether the "case" is specially suitable for electrical treatment or not. However, as electrical engineers we must not complain of this, for it means that probably more apparatus of this kind is required than would otherwise be the case, although in the long run it is doubtful if the industry gains by anything but the safest practice. An enthusiast in the field of electro-medical treatment and an expert in the design and manufacture of the necessary apparatus is Mr. H. J. Dowsing, and his company (the Dowsing Radiant Heat Co.) has issued a pamphlet in which some new electro-medical apparatus is fully illustrated and described. The subject is essentially a specialised one, and a consideration of the matters contained in the booklet is best left to those familiar with this class of electric accessories. It is sufficient to say here that long and intimate connection with this branch of work makes Mr. Dowsing's specialities of interest to all who appreciate good design and finished workmanship.

VULCANISED INDIARUBBER WIRES AND CABLES.—The Felten & Guilleaume-Lahmeyerwerke A.G., of Mulheim-on-Rhine, forward their latest catalogue dealing with the subject of vulcanised rubber wires and cables. In this list full details of all the various types of cables insulated in this way are set out, and the catalogue should be of great service to those whose work requires them to invest in this class of goods.

OIL-IMMERSED TRANSFORMERS.—The Lahmeyer Electrical Co. have ready a new list dealing with their latest types of single and three-phase oil-immersed transformers.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during August, 1909, and (*b*) during the current year from Jan. 1 to Aug. 31, with the increases or decreases compared with the corresponding periods of 1908:—

Electrical machinery (*a*) £47,903 (increase £12,965), (*b*) £337,830 (decrease £95,037); telegraph and telephone cables (*a*) £11,455 (decrease £564), (*b*) £84,266 (decrease £3,065); telegraph and telephone apparatus (*a*) £15,568 (decrease £1,033), (*b*) £120,609 (decrease £10,415); other electrical wires and cables, rubber insulated (*a*) £9,441 (increase £3,304), (*b*) £62,189 (increase £10,323); with other insulations (*a*) £3,592 (decrease £4,727), (*b*) £84,266 (decrease £3,065); carbons (*a*) £8,467 (decrease £3,357), (*b*) £85,300 (decrease £24,683); glow lamps (*a*) £19,472 (decrease £14,895), (*b*) £267,609 (increase £88,692); arc lamps and electric searchlights (*a*) £236 (decrease £369), (*b*) £9,126 (increase £6,147); parts of arc lamps and searchlights (other than carbons) (*a*) £5,376 (decrease £441), (*b*) £38,715 (increase £2,153); primary and secondary batteries (*a*) £2,207 (decrease £700), (*b*) £29,293 (decrease £3,311). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £82,760 (decrease £27,846), (*b*) £821,325 (increase £34,801).

Exports.—The exports of electrical machinery, material, &c., (*a*) during August, 1909, and (*b*) during the current year from Jan. 1 to Aug. 31, and the increases and decreases compared with the corresponding periods of 1908, are as follows:—

Electrical machinery (*a*) £144,264 (increase £45,963), (*b*) £974,488 (increase £107,779); telegraph and telephone cables (*a*) £42,133 (increase £16,458), (*b*) £477,006 increase £135,519); telegraph and telephone apparatus (*a*) £11,737 (decrease £3,779), (*b*) £185181 (increase £76,104); other electrical wires and cables, rubber insulated (*a*) £26,367 (increase £5,485), (*b*) £175,792 (decrease £4,152); with other insulations (*a*) £21,882 (decrease £31,947), (*b*) £197,205 (decrease £19,064); carbons (*a*) £863 (increase £155), (*b*) £6,051 (increase £330), glow lamps (*a*) £7,168 (increase £2,580), (*b*) £48,134 (increase £11,776); arc lamps and searchlights (*a*) £1,536 (increase £265), (*b*) £13,447 (decrease £778); parts of arc lamps and searchlights (other than carbons) (*a*) £1,536 (increase £265), (*b*) £9,862 (decrease £702); primary and secondary batteries (*a*) £4,123 (decrease £5,355), (*b*) £70,177 (increase £20,721). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £159,188 (decrease £3,172), (*b*) £1,433,624 (increase £239,932).

COMPANIES' MEETINGS AND REPORTS.

BRITISH THOMSON-HOUSTON CO. (LTD.)—The directors' report for the 12 months ended March 31st states that the buildings and machinery at Rugby have been maintained in first class condition during the year, and while the directors have not been able to make depreciations (except as hereinafter mentioned) they have made a number of improvements and additions, the most important being the extension of the steam plant, at a cost of £8,766. They have also followed their usual practice of making reserves to cover risks in connection with bad debts, depreciation of shares held by the company and for other contingencies. As stated in the last report, the company now owns all the patents for the United Kingdom for Curtis steam turbines, excepting the marine rights. During the financial year the company sold 12 turbines, aggregating 15,000 kw., and the directors feel confident that the business in steam turbines will be large, due not only to the unrivalled excellence of the company's apparatus, but also to the unique fact that the company can supply either the vertical or the horizontal type. Since the end of the year under review the company has sold 18 turbines, aggregating 18,569 kw. The volume of business in this direction during the year has not been satisfactory, due to the depressed condition of trade, yet a large number of important contracts have been secured, and marked progress has been made. In central station developments the most important contracts have been for turbines. The quantity of electrical equipment for tramway and railway work sold in Great Britain during the year has been very small, but the company has received its fair share of this business. Several important contracts for switchboards have been closed during the year. The company has made further satisfactory progress in the development of metallic filament (tungsten) lamps, and, to meet the increasing demand, is extending its manufacturing facilities.

Under the terms of the trust deed securing the issue of the debentures, the company had to pay to the truestes on Feb. 28 last £3,339, to be applied by them in purchasing debentures in the market. Debentures of the par value of £3,500 were purchased prior to March 31, making the total par value of debentures retired to date £7,060. The directors regret that the balance sheet shows a loss of £824. 17s. 5d. as the result of the year's working after paying interest on debentures and loans. They deem it wise, however, to write off certain items, and to that end have carried into the profit and loss account the balance brought forward from last year (£2,466. 11s. 7d.) and the reserve of £15,109. 1s.

BROWN, BOVERI & CO. (LTD.) (MANNHEIM)—The net profit for the past year was 525,195 marks (about £26,260), against 519,643 marks (£25,980) last year, the dividend being 6 per cent. as before. Trade has been quiet, whilst competition has been very keen, but profits have not been affected owing to economies effected at the works and the satisfactory profits on some of the company's special productions. The steam turbine branch of the business is developing satisfactorily, a number of repeat orders being on hand. During the past year or two paper manufacturers have shown considerable interest in the electric drive, and the company are installing the complete plant for power generation and distribution at three of the largest German paper works. They are building two 1,000 H.P. electric locomotives for the Baden State Railway for the Wiesental line, and have other orders in connection with railway electrification schemes.

DUMBARTON BURGH & COUNTY TRAMWAYS CO. (LTD.)—Major Heaton Ellis stated at the meeting last week that the total revenue for the past year was £19,495. He hoped, and he was led to believe, that the depression which had been so marked during the last year was gradually lifting, and that trade on the Clyde and in the district served by the company was improving. After payment of debenture interest and the full preference dividend they carried forward £3,000.

DUNDEE, BROUGHTON FERRY & DISTRICT TRAMWAY CO. (LTD.)—The report for the year ended July 31 states that the total profit was £1,512. The directors recommend the final preference dividend, placing £600 to renewals fund, £600 to the fund for redemption of debenture stock, carrying forward £312.

UNITED ELECTRIC CAR CO. (LTD.)—During the year ended June 30 the works have been efficiently maintained out of revenue. After paying debenture interest (£2,500) and charging £5,645. 18s. 11d. for depreciation, the profit for the year is £8,896. 7s. 4d., to which is added £6,187. 1s. 8d. from last year, making £15,083. 9s. Deducting preference dividend (£3 000) the available balance is £12,083. 9s. The balance preference dividend absorbs £3,000, and a dividend of 2½ per cent. (less tax) on the ordinary shares for the year require £3,750, leaving £5,333. 9s. to carry forward.

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

NATIONAL LIGHTING CORPN. (LTD.) (104,780.)—Reg. Aug. 30, capital £1,000 in £1 shares, to carry on the business of electricians, manufacturers of and dealers in electric light fittings and electrical appliances and novelties, &c. Private company. First directors, A. Lange, I. Frohwein and S. Mundler. Reg. office, 35, Cock-lane, London, E.C.

PLUTTE, SCHEELE & CO. (LTD.) (104,840.)—Reg. Sept. 3, capital £6,000 in £1 shares, to adopt an agreement with F. Plutte for the acquisition of the business of Plutte, Sheele & Co., and to carry on the business of manufacturers and sellers of articles and accessories required in the electrical and allied trades, &c. Private company. First directors, J. N. Cooper and P. Kuppers. Reg. office, 18 and 19, Queenhithe, London, E.C.

MORTGAGES AND CHARGES.

"Z" ELECTRIC LAMP MFG. CO. (LTD.)—Particulars of £25,000 debentures, created Aug. 13, 1909, have been filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

ELECTROLYTIC ALKALI CO. (LTD.)—Issue on Aug. 16 of £3,700 debentures, part of a series of which particulars have already been filed.

LEPEL WIRELESS SYND. (LTD.)—Charge, dated Aug. 13, 1909, to secure £200, charged on proceeds to be received from the Government in respect of the first two stations which the syndicate is delivering to the Admiralty. Holder, Sir Thomas Myles.

RECEIVERSHIP.

NEW IGNITION SYND. (LTD.)—A notice of the appointment of H. P. Walters, 15, George-street, Mansion House, E.C., as receiver and manager, by Order of Court dated Aug. 26, 1909, has been filed.

CITY NOTES.

MEMORANDA (Sept. 9).—**Bank rate 2½ per cent. (since April 1, 1909). Price of silver, $23\frac{11}{16}$d. per oz.** Consols $83\frac{11}{16}$—$83\frac{13}{16}$ **for money and** $83\frac{3}{4}$—$83\frac{7}{8}$ **for account.** Consols Pay Day, Oct. 1; **Stock and Shares** Continuation Days, Sept. 27 and Oct. 12; **Ticket** Days, Sept. 28 and Oct. 13; **Pay Days,** Sept. 10 and 29; Mining Shares Carry Over Days, Sept. 24 and Oct. 11.

PRICES OF METALS (London).—*Copper*, cash, $59\frac{1}{16}$; three months $59\frac{15}{16}$. *Lead*, English, $12\frac{15}{16}$—$13\frac{1}{4}$; foreign, cash, $12\frac{3}{4}$; three months, $12\frac{7}{8}$. *Spelter*, cash, $22\frac{5}{8}$; three months $22\frac{7}{8}$. *Tin*, English, 134—136; foreign, cash, $135\frac{3}{4}$; three months, $137\frac{1}{8}$. *Iron*, Cleveland, cash, 51/0½, and three months, 51/9½. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BRITISH COLUMBIA ELECTRIC RAILWAY CO (LTD.)—The directors have issued a circular stating that there is a continued increase in the earnings; that the conditions prevailing in British Columbia have been carefully examined, and they are of opinion that, so far from any likelihood of the volume of business abating, there is practically no doubt that it will continue to increase even more rapidly for the next four or five years than it has done in the past. In these circumstances the company has undertaken many extensions for meeting the requirements of transportation in its territory, necessitating a further increase in the supply of power, rolling stock, &c. The directors have therefore decided to make a further issue of £500,000 of capital, and to offer same to the preferred and deferred ordinary stockholders.

CANADIAN GENERAL ELECTRIC CO. (LTD.)—The directors have declared a dividend of 1¾ per cent. for the quarter ending 30th inst. (at the rate of 7 per cent.) on the common stock.

EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)—Mr. William Murray, of the firm of Williamson, Murray & Co., has joined the board of this company.

JAMES KEITH & BLACKMAN CO. (LTD.)—The directors recommend a dividend of 5½ per cent. on the preference shares for the past year, carrying £2,301 forward.

SAO PAULO, TRAMWAY, LIGHT & POWER CO.—The directors have declared a quarterly dividend of 2½ per cent. on the capital stock, payable Oct. 1.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 1	1,612	+ 56	13	20,949	− 600
Airdrie	Aug. 27	247	+ 13	34	7,411	− 100
Anglo-Argentine	Sept. 2	40,190	+ 4,537	35	1,362,409	+ 81,627
Ayr Corporation	„ 4	314	+ 17	16	6,513	− 192
Baker St. & Waterloo Ry.	„ 4	2,765	− 225	9	25,995	+ 650
Barnsley	Aug. 27	205	− 26	34	5,745	− 316
Barrow	„ 27	263	− 20	34	7,904	− 606
Bath Electric Trams, Ltd.	Sept. 1	911	+ 115	35	27,299	+ 1,299
Birmingham Corporation	„ 4	6,314	− 42	23	148,003	+ 3,686
Birmingham & Mid.	Aug. 29	860	+ 16	33	27,813	+ 337
Blackburn Corporation	Sept. 1	1,051	− 61	23	26,052	− 988
Blackpool and Fleetwood	„ 4	1,145	+ 144	...	...	...
Bolton Corporation	„ 5	2,375	+ 132	23	54,228	− 575
Bombay	Aug. 5	R35,359	+ R2,017	31	R1,161,955	+ R66,788
Bournemouth Corporation.	...	...	...	...	...	...
Bradford Corporation	Sept. 4	5,098	+ 363	22	112,580	+ 2,477
Brighton Corporation	„ 6	1,218	+ 182	23	24,423	+ 1,119
Bristol Trams & Carriage	„ 3	5,970	+ 909	15	89,599	+ 4,038
Burnley Corporation	„ 4	1,352	+ 26	23	29,618	− 47
Burton Corporation	„ 5	265	− 22	23	6,209	− 170
Bury Corporation	„ 5	1,185	− 14	‡23	27,269	− 605
Calcutta Tramways Co.	„ 4	R46,434	− R1,392	9	R444,582	+ R25,156
Camborne-Redruth	„ 4	131	− 1	36	4,416	− 132
Cardiff Corporation	...	...	...	...	...	...
Cavehill	Aug. 27	105	+ 13	34	3,059	− 137
Central London Railway	Sept. 4	4,695	− 2,455	9	44,199	− 18,545
Charing C., Euston & H'stead	„ 4	3,480	+ 275	9	32,690	+ 4,115
Chatham & Dist. Lt. Rys.	„ 3	1,000	+ 152	38	28,760	+ 1,690
City & South London Rly.	„ 5	2,970	− 132	9	27,321	+ 1,170
City of Birmingham	Aug. 27	2,663	+ 7	34	95,192	+ 875
Colchester Corporation	Sept. 1	225	− 8	9	1,856	− 860
Cork Electric Trams Co.	„ 2	501	+ 19	9	15,482	− 767
Croydon Corporation	...	...	...	...	...	...
Devonport & Dist. Trams	Aug. 27	384	− 108	34	12,597	− 3,071
Dover Corporation	Sept. 4	268	+ 13	23	5,259	− 368
Dublin & Lucan Railway	„ 3	166	+ 15	9	1,561	+ 55
Dublin United	„ 3	5,822	− 14	19	56,628	+ 1,235
Dudley-Stourbridge	Aug. 27	894	+ 25	34	27,903	− 726
Dundee Corporation	Sept. 1	1,368	+ 144	†16	18,899	− 422
East Ham Council	„ 4	978	+ 117	§22	23,119	+ 3,210
Exeter Corporation	„ 3	370	+ 29	23	8,201	+ 599
Gateshead & Dist. Trams	Aug. 27	495	− 28	34	33,885	− 295
Glasgow Corporation	Sept. 4	17,021	+ 212	‖14	220,572	− 3,818
Glossop Trams	„ 4	119	− 6	36	4,397	− 121
Gravesend—Northfleet	Aug. 27	219	+ 26	34	7,133	− 139
Great Northern & City Rly.	Sept. 4	1,241	− 45	9	11,128	− 48
Gt. Northern, Piccadilly, &c	„ 4	4,645	− 190	9	43,660	+ 675
Greenock & Port Glasgow	Aug. 27	667	+ 86	34	18,729	+ 526
Hartlepool Tramways	„ 27	276	− 16	34	8,017	− 223
Hastings Elec. Trams Co.	Sept. 2	1,591	+ 238	5	12,895	− 135
Hong Kong	„ 4	$9,159	+ $1,225	...	...	...
Huddersfield Corpn.	...	...	...	...	...	...
Hull Corporation	„ 4	2,695	+ 255	22	57,068	+ 1,689
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	„ 1	153	+ 6	22	3,068	− 194
Ipswich Corporation	„ 4	485	+ 34	23	9,787	+ 143
Isle of Thanet Co.	„ 4	1,666	+ 203	§40	28,328	+ 305
Jarrow	Aug. 27	134	+ 14	34	4,012	+ 369
Keighley Corporation	Sept. 2	178	+ 23	22	3,905	+ 116
Kidderminster & District	Aug. 27	130	+ 2	34	3,755	− 221
Kilmarnock Corporation	Sept. 4	138	− 5	16	2,476	− 88
Lanarkshire Trams Co.	„ 2	1,433	+ 167	35	41,791	− 702
Lancashire United	„ 1	1,319	− 31	35	46,615	− 565
Leamington	Aug. 27	209	+ 12	34	5,977	+ 182
Leeds Corporation	Sept. 4	6,839	+ 336	23	156,378	+ 2,814
Leicester Corporation	„ 4	2,196	− 16	9	20,495	− 209
Leith Corporation	„ 4	635	+ 123	16	10,527	+ 1,318
Lincoln Corporation	„ 4	123	+ 2	23	2,882	+ 104
Liverpool Corporation	Aug. 28	10,818	+ 207	‖34	367,376	− 2,375
Liverpool Overhead Rly.	Sept. 5	1,379	+ 46	‡10	14,787	+ 90
Llandudno & Colwyn Bay Ry	„ 3	654	+ 106	40	11,384	+ 1,907
London County Council	Aug. 21	37,122	+ 1,763	§30	747,525	+ 26,198
London United	Sept. 4	6,802	− 108	‖20	216,585	− 20,789
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	„ 4	209	+ 12	22	4,355	− 284
Manchester Corporation	„ 4	14,868	− 83	23	343,106	− 3,406
Mersey Railway	„ 4	1,894	+ 19	9	17,146	+ 570
Merthyr	Aug. 27	236	+ 17	34	7,320	+ 103
Metropolitan Dist. Railway	Sept. 4	9,069	+ 21	9	84,193	+ 5,500
Metropolitan Elec. Trams	Aug. 27	6,573	+ 1,072	34	209,768	+ 16,535
Middleton	„ 27	358	− 35	34	11,628	− 949
Nelson Corporation	Sept. 4	136	+ 7	§22	3,213	− 85
Newcastle-on-Tyne Corp.	„ 4	3,683	− 60	22	88,190	− 1,160
Newport (Mon.)	„ 4	649	+ 2	23	15,430	− 308
Northampton Corporation	„ 3	491	+ 25	§23	11,293	+ 292
Oldham, Ashton & Hyde	Aug. 27	627	+ 55	34	19,106	− 1,218
Oldham Corporation	Sept. 5	1,718	− 145	24	44,541	− 3,273
Perth (N.B.) Corporation	„ 1	168	+ 13	15	2,645	...
Perth (W.A.) Elec. Trams	„ 3	1,363	+ 115	35	49,261	+ 232
Peterborough	Aug. 2	134	− 7	31	4,012	− 330
Portsmouth Corporation	...	...	...	...	...	...
Potteries	„ 27	1,781	+ 94	34	60,064	− 1,284
Preston Corporation	Sept. 1	772	− 10	9	6,957	− 57
Rotherham Corporation	„ 2	590	− 12	23	13,281	− 593
Rothesay	Aug. 27	521	+ 71	34	8,039	− 129
Salford Corporation	Sept. 6	4,586	+ 99	‡23	105,751	− 3,394
Sheerness	Aug. 27	73	+ 4	34	1,753	− 211
Sheffield Corporation	Sept. 5	5,601	+ 185	§23	131,759	− 1,236
Singapore Trams	„ 4	$9,849	+ $975	...	...	...
South Metropolitan	Aug. 27	914	+ 130	34	27,238	− 394
South Staffs	„ 27	873	− 27	34	28,500	− 1,445
Southend Corporation	Sept. 1	789	+ 111	22	13,582	+ 2,111
Southport Tramways	Aug. 27	374	+ 51	34	10,075	− 311
Stalyb'dge, Hyde, &c., Jt. Bd.	Sept. 4	742	− 11	§22	17,802	− 682
Sunderland Corporation	„ 5	1,235	+ 62	23	27,149	− 910
Sunderland District	„ 1	473	− 51	44	20,285	− 914
Swansea Trams	Aug. 27	1,077	+ 88	34	32,825	+ 575
Swindon Corporation	Sept. 1	154	− 3	...	...	...
Taunton	Aug. 27	57	+ 10	34	1,360	− 51
Tynemouth and District	„ 27	447	+ 82	34	8,730	+ 501
Tyneside Trams Co.	Sept. 1	446	+ 14	9	4,267	+ 222
Wallasey District Council	„ 4	978	+ 38	§22	22,018	+ 523
Walsall Corpn.	„ 4	503	− 11	35	11,957	− 1,175
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	Aug. 26	2,288	+ 252	21	50,775	+ 3,042
Weston-super-Mare	„ 27	434	+ 20	34	5,531	+ 264
Wolverhampton Co.	„ 27	432	− 16	34	14,274	− 1,311
Wolverhampton Corpn.	Sept. 1	771	− 54	9	7,387	− 322
Worcester	Aug. 27	319	+ 8	34	9,655	− 70
Wrexham	„ 27	113	− 2	34	3,336	− 148
Yorkshire W.R. Trams	Sept. 5	1,237	+ 53	36	42,771	...
Yorkshire Woollen District	Aug. 27	976	+ 35	34	30,880	− 383

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed., Sept. 8.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Sept. 8 Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord	9½ −9¾	6 3 0	Mar, Sep	9½	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½ −10	4 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 −10½	5 14 0	Feb, Aug	10	10⅛
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 −104	4 6 6	Jan, July	101	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7½ −7⅞	6 7 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅞ −8	4 8 0	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97 −100	4 0 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 −4½	5 16 6	Feb, Aug	4½	—
5	2/3	Do. 4½ per Cent. Pref.	4¾ −4⅞	4 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 −99	4 1 0	Jan, July	97½	97½
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	99½ −101½	4 8 6	..	100½	100
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅝ −4⅛	5 2 6	Jan, July	—	..
5	2/6	Chelsea Electric Supply Ord.	3⅞ −4⅛	4 9 3	March	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 −103	4 7 0	June, Dec	..	—
10	5/0	City of London Electric Lighting Ord.	10¼ −10¾	5 10 0	Feb, Aug	10½	10⅜
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾ −12¼	4 11 0	Jan, July	—	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 −103	4 7 6	Jan, July	102	—
5	..	County of Durham Elec. P.D. Ord.	1¾ −2¼	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 −3½	3 11 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅞ −8⅜	5 3 0	Feb, Aug	8	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½ −11	5 9 0	Mar, Sept	10⅞	10⅝
St.	4½%	Do. 4½% Deb. Stock (red.)	104 −107	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 −108	4 7 6	May, Nov	—	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ −5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 −5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 −100	4 10 0	Feb, Aug	—	..
5	4/6	Hove Electric Lighting Ord.	7¾ −7⅞	5 11 6	April, Oct	7¾	7¾
5	4/0	Kensington & Knightsbridge Ord.	6½ −7	5 14 0	Feb, Aug	6¾	6¾
5	6%	Do. 6 per Cent. 1st Pref.	5⅝ −6⅛	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 −98	4 2 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85 −89	5 1 0	Jan, July	..	..
8	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 8 8	Mar, Sept	..	..
5	3/0	†Do. 6 per Cent. Pref.	5 −5¼	5 14 0	Mar, Sept	—	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 −97	4 2 6	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	4⅛ −4⅝	5 19 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ −5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ −86½	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Db.	95 −98	4 12 0	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	4⅞ −5⅛	4 0 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	85 −87	5 4 8	Jan, July	..	..
5	2½%	Newcastle Elec. Supply Ord.	4⅛ −4⅝	2 14 0	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4½ −5	5 0 0	Feb, Aug	..	.
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 −99	4 1 8	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 19 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 −91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	11¾ −12¼	5 10 0	March	12	—
5	4/6	Oxford Electric Ord.	6 −6½	5 8 0	March	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 −98	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8½ −9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 4	Feb, Aug	—	—
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	81 −83	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord.	9/16 −11/16	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2⅝ −3	6 16 0	April	..	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 −103	4 17 0	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	5/16 −9/16	4 14 0	..	..	—
1	0/3⅜	†Do. 7 per Cent. Cum. Pref.	1⅛ −1¼	5 12 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	102 −105	4 6 0	April, Oct	—	—
5	2/6	Urban Electric Supply Ord.	½ −1	—	April, Oct	—	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1½ −2	..	April, Oct	..	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	77 −81	5 11 6	April, Oct	80	78½
5	5/0	Westminster Elec. Sup. Ord.	8½ −9	5 11 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 −5⅜	4 3 6	Jan, July	..	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	99 −101	3 19 0	Jan, July	100½	99½
1	..	Bath Elec. Trams Pref. Ord.	¼ −⅜	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	9/16 −11/16	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 −91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	87 −90	5 0 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8 −8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8 −8½	4 14 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100 −101	3 19 0	Feb, Aug	.	—
10	..	British Electric Traction Ord.	9/16 −15/16	..	June, Dec	..	—
10	8/0	Do. 6 per Cent. Cum. Pref.	2 −2½	12 0 0	Feb, Aug	2⅜	2⅜
St.	5%	Do. 5 per Cent. Perpetual Debs.	85 −85	5 13 0	April, Oct	86	85½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 −67	6 14 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	62 −64	4 14 0	Feb, Aug	62½	..
St.	4%	Do. 4 per Cent. Pref. Stock	85 −87	4 12 0	Feb, Aug	83	85
St.	2½%	Do. Deferred Stock	43 −45	5 11 0	Feb	43½	..
100	4%	Do. 4 per Cent. Debs.	101 −103	3 18 0	Jan, July	102¾	102¾
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	94 −96	4 3 6	Jan, July	94¼	94
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ −5½	4 15 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	31 −33	4 15 0	Feb, Aug	32¼	31½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	108 −110	4 11 0	Feb, Aug	..	..
St.	5%	Do. (1896)	104 −107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100 −103	5 2 6	Feb, Aug	..	..
St.	5%	Do. (1903)	93 −96	5 4 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 −102	3 18 0	May, Nov	..	..
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾ −13¼	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ −1	..	Feb, Aug	..	..
10	..	G. Northern, Picc. & Brompton 4% G. Pf	7¾ −8½	—	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 −97	4 2 0	Jan, July	95¼	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¼ −1¾	..	Mar, Sept	..	—
St.	4½%	Do. 4½ Db. St.	79 −81	5 11 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	1 −1½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 −6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80 −83	5 10 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅜	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58 −63	6 7 0	Jan, July	..	—
10	5/6	†Lanarkshire Tramways	9¾ −10	5 15 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	89½ −90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	¼ −½	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	5 −5	8 6 8	Feb, Aug	—	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2¼ −2¾	..	Jan, July	2½	2½
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 −70	5 14 0	Jan, July	67½	..
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	..	..
1	10⅜	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	½	..
1	—	Do. Deferred	[illegible]	..	April	[illegible]	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 1 6	Feb, Aug	[illegible]	[illegible]
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 −96	4 11 0	Jan, July	94½	..
St.	1%	Metropolitan Railway Consolidated	35 −35½	1 5 6	Feb, Aug	35⅞	35
St.	2¾%	Do. Surplus Lands Stocks	65 −67	4 5 6	Feb, Aug	66⅜	65¾
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3 16 9	Feb, Aug	89⅜	89⅜
St	3½%	Do. 3½ per Cent. "A" Preference	86 −88	3 19 0	Feb, Aug	87½	85⅜
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 −85	4 1 0	Feb, Aug	85½	84½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 −94	3 14 6	Jan, July	93½	92⅞

*In calculating the yield allowance has been made for accrued interest but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shr.	Last Divi-dend	Name.	Price Wed., Sept. 8.	Rate % Yield-ed.	Dividend Due.	Business Week to Sept. 8. High-est.	Low-est.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*		£ s. d.			
St.	3½	Met Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.	16 —16½	—	Feb, Aug	16½	16
St.	..	Do. Extension Pref. (5 per Cent.)	48 —50	—	Feb, Aug	49½	48
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	66 —68	5 3 6	Feb, Aug	67	66½
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	77½	77½
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	—	..
St.	3%	Do. Guar. Stock 4 per Cent.	94 —97	4 2 6	Mar, Sept	95	94
St	6%	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9	Jan, July	113½	..
St.	4%	Do. 4 per Cent. Ditto	94 —96	4 4 0	Jan, July	95½	95
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—⅞	6 14 0	Feb, Aug	..	—
St.	4½%	Do. 4½ per Cent. Deb Stock	86 —89	5 1 0	May, Nov	..	..
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5%1stMt.Db.	81 —85	5 18 0	Jan, July	81½	..
..	..	UndergdE.Rys.Lon.6% In.bds.with coup.8	37 —39	..	June, Dec	37	—
..	5	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	102½
—	4½	Do. 4½% Bonds with coup. 8	89 —91	4 19 0	..	89½	89½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
St.	..	Anchor Cable Co. 4½% Deb. Stock	102 —104	—	..	102½	102½
1	..	Aron Electricity Meter Ord.	¼—⅜	..	..	—	..
1	1/4½	Do. 6% Cum. Pf.	⅞—1⅛	6 17 0	April, Oct	—	..
1	2/4½	Babcock & Wilcox Ord.	4⅛—4⅜	4 15 3	April, Oct	4½	4⅜
1	0/7½	Do. Pref.	1⅛—1½	4 6 0	..	—	..
5	6/0	British Insulated & Helsby Cables Ord.	7½—7¾	6 7 0	July, Feb	7⅝	..
5	3/0	Do. 6 per Cent. Pref.	6⅛—6⅜	4 12 0	Jan, July	..	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	—
St.	4½%	†British Thoms'n-Houst'n 4½% 1st Mt.Db.	89 —94	4 16 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅛—⅜	..	Feb, Aug	—	—
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	98½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	..	..
St.	4½%	†BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	41 —46	9 18 9	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	23½	..
5	1/0	Callender's Cable Con.Ord.	10⅛—11⅛	5 17 0	Jan, July	10⅝	10⅝
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5¼	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	2 —2¼	5 18 0	May, Nov	2⅛	2⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106 —109	4 2 6	Feb. Aug	..	..
1	1 0½	Chadburn's (Ship) Telegraph Ord.	1⅝—1⅞	6 11 9	March ..	—	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	—
1	0/7½	Consolidated Electrical Co.	⅞—⅝	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1⅛—1⅜	9 8 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	..	—
5	3/0	*Crompton & Co. (Nos. 1 to 85,000)	⅞—1⅛	3 7 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	90 —93	5 7 6	Jan, July	..	..
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
1	2/0	Dick, Kerr & Co. Ord.	1⅛—1⅜	7 12 0	Sept	1⅛	1⅛
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 0	Sept	1⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 6 0	Jan, July	..	—
2	..	Electric Construction Co.	1⅛—1⅜	..	Jan, July	1⅛	—
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	9 16 0	July	..	—
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	65—69	5 16 0	Jan, July	67	..
St.	5	Ferranti Ltd. 5 per Cent.1st Mt.Db.St.	71—77	6 10 0	..	..	..
10	6/0	General Electric (1900) 5% Cum. Pref.	7½—8⅛	6 1 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	5,0	†Henley's Telegraph Works Ord.	12½—13½	5 15 6	Feb, Aug	13	12⅞
5	2/3	†Do 4½ per Cent. Pref.	5⅛—6⅛	4 2 0	Feb, Aug	6⅛	6⅛
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c.,Wrks.	14⅞—15½	6 9 0	Feb, Aug	15½	..
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—10⅞	..	..	—	—
100	4%	Do. 4 per Cent. Debs. (red.)	100 —102	3 19 0	April, Oct	—	..
1	..	National Elec. Construction Co.	⅛—⅜	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	..	May, Nov	..	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock	82 —86	5 5 0	Jan, July	83	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	—
12	12/0	Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	..	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	102½	102½
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 7 0	—	2⅛	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1⅜	4 0 0	—	1⅛	1⅛
St.	5%	Do. 5 per Cent. non-Cum. Preferred	112 —115	4 6 6	—	114	112⅞
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk.(red)	101½—103½	3 17 6	June, Dec	—	—
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	106	105
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 0	..	106½	106
10	8/0	J. G. White & Co. 6% Cm. Pref.	9½—10½	8 6 0	..	..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅞—3⅛	9 12 0	Apr, Oct	3	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3⅛	—	June, Dec	..	..
100	5%	Do 5 per Cent. Debs. (red.)	95 —96	5 4 0	June, Dec	94½	..
St.	15/0	Anglo-American	61½—62½	5 3 6	F,My,Ag,N	61½	..
St.	30/0	Do. Preferred	103½—104½	5 15 0	F,My,Ag,N	103½	103⅞
St.	8 0	Do. Deferred	21½—21¾	1 18 6	F,My,Ag,N	21⅛	20⅞
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	90½	—
10	6/0	Cuba Submarine Ord.	7⅛—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3 —3½	5 14 0	April, Oct	—	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅛—8⅜	5 12 9	April, Oct	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 —102½	4 8 0	Jan, July	..	..
20	5,0	Direct United States Cable	13 —13½	6 6 0	Ja,Ap,Jy,O	13½	13
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	129 —131	5 7 0	Ja,My,Jy,O	129½	128
St.	17,6	Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,Jy,O	86	86
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	..	..
10	.,6	Eastern Extension	11½—12½	5 14 0	Ja,Ap,Jy,O	11½	11½
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	..	..
10	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	3 8 0	May, Nov	..	..
10	6%	G.N. of Copenhagen), with Coupon 77	26 —27	6 13 6	Jan, July	26½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db.(red.)	100 —102	4 9 0	June, Dec	..	..
20	52/6	Indo-European ex all	61½—62½	5 16 9	May, Nov	13	..
100	$1	Mackay Companies Common	82 —86	4 13 0	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	74 —78	5 2 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞—⅝	..	April	..	..
1	4%	Pacific & European Tel.4% Guar.Dbs.(red.)	100 —102	3 18 0	June, Dec	1	1⅛
10	1/3	West Coast of America	1⅛—1⅜	4 8 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅞—1⅛	..	May, Nov	1⅛	⅞
10	6/0	Do. 6 per Cent. 1st Pref	8 —8½	7 1 0	May, Nov	8½	8⅛
10	5/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	101 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	13½—13¾	5 2 0	Mr,Jn,O,D	13½	13½
St.	4%	Do. 4 per Cent. Deb Stock (red.)	103 —105	3 18 0	June, Dec	..	..
—	6	Western Union Telegh. $1 000 4% Bonds	98 —100	4 0 0	..	..	..

Shr.	Last Divi-dend	Name.	Price Wed., Sept. 8.	Rate % Yield-ed.	Dividend Due.	Business Week to Sept. 8. High-est.
		TELEPHONES.		£ s. d.		
100	2$	Amer. Telephn. & Telegh. Cap. St.	144 —146	5 10 0	..	146
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	96½—98½	4 1 6	Jan, July	—
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	103½—105½	4 16 0	Mar, Sept	..
5	5 0	Chili Telephone	8 —8⅜	4 15 6	August ..	..
1	0/7½	Monte Video Telephone Ord.	1⅛—1⅜	6 8 0	Nov	..
1	0/6	Do. 5 per Cent. Pref.	⅞—⅝	5 14 8	May, Nov	..
St.	6%	National Co. Pref. Stock	106 —107½	5 11 6	Feb, Aug	107½
St.	6%	Do. Def. Stock	121½—123½	4 17 0	Feb, Aug	122½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—10⅞	5 9 0	Feb, Aug	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—10⅞	5 9 0	Feb, Aug	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅜	4 8 0	Feb, Aug	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	98½
St	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	101½
1	1/0	Oriental	1⅛—1⅜	5 8 9	April, Oct	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 0	April, Oct	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	87½
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100½—102½	4 8 6	Jan, July	..
5	5/0	United River Plate	6⅞—7⅛	5 11 0	July	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5½—5⅞	4 9 0	June, Dec	5⅞
St	4½%	Do. 4½ Deb. St. Red.	104 —106	4 5 6	Jan, July	..
		FINANCIAL INVESTMENT, &c.				
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..
10	5/6	Globe Telegraph & Trust	10½—10⅞	6 7 0	Sp DcMrJu	10½
10	3/0	Do. 6 per Cent. Pref.	13⅞—14⅛	4 4 0	SpDcMrJu	14⅛
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.				
£	—	Anglo-Argentine 5% Cum. 1st Pref.	4⅜—1⅛	5 2 6	April, Oct	4⅛
£	—	Do. 5% Cum. 2nd Pref.	4⅛—4⅜	5 4 0	Jan, July	4⅛
St.	4%	Do. 4% Deb. Stock	91½—93½	4 5 6	June, Dec	93½
St.	..	Do. 4½% Deb. Stock	97½—99½			97
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	103
5	3 6	Brisbane Electric Trams. Invest. Ord.	6⅞—7	4 6 0	May	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	..
St.	6%	British Columbia El.Ry.Df. Ord.	144 —149	5 6 6	Mar, Sept	141
St.	6%	Do. Pref. Ord. Stock	117 —122	4 18 0	May, Nov	119
St.	5%	Do. 5% Cum. Perp. Pref. Stock	107½—110½	4 11 6	Jan, July	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	—
St.	4½%	Do. 4½% Perp. Con. Deb. St.	103 —105	4 1 0	..	103½
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	98½
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	91 —95	6 6 0	Feb, Aug	..
5	2/0	Calcutta Tramways (1 to 137,610)	4⅞—5	4 0 0	Mar, Sept	..
100	5%	Do. 5 per Cent. Cum. Pref.	4⅞—5	5 0 0	Jan, July	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	99½
St.	—	Cape Electric Tram Shares	⅛—⅜			
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5½—5⅞	4 1 6	F,My,A,N	5⅝
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	92 —96	5 4 0	Feb, Aug	—
1	..	Kalgoorlie Elec. Trams Sh.	⅛—⅜			..
100	6%	Do. 5 per Cent. "A" Deb. Stock	91 —94	5 6 0	Jan, July	..
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 12 0	Jan, July	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 4 9	July	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 1 0	Jan, July	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	98 —102	4 18 0	Jan, July	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —97	5 2 0	Jan, July	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds.	95 —97	5 3 0	Feb, Aug	..
100	$1½	Mexico Trams Co Com. St.	128 —131	3 16 6	..	129½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	93½—95½	5 5 0	..	95
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	..
1	0/6	Perth Elec. Trams Ord.	⅞—⅝	8 0 0	May	..
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅞—6⅛	5 4 8	..	—
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..
100	..	Rio Janeiro Tram, Lt. & P. Co.	90½—92½	..	..	90½
..	5%	Do. 30 yr. Gold Bnds.	94 —96½	5 4 6	..	95
100	5%	Do. 50 yr. Mt. Bnds.	85½—86½	5 16 0	..	86½
—	$1½	Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —150	6 6 9	..	149½
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	101½
100	4½%	†Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.				
5	8/0	†Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅞—5⅛	5 17 6	Mar, Sept	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	8⅞—9⅛	6 1 6	..	..
St.	4½%	Do 4½ per Cent. Deb. Stk. (red.)	93½—95½	4 18 6	Jan, July	..
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	93½—95½			
5	4/9	Calcutta Elec. Supply Ord.	6 —6½	6 8 0	April, Oct	6⅛
100	$1½	Canadian Gen. Elec. Co. Com. St.	122 —127	5 13 0	..	126
100	$3½	Do. 7% Cm. Pf. Stock	119½—121½	5 15 0	..	121
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..
500	5%	†Elect. Development Co of Ontario	84 —86	5 16 0	—	81½
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	..
10	1/	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—⅜	—	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—⅝	6 18 3	April, Oct	—
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83 —85	5 19 0	..	83½
St.	$1	Mexican Lt & Power Co. Com. St.	70 —71	8 0 0	—	74½
500	5%	Do. 5% 1st Mort. Gold Bnds.	85½—87½	5 14 8	..	87½
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	127 —131	4 15 0	F,My,A,N	128½
1	1/7½	River Plate Electricity Co. Ord.	1⅛—1⅜	5 11 0	April	..
1	1.2½	Do. 6 per Cent.non-Cum.Pref	1 —1⅛	5 6 8	May	..
St.	6%	Do. 5 per Cent. Deb. Stock	103 —106	4 11 0	Jan, July	104
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅛—5⅜	5 5 8	April, Oct	..
5	8/0	Do. 2nd Pref.	5⅞—6	5 0 0	..	..
100	4%	Shawinigan Water & Power Co. Ca	98 —100	4 0 0	—	98½
..	5%	Do. 5 per Cent.Bds.	105 —107	4 13 6	Jan, July	107
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	98½—99½	4 10 6	—	99½
St.	4½%	Toronto Power Co. 4½ Db St.	99½—100½	4 9 6	..	..
..	6%	Victoria Falls Power Co. Pref.	5⅛—5⅜	5 14 9	Jan, July	..
1	..	Do. 16/- paid	1⅛—1⅜	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex dividend ‡ The London Stock Exchange Committee have declined to quote th

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NOTES.

Electricity in Mines.

At a recent meeting of the Council of the Durham Miners' Association a resolution was brought forward to the effect that electrical machinery and cables should be taken out of mines, as they were a source of danger. Apparently the resolution was not fully considered, as it was withdrawn on an explanation being given that a Select Committee had been appointed by the Government to consider the question, and also that the owners were willing to arrange a meeting on the subject. The fact, however, that such a resolution was placed upon the agenda is sufficient indication that there is some agitation against the use of electricity in mines. We think it will be generally felt that any feeling of this kind is rather late in the day, considering the extensive use to which electricity is now applied. For example, there are well over 1,000 collieries in which electric coal cutters are employed, and electrical energy for other purposes is in even still greater use. Moreover, there does not seem to be any very real foundation for alarm. Accidents are of two kinds, being either general explosions or accidents to individuals. On referring to the reports issued by the Home Office it will be found that a very small proportion of the explosions has been attributed to electrical causes, and in still fewer cases has any satisfactory evidence been brought forward. Also fatal individual accidents due to electricity form a very small proportion of the whole. In fact last year the number of such accidents was only about 1 per cent. of the total.

With regard to individual risks, these are due to one cause, namely, the possibility of electric plant of one kind or another becoming electrified. This is now well recognised, and, considering that an electrical inspector of mines has been appointed, there should not be any great difficulty in seeing that plant is so effectively earthed that no danger can result. In the case of fiery mines, there are two alternatives. One of these is the use of electrically-driven compressors in the non-fiery part of the mine, from which coal cutters can be worked at any desired point. Recent years, however, have provided another means of overcoming the difficulty, namely, by the use of flame-proof motors, which seem to be as effective as the ordinary Davy lamp. It should, therefore, be easy to secure adequate safety. In such cases, wild statements are certain to be made as to all sorts of imaginary risks. As an instance of this kind of thing we notice in one of our contemporaries a story of a defective machine in which the terminal for connecting the field coils was found to be "in actual contact with the armature." Stories of this kind, no doubt, have their effect, and we cannot expect to be without them.

The Candle-power of Metal Lamps.

It would be unfortunate if the term "candle-power" as applied to metal filament lamps were to become merely a nominal expression, but to judge from a considerable proportion of the metal lamps at present on the English market, this retrograde step appears to be rapidly taking place. Of course, the first step in this direction was brought about by the fact that this country had to depend for some time on Continental manufacturers for the supply of such lamps. It seems, however, that some English

manufacturers are now copying foreign lamps, even as regards their rating in Hefner candle-power. We admit that owing to the number of foreign lamps rated in Hefner units at present in use or on the market those of English manufacture appear to the public to be, comparatively, of inferior efficiency, and the temptation to adopt the smaller unit of candle-power is, therefore, great; but we understand that metal filament lamps of English manufacture do not in some cases reach, even on the Hefner basis, their stated candle-power. Thus, 100-volt lamps of so-called 16 c.p. frequently give, on being tested, only from 13 to 14 English, or International, candles, although they should give about 14·4, if rated originally on the Hefner basis. This latter delinquency cannot be defended on any grounds, and is likely to do harm by fostering the impression that electric lamps do not give sufficient light compared with incandescent gas lamps. The whole question shows the disadvantages resulting from the use of two standards, a state of things which we hope will be remedied by Germany deciding to fall into line with other countries and to adopt the International candle.

The London County Council Tramways.

The inauguration of a tramway service across Blackfriars Bridge on Tuesday last, following the official opening of the new portion of that thoroughfare, marks an important step in the development of the electric tramway service of London. Hitherto, the only connecting link between the northern and southern tramway systems has been Westminster Bridge, but although the newly opened track over Blackfriars Bridge facilitates the interchange of traffic between these two almost independent tramway systems, the Kingsway shallow tunnel, which only admits single deck cars, still remains to throttle "through-running" on an extensive scale. A feature of the London County Council tramways has always been the discharge of passengers at a number of inconveniently situated termini—that is, inconvenient from the point of view of passengers desiring to reach the city or main business areas—and although improvements in the facilities for the transfer of traffic could, and, no doubt, will be eventually provided, the conditions prevailing in London are likely always to prevent the organisation of traffic on the lines customary in other cities in this country and abroad.

It is interesting to notice in connection with the new route over Blackfriars Bridge that the tramway track has been placed at one side of the road and very close to the footpath, resembling in this respect the tramway route over Westminster Bridge and along the Embankment. Where the tramway track is so situated, it causes much confusion and danger to persons crossing the road, owing to the traffic proceeding in so many discordant streams, but this point is not of much consequence in the case of a bridge where there is little necessity to cross from one footpath to the other. As a general rule, however, the slowly moving traffic should be located at the sides of the roadway and the more quickly moving vehicles should be confined to the centre of the main thoroughfares. At present the arrangements for dealing with the altered traffic conditions on the new section of route are probably not complete, but the system of allowing passengers to board the cars indiscriminately is likely to lead to many accidents. In this connection the Continental system of numbered tickets has much to recommend it, although it might not prove acceptable in this country.

Joint Meeting of Mechanical Engineers.—It is announced that the invitation from the Institution of Mechanical Engineers of Great Britain to the American Society of Mechanical Engineers, suggesting a joint meeting in this country in August, 1910, has been accepted by the American Society.

Telephone on Monte Rosa.—What is stated to be the highest telephone line in the world has just been completed. It runs to the Margherita Observatory near the summit of Monte Rosa, over 15,000 ft. high, and will enable those at the University to communicate with Milan and Rome. Both the observatory and the telephone line have been constructed at the expense of Queen Margherita of Italy in the interests of science.

The Institute of Metals.—Among the Papers to be presented at the autumn meeting of the Institute of Metals, which will be held at Manchester on October 14th and 15th, are: "The Constitution and Properties of the Ternary Alloys, Aluminium—Copper—Tin," by J. H. Andrew, M.Sc., and C. A. Edwards; "Some Causes of the Corrosion of Copper and Brass," by E. L Rhead; and "The Elastic Breakdown of Ductile Materials," by Prof. C. A. Smith, M.Sc.

Society of Engineers.—It will be remembered that this year, and for the next four years, the Council has instituted a prize, known as the "Status Prize," for the best essay on "How to Improve the Status of Engineers and Engineering, with Special Reference to Consulting Engineers." The result of this year's competition has been that Mr. G. Allan Thomas has been awarded the prize, and he will read his essay at the meeting of the society to be held on October 4th, at 7:30 p.m., at Caxton Hall, Westminster.

Institute of Marine Engineers.—Electrical engineers will be pleased to hear that at a meeting of the Council last week it was decided to award the Denny gold medal to Mr. W. P. Durtnall for his Paper on "The Generation and Electrical Transmission of Power for Main Marine Propulsion and Speed Regulation." This Paper was read at the Franco-British Exhibition, an abstract appearing in our issue of July 31, 1908, and it was considered by the Council to be the best of the Papers submitted in competition for the medal during the session 1908-9.

Electric Drive for Battleships.—The "Electrical World" reports that Prof. R. A. Fessenden has recently submitted a proposition to the U.S.A. Navy Department for the equipment, experimentally, of a war vessel with turbo-electric drive. Prof. Fessenden's plan is to use steam turbine three-phase generators, with induction motors on the propeller shafts. He claims that higher power can be obtained with less weight under this system than with any other. The Navy Department has as yet made no decision as to whether it will make the experiment.

Railway Electrification in Brazil.—The "Railway and Engineering Review" reports that Messrs. Griffiths & Co., of London, have sent in a proposal to the Minister of Public Works of Brazil, for the electrification of the suburban lines of the Central Railroad to the station of Deodoro. It is estimated that the whole work will cost £1,000,000, and that there will be a reduction of at least £200,000 per annum in running expenses as a result of the electrification, which will at first be undertaken as far as D. Clara, while a third line will be laid as far as that station. Subways and bridges are to take the place of level crossings. The running time to D. Clara will be 30 minutes, and no stop will exceed 22 seconds.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tangier—Cadiz	May 19, 1909	—
Tourane—Amoy	June 17, 1909	—
Assab—Perim	July 8, 1909	
Gibraltar—Tangier	Aug. 7, 1909	Sep. 10, 1909
Dakar—Conakry	Aug. 19, 1909	—
Balik Papan—Kwandang	Sept. 2, 1909	Sep. 14, 1909
Sheik Seyd—Perim	Sep. 15, 1909	—

Impulse Turbines.—Messrs. Willans & Robinson, of Rugby, after prolonged experiments, are placing on the market a steam turbine of the impulse type, intended to meet those cases in which a speed of as high as 3,000 revs. per min. is admissible. This will provide for a capacity up to 1,500 kw. The turbine has been designed with a view to efficiency as well as simplicity. The rotating element consists of two wheels only, but the economy realised compares favourably with that of any other turbine. In future, therefore, Messrs. Willans & Robinson will be in a position to supply either turbines of the Parsons or of the impulse type, and will be glad to put forward the type most suitable for the conditions to be met.

Central Stations and Ice Manufacture.—It is announced in the "Electrical World" that the Light, Heat & Power Co., of Montreal, is about to use electric power in refrigeration. Water will be obtained from artesian wells and frozen by electric power. The ice is to be turned out in any shape desired, which will obviate the necessity of the icemen cutting it on delivery. The plant proposed to be installed will cost between £25,000 and £30,000, and it will then be possible to sell ice at a much lower price than at present. It is understood that a similar scheme has been proposed to the directors of the Winnipeg Electric Co., where the river from which the ice harvest is obtained is not of the purest.

Faraday House Journal.—The September issue of this journal will prove of more than usual interest to Faradians, containing, as it does, an excellent portrait and memoir of the late Principal of Faraday House, whilst the personal notes include particulars of the career and activities of the new Principal, Dr. Alexander Russell, M.A. The articles, as usual, cover wide interests, as is evident from their titles, viz., "Reliability of Electrical Apparatus in Large Central Station Design," by A. J. P. McCarthy; "Notes on Boiler Evaporation Tests," by W. G. R. Crow; and "Forms of Final Drives in Motor Vehicles," by T. C. Harrison," the authors in all cases being Faradians. The list of those who have obtained certificates since January 1st doubtless contains the names of several prominent electrical engineers of the future.

Faraday House.—Mr. William Buchanan, B.Sc., Assoc.R.C.S., Wh.Sch., has been appointed lecturer on electrotechnics and the design of electrical machinery at Faraday House, London. Mr. Buchanan had a distinguished college career, first at the Royal College of Science, London, and subsequently at Glasgow University, where he was Thomson Experimental Scholar in Lord Kelvin's laboratory. He has been for 15 years with the Electric Construction Co. (Wolverhampton), first as designer of alternating-current machines and subsequently as chief engineer. Amongst the more important machines constructed from his designs are many of the generators, boosters, transformers, &c., at the G.W. Railway's power house at Park Royal and at the Greenwich power house of the London County Council. The capacity of the plant designed by Mr. Buchanan for the L.C.C. alone amounts to nearly 22,000 kw. This includes four three-phase slow speed generators, each of 5,500 k.v.a. He has also designed several large high-speed turbo-alternators.

Development of the Thury System.—We are informed by Messrs. Dick, Kerr & Co., that the well-known series direct-current transmission line from Moutiers to Lyons, which has been in operation since 1905, has proved such a remarkable success that very important developments are about to take place. As will be remembered, the generating station itself is situated near Moutiers (Savoy) and takes its power from the River Isère, the generating plant consisting of high-tension direct-current machines and high-tension alternators. The capacity of the high-tension direct-current plant at present installed is 6,400 H.P., and energy is transmitted at a pressure of 57,600 volts to Lyons, a distance of 180 km., by means of two conductors, each of 9 mm. diameter. Parallel to the continuous-current line is a three-phase line going to the same point. At Lyons the direct-current energy is transformed by a number of motor-generators. The series system has not only demonstrated its elasticity, but has proved to be so reliable and easy to operate that the companies have decided to carry out at once extensions on a large scale. A generating station is to be erected at La Bridoire (Savoy), in which three generating high-tension direct-current units will be installed, each of 2,000 H.P. at 428 revs. per min. These will operate with a current of 150 amperes and at a pressure of 8,000–9,125 volts. A second generating station on the Roziers, at Bogel (Savoy), will consist of two generating groups, each consisting of two double machines driven by the same turbine and capable of giving an output of 3,500–4,000 H.P. at 428 revs. per min., and delivering a current of 150 amperes and a pressure of 16,000–18,250 volts. A corresponding amount of direct-current motor-generator plant will be placed in the Vaulx-en-Velin sub-station. The total capacity of the direct-current high-tension generating plant, when the extensions are complete, will be 15,000 kw., and the three generating stations connected in series will deliver 150 amperes at 100,000 volts. This will be a notable development, since, for the first time in Europe, an operating pressure of 100,000 volts will be reached; and it is claimed that this pressure is not the limit which can be achieved on this system.

The Equipment of Wireless Stations.—In connection with the recent destruction of the Marconi Company's station at Glace Bay, Nova Scotia, "Engineering News" remarks:—"A survey of the conditions under which the disaster arose shows that a marked disregard of a few recognised engineering principles paved the way for the embarrassment and temporary lack of prestige which this company now faces. High-tension electrical apparatus of considerable power was housed in wooden shacks located beyond the reach of any local fire department and evidently were equipped with no adequate private means of fighting fire under the peculiar conditions prevailing. The whole arrangement seems to have been temporary, though the service was advertised as permanent. The combination of light inflammable structures, lack of fire protection and lack of duplicate apparatus might have been expected to be too much for reliable service. The critics of this trans-Atlantic service have been numerous, particularly on the other side of the ocean. One might have supposed that their criticisms would have led the operating company to be alert, and one may now believe that the other wireless concerns will see where their own plants need inspection. The importance of wireless telegraphy to maritime service demands that all possible safeguards be sought for continuity of service at important shore stations."

ARRANGEMENTS FOR THE WEEK.

Municipal Tramways Association.

WEDNESDAY, September 22nd.

10:30 a.m. Reception by the chairman and members of the London County Council, at the County Hall, Spring Gardens, London, S.W.

11 a.m. Conference in the Council Chamber at the County Hall. Presidential Address by Mr. A. L. C. Fell, and Paper on "Medical Examination of Tramway Employés," by Councillor A. W. Chapman.

1 p.m. Luncheon at the Trocadero Restaurant (at the invitation of the chairman of the London County Council).

3 p.m. Resumption of Conference. Paper on "The Central Repair Depot of the London County Council Tramways," by Mr. W. E. Ireland.

7:30 p.m. Association Dinner at the Garden Club, Imperial International Exhibition, Shepherd's Bush.

THURSDAY, September 23rd.

10:30 a.m. Meeting of Managers' Section in the County Hall.

11 a.m. Conference in the Council Chamber at the County Hall. Papers on "Some Comparisons of Continental and British Methods of Operating Tramways," by Mr. A. R. Fearnley, and on "Current Consumption," by Mr. R. S. Pilcher.

1 p.m. Luncheon at the Holborn Restaurant (at the invitation of the chairman and members of the Highways committee of the London County Council).

2:45 p.m. Visit to the Central Repair Depot and Greenwich Generating Station of the London County Council Tramways.

9 p.m. Reception at the Mansion House by the Lord Mayor of London.

FRIDAY, September 24th.

10:15 a.m. Business Meeting of the Association in the County Hall.

1.55 p.m. Special train leaves Waterloo Station (L. & S.W. Rly.) for excursion to Windsor.

7:55 p.m. Reception in the Guildhall by the Mayor and Corporation of Windsor.

SATURDAY, September 25th.

JUNIOR INSTITUTION OF ENGINEERS

3 p.m. Visit to the Imperial International Exhibition, Shepherd's Bush, for inspection of engineering, scientific and other features of interest.

THE STARTING TORQUE OF THREE-PHASE MOTORS, WITH SQUIRREL-CAGE ROTORS.*

BY MAX KLOSS, DR.ING.

Summary.—In order to produce a standard torque-slip curve for a three-phase motor, the slip at maximum torque is introduced as a characteristic constant of the motor. The equation of the torque slip curve is obtained, and a simple diagram is given connecting the starting torque with the slip. It is shown what normal slip is to be provided for obtaining a given starting torque. Finally the running-up torque is shown to be more important than the static starting torque, and points in design, so that a motor shall run up satisfactorily, are considered.

1. *Introduction.*—It is well known that the starting torque of a three-phase motor depends on the resistance in the rotor circuit. With a slip-ring rotor it is an easy matter to obtain any desired starting torque up to the maximum torque of the motor simply by inserting a suitable resistance between the slip-rings, which is cut out gradually while the motor is running up to speed. With a squirrel-cage rotor the resistance in the secondary circuit is fixed once for all, and therefore the starting torque is definitely fixed when the amount of resistance in the rotor circuit is decided upon. It is, of course, clear that by choosing a high resistance a very good starting torque can be obtained. However, this high resistance, being permanently in circuit, would involve high copper losses under normal running conditions, and therefore greatly reduce the efficiency of the motor. It is therefore necessary to make a compromise between an efficient starting torque and economical running of the motor. If a great starting torque is absolutely essential one has got to face the fact that it is to be paid for by sacrificing some of the efficiency. Besides this, the slip of the motor will be increased on account of the high resistance, which means that the variation in speed between no-load and full-load becomes greater. The object of the following article is to show the relations between the starting torque and the slip.

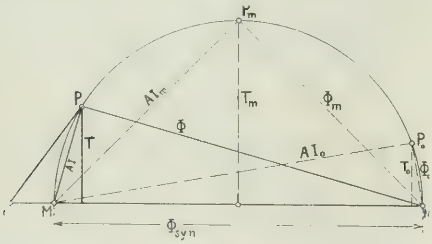


FIG. 1.

2. *The "Torque Slip" Curve.*—The shape of the curve connecting the torque of a three-phase motor with its slip is well known. At synchronous speed (that is, with the slip $\sigma=0$) the torque is zero. It increases almost proportionally with the slip, afterwards more slowly, reaching a maximum torque at a certain slip, σ_m, and decreases again with increasing slip, until the motor comes to rest ($\sigma=1$). The mathematical relation between the two quantities can be derived from the well-known Heyland diagram, which is shown in Fig. 1 in its simplest form, without corrections for primary losses. We shall see later on that this simplification will not affect very greatly the results of our investigation. Further, it should be understood that under the term "torque" we mean the total mechanical torque yielded by the rotor, that is, besides the useful load torque, it includes the necessary torque to overcome the friction and windage.

In the following investigation all quantities refer to the rotor only. For the sake of simplification of the formulæ we have therefore omitted the usual Index 2, denoting the quantities referring to the secondary circuit.

LIST OF SYMBOLS USED.

I = current in rotor.
Φ = flux passing through the rotor winding,
T = torque exerted by the rotor, including friction and windage.
c = frequency of the rotor.
σ = slip = $(n_{syn} - n)/n_{syn}$, where n = number of revolutions per minute.
A, B and C are constants.

The maximum torque is denoted by the index "m," which is also affixed to all other quantities referring to the condition of maximum torque T_m, for instance, σ_m means the slip at maximum torque T_m. The index "syn" denotes the values corresponding to the condition of synchronous speed ($\sigma_{syn}=o$). The index "o" denotes the condition of start ($\sigma_0=1$, rotor at rest).

In the Heyland diagram, Fig. 1, let P be a load point. Then the distance PN represents the flux Φ passing through the rotor winding under those conditions. The distance MP is proportional to the rotor current I. In order to combine this distance in a formulæ, together with the flux PN, we must introduce a constant A for the scale of I, and therefore call the length MP = AI. The vertical to the basis MN, erected through P, represents the total torque T. For synchronism the point P coincides with M, and MN is therefore the rotor flux Φ_{syn}. Point P_m denotes the condition of maximum torque T_m, with the corresponding flux $P_mN=\Phi_m$ and $MP_m=AI_m$. The conditions of start are represented by the point P_0, the starting torque being T_0, whilst the flux is Φ_0 and the secondary short circuit current is given by the line $MP_0=AI_0$.

The current I is equal to the rotor E.M.F. divided by the resistance, and, therefore, for a given winding, with constant resistance, proportional to the product of flux Φ and frequency c. Or, as the rotor frequency c is proportional to the slip σ, we can write

$$I = B\sigma\Phi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Further, the torque T is proportional to the product of current and flux

$$T = CI\Phi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From the Heyland diagram, Fig. 1, we find the geometrica relation

$$(MP)^2+(PN)^2=(MN)^2$$

or

$$A^2I^2+\Phi^2=\Phi^2_{syn} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

From formula (1) and (2) we find

$$T=BC\sigma\Phi^2 \quad . \quad . \quad . \quad . \quad (4)$$

and from (1) and (3)

$$\Phi^2=\Phi^2_{syn}/(1+A^2B^2\sigma^2) \quad . \quad . \quad . \quad . \quad . \quad (5)$$

By substituting this relation in formula (4) we find

$$T=\frac{BC\sigma}{1+A^2B^2\sigma^2}\Phi^2_{syn} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

For the condition of maximum torque formula (5) will read

$$\Phi^2_m=\Phi^2_{syn}/(1+A^2B^2\sigma^2_m) \quad . \quad . \quad . \quad . \quad . \quad (5A)$$

and direct from the diagram $\Phi^2_m=\frac{1}{2}\Phi^2_{syn}$

$$\therefore \quad 1+A^2B^2\sigma_m^2=2, \text{ or } A^2B^2=1/\sigma_m^2.$$

With this value formula (6) becomes

$$T=\frac{BC\sigma}{1+(\sigma/\sigma_m)^2}\Phi^2_{syn} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6A)$$

and for the case of maximum torque (with $\sigma=\sigma_m$) we have

$$T_m=\frac{BC\sigma_m}{2}\Phi^2_{syn} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

By dividing formula (6A) by (7) we find

$$T/T_m=\frac{2(\sigma/\sigma_m)}{1+(\sigma/\sigma_m)^2}=\frac{2}{\sigma/\sigma_m+\sigma_m/\sigma} \quad . \quad . \quad . \quad . \quad (8)$$

This equation gives us the relation between the torque T and the slip σ; of course, not in their actual units, but in fractions of the maximum torque T_m and of the corresponding slip σ_m. These two quantities, however, are constants of the motor depending on the dimensions, windings and voltage. The great advantage of writing the formula in the form given by (8) is that it holds good for any motor and the curve which can be plotted from it with $x=\sigma/\sigma_m$ as abscissæ and $y=T/T_m$ as ordinates can be used as a standard curve for all motors independent of the actual values of torque and slip. This curve is shown in Fig. 2. This figure also shows some features of the curve which enable us to draw it very quickly. The equation of the curve is $y=\frac{2}{x+1/x}$. For $x=1$ we find $y=\frac{2}{2}=1$. This gives the vertex "V" of the curve. For all other values of "x," "y" is smaller than 1. For small values of x the reciprocal $1/x$ is so great that x can be neglected against its reciprocal value, and therefore the equation for y will be approximated by the formula

$$y^1=\frac{2}{(1/x)}=2x.$$

This is the equation of a straight line from the origin to the point $y=2$ at $x=1$. The straight line is the tangent to the torque slip curve at the origin. Further, for large values of x the reciprocal $1/x$ can be neglected against x, and therefore in these cases the equation of the curve can be approximated by

$$y''=2/x.$$

This is the equation of a hyperbola going through the same point $y=2$, $x=1$ as the straight line mentioned before. This common point lies above the vertex of the torque curve at double its height. Fig. 2 shows clearly that for values of x greater than 5 the torque-slip curve follows the hyperbola very closely.

* Reproduced, by permission, from the "Electron."

Another help for plotting the torque curve can be found by determining the point of inflection which is denoted by E, and which can be found by differentiating the fundamental equation twice, and by letting the second differential coefficient become zero. If this is done one finds the corresponding co-ordinates for the point of inflection, $x=\sqrt{3}$ and $y=\frac{1}{2}\sqrt{3}$; that is, $x=1{\cdot}73$ and $y=0{\cdot}866$. The tangent at this point of inflection cuts the axis of abscissæ at the point F for which $x=5{\cdot}2$. Any other points of the curve can be quickly found always in pairs, because if we know the ordinate y for the point x, we know that the ordinate for the abscissa $1/x$ will be the same. For instance, for $x=2$ the ordinate is $y=2/(2+\frac{1}{2})=0{\cdot}80$. The same ordinate will be obtained for $x=\frac{1}{2}$. These two points are marked with B and C in Fig. 2. Another relation which follows from the comparison between the equation of the torque curve and the equation of the hyperbola is that for a given ordinate—say, for instance, for $y=0{\cdot}8$ in Fig. 2, the abscissa A B for the left branch of the torque curve is always equal to the difference C D between the right branch of the curve and the hyperbola, the corresponding abscissa A D of the hyperbola always representing the sum of the abscissæ $x+1/x$, where x refers to the torque curve.

Condition of Stable Running.—In order to ensure stability of running with a given load torque it is necessary that with decreasing speed the torque yielded by the rotor must increase, because, if this condition is fulfilled, any tendency of dropping in the speed will at once be met with by an acceleration due to the increased torque exerted by the rotor. It is clear that this condition is fulfilled by that portion of the curve between the origin (point of synchronism) and the vertex "V" (point of maximum torque). This is

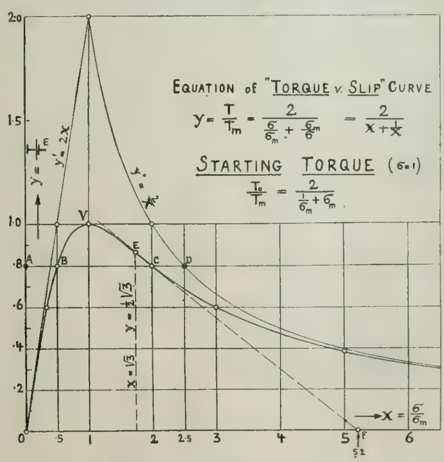


FIG. 2.

the *stable branch* of the curve on which the motor will run under normal working conditions at a definitely given speed for a definitely given torque. The other part of the curve, beyond the vertex "V" is the *unstable branch*. With a constant load torque the rotor cannot run on this part of the curve. It will either accelerate until stable condition is reached between "O" and "V" or it will slow down until it comes to rest. (In exceptional cases—for instance, when a motor drives a fan—it might be possible that it can be got to run on the branch beyond the vertex "V"; however, the motor will then always be apt to great fluctuations in speed, and will be very sensitive for small variations of the supply pressure.)

3. *The Starting Torque and its Relation to* σ_m.—As already mentioned, the standard curve shown in Fig. 2 gives the torque as a fraction of the maximum torque T_m and the slip as a fraction or multiple of the corresponding slip σ_m. In order to apply the curve to a particular case it is therefore only necessary to know these two constants of the motor T_m and σ_m. The *starting torque* T_0 is determined by the condition of 100 per cent. slip—that is, for $\sigma=1$. If we substitute this value in formula (8) we find for the *starting torque*

$$T_0/T_m=\frac{2}{\frac{1}{\sigma_m}+\sigma_m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

This equation is of the form $y=\frac{2}{\frac{1}{x}+x}$, which is identical with the equation of the standard torque-slip curve. This curve, as given in Fig. 2, can therefore also be used to show the relation between the starting torque and the characteristic machine constant σ_m. However, the physical meaning of the curve is now different to what it was before. The original curve gives the torque yielded by the motor for *various speeds* (or slips) with a *constant resistance* in the rotor circuit. If, however, the curve is used to illustrate the formula (9), it gives the *starting* torque (that is, with the rotor being at rest) obtained with *various* values of the machine constant σ_m, that is to say, with *various values* of the *rotor resistance*.

Example.—If a motor is so designed that the slip at maximum torque is 20 per cent., that is, $\sigma_m=0{\cdot}20$, then the starting torque can be read off the curve in Fig. 2 for the abscissa $x=0{\cdot}20$. As the curve is rather steep at this range, we can take advantage of the fact proved before, that the ordinates are always equal for reciprocal values of abscissæ. We can, therefore, read off the starting torque corresponding to the abscissa $1/0{\cdot}20=5{\cdot}0$. We find the starting torque $T_0=0{\cdot}385T_m$.

4. *Determination of* σ_m.—Seeing that the slip σ_m at maximum torque is such a useful constant of the motor, the question arises how to determine this value. There are various ways of doing this. If the motor has been calculated, and the slip σ_n at *normal* torque T_n is already known, then we only need plot the Heyland circle and determine the maximum torque T_m. If we then calculate the ratio of normal torque to maximum torque T_n/T_m we can read off our standard torque-slip curve, Fig. 2, the corresponding abscissa σ_n/σ_m; or, here again, we may with advantage use the flatter branch of the curve beyond the vertex and find the reciprocal σ_m/σ_n, from which the desired value for σ_m can be found by multiplying with the given value for σ_n.

Example.—For a motor with 3·0 per cent. slip at normal load and rated so as to give the usual 100 per cent. overload capacity, with, say, 15 per cent. margin, the normal torque will be about $T_n=0{\cdot}425T_m$. For this ordinate we find from the flat branch of our curve $x=4{\cdot}50=\sigma_m/\sigma_n$. Therefore the required value for σ_m will be $\sigma_m=4{\cdot}50\times3{\cdot}0$ per cent. $=13{\cdot}5$ per cent. This figure being known, we can calculate or read off the curve the starting torque as shown in the previous paragraph.

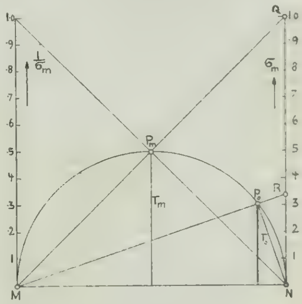


FIG. 3.

Another way of determining σ_m is to calculate it directly. From the Heyland diagram we know the synchronous rotor flux Φ_{syn} and the ideal secondary short-circuit current I_k. From these two figures we find the corresponding values referring to maximum torque, namely, $\Phi_m=\Phi_{syn}/\sqrt{2}$, and $I_m=I_k/\sqrt{2}$. From this figure and from the resistance R of the rotor circuit we can calculate the rotor E.M.F. necessary to drive the current through the winding, and this E.M.F. must be $=K\sigma_m\Phi_m$, where K is a coefficient depending on the winding particulars. σ_m can therefore be found.

A third method of determining σ_m is based on the fact that the power supplied to the rotor is split in two parts, one being transformed into mechanical power, which is equal to the product of torque and angular velocity, and the remainder being dissipated in the winding of the rotor in the shape of heat. The slip is always equal to the ratio of copper loss in rotor to rotor input and the rotor input is equal to the torque multiplied with the *synchronous* angular velocity. The machine constant σ_m can therefore be found from the relation

$$\sigma_m=\frac{\text{Rotor copper loss with current } I_m}{C\times T_m\times\text{synchronous angular velocity}},$$

where C is a constant to give the mechanical input in watts. Now, as I_m and T_m are constants of the motor, the slip σ_m at maximum torque is proportional to the rotor resistance. If therefore σ_m has been calculated, or found otherwise for a given rotor resistance, one can say straightaway what the resistance in the rotor should be in order to give another value of σ_m corresponding to another starting torque.

5.—*Geometrical Determination of the Starting Torque.*—Fig. 3 shows a very simple construction for the starting torque with a given value of σ_m or vice versa. At the end N of the base line of

the Heyland circle we erect a vertical which is cut by the direction of MP_0 in the point Q at a height NQ equal to $2\,T_m$ = MN. Further, we produce the line MP_0 beyond the starting point P_0 until it cuts that vertical in R. We will call the ratio NR/NQ = z. Then we have two similar triangles $\Delta MP_0N \sim \Delta MNR$, and therefore

$$z = NR/NQ = NR/MN = P_0N/MP_0 \quad . \quad . \quad (10)$$

$$\therefore \quad z^2 = (P_0N)^2/(MP_0)^2$$

$$\text{and } 1+z^2 = \frac{(MP_0)^2+(P_0N)^2}{(MP_0)^2} = (MN)^2/(MP_0)^2 \quad . \quad . \quad (11)$$

Further $\dfrac{T_0/MP_0 = P_0N/MN \quad \text{or} \quad T_0 = MP_0 \cdot P_0N/MN}{T_m = \frac{1}{2}MN}$

$$\therefore \quad T_0/T_m = \frac{2 \cdot MP_0 \cdot P_0N}{(MN)^2} = \frac{2(MP_0)^2 \frac{P_0N}{MP_0}}{(MN)^2}.$$

If we here substitute the values from formulæ (10) and (11) we find

$$T_0/T_m = \frac{2z}{1+z^2} = \frac{2}{1/z+z} \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

This is precisely the same formula as No. (9), namely,

$$T_0/T_m = \frac{2}{1/\sigma_m+\sigma_m}.$$

The ratio z is therefore identical with the motor constant σ_m, and if we take the distance NQ as unity we can read off σ_m directly, as given by the scale written on the vertical NQ.

The diagram, Fig. 3, shows also a vertical line erected at the point M. This line is to be used for values of $\sigma_m > 1$. Then the *reciprocal* of σ_m is to be read off the left scale. Such high values, of course, will never occur in squirrel cage motors, but the construction will be of value to determine the resistance to be connected to a slip-ring rotor for obtaining a given starting torque.

This diagram serves a two-fold purpose. One can use it for finding the starting torque when σ_m is known, if one does not prefer to calculate it from formula (9), which is quite a simple matter. However, for the solution of the other problem, to determine the necessary value of σ_m for a specified starting torque, the diagram is far handier than the formula, as the solution of (9) to give σ_m as a function of T_0/T_m will lead to a formula containing the square root of a difference which is not so handy for calculation with a slide rule.

6. *The Relation between Starting Torque and Normal Torque.* We saw in paragraph 3 that with a given rotor resistance—that is, with a given value of σ_m, the *starting* torque T_0 is fixed as a fraction of the maximum torque T_m. The *normal* torque T_n, however, is not a fixed quantity of the motor depending on its constants, but depends on the *rating* of the motor. Two absolutely identical motors may have quite different normal torques due to different conditions of load for which they are to be used. The rating of a motor entirely depends on the overload capacity which is specified. If the motor load is such that no great overloads can occur we can run the motor at a higher point of the Heyland circle than would be permissible in case a high overload capacity is required. From this it is clear that the ratio of starting torque to normal torque is not a mathematically defined quantity for a given motor, but varies in accordance with the rating of the motor. This rating is given by the ratio T_n/T_m. We then have, if σ_n is the slip at normal torque,

$$T_n/T_m = \frac{2}{\frac{\sigma_n}{\sigma_m}+\frac{\sigma_m}{\sigma_n}} \quad \text{and} \quad T_0/T_m = \frac{2}{\frac{1}{\sigma_m}+\sigma_m}.$$

The required ratio of starting torque to normal torque is therefore

$$T_0/T_n = \frac{\frac{\sigma_n}{\sigma_m}+\frac{\sigma_m}{\sigma_n}}{\frac{1}{\sigma_m}+\sigma_m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

For a given rating T_n/T_m, the quotient σ_n/σ_m is given as well, and therefore the numerator of this formula is a constant, so that we may write

$$T_0/T_n = \frac{M}{\frac{1}{\sigma_m}+\sigma_m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13\text{A})$$

This can be represented by a curve similar to the standard torque-slip curve, Fig. 2, but with other scales for the co-ordinates. For each particular value of T_n/T_m we have one curve representing formula (13) or (13A) with a particular value of M. For another rating T_n/T_m the value of M will be different, and therefore another curve will hold. A set of such curves for various ratings of the motor is given in Fig. 4. The abscissæ represent the ratio of starting torque to normal torque T_0/T_n, whilst the ordinates show the slip σ_n to be provided at normal load in order to obtain the required starting torque. The rating T_n/T_m is written on each curve. There is another set of figures "K" written on as well. These represent the "overload capacity" of the motor. In these figures a margin has been allowed to ensure that the motor will not fall out of step when yielding the specified overload torque. We have, for this reason, assumed that the maximum overload torque is still 15 per cent. below the pulling-up torque T_m.

With the usual overload capacity of 100 per cent., we have therefore assumed a rating $T_n/T_m = 1 - 0{\cdot}15/2 = 0{\cdot}425$. The corresponding curve is shown as a thick line in Fig. 4. From this curve we find that in order to obtain a starting torque T_0, equal to the normal torque T_n, we must provide about 5 per cent. slip at normal load. Or if $1\frac{1}{2}$ times normal torque is required we must so design the rotor that it gives 8 per cent. slip at normal load. These figures show at once how much the efficiency of the motor will be affected by increasing the starting torque. Of course, it is clear that in rotors with great slip special precautions must be taken to get rid of the heat in an efficient way. The set of curves show that the same ratio of starting torque to normal torque T_0/T_n can be obtained with *less* slip if we choose a motor with a higher overload capacity, which, of course, costs money, since it means a bigger motor for a given output. This has also another disadvantage, which will be shown in the following paragraph.

7. *The Rush of Current at Start.* The current which the motor takes at start is the short-circuit current, which is a definitely defined value, depending on the dimensions, windings and voltage. As the start point P_0 (Fig. 1) lies above the basis of the Heyland circle, the short-circuit current will be the smaller the higher P_0 lies, that is, the higher the required starting torque is. This sounds rather paradoxical, but is explained by the fact that the effective rotor flux increases with increase of rotor resistance, and therefore a higher starting torque is obtained in spite of the decrease of current.

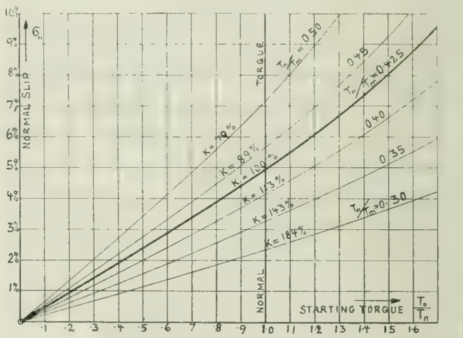


Fig. 4.

In practice, it is not so much the actual amount of current rush that is of importance, but merely its ratio to the normal current. This ratio depends again on the rating of the motor. With a given circle diagram the relative rush of current will be the smaller the higher the working point P (Fig. 1) lies on the circle, and the rush will be greater if P lies low. That is to say, a motor rated to give a high overload capacity will have a big rush of current at start. This is the disadvantage mentioned before. The advantage of such a motor—namely, to give a high starting torque without too great a slip at normal load—is therefore to be paid for with a big rush of current.

The quantitative value of the rush also depends on the magnetising current. It will be greater for motors with small magnetising currents (that is, with high-power factor) than for those with low-power factors. The following table gives an index of the approximate rush of current when the motor is switched straight on to the mains relating to different ratings :—

Rating : Overload capacity	70%	100%	150%	200%
Rush of current	3·5 to 3·8	4·0 to 4·4	4·8 to 5·6	5·5 to 6·7

The overload capacity is again assumed with a 15 per cent. margin. The lower values of the rush refer to low-power factor motors, the higher values to high-power factors. If such a rush of current is not permissible for the supply it can be reduced either by the well-known star-delta start or by the use of an auto-transformer. However, it must be understood that with such reduction of the starting current the *torque* is decreased in the same ratio.

The *star-delta start* reduces the rush of current taken from the mains and the torque approximately to 1/3=33 per cent. of that value which would be obtained by starting up straight from the mains. The curves given in Fig. 4 may be used for star-delta start if the scale of the abscissæ is reduced to one-third of the figures written on the axis.

The *auto-transformer* has but one advantage over the simple star-delta switch. in that it allows the torque and consequently the rush of current to be adjusted within a certain range, but it is not right to believe (as is often done) that it will enable one to obtain a high starting torque with a reduced current.

8. *The Crawling of Squirrel-Cage Rotors.* The speed-torque curve shown in Fig. 1 gives the ideal conditions with the assumption of sinoidal distribution and variation of flux and current without higher harmonics, also, as already mentioned, with no losses in the stator. In practice, these conditions will not be fulfilled. The drop in voltage in the stator winding will reduce the maximum torque. But if due allowance is made for that, the curve, Fig. 1, may still be used, as its general shape will not be materially altered by the varying E.M.F. As a matter of fact, if the torque-slip curve is plotted from the corrected Heyland diagram, one finds that T/T_m is *greater* for a given slip than would follow from the standard curve Fig. 1. This curve is therefore on the safe side. The same refers to the curves Fig. 4, as far as the influence of the primary copper loss is concerned.

However, there are other disturbing factors which cause the torque-slip curve to deviate from the ideal curve to a much greater extent and with more serious consequences than the influence of the Ohmic drop. These deviations are the cause of what is known as "Crawling of Squirrel-Cage Rotors." Most rotors of the usual designs show this bad feature to a greater or less degree. When they are loaded with a torque equal or even somewhat less than

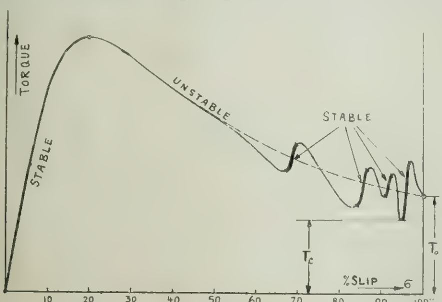


Fig. 5.

the "starting torque" (as determined statically by means of a lever with a weight at its end) they start, indeed, from rest, but then keep on crawling slowly without running up to full speed. In order to enable them to run up the torque is to be decreased sometimes considerably below the static starting torque.

This is a very important fact, which shows that it is not safe to design the motor so that it gives the "starting torque at rest," as found from the ideal curve and from the set of curve given in Fig. 4. Not the *static starting torque*, but what we may call the "*running-up torque*," is the figure which has to comply with the starting torque called for in the specification.

Fig. 5 shows a torque-slip curve as it can be found from tests on a squirrel-cage motor of the usual design. There are several ripples in the curve, and it is obvious from the definition given in the beginning of this article that all those parts of the curve which are marked by thick lines represent stable running conditions for the rotor. The lowest point of these ripples (which is always at the first ripple from starting point) represents the maximum "running-up torque," that is, that critical value of torque T_c (Fig. 5) against which the rotor will just run up to full speed. If the load torque is greater than T_c, the rotor will crawl at a low speed. By varying the torque and reading the speed the stable branch of the curve at crawling speed can be determined by test without any difficulties. Besides this first critical crawling speed, the curve, Fig. 5, shows some more stable parts at higher speeds. This does not seem to be generally known, because the rotor runs up through these critical speeds as soon as the load torque is decreased below the value T_c. However, with some patience and some skill one can manage to catch the rotor at a higher critical speed. It is only necessary to load the motor by means of a rope brake with a torque greater than T_c. When the rotor crawls at the first critical speed one must lift the brake weight a little so as to allow the rotor to accelerate until it has passed the low part of the first ripple. Then (not too soon and not too late) the whole brake weight is to be put on again, when the rotor will run steadily at a higher critical speed. Moreover, it is easy to detect the existence of such higher critical speeds by ear, because the ripples of the torque curve produce a variation in the acceleration when the rotor runs up to speed, and this can be noticed by the uneven change of the musical note which the rotor produces

It would lead too far, in view of the restricted space available for this article, if we were to discuss the causes of these ripples. They have been thoroughly investigated, and we are able to calculate the various critical speeds. In connection with this, it might be of interest to know that the existence of such higher critical speeds and their figures were first found by theoretical considerations and the different critical speeds pre-calculated and then proved and found to be correct by actual test figures. If one only knows the cause of a trouble one can very often find means to obviate it. This is also true in the present case. It can be proved by theory and practical results that it is possible to reduce the detrimental ripples of the torque curve to a minimum by a proper design of the motor.

If this is not carried out there is nothing else left but to face the fact that a relatively higher *static* starting torque is to be provided for, so that the critical running-up torque meets the specification. The difference between these two quantities (T_c and T_0) can be of the order of 30 to 40 per cent. In large motors of usual design the conditions may even be worse, as it may happen that with star-delta start the motor fails to run up even at light load, the critical torque T_c being lower than the friction torque.

The usual way to overcome these difficulties is to provide a *higher* resistance in the rotor circuit. That is to say, one would have to design the motor with a rather higher slip at normal load and consequently with a rather lower efficiency than would follow from the standard curves, Figs. 1 and 4. This is the reason (mentioned in the beginning of this article) why we have used the simplest form of the Heyland diagram. It would, of course, be unreasonable to use a complicated form giving a result more accurate by, say, 10 per cent., and afterwards add a safety margin of 30 to 40 per cent. on account of other reasons, and in the *other* direction to the correction of the 10 per cent.

Another way of meeting the uncertainty in providing the correct running-up torque is very often recommended. This is the use of an auto-transformer, by means of which "the starting torque can be adjusted."

The Siemens squirrel cage motors are so designed that the detrimental ripples in the torque curve are almost entirely suppressed, and that, therefore, their tendency to crawl is reduced to a minimum. They are so designed that they can develop a "high running-up torque" without having more slip (and therefore lower efficiency) than is determined by the ideal standard curves. The use of an expensive auto-transformer is therefore *not required* in connection with Siemens' squirrel-cage motors except in those cases where the load torque against which the motor will have to start is not definitely known beforehand. In all other cases a star delta switch is sufficient, or, for small motors, an ordinary triple-pole switch.

Summary.

In order to produce a standard torque-slip curve for a three-phase motor the slip σ_m at maximum torque is introduced as a characteristical constant of the motor. The equation of the torque-slip curve is derived

$$T/T_m = \frac{2}{\frac{\sigma}{\sigma_m} + \frac{\sigma_m}{\sigma}},$$

and the features of the curve are discussed.

The relation between starting torque and σ_m is shown

$$T_0/T_m = \frac{2}{\frac{1}{\sigma_m} + \sigma_m},$$

and a simple diagram given for this relation.

The relation between starting torque and normal torque is developed, and curves are given to show what normal slip is to be provided for obtaining a given starting torque.

The rush of current is discussed and figures given for various ratings of the motor.

The crawling of squirrel-cage rotors is discussed and explained as being due to ripples in the torque curve, which produce stable running conditions at slow speeds. The "running-up torque is shown to be the more important figure than the static starting torque, and it is pointed out that, in order to get the motor to run up properly, either a greater slip at normal load is to be provided than would follow from the ideal curves, or special care is to be taken in the design of the motor to reduce those ripples to a minimum, as is the case with the Siemens squirrel-cage motors.

LARGE GAS ENGINES.*

BY P. R. ALLEN.

Summary.—The history of gas engines is first briefly reviewed, followed by details of construction of the various parts of large engines. A comparison is next made between steam and internal combustion engines from the technical and also the commercial point of view, and instances are given of large installations of gas plant.

The author deals with the aspect of the gas engine, as compared with steam power, on somewhat general lines, and first describes the Otto cycle and the early history of gas engines. The two-cycle engine seems really to have been first practically worked out by Mr. Dugald Clerk, but was apparently not built on any large scale until the Oechelhauser and the Körting engines began to be constructed. Although both these types are always spoken of as "two cycle" engines, there is a considerable difference in their exact action. Körting takes a long cylinder, with a series of exhaust ports in the middle, and has a long piston, which only covers these exhaust ports for a short period at each end of the stroke. He then uses two pumps, one supplying gas and the other air. These pumps are worked by a crank approximately at right angles to the main crank, and deliver air and gas under a pressure of a few pounds through two separate ducts or channels, which only join just above the inlet valves, of which there is one at each end of the cylinder. As far as impulses go, a single-acting engine of this sort is just the same as a single acting steam engine, and a double-acting Körting engine has two impulses every revolution, the same as an ordinary steam engine.

In the Oechelhauser engine, instead of having the exhaust ports in the centre of the cylinder the ring of holes is placed at one end, and the gas ports and air ports in separate rings at the other end. Two pistons are employed, which alternately approach and recede from one another. These pistons are connected to the opposite webs of a three-throw crank, and in the course of one revolution alternately approach and recede from one another. When they are nearest to each other in the middle of the cylinder the charge of mixture is compressed ready for firing, and the cranks are approximately on the dead centre. When the ignition takes place, one piston goes in one direction and the other goes in the other, so that at the end of the explosion stroke the exhaust ports are open at one end, and the gas and air inlet at the other. The air inlets are nearer the centre of the cylinder than the gas, and the incoming air therefore tends to sweep out the products of combustion and interpose a barrier of pure air between the exhaust ports and the supply of mixture. A single cylinder cannot be made double acting, and there is only one working stroke in one revolution. The air and gas are supplied by two independent pumps, as in the Körting engine, or by one single double-acting pump worked off the back crosshead, or in some cases by an independent crank. There are several possible systems of working outside the four-cycle Otto and the two-cycle Körting or Oechelhauser; but they are not at present put into practical use. The six-stroke cycle in which, after the exhaust stroke, a separate charge of pure air is drawn in and then expelled between the exhaust stroke and the suction stroke, came into a certain amount of favour. It no doubt formed a most effective scavenge, but the same result has since been obtained, particularly on the Premier engine, with a four-stroke cycle, combined with an independent air pump for supplementing the discharge from the exhaust. Considering next the construction of a large tandem horizontal engine, an arrangement largely used on the Continent, there are five main pieces forming the framework. The first piece is a very massive bed plate, carrying the crank shaft; the second is the first cylinder; the third is a bridge or intermediate piece supporting the rear of the first cylinder and the front of the second cylinder; the fourth member is the second cylinder, and the fifth is a supporting piece at the back end of this second cylinder. What practically amounts to a continuous piston rod is employed; that is to say, two piston rods are joined together in the central slipper working in the intermediate guide, the front piston rod being attached to the crosshead, while the end of the back piston rod works in a guide in the rear piece. It is usual to anchor only the front bed plate to the foundation, and to allow the rest of the engine a limited amount of expansion endways. The ends of the cylinders are cast solid with the outer shell, and there are two rows of studs provided, the outer circle transmitting the stresses to the frames, while the inner circle of studs holds the cylinder heads in position. This is, perhaps, not the nicest way of dealing with the matter theoretically, but it has been found to answer very well in practice. On the Continent the use of double throw cranks is almost universal, the crank shaft being supported by a bearing on each side of the crank, but in the United States, where the building of large gas engines has made great progress, the overhung or single crank is much more in favour. This has the supposed advantage of enabling a twin-engine to be built with only two bearings, the flywheel or rotating part of the dynamo being free to adjust itself between the two sides. At the same time this necessitates a very much heavier bed, as the stresses are only transmitted quite obliquely.

Mention is also made of the systems of regulating. Practically, there are three sorts of governing: quality governing, in which the amount of mixture admitted is always the same, but the quality is varied by increasing or decreasing the amount of gas. This enables constant compression to be always assured. The second division is quantity governing, in which the quality of the mixture is kept the same, but the amount admitted each stroke is varied. Strictly speaking, this implies a variable compression. The third way is to throttle both the air and mixture, and this is done on high-speed vertical engines apparently successfully. Altogether, the regulation of fuel to internal combustion engines is a very complex subject, and anyone specially interested is advised to consult the writings of Prof. Mattho.

The internal combustion engine differs from the steam engine, inasmuch as a certain amount of heat has to be deliberately wasted; that is to say, the cylinders, cylinder heads and, in large engines, the pistons and exhaust valves have to be water cooled. It has been very frequently proposed to utilise the heat in the cylinder jackets as a means of raising steam, and, with the recent developments made in exhaust steam turbines, it is open to consideration whether it might not pay in a large installation, even taking into account the extra capital outlay. However, the heat rejected in the exhaust is now systematically made use of, the burned gases being turned through a multitubular boiler before being turned into the atmosphere. An ordinary gas engine may be roughly reckoned to consume about 70 cubic ft. of producer gas having a value of 145 B.T.Us. per cubic foot per brake-horse-power-hour, and this will be found to raise about 2 lb. of steam at 70 lb. pressure for each brake-horse-power-hour exerted.

The author next refers to the fuel used for engines and the types of producers, and mentions that a very considerable impetus was given to the construction of large gas engines in this country when the Mond system of using bituminous fuels and gasifying them at a low temperature, at the same time recovering sulphate of ammonia as a by-product, was proposed. The author has been connected with the working of one of these plants capable of gasifying 700 tons a week, which was put up at a works at Weston Point seven years ago, and he can readily testify to the absence of trouble and the economy resulting from its use. The calorific value of the gas and the yield of sulphate of ammonia to a certain extent bear an inverse relation to one another, *i.e.*, the higher the yield of ammonia the lower the calorific value of the gas, but a very desirable figure to aim at is about 145 B.T.Us. per cubic foot lower value. In all plants gasifying at a low temperature a considerable amount of tarry vapour passes off, and this is in such a form that it cannot be extracted at the high temperature which it possesses when it leaves the plant itself. Different ideas prevail as to the efficacy of dry cooling and wet washing; in the author's opinion, the better way is first to cool it to as near as possible atmospheric temperature, and then pass it through some form of washer. The tar recovered in this way contains about 40 per cent. of water, but it can be drained to some extent and burned as a fuel, or it may be treated for its pitch and creosote, as is done at Messrs. Beardmore's works in Glasgow.

Considering finally the commercial comparison between the gas engine, or internal combustion engines generally, and the steam engine, it may be safely stated that the consumption of fuel in a gas engine is only about half that in a steam engine, *i.e.*, in the ratio 9·5 : 17·5. Installations of 20,000 H.P. and upwards driven by large gas engines are now to be met with in several places. At Bruckhausen, near Duisberg, the author has seen 24,000 H.P. under one roof, and at Cary 65,000 H.P. from one installation. Most of the Continental steel works do not deem it necessary to provide any spare steam plant as a stand-by for their gas engines, so that the practicability of working a large gas-driven station may be taken as settled. However, in this country, the electrical engineer who is responsible for most of the power schemes that come forward has hesitated on the ground of capital expenditure to recommend large units and producer plants. Anyone who wants to familiarise himself with the pros and cons of the case cannot do better than study Messrs. Andrews & Porter's recent Paper read before the Institution of Electrical Engineers. These gentlemen have since reduced their opinions to the form of a slide rule, which anyone can use with a few minutes' instruction.

At the present time it must be admitted that the large gas engine is

* Abstract of a lecture delivered on "Engineering Day" at the Imperial International Exhibition, Shepherd's Bush.

a more expensive machine to construct than a steam engine or especially a steam turbine, and a glance at the respective indicator diagrams shows at once why this must be so. To obtain a mean effective pressure of, say, 70 lb. in a gas engine cylinder, the crank-shafts, bearings and all the working parts have to be made to stand the explosion pressure, say 350 lb., while in a steam engine the maximum pressure coming on any part rarely exceeds from 180 lb. to 200 lb. However, assuming for the moment that the capital expenditure on a large gas engine plant with producers is too high, the moment that you begin to use the gas engine in connection with the waste gases from blast furnaces and coke ovens the position at once becomes quite different; in the blast furnace and coke oven you have the producer already made; you burn the gas in the engine to just the advantage you do under the boilers; the total space occupied by the plant is less, and the total capital cost works out as less.

The author cannot go into the question of oil engines, but he mentions that as an auxiliary to the sailing ship, a moderate sized oil engine will prove a valuable investment, as in fair weather the engine needs no attention, while in calms and unfavourable winds the ship can at all events make a certain amount of progress. Anyone who has been engaged in the sailing ship business trading round Cape Horn will appreciate the occasions when it would prove useful.

THE ARTHUR WRIGHT ELECTRICAL DEVICE FOR EVALUATING FORMULÆ AND SOLVING EQUATIONS.*

BY ALEXANDER RUSSELL, M.A., D.SC., AND ARTHUR WRIGHT.

The Slide Resistances.—In the electrical device described below the principle of the ordinary logarithmic slide rule is combined with addition and subtraction, by utilising the laws according to which resistances combine in series or parallel. The products

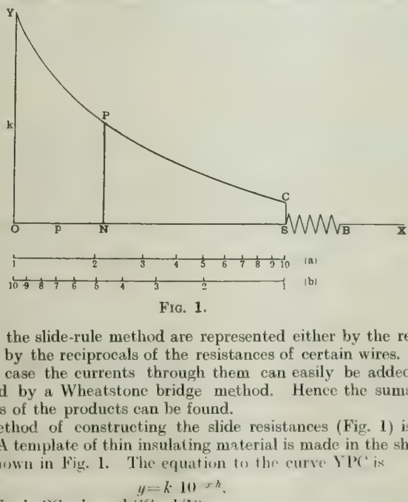


FIG. 1.

found by the slide-rule method are represented either by the resistances or by the reciprocals of the resistances of certain wires. In the latter case the currents through them can easily be added or subtracted by a Wheatstone bridge method. Hence the sums or differences of the products can be found.

The method of constructing the slide resistances (Fig. 1) is as follows: A template of thin insulating material is made in the shape OSCY, shown in Fig. 1. The equation to the curve YPC is

$$y = k\,10^{-x/h},$$

where $OY = k$, $OS = h$, and $SC = k/10$.

This plate is wound uniformly with a hundred turns of No. 36 insulated manganin wire, the temperature coefficient of which is negligible, and the wires are practically parallel to OY. At points along OS the insulation of this wire is removed, and contact with the wires is made by the contact-finger described below. The scale OS is logarithmic. If p, for instance, be the reading at the point N, we have

$$ON = h \log p,$$

and thus

$$y = PN = k/p.$$

The resistance of the wire between O and N will be approximately proportional to the area ONPY. This area is given by

$$\int_0^x y\,dx = k\int_0^x 10^{-x/h}\,dx$$
$$= \frac{hk}{\log_e 10}\left(1 - \frac{y}{k}\right).$$

If, then, the wire on the frame has a resistance 9R/10, and a coil SB of resistance R/10 be put in series with it, the resistance from N to B will equal (y/k)R, that is, R/p.

When the resistances are fixed on the device, the resistance between N and B is in circuit, and this always equals R/p, where p is the reading on the top scale [(*a*), Fig. 1]. If we have n of these slide resistances in parallel, and their readings are $p_1, p_2, \ldots p_n$, the sum of the currents will be

$$(E/R)\,(p_1 + p_2 + \ldots + p_n),$$

where E is the applied P.D.

Instead of having the logarithmic scale placed as in (*a*) Fig. 1, we may reverse it and place it as in (*b*). If p' be the value of ON read on this scale, we obviously have $p' = 10/p$; and hence the resistance between N and B is $(R/10)p'$. If the n resistances be now connected in series, their combined resistance will be

$$(R/10)\,(p_1' + p_2' + \ldots + p_n');$$

and if E be the applied P.D., the current flowing through them will be

$$(10E/R)\,/\,(p_1' + p_2' + \ldots + p_n').$$

In some problems it is more convenient to use the scale placed as in (*a*), and in others it is more convenient to use it as in (*b*). In what follows, unless otherwise stated, we shall suppose that it is placed as in (*a*).

The Index Line.—Corresponding to the slides in the ordinary slide rule the slide resistances are movable. If we wish to form the product pq, we move the slide so as to make the index line I I′ (Fig. 2) lie over the reading p, and we then move the contact-finger until it makes contact at N, where TN, on the logarithmic scale is q. The resistance NB will then equal R/pq.

The Contact Fingers.—The ordinary contact finger is a straight piece of metal wire ONP (Fig. 3), which is capable of rotation about a point O fixed on a sliding bar parallel to and vertically over the index line I I′. This bar can move in the direction of its length. A pointer, L, attached to it moves along a fixed logarithmic scale KQ. The length of this scale is made equal to h, and so

$$KL = h \log x = OT.$$

The contact finger OP can be

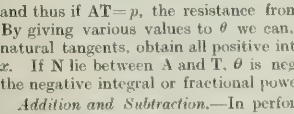


FIG. 2.

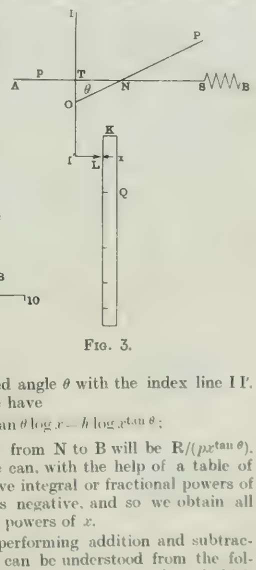


FIG. 3.

adjusted so as to make any desired angle θ with the index line I I′. If the contact be made at N, we have

$$TN = OT\tan\theta = h\tan\theta\log x = h\log x^{\tan\theta};$$

and thus if $AT = p$, the resistance from N to B will be $R/(px^{\tan\theta})$. By giving various values to θ we can, with the help of a table of natural tangents, obtain all positive integral or fractional powers of x. If N lie between A and T, θ is negative, and so we obtain all the negative integral or fractional powers of x.

Addition and Subtraction.—In performing addition and subtraction, the action of the apparatus can be understood from the following diagram. P and Q are the terminals of a wire bridge, of which O is the middle point (Fig. 4). One pole of a battery of dry cells is connected with O and the other pole is connected with the B ends of the slide resistances, A_1B_1, A_2B_2, and A_3B_3. A galvanometer connects P with Q. Let us suppose that we have to find the value of $a_2 + a_3$. We connect Q with the contact-fingers of A_2B_2 and A_3B_3 respectively, and set the fingers at the marks a_2 and a_3 on their respective scales. We then join P with the contact-finger of A_1B_1, and closing the keys we adjust the position of this finger until there is no deflection on the galvanometer. In this case let the reading on the slide A_1B_1 be a_1. If E be the potential at R, and V be the potential at P or Q, then, since the currents in PO and QO are equal, we have

$$(E-V)/(R/a_1) = (E-V)/(R/a_2) + (E-V)/(R/a_3),$$

and thus

$$a_1 = a_2 + a_3.$$

To find $a_2 - a_3$, all we have to do is to change the connection of the finger of A_3B_3 from Q to P. Proceeding as before, a_1 now gives us the value of $a_2 - a_3$.

* Abstract of a Paper read before the Physical Society. A short account of this Paper appeared in our issue of July 2nd, p. 468.

The Use of the Arms of the Bridge.—Terminals are connected at points P_1, P_2, P_3, Q_1, Q_2 and Q_3 of the bridge wire (Fig. 5). These points are chosen so that if the resistance P_1Q_1 be $2r$, the resistances of OP_1, OP_2 and OP_3 are equal to r, $r/10$ and $r/100$, and also to the resistances of OQ_1, OQ_2 and OQ_3 respectively. The effect of connecting a slide resistance with P_2 instead of P_1 is to divide its value by 10. Hence, if we were adding 8·8 to 0·75, we would put the contact-finger of one slide on 8·8 and connect it with P_1, and the contact-finger of another slide on 7·5 and connect it with P_2. Suppose also that the value of x was 123. In this case we could only obtain a balance when it was connected with Q_3.

Cubic Equation.—Let us suppose that the cubic equation is

$$x^3 + a_2x^2 - a_1x + a_0 = 0,$$

where a_2, a_1 and a_0 are positive numbers.

The arrangement of the apparatus for solving this equation is shown in Fig. 5. The bridge-wire is indicated between P_1Q_1. We

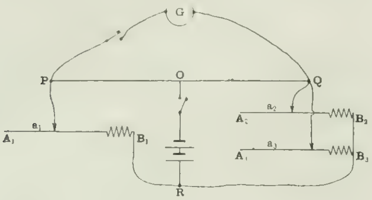


FIG. 4.

move the slides AB, A_1B_1, A_2B_2 and A_3B_3, so that the readings 1′ a_2, a_1 and a_0 on their logarithmic scales are on the index-line II., The ends of the contact-fingers touching AB, A_2B_2 and A_3B_3 are connected with P_3 and the finger touching A_1B_1 with Q_3. The fingers through N, N_1, N_2 and N_3 makes angles $\tan^{-1} 0$, $\tan^{-1} 1$, $\tan^{-1} 2$ and $\tan^{-1} 3$ with the index-line. The battery and galvanometer-keys being closed, the bar to which the fingers are connected is gradually lowered. When the galvanometer deflection is zero let us suppose that x is the reading on the logarithmic scale S. In this case we have

$$\frac{E-V}{R/x^3} + \frac{E-V}{R/a_2x^2} + \frac{E-V}{R/a_0} = \frac{E-V}{R/a_1x},$$

and thus $x^3+a_2x^2-a_1x+a_0=0$. Hence x is one of the roots of this equation.

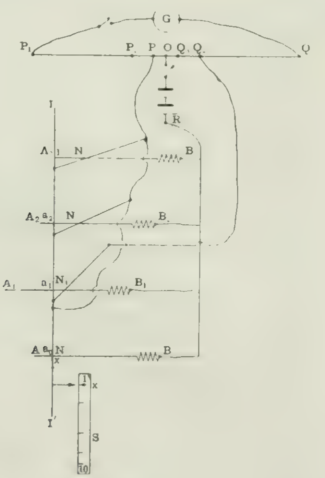


FIG. 5.

When a contact finger, N_1 for instance, reaches the end of its slide N_1B_1 will be R/10. If we now move the slide A_1B_1 so that A_1 is on the index-line, unclamp the contact-finger and move it parallel to itself until N_1 is over A_1 and then reclamp it, the resistance of N_1B_1 will be R. If, then, we disconnect the finger N_1 from Q_3 and connect it with Q_2 the deflection on the galvanometer will not be altered, and so we can continue to increase x. It will be seen that as x increases from 1 to 10 the contact-finger N_3 traverses A_3B_3 three times. The first time N_3 gets to the end of its scale it is connected with P_3 and moved back to A_3. The second time it reaches the end it is connected with P_1 and again moved back.

The device enables us to find any real root of the equation, greater than 10^n and less than 10^{n+1}. All we have to do is to find the root of the equation

$$x^3 + (a_2/10^n)x^2 - (a_1/10^{2n})x + a_0/10^{3n} = 0,$$

lying between 1 and 10, and multiply the result by 10^n. By solving a similar subsidiary equation we can find the approximate values of the roots of the equation which are less than unity.

Equations involving a greater number of powers of n are solved by correspondingly increasing the number of slides.

Tracing Curves Electrically.—Suppose we desire to find the graph of the curve

$$y = a_px^p + a_qx^q - a_rx^r + \ldots = f(x),$$

where p, q, r . . . may be positive, fractional, or negative indices. We set the contact-fingers at angles $\tan^{-1}p$, $\tan^{-1} q$, . . . with the index-line, and move the slide resistances until the readings on the scales are a_p, a_q, ... The contact-fingers on the slide resistances representing the positive terms are then connected with P, and the other contact-fingers with Q. In addition we have a slide resistance Y with a vertical finger, which is also connected with Q. The fingers are moved down through a given distance x on the logarithmic scale, and the value of the reading y on the slide resistance Y when there is no deflection of the galvanometer is then found. In this way simultaneous values of x and y can be rapidly obtained, and hence we can readily plot the curve.

The curve could also be traced automatically by making the spot of light from a mirror galvanometer, connected between P and Q, fall on a strip of sensitive paper which is constrained to move so that its velocity is always proportional to the rate at which x is increasing. The points where the trace cuts the line of zero deflection would give the roots of the equation $f(x)=0$, and the turning points of the trace would give the roots of $f'(x)=0$. In the same way the integral curve

$$y = \int_0^x f(x)\,\partial x,$$

could be drawn automatically.

If the slide resistances were made of large size so that they could carry appreciable currents, recording ammeters and voltmeters could be employed to trace the curves.

SAFE USE OF ELECTRICITY IN COAL MINING.*

BY G. R. WOOD.

Owing to recent disastrous explosions in coal mines, many of which were attributed to dust produced by motor-driven machines, some interesting statistics were compiled of the amount of dust produced by various mining methods. One set of figures, from results obtained at the mines of the Washington Coal and Coke Co., gave 1·80 lb. of dust (screened through a forty-mesh screen) per square foot undercut, for hand mining, 4·58 lb. for puncher machines and 1·48 lb. for chain machines with pick-pointed bits. Results from two other mines gave 6·18 lb. for the puncher machine and 2·43 lb. for the chain machine with standard chisel bits. In a mine generating explosive gas in large quantities it is advisable to keep all electrical wires, and, so far as possible, electrical apparatus, on the intake air, for obvious reasons.

Discussing the danger of high-potential electric currents, the author considers that the higher voltages, as 500 volts, to which a large number of plants have in recent years been changed, usually from 250 volts, are far more dangerous than the lower voltage. Proper methods of resuscitation of persons who received shocks by the electric current would prevent many fatalities, and instances are given in support of this contention. In regard to safety of the men, it has been considered useless for some years past to insulate electric wires underground, since there seems to be no commercial insulation which is of value after a few years' use, or in some cases, a few months' use. It has therefore been preferred to use bare wires, even for machine lines in room headings, and depend on the miners' intelligence to recognise the danger of a bare wire. In this connection it is interesting to note that at the testing station of the Geological Survey in Pittsburg the electrical department is making some experiments on various insulations subjected to extreme mining conditions. Cables with rubber and other insulations are submerged in acid

* Abstract, from the "Electrical Review and Western Electrician," of a Paper presented to the Coal Mining Institute of America.

mine water, readings taken of their initial insulation resistance, and these readings repeated at frequent intervals. The weakness of the insulation will be shown by the gradual or sometimes sudden drop in these values.

An insulation called varnished cloth, or varnished cambric, tested at this station, has been used by the author under mine conditions, and has been subjected to severe service for over two years without any sign of trouble. This does not seem to be affected by acid and is perfectly moisture-proof. The cost of this insulation will, it is believed, be considerably less than the best rubber, and if the results obtained at the testing laboratory equal those found in practice, the author believes it will be only a short time until it can be confidently recommended that all machine wires carrying 500 volts or over be insulated where carried on room headings.

Bare wires can, of course, be used where the wires are carried through air courses or off the travelled roads. So far as the trolley is concerned, it is out of the question to consider protecting this for its entire length. At all places, such as partings, turnouts, and where the travelling roads cross the haulage road, the trolley wire can be protected by means of a trough or a single board projecting below the level of the trolley and firmly supported from the roof. In a large number of mines, all branches from the main trolley, on which but one locomotive works at a time, are sectionalised by the use of automatic trolley switches, which cut the current off the branch except when the locomotive is working thereon.

It has been found by experiment that in many mines where the rails are in contact with the earth and the headings are wet with acid moisture, part of the return current, amounting in some cases to 60 per cent., is carried by the earth. Electrolysis in the pipes parallel and near to the track is caused by the current where it enters and leaves these pipes. In flowing through moist earth from the pipe to the rail it will carry part of the iron of which the pipe is composed into the earth toward the rail. This is prevented by using copper connections for the current from rail to pipe and back.

The use of electric lights in mines is strongly recommended, particularly at partings, turnouts, and all points where men must travel along or across the rails. It is advisable to have more than one circuit where lights are used as danger signals, to provide for burn-outs. In some mines red lamps are installed at the danger points and show only when the current is on the wires at the parting.

In all cases where large tracts of coal are to be developed, the author recommends the use of 275 volts potential, using high-tension alternating-current transmission from the central plant, and locating substations as close to the work as possible. Where the cover is excessive, these substations can be located underground at the centre of distribution. Wherever the cover is light, it would usually be preferable to have the substations overhead and the direct-current cables taken into the mine through boreholes.

Reference is finally made to the three-wire system, and it is mentioned that in some mines a balance is maintained within 15 per cent., rising occasionally to 25 or 30 per cent.

ELECTRIC CRANES.*

BY H. H. BROUGHTON.

(*Continued from page 827.*)

Summary.—The author here deals with the mechanism required for effecting the traversing and travelling motions. The article opens with a brief discussion on the determination of the size of motor required for each motion, and "constants" of American cranes are given. Then follow notes on slipping drives, axles, axle-boxes, roller bearings and track wheels. Constants are given in order to enable the several parts to be correctly proportioned. Traversing and travelling mechanism arrangements are also described.

Axles.—The axles are treated as beams and the worst conditions of loading are assumed. The bending moment at any section can be determined either graphically or by calculation. The former method is, in some respects, the better of the two, as we have a picture of the forces acting at every point of the axle, and can, therefore, design it accordingly.

As the stress alternates from a positive to a negative maximum once each revolution, the working stress, according to Prof. Lilly's formula, should be

$$\frac{5}{1-\frac{1}{2}\left(\frac{1}{1}\right)} = 3{\cdot}33 \text{ tons per square inch.}$$

and this is in close agreement with the practice of designers.

As far as possible "overhung" wheels should be avoided. The most satisfactory arrangement of truck is that in which axle boxes are provided on each side of the truck wheels, together with a bearing close up to the driving spur. Lower bearing pressures and other advantageous features to some extent counteract the higher initial cost of the arrangement. We have come across trolleys in which two bearings have sufficed to support the truck wheels and driving spur, but such unworthy practice cannot be too strongly condemned.

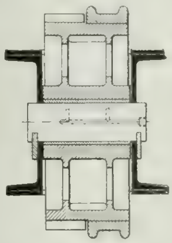


Fig. 105.—Fixed Axle and Bushed Wheel.

Fixed axle pins and bushed wheels (Fig. 105) are used to a great extent by Continental firms. Although English crane builders of repute discourage the method, it can, nevertheless, be relied upon if the bearing pressures are not excessive and the lubricating arrangements satisfactory. Furthermore, it is inexpensive.

Several types of bearings and axle boxes are depicted in Figs. 106 to 110.

When the axle pins are fixed it is customary to provide heavy bronze bushings in the truck wheels. Holes bored up the centres of the pins serve to carry the grease required to lubricate the bearings.

The axle boxes depicted in Figs. 106 to 109 are characterised by the novel lubricating arrangement. This method of lubricating was introduced by Adamson & Co., and has been adopted by a number of builders. Referring to Fig. 106, it will be seen that the wooden roller R, loosely mounted on a pivoted arm, A, is pressed against the axle S by means of the weight W. The lower part of the roller

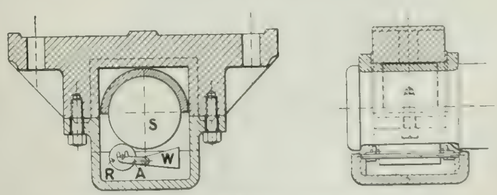


Fig. 106. "Under" type Self-lubricating Axle Box.

dips into an oil bath, and, as the axle rotates, the roller is turned round and oil is carried on to the axle.

In some cases it may be advisable to provide a stiff grease lubricator in the top of the box to protect the journal from injury if through any cause overheating should occur.

A bearing pressure of 800 lb. to 1,000 lb. per square inch of projected area may be allowed, so that when the wheel pressure and diameter of axle are known the length of journal required can quickly be determined.

The advantages of roller bearings over the solid type are well known, and a number of boxes and wheel bushings, embodying the roller-bearing principle, adapted to withstand the severe service imposed, have been designed. Of these, perhaps the best known and the one most widely used

is that manufactured by the Hyatt Roller Bearing Co. From Fig. 110 it will be seen that the distinctive feature of the Hyatt flexible roller bearing is the roller, which is made from a strip of steel wound into a coil of uniform diameter. The advantage of a roller of this construction lies in its flexibility, which enables it at all times to present a bearing along its entire length, ensuring a uniform distribution of load on the roller itself, as well as the surfaces on which it operates. It will also be seen

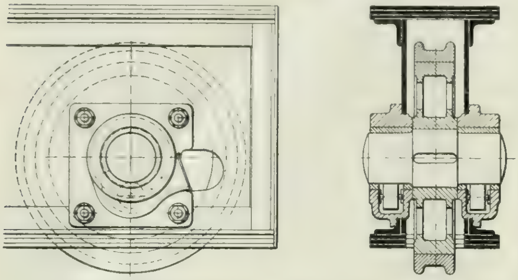


FIG. 107.—SELF-LUBRICATING AXLE BOX, BY ADAMSON & CO.

that the roller acts as an oil reservoir, while the spiral and roller together perform the function of an oil carrier, thereby assuring perfect lubrication of the bearing surfaces.

The summarised results of two tests made to determine the difference in efficiency between Hyatt bearings and bronze bearings are given below :—

TEST A.

The bearings were used in the bridge truck wheels of a 15 ton crane, and the tests show the power required (*a*)

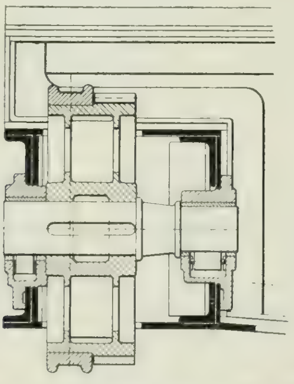


FIG. 108.—SELF-LUBRICATING AXLE BOXES AND END TRUCK DRIVING WHEEL.

with the wheels equipped with bronze bushings and (*b*) with the wheels equipped with Hyatt roller bearings.

Weight of crane, without load	34,000 lb.
Weight of load	28,000 lb.
Total weight	62,000 lb.

Diameter of truck wheel 21 in., diameter of axle 3½ in. ; motor, 15 B.H.P., 220 volts.

(*a*) *Test with Bronze Bushings.*

No load on hook : 18 amperes, 80 lb.-ft. torque, 5·2 B.H.P., 340 revs. per min.

28,000 lb. on hook : 30 amperes, 158 lb.-ft. torque, 8 B.H.P., 265 revs. per min.

(*b*) *Test with Hyatt Roller Bearings.*

No load on hook : 16 amperes, 68 lb.-ft. torque, 4·6 B.H.P., 356 revs. per min.

28,000 lb. on hook : 22·5 amperes, 110 lb.-ft. torque, 6·4 B.H.P., 305 revs. per min.

Percentage of power required for full load with roller bearings as compared to bronze bushings :—

Torque	70·0 per cent.
Brake horse-power	80·0 ,, ,,
Increase in speed of crane	80·0 ,, ,,
B.H.P. for equivalent speed	69·5 ,, ,,

The small variation of power with no load on the hook is due to fixed losses in the gears, bearings, rolling and flange friction.

TEST B.

This test was made by Wellman, Seaver & Head on an open-hearth charging machine of the light high-ground type.

Complete weight of machine without load	19 tons.
Diameter of truck wheel	24 in.
Diameter of axle	3½ in.
Travelling speed	300 ft. per min.

When fitted with Hyatt roller bearings the travelling motor took 18 amperes on a 450 volt circuit, showing a current consumption at the rate of $18 \times 450/746 = 10{\cdot}9$ H.P.

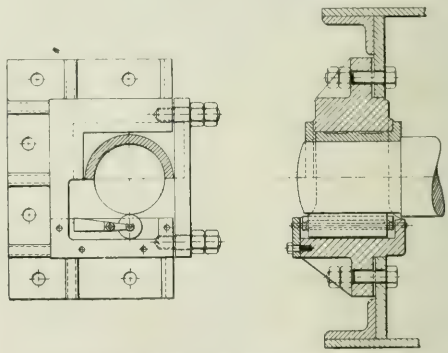


FIG. 109. END-TYPE SELF-LUBRICATING AXLE BOX, BY BROADBENT & SONS.

Calculated horse-power required at starting with bronze bearings lubricated : As calculated by a reliable formula, 15·6 H.P. would be required, taking the gear at 65 per cent. efficiency. This, however, takes no account of the acceleration power required, and as these machines are designed to get up their full speed very quickly, the power required for acceleration would probably add on several horse-power, which would be read on the ammeter in the case of the machine fitted with roller bearings, although it does not appear in the formula used to determine the horse-power when the machine is fitted with bronze bearings, as it is usual to overload a series motor to this extent.

If we allowed 25 ft. of travel in which to get up full speed of the machine, the tractive effort required at starting would be increased by nearly 60 per cent., which is equal to about 3·5 H.P.

Machine fitted with roller bearings	10·9 H.P.
Machine fitted with bronze bearings	19·1 H.P.

For the above description we are indebted to the Hyatt Roller Bearing Co.

Track Wheels.—In order to minimise wear of the treads and rails, and to ensure a low tractive effort, it is necessary to use track wheels of large diameter. On account of the heavy loads imposed, they should be made of steel or be provided with steel tyres. For steel-tyred wheels rolling

on steel rails a pressure of 600 lb. to 800 lb. per inch of diameter and per inch of width of tread may be assumed.

The construction shown in Fig. 111 (*h*) is frequently adopted for the driving wheels. The spur wheel is formed in one piece with the track wheel centre, which is of cast-steel. The double-flanged tyre, bored out and shrunk on the centre, is turned on the tread. It is usual to allow 0·001 of the diameter for "shrinking on." Some makers form the tyre as shown in Fig. 111 (*e*). In special cases it may be necessary

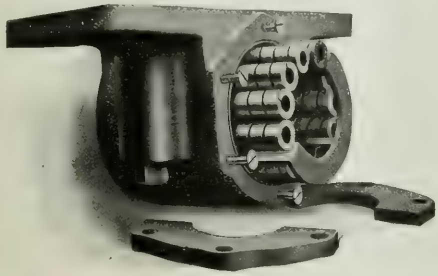


FIG. 110.—HYATT AXLE BOX WITH END PLATE REMOVED.

to fix the tyre to the wheel centre by means of stud bolts, as in locomotive practice, but, generally speaking, the grip due to shrinkage is sufficient.

For cranes of large capacity it is necessary to use more than four wheels in order that the pressure per wheel shall not be excessive. When two sets of rails can be provided, as is often the case with the bridge of overhead travelling cranes and hammer cranes, the double wheels shown in Fig. 111 (*j*) are used. When limited side clearance or other

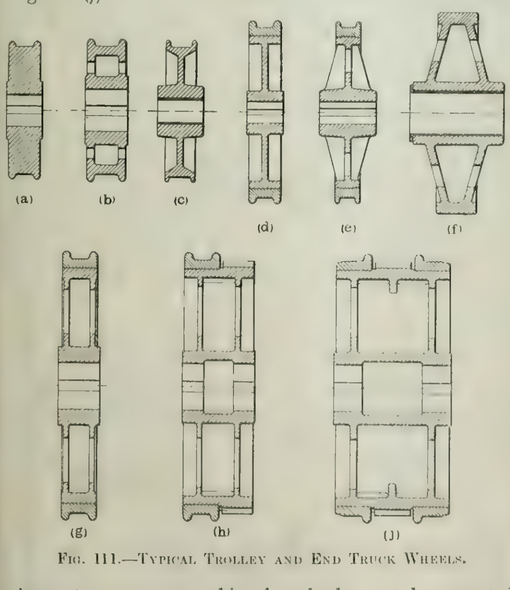


FIG. 111.—TYPICAL TROLLEY AND END TRUCK WHEELS.

circumstances prevent this, the wheels must be mounted in pairs in compensating trucks, so as to equalise the loads. The construction of several of these trucks was described in the article on structural steelwork,* to which the reader is referred for further particulars.

The method of designing the gearing is the same as that described in the article on lifting mechanism.†

(*To be continued.*)

* THE ELECTRICIAN, January 8, 1909. † *Ibid.* April 9, 1909.

POWER CHARACTERISTICS OF THE TUNGSTEN FILAMENT.*

BY CHARLES P. STEINMETZ.

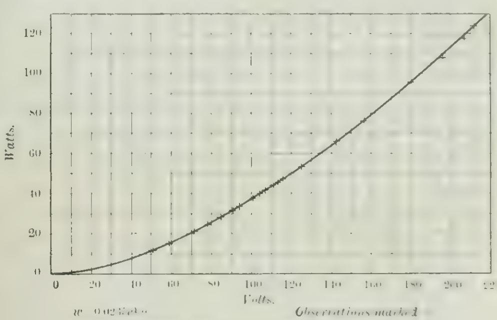
As in the tungsten filament incandescent lamp the resistance increases with the temperature, the power consumption varies at a rate which is less than proportional to the square of the impressed voltage. It therefore was interesting to investigate experimentally the manner in which the power consumption increases with increase of voltage.

In pursuit of an extended investigation on the radiation law of the tungsten filament, a series of tests had been made with precision on a number of modern tungsten lamps extending over a wide range of candle-powers. Taking the readings very quickly, by experts especially trained in photometric work, it was possible to reach 10 times the rated candle-power of the lamps without any appreciable impairment or change of the filament or blackening of the globes, as evidenced by the lamp showing its original candle-power and efficiency after the test. For these data the writer is indebted to Mr. F. C. Marshall of the Harrison Lamp Works.

Analysing the relation between the power consumption and the impressed voltage, the interesting result was found that the power consumption varies proportional to the 1·6 power of the voltage—that is, follows a law analogous to that of the hysteresis loss in iron in an alternating magnetic field, and thus can be expressed by the equation $w = 0{\cdot}0235e^{1{\cdot}6}$.

The lamp was a 32 c.p. 40-watt lamp, and was run up to 320 c.p. Alternate check readings were taken at 103-104 volts, on which the lamp gave its normal candle-power.

In the accompanying illustration is shown the curve of 1·6 power, with the observed values of power marked by crosses. As will be seen, the coincidence is so close as to give no noticeable deviation in the scale of the curve.



EXPERIMENTAL CURVE 1·6 POWER.

About 18 years ago the writer observed that the relation between the power loss in iron in an alternating magnetic field and the magnetic density can, with good approximation, be empirically expressed by a law of 1·6 power: $w = \eta B^{1{\cdot}6}$.

This law of hysteresis is still an empirical law, and all attempts to derive it rationally from theoretical considerations have thus far failed. It therefore is especially interesting to observe the same law of the 1·6 power, showing the relation between the consumption and voltage of tungsten lamps, especially as in the tungsten lamp the law of the 1·6 power is not only an empirical law, but can rationally be derived as a theoretical conclusion from the temperature law of metallic resistance, $r = aT$ and the normal radiation law, $R = bT^4$, where T = absolute temperature and R = total radiation power.

THE EFFECT OF LIGHT ON SULPHUR INSULATION.†

BY FRED. W. BATES.

During a series of experiments on the ionisation of the air in closed vessels the writer used an electroscope in which the leaf system was supported on sulphur insulators. When an attempt was made to calibrate the instrument large variations in the rate of leak were noticed, which seemed to depend on the intensity of the light falling on the leaf system. A series of experiments was

* From the "Electrical World." Somewhat abbreviated.

† Abstract of a Paper read before Section A of the British Association, at Winnipeg.

then undertaken to discover whether any such definite relation existed.

It was found that the average day rate of leak was greater than the average night rate, that bright sunlight falling on the insulation increased the rate very greatly, while even partially excluding the light decreased it perceptibly.

By intercepting some of the sun's rays by means of either cobalt blue or red glass the rate of leak was much lessened, and by totally excluding the light from the insulation the day rate of leak was reduced to practically the same as the night rate.

The theory that this change of rate of leak was due to a rapid and violent change in the rate of ionisation of the air in the vessel was early abandoned, for it was found that by merely causing the sunlight already shining into the vessel to fall directly on the sulphur insulation, a great increase in the rate of leak was obtained, although there was no more sunlight entering the electroscope than formerly. The theory that sulphur is affected in much the same way under sunlight as zinc is under ultra-violet rays was also abandoned, for it was found that positive and negative charges leaked equally fast under similar conditions. An electroscope was constructed with a guard ring about the sulphur insulation which was on the exterior of the vessel and thus completely exposed to the light.

In daylight, when the guard and the leaf carried charges opposite in sign, the leaf lost its charge and in time acquired a charge similar in sign to that on the guard, but when both guard and leaf carried the same kind of charge the charge on the leaf increased if initially less than that on the guard, but decreased if initially greater. On the other hand, at night either kind of change leaked away from the leaf even with the guard changed, which was undoubtedly due to the ionisation of the air in the vessel.

The conclusion is that sulphur in the presence of light becomes to a slight degree a conductor of electricity and the greater the intensity of the light the greater the conductivity. And further, that the leak due to ionisation is less than that due to the increase in the conductivity of the sulphur, exposed even to ordinary daylight. It is necessary, therefore, that great care should be taken when measuring small electrical charges with instruments having sulphur insulation to keep light from falling on the sulphur.

A series of preliminary investigations, in which amber and ebonite were used as insulators, indicated a slight increase in the conductivity of ebonite in strong sunlight, but amber did not show any effect. The importance of the effect of light on insulation was so great that the writer purposes investigating thoroughly with these and other materials in order to find its extent, and also, if possible, to discover the exact nature of the change produced by light on sulphur.

THE POULSEN SYSTEM OF RADIO-TELEGRAPHY.

On Saturday last an interesting demonstration was given at the radio-telegraphic station at Cullercoats of the working of Dr. Poulsen's ingenious photographic receiver.

This station, which is equipped with both arc and spark apparatus, has already been very fully described in these columns; first, in an article published on November 16, 1906, giving details of the arc apparatus, and, more recently, June 4, 1909, in our report of Mr. Sorensen's Paper before the Newcastle Section of the Institution of Electrical Engineers, which is chiefly concerned with the spark apparatus now being used commercially for ship-to-shore messages.

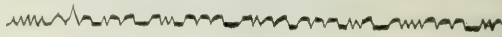
For some time past experiments have been carried out at this station, in conjunction with a similar one at Lyngby, in Denmark, about 600 miles distant, with a view to perfecting Dr. Poulsen's high-speed system of transmission. In this system the receiving apparatus is exceedingly simple. A thermo-couple, or contact rectifier, is used as detector, and the unidirectional current thus obtained passed through an Einthoven galvanometer, the vibrating wire of which is of platinum or gold, prepared by the Wollaston process, about 6 cm. long and having a resistance of 100 ohms if gold and 400 ohms if platinum. Its motion is made dead-beat by shunting it with a resistance of about 1,500 ohms. A vertical image of this wire (the image being considerably improved by smearing the wire with a little lamp black) is projected by means of a microscope on to a horizontal slit, behind which a strip of sensitive paper moves. This strip, after passing the slit, is guided by pulleys through the troughs of two bird fountains, being developed in the first and partially fixed in the second. If a permanent record is required, the tape, on leaving the instrument, is run into a second fixing bath.

The rectifier actually used in the experiments shown consisted of a small fragment of galena and one of metallic tellurium pressed together.

The highest speed at which messages have been received at Cullercoats from Lyngby is 100 words per minute. At this speed, with the power at present used (about 7 kw.), the deflections of the galvanometer are rather small, and consequently the indications on the tape are not very easy to read. However, over shorter distances this speed has been found quite practicable, and, indeed, between Lyngby and Copenhagen, a speed of 300 words per minute has been attained. Probably, by the use of more powerful radiation, these high speeds will be found quite workable over much greater distances.

The messages actually received on Saturday were at 50 words per minute, and as will be seen from the illustration the printing at this speed is exceptionally clear.*

The working of the apparatus was very smooth indeed; there is very little to get out of order. The most delicate part, the galvanometer wire, is completely enclosed, and is only likely to be damaged by a sudden rush of current due to an



atmospheric disturbance, or to the receiving circuit being accidentally left connected to the air wire when transmitting. Even this is not a very serious matter, as spare wires, already soldered to supports, are kept, and require no great skill to fix in position.

At present it is only possible to transmit from Cullercoats by hand, the only automatic transmitter that has yet been constructed being at Lyngby. This circumstance was one disappointing feature of the demonstration, and much additional interest would have been provided if the complete mechanism of this sending apparatus could have been examined.

* Similar records appeared in THE ELECTRICIAN, April 24, 1908, p. 50.

A NEW TYPE OF REACTANCE COIL.

BY R. LIVINGSTONE.

The usual design of reactance coil shown in Fig. 1 has a very high leakage coefficient. In some cases only 25 per cent. of the lines passing through the coil actually cross the gap at *a*, the remainder of the lines taking other paths than the gap. On account of this leakage it is difficult to predetermine the actual impedance of the coil, and large variations in the length

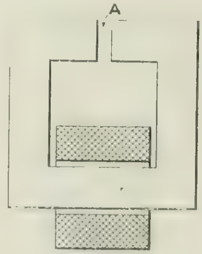


FIG. 1.

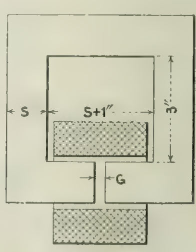


FIG. 2.

of the gap make only a small change in the impedance. The leakage lines are also harmful in heating up the end turns of the copper and any metal (such as the iron case) within reasonable distance. To overcome the above defects the writer has designed a reactance coil in which the winding surrounds the air-gap, as shown in Fig. 2, the intention being to reduce the leakage as far as possible. The result of actual tests on this type of reactance coil shows a very considerable improvement on the type shown in Fig. 1. There is still, of course, a certain amount of fringe to the air-gap, but this can easily be allowed

for in the calculations. The maximum flux in millions of lines is given by

$$M=\frac{22\cdot5\times \text{volts}}{n\times \text{turns}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

when n =cycles per second. The maximum A.T. for the gap is A.T.=0·313 Bg, when B=density in lines per square inch and g=length of gap in inches. For a sine wave the maximum

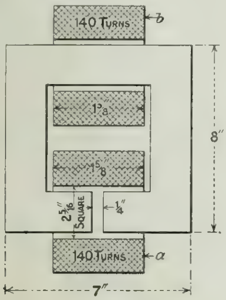


Fig. 3.

value is $\sqrt{2}$ times the virtual, so that the virtual amperes to give the required choke will be

$$A=\frac{0\cdot222B.g.}{\text{turns}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From equations (1) and (2) we have

$$\text{turns}=\sqrt{\frac{5\times10^6\times g\times \text{volts}}{n\times A\times \text{gap area}}} \quad . \quad . \quad . \quad (3)$$

The gap area should be the area of the iron core plus an allowance for fringing depending on the inside dimensions of

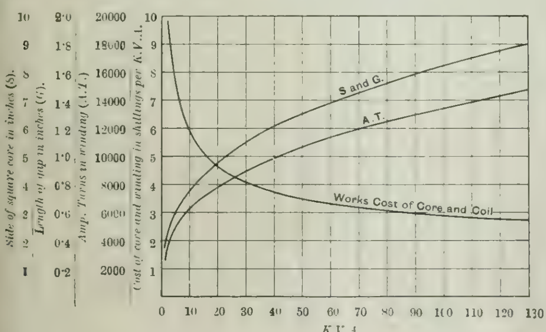


Fig. 4.—Single-phase Reactance Coil, 50 cycles.

the coil and its length. The less clearance between the coil and the core and the shorter the coil the smaller will be the allowance.

A comparison of tests on the experimental coil shown in Fig. 3 is given in the following table :—

Current through coil a.			Current through coil b.		
Amps.	Volts across a.	Volts across b.	Amps.	Volts across b.	Volts across a.
8·1	22·0	22·0	8·1	42·5	17·0
9·95	27·5	26·2	9·95	46·5	20·5
12·45	34·0	31·3	12·45	51·5	21·5

From this table it can be seen that when the coil is round the gap there is no external leakage so long as the iron is not saturated ; but when the coil is round the yoke and the iron unsaturated only 40 per cent. of the lines go through the gap, and the remaining 60 per cent. are leakage lines external to the iron core. Since the design shown in Fig. 2 has practically no external field, the metal cases can be made quite small, and if made of iron will not increase the amount of choke.

The diagrams shown in Figs. 4 and 5 give dimensions and costs for any size of reactance coil up to 130 k.v.a. for 25 and 50 cycles.

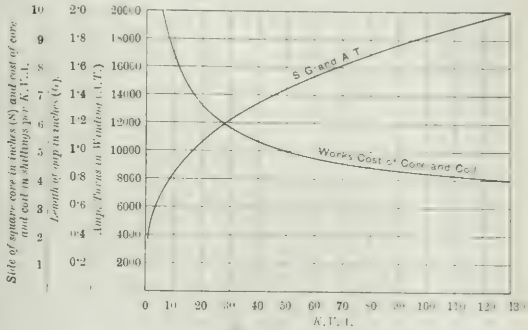


Fig. 5.—Single-phase Reactance Coil, 25 cycles.

The dimensions are only suitable for the type shown in Fig. 2 and for a depth of winding of 2 in. Three-phase choke coils can be made to give as good results as single-phase coils with the construction shown in Fig. 6, and the dimensions of core, coil and gap can be obtained from Fig. 4 or 5, using the kilovolt-ampere per phase as the rating.

For example : A single-phase coil to give 50 volts choke with 1,000 amperes at 25 cycles (50 k.v.a.) would have a core $7\frac{1}{4}\times7\frac{1}{4}$ and a gap $1\frac{1}{2}$ long. The winding should have 14,400 A.T., so that the number of turns is $14\frac{1}{2}$. The works cost is 5s. per

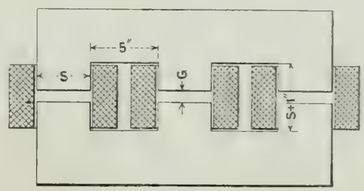


Fig. 6.

kilovolt-ampere for the core and coil, so that the total works cost for core and coil is £12. 10s.

A three-phase coil to give the same output per phase would have the same dimensions of core and gap, and each coil would be the same as the single-phase coil. The works cost would be about $2\frac{1}{2}$ times the cost of the single-phase coil.

THE SEPARATION OF NEW RADIO-ACTIVE DISINTEGRATION PRODUCTS.*

BY DR. OTTO HAHN.

The disintegration theory of Rutherford and Soddy has brought forward a long list of radio-active products which have distinct chemical and physical properties, and which may be separated by various methods. Some of these products emit α particles, some β particles, some emit α and β particles and some do not seem to emit rays at all.

The α particles for each special product are emitted with a quite definite speed which is characteristic for the product, but this apparently does not hold true for the β rays. The absorption curves for the β rays are in some cases complex, and seem to indicate complex β rays ; in some cases the absorption curves indicate only one type of rays.

* Abstract of a Paper read before Section A of the British Association, at Winnipeg.

In collaboration with Dr. Lise Heitner, the author began two years ago an investigation of all the various β ray products with the view of comparing all the separate products under identical conditions. As the result they put forward, as a working hypothesis, that single radio-active products emit only one type of radiation, either homogeneous a particles or homogeneous β particles.

In the view of this hypothesis all products emitting a and β rays or complex β rays must be complex and separable into two or more single products.

The working hypothesis proved fertile in the case of the active deposits of thorium, actinium and radium. The active deposit of thorium consists of four different single products—viz., A, B, C and D. Thorium D being a new product with a life period of three minutes, emitting β rays which were formerly ascribed to thorium C. The active deposit of actinium consists of three different single products, A, B and C, the latter having a period of 5·1 minutes and emitting β rays which before had been attributed to actinium B.

In the quickly decaying active deposit of radium we have apparently single β rays from radium B and complex ones from radium C. Hence radium C must be complex and consist of three products, one a and two β-ray substances. It is, of course, a matter of great difficulty to separate by chemical means very quickly decaying products, and use was therefore made of the "recoil method" of separating radio-active disintegration products. The effects in the case of radium C were very weak, but this was to be anticipated. Supposing the a rays to be emitted from the last product of radium C, the result seems to show that really radium C is complex, comprising besides one product of 19 minutes duration another of 1–2 minutes, and yet a third with a still shorter life.

But there is still a better possibility of proving the correctness of the hypothesis. The authors have found that radium itself emits β rays of a quite distinct character. As it has long been known that radium itself emits also a particles, in the view of the hypothesis radium itself must be complex and consist of two different products, say, radium and radium x.

Some recent experiments seem to indicate that this might be the case, and it looks as if radium itself emits easily absorbable β rays only, and the hypothetic substance radium x emits the well-known a particles.

If further work should prove radium to be complex there is little doubt that the few other radio-active transformation products which still emit complex rays are complex and therefore to be separated. We might then be in a position to find some relation between the life period and other qualities of the products and the kind and velocity of the rays the particles emit.

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS.*

The committee in the first place record their sense of the great loss electrical science has sustained by the death of Prof. Ayrton, F.R.S. The revival of the Electrical Standards committee was proposed by him at the Swansea meeting in 1880. He had been a member since that date, and much of the work of the committee owes its initiation to his inspiration.

Reference is next made by the committee to the International Conference on Electrical Units and Standards, and the report of the Conference is printed as an appendix to this report.

In their last report the committee suggested the republication of the reports of the original committee from 1862 to 1871, and of the present committee from 1881, as a memorial to the connection of Lord Kelvin with their work. They are glad to learn that the recommendation from the committee of Section A in favour of this course has been accepted by the Council, and that a proposal to undertake the projected republication will be made to the General Committee at Winnipeg. The committee are greatly indebted to Mr. R. K. Gray for a generous donation of £100 towards the expenses of this work.

* Abstract of a report presented at Winnipeg. The committee consists of Lord Rayleigh (*Chairman*), Dr. R. T. Glazebrook (*Secretary*), Profs. J. Perry, W. G. Adams and G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Profs. A. Schuster, J. A. Fleming, and Sir J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Prof. S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir A. W. Rücker, Prof. H. L. Callendar, and Messrs. G. Matthey, A. P. Trotter, T. Mather and F. E. Smith.

In the appendix to the report of the committee for 1905 it is stated that slight variations in the E.M.F. of the Weston normal cell can be produced by 12½ per cent. cadmium amalgam. A preliminary investigation showed that the variations were generally very small and not easily reproduced. In general the E.M.F. was normal at 0°C. A more exhaustive investigation has now been completed at the National Physical Laboratory, and the results show that in general the 12½ per cent. amalgam may be used from 0°C. to above 60 deg. without any appreciable error, but the E.M.F. of a standard cell containing such an amalgam *may be* very normal at all temperatures below 12°C. The limits of temperature for the general use of a 12½ per cent. amalgam are very nearly 1° C. to 62 C. A 10 per cent. amalgam may be used between 0°C. and 51°C.

Progress with the Lorenz apparatus has been slow but satisfactory. The difficulties attending the driving have been overcome to a considerable extent; an electric motor will be installed. The iron of the motor has been demonstrated to have no appreciable effect on the mutual induction of the Lorenz system when a small addition to the electrical system is introduced.

A comparison between the standards of resistance used at the National Physical Laboratory, the National Bureau of Standards and the Physikalisch-Technische Reichsanstalt has been made by the use of some hermetically sealed standards belonging to the Bureau of Standards. The following tables give the results obtained:—

Table I.—*Giving the Results of Comparisons made February-March,* 1908. *Values at* 20 C.

No. of coil.	Resistance as determined at			Difference. Parts in 100,000.	
	N.B.S. Jan.	N.P.L. Feb.	P.T.R. Mar.	N.P.L. N.B.S.	N.P.L. P.T.R.
1. (B.S. 1,102A)	0·99980$_1$	0·99982$_9$	0·99981$_6$	2·8	1·3
2. (B.S. 1,102B)	0·99975$_0$	0·99977$_6$	0·99975$_9$	2·6	1·7
3. (B.S. 1,102C)	1·09000$_0$	1·00002$_2$	1·00001$_0$	2·2	1·2
12. (B.S. 2,415D)	0·99998$_2$	0·99999$_7$	0·99997$_5$	1·5	2·2
1. (B.S. 3,946E)	99·990$_3$	99·991$_5$	99·991$_6$	1·2	−0·1
2. (B.S. 3,946F)	99·985$_8$	99·987$_1$	99·987$_2$	1·3	−0·1
1. (B.S. 3,946I)	999·90$_2$	999·92$_0$	...	1·8	...
2. (B.S. 3,946J)	1000·01$_9$	1000·03$_5$	...	1·6	...
			Mean...	1·9	1·0

Table II.—*Giving the Results of Comparisons made November,* 1908, *to March,* 1909. *Values at* 20°*C.*

No. of coil.	Resistance as determined at				Difference. Parts in 100,000.	
	N.B.S. Sept., 1908.	N.P.L. Nov., 1908.	P.T.R. Nov.,'08, Jan.,'09.	N.P.L. Feb.-Mar.,'09.	N.P.L.-N.B.S.	N.P.L.-P.T.R.
1. (B.S. 1,102A)	0·99999$_7$	1·00002$_3$	...	...	2·6	..
2. (B.S. 1,102B)	0·99999$_7$	1·00002$_2$	...	...	2·5	..
3. (B.S. 1,102C)	1·00000$_0$	1·00001$_6$	...	...	1·6	...
4. (B.S. 1,102D)	0·99999$_4$	1·00001$_1$	0·99999$_0$	1·00001$_5$	2·1	1·6
11. (B.S. 5,315C)	0·99999$_1$	1·00001$_4$	1·00000$_8$	1·00002$_5$	2·9	1·2
12. (B.S. 5,315D)	0·99998$_1$	1·00000$_3$	1·99998$_9$	1·00001$_1$	2·6	1·8
1. (B.S. 3,946E)	99·991$_6$	99·994$_5$	...	...	2·9	...
2. (B.S. 3,946F)	99·987$_5$	99·990$_7$	...	...	3·2	...
				Mean ...	2·5	1·5

The unit coils Nos. 1 and 2 were adjusted at Washington on September 23, 1908, so as to give values more nearly equal to the nominal. The changes made were +0·00019$_6$ ohm and +0·00024$_7$ ohm respectively. Analysis of all the data relating to the comparisons indicates that the coil No. 11 (Table II.) changed by about 0·00001 ohm during transportation from Teddington to Charlottenburg. No. 12 is a comparatively new coil, having been sealed in January, 1908. At the Bureau of Standards (Washington) wire coils were employed as standards in all the comparisons.

The values given by the N.P.L. in Table I. are in terms of the N.P.L. mercury standards of resistance, which were set up in November to December, 1907. The N.P.L. values in Table II. are in terms of the mercury standards of resistance which were erected in February, 1909. With respect to the values given by the Reichsanstalt in Table I., Dr. Lindeck states: "The last complete series of measurements on the standards of the Reichsanstalt was carried out at the end of January and the beginning of February. The values given in the table (I.) are based upon this series." In Table II. the P.T.R. values depend upon the values assigned to a wire standard of the Reichsanstalt which had been kept for about

a year in an atmosphere of constant humidity, and frequently compared with other standards of resistance.

In conclusion, the committee recommend that they be reappointed for the purpose of continuing their researches on the standards, and carrying out the republications of the reports if sanctioned by the general committee, that Lord Rayleigh be chairman and Dr. R. T. Glazebrook secretary.

The appendix attached to the report contains an account of the proceedings at the International Conference on Electrical Units and Standards, 1908, a list of the delegates, the resolutions passed and the specifications adopted. The last mentioned were given in our issue of October 30th last, whilst an account of the Conference appeared in that and previous issues.

EVEN HARMONICS IN ALTERNATING-CURRENT CIRCUITS.*

BY J. B. TAYLOR.

In the usual presentation and consideration of wave-forms in alternating-current circuits we are so used to the mathematical expressions which omit the second, fourth, sixth, &c., harmonics, and so generally assume that these even harmonics can be neglected at the outset, that a short consideration of usual and special conditions giving rise to even harmonics in alternating-current circuits seems opportune.

From discussion with many engineers I find that the following misconceptions are quite popular: (*a*) There can be no second harmonics in alternating-current circuits, because this would result in a direct-current component in the circuit, obtained without commutator or other rectifying device. (*b*) Even harmonics cannot be handled by typical transformers, so that should there be any even harmonics at one part of the circuit these will be in some way suppressed or balanced at the first transformation. (*c*) Wave-forms of E.M.F. from commercial generators do not contain even harmonics, hence nothing can give rise to them later in the system.

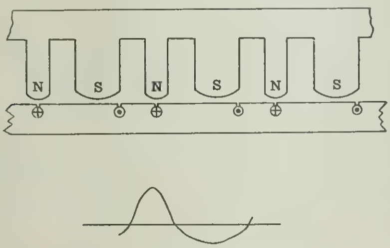


FIG. 1.

The average text-book on alternating currents, at some point usually near the introduction, states that windings and poles of commercial generators are symmetrical, so that alternate waves will be of the same shape and hence have no even harmonics. Little or no reference to even harmonics is made later in such books. As a matter of fact, telephone lines, transformers and receiving apparatus have to deal with even as well as odd harmonics. Also there is no difficulty in constructing an alternating-current generator to have a wave-form containing considerable even harmonics, when such are desired. There is also no difficulty in connecting standard generators in series or in parallel; and with a 25 cycle generator, say, and a 50 cycle generator, the resulting wave-form will have pronounced even harmonics.

If an alternating-current generator has a symmetrical armature winding and unsymmetrical north and south poles, the even harmonics will not appear. If the winding is unsymmetrical with the north and south poles symmetrical, again the even harmonics will be absent. The combination, however, of an unsymmetrical winding with unsymmetrical poles, will in general bring out even harmonics. Fig. 1 shows diagrammatically such an alternating-current generator with approximate wave-form due to the special arrangement of winding and the differently shaped north and south poles.

Neglecting the special case of the telephone, of more practical consideration than what has preceded are typical commercial systems in which even harmonics are likely to be introduced, and the effect of these harmonics on transformers. The simplest way in which even harmonics may be brought into an alternating-current system is by earthing at more than one point, and these points may be neutral or not. A neighbouring direct-current traction system causes direct current, in a greater or less amount, depending on bonding and other features, to be shunted into the alternating-current system. This current flows through the transformer windings, giving a "magnetic biased" condition. This shunted or leakage direct current may easily be as much as, or greater than, the exciting current of the transformer, which will give normal or greater magnetic density in the iron; and since many transformers are worked well up toward the saturation point, the iron in the transformer may be nearly saturated before any connection is made with the alternating-current supply. The magnetising current under the conditions described—that is, with direct current in the windings of the same order of magnitude as the normal exciting current—does not cause the exciting current to become of the order of a short-circuit current, nor even full-load current. This is because the iron, instead of working from the saturated condition as a mean point, works about a mean point not far from zero. A convenient way of introducing direct current into a transformer winding, without at the same time allowing the direct-current circuit to become a load or short-circuit on the transformer, is to arrange two transformers, preferably identical, with their primaries connected in parallel, and the secondaries (with alternating potential balanced) in series with any convenient source of direct current. Another combination of apparatus which may introduce direct current in transformer windings is a synchronous converter connected for three-wire service, the neutral of the three-wire service being connected with the transformer neutrals. With this combination, the difference between the currents on the two sides of the lighting system passes through the transformer windings. If the transformers are "diametrically connected" to the converter,

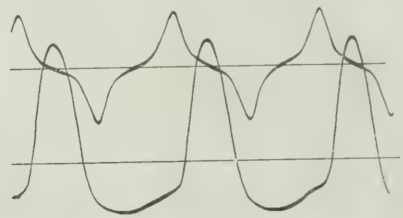


FIG. 2.—RECORD SHOWING PRONOUNCED SECOND HARMONIC IN TRANSFORMER MAGNETISING CURRENT DUE TO DIRECT CURRENT IN WINDINGS.

Upper curve—Electromotive force at terminals from [illegible] cycle generator.
Lower curve—Exciting current.

this direct current will divide; and if the resistance of transformer and converter connections are symmetrical from the neutral point, this divided direct current will cause no magnetic flux. With the direct-current neutral derived from star-connected transformers, direct current from the neutral does give a "biased" magnetic condition in the transformer iron, with accompanying increase of transformer exciting current and change in wave-shape. Since this current divides among three transformers, and its magnitude is not great, unless the lighting system is badly unbalanced, little additional transformer heating is likely to be noticed. Star-connected transformers have been so used with converters for a number of years without serious results. However, a diametrical connection seems preferable when laying out a new system.

Conclusion.—The leakage of direct current into transformer windings—unless these currents are of themselves sufficient to cause considerable additional heating in the windings—will not indirectly cause sufficient increase in the exciting current to cause serious overheating or burn-out. I have already proposed the use of counter E.M.F. cells to check the leakage of direct currents, but have not yet seen a case where the magnitude of these currents was sufficient to warrant such additional and undesirable complication of apparatus.

* Abstract of a Paper read before the American Institute of Electrical Engineers.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Hydro-Electric Developments and Engineering." By Frank Koester. (London: A. Constable & Co.) 21s. net.

"Science Abstracts." August, 1909. Vol. XII. Part VIII. Section A—Physics. Section B—Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. net.

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ELECTROLYSIS BY EARTHED RETURNS IN AMERICA.

We are so accustomed to immunity from trouble by earthed returns in this country that it sometimes comes as a surprise that considerable difficulties should be experienced elsewhere. As is well known, the Board of Trade has very stringent rules on the question. Not only is the pressure between an earthed return and any neighbouring pipe limited to a maximum of $4\frac{1}{2}$ volts if the return is positive, and to a pressure equivalent to that required for the electrolysis of water in the case of the earth return being negative, but the drop along the track is limited to 7 volts. These regulations have been found to be extremely effective in practice, notwithstanding the fears of many engineers that water pipes and gas pipes would suffer unduly through the advent of electric tramways.

In America there are no such regulations, with the result that serious trouble arises from time to time. As an example, we may refer to the case of Peoria, which is remarkable not merely from the electrolytic point of view, but as an example of the characteristic way in which legal matters are handled in America. It is 12 years since the Peoria Water Works brought an action against the company running electric tramways in the town. Apparently judgment was given in the first instance in 1900, but

various objections were raised, and the case has dragged on so that a further judgment has only recently been given. During this period numerous leaks have been discovered in the 30 in. and other mains. Two breaks have occurred in the 30 in. and nine in the 20 in. main, and instances have been found where the depth of pitting was 0·55 in. in a total thickness of $\frac{7}{8}$ in. Although the bonding has been improved in recent years the trouble has not decreased, owing to the fact that the size of the undertaking has become greater. The present judgment gives damages to the plaintiff, and restrains the defendant from causing further injury. But it discloses a good deal of hopelessness as to how the further injury is to be avoided, as it points out that a fraction of a volt will cause electrolysis, that there is no known method by which the plaintiff can protect the water system, and that there is no complete remedy except the entire removal of electric current, which is impossible so long as an earthed return is used. This is rather a curious view to take up. It is generally admitted that electrolysis will take place with even a fraction of a volt, but there is a vast difference between the electrolysis so produced and that due to pressures exceeding $1\frac{1}{2}$ volts. So long as the electrolysis is sufficiently slight, it is to all intents and purposes harmless as far as the commercial life of water mains is concerned.

Another case is that of Winnipeg, where the city electrician recently expressed the view that a fire had been caused by stray currents from the electric railway. Consequently, Prof. L. A. HERDT, of McGill University, was called in, and has reported upon the general state of affairs. The condition disclosed is certainly bad. The bonding is very poor, and the soil, on the other hand, is exceedingly good from the point of view of affording an alternative path. At present all the current is supplied from one generating station in the centre of the city, apparently without sub-stations. The general state of things is well illustrated by the fact that at one point the tracks are bonded to return feeders of a total sectional area of 6,848,000 circular mils, and the drop between this point and the negative 'bus bars, if the feeders were carrying the whole current, would be 12 volts. As the distance is only 1,200 ft. this means a drop of 1 volt per 100 ft., which is an extraordinarily high figure. Along certain streets the pipes are positive to the rails, and in the basement of one of the blocks a current of 50 amperes was observed on connecting an ammeter from the pipes to the telephone cables which are bonded to the 'bus bars. We doubt, however, if such an observation is of much value as an indication of what currents are flowing, because the same current will certainly not flow when the metallic connection is removed. The remedy suggested by Prof. HERDT consists of the installation of sub-stations at different points of the system, so as to diminish the amount of current returned through the rails in the centre of the city, proper re-bonding of all tracks, special bonding and cross-bonding at intersections, and a system of inspection of track returns by the Winnipeg Street Railway Co. It is remarked that the current density in the rail returns should be kept low, owing to the very low resistance of the soil, and that all bonds showing a resistance equivalent to more than 4·5 ft. of rail should receive attention.

It is clear that the amount of money invested in a tramway system can be brought down to a minimum if electrolytic troubles are neglected, but in such cases the business of transportation is carried on irrespective of the rights of existing interests. This latter point does not seem to be fully appreciated in America, or surely legislative steps would have been taken long ago to put electric traction on a proper basis so that no material harm should result.

REVIEWS.

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Electric Lighting and Power Distribution. By W. PERREN MAYCOCK. Vol. I., 7th edition. (London: Whittaker & Co.) Pp. xix—591. 6s. net.

The first edition of this book appeared 16 years ago. It has been largely used by the class of students for whom it was specially intended, namely, those taking the elementary and ordinary courses of the City and Guilds of London Institute. An electrical text-book needs constant revision if it is to keep abreast of the subject and the gradually widening syllabuses. In the present instance the book has been practically re-written and has increased in bulk by 167 pages and over 100 illustrations.

The revision appears to have been done very carefully, and the information is not only always correct but is put in as simple a manner as possible. The author evidently assumes throughout that the reader has an extremely elementary, if any, knowledge of mathematics.

The first of the nine chapters deals with the fundamental and mechanical units. After studying this chapter the most elementary student should have clear ideas as to the distinction between energy, force, work, power and momentum. The table of metric units and multiples is very complete, and although this section is marked with an asterisk as an indication that it should be studied by the student taking only the elementary stage, the latter would have our sympathy if he skipped the "hectares" and the "dekares." In Chapter II. the various electrical units are discussed, together with the simple laws expressing their relations to one another and to the thermal unit. In these days, when the labels on instruments and machines have often a Teutonic aspect, in spite of the name-plate, it might be as well to warn a student that the capital Ω means ohms and not megohms on the Continent. On p. 35 it is stated that carbon has a negative temperature coefficient. This statement needs a little qualification in view of the metalised carbon filament. It is a little unfortunate that after putting it in italics to make it striking, the printer should have called the unit of heat the "calerie." Several pages are devoted to capacity and condensers, mention being made even of the Moscicki type.

Chapter III. is devoted to the magnetic effects of electric currents and to magnetism in general. The construction and design of various types of electromagnets are considered very fully. Chapter IV. deals with electromagnetic induction. Self and mutual induction are explained and the "henry" defined. The converse phenomenon of the magnetic drag on a current-carrying conductor is then considered. In studying the action of the condenser across the break of an induction coil, a student knowing nothing of electrical oscillations will be sorely puzzled to see how it can "help the battery current to overcome the inductance of the coil more quickly on the make of the circuit."

Chapter V. deals with bells, indicators, alarms, &c., together with primary cells. There is an error on p. 159; bells of the type shown in Fig. 62 may be connected in series without an ordinary bell to act as make-and-break. Very good wiring diagrams are given for bell circuits of every kind.

In Chapter VI. we return to magnetism. The properties of

iron and steel, and the magnetic circuit are considered very fully. Instead of describing the modern methods employed for accurately testing iron stampings, eight pages are devoted to Dr. Drysdale's permeameter, which, although ingenious, is little used. The warning, on p. 261, as to the necessity of quickly reading the magnetometer to avoid the effects of magnetic viscosity, is calculated to give the student a very exaggerated idea of this phenomenon.

Chapter VII. covers the whole range of simple electrical measuring instruments and is very well done. In devoting four pages to galvanometer shunts, the author might have mentioned the Universal type. The very lucid description of the Bridge-Megger would be improved by the addition of a word of warning as to the accuracy to be expected when using it to measure low resistances.

The last two chapters deal with the construction of modern dynamos and motors, and contain a large number of good diagrams and photographs.

A very useful feature of the book is the numerous collection of exercise questions which follows every chapter.

G. W. O. Howe.

Magnetism and Electricity. By S. S. Richardson. (London: Blackie & Son.) Pp. viii.—592. 5s. net.

Mr. Richardson is to be congratulated on the success which has attended his efforts, for his book is a welcome addition to the already long list of text-books on electricity and magnetism. A very useful feature consists in the details which are given of laboratory experiments, so that the student has a practical hand-book as well as a text-book on theory. In this connection it might be amplified so as to include a few more of the simple exercises, such as the measurement of nearly equal low resistances by the Carey-Foster bridge, battery resistance by Mance's method, low resistance by split coils, &c. Under the heading, "Use of Different Modes of grouping Cells," the author has given the following rule: "Arrange the cells so that the resistance of the battery is as nearly as possible equal to the external resistance," and then proceeds to "prove" the rule by showing algebraically that the current is a maximum when the external resistance is *equal* to the internal resistance. Of course the latter is true, but the former is not invariably. With regard to the definition of E.M. units of current on p. 358, it would probably be better to make the length of conductor equal the radius of the arc (viz., 1 cm.), so that the force at the centre is unity instead of 2π. Taken as a whole, however, the book is an admirable one, especially for students intending to read for an intermediate science degree examination.

Le Réglage des Groupes Electrogènes. By J. L. Routin. (Paris: "La Lumière Electrique.") Pp. iv.—155.

This work is a very valuable addition to the literature that has been published on the speed and voltage regulation of electric generating sets, and will be welcomed by those who have to deal with problems of such a nature.

The subject matter is divided into three chapters, in the first of which general principles governing speed and voltage regulation are discussed. The second chapter is devoted to an analytical and graphical treatment of regulation, and forms the major part of the book. The first part of the chapter deals with the conditions for equilibrium in permanent working for the various prime movers in present use. The graphical treatment of regulation, which follows, is a development of the method due to Léauté. The "Léauté cycles" show the effect of a change in load on the set before equilibrium is reached. In the analytical treatment three cases are considered—for constant speed of operation, for a speed of operation proportional to the disturbance to be corrected, and also for a speed of operation proportional to the acceleration of the generating set. The calculation of the voltage regulation at constant speed, and a section on electro-mechanical regulation complete the chapter.

The concluding chapter is devoted to descriptions of special regulating apparatus which realise the various conditions assumed in the analytical treatment. An ingenious electro-mechanical regulator is described which operates at a speed proportional to the variation in load on the set, and it is also shown how that with several alternators working in parallel, the whole of the generators can be regulated from one central point by means of a special electric servo-motor regulating apparatus.

The treatise shows throughout that it is the work of one who has made a thorough study of the subject of the regulation of electric generating sets. The subject—difficult and complex though it is—is treated throughout in a very clear and able manner. In the analytical treatment there is of necessity an abundance of mathematics, but this will not be objected to by those for whom the work is intended, *i.e.*, those who wish to master fully the problems of the regulation of electric generating sets.

A. E. C.

THE BRITISH ASSOCIATION AT WINNIPEG.

(From our own Correspondent.)

Wednesday, August 25th.

The 79th meeting of the British Association was inaugurated at Winnipeg on August 25th by Sir J. J. Thomson's presidential address, of which an abstract was given in our issue of August 27th.

The President's address was given in a large new theatre in the city, and it seemed hard to believe that the site was open prairie only a few years ago. The theatre was packed with people and somewhat hot, but fortunately its acoustic properties were excellent, and the address was plainly audible in all parts of the hall.

The members of the Association appear to have been very favourably impressed by the broad and open streets, well lined with trees, and the clean and prosperous appearance of the town. The city presented a very busy appearance, as, in addition to the Association meeting, there was at the same time a medical convention and horticultural show.

Thursday, August 26th.

Section G.

The chief papers of electrical interest on Thursday were the presidential address to Section G by Sir William White, the address to Section A by Prof. Rutherford, and the description of the new scheme for the supply of electric power to the City of Winnipeg.

Sir William White's address was chiefly concerned with naval matters (and was given in abstract in our issue of August 27th). A vote of thanks was moved by Lord Strathcona, who referred to his first crossing of the Atlantic in 1838 in a sailing ship, taking 42 days over the voyage. He expressed a hope that all the members would be able to cross to the Pacific Coast and see the land which all Canadians looked upon as a great inheritance. He also hoped that before very long they would have 25-knot ships crossing the Atlantic to Montreal and performing the voyage in $4\frac{1}{2}$ days.

The description of the new electric power scheme was written by Mr. C. B. Smith, the engineer, but read in his absence by Mr. Chase. It was intended as a preliminary description of the plant which was to be visited by Section G on the following Saturday. This plant is being constructed by the Winnipeg city authorities, and will have to compete with the present supply given by the local company. As this supply is given at 60 cycles it was decided to use the same frequency in the municipal plant, although 25 cycles would have been better from the standpoint of the transmission line. The adoption of this frequency limited the voltage which could be employed to 66,000 volts at the generating end. If a lower frequency could have been used a higher voltage would probably have been adopted in view of the length of transmission (77 miles). Power is obtained from the falls on the Winnipeg river at Point Du Bois, where, by erecting a dam across the stream, a head of 45 ft. has been rendered available, and a storage lake eight miles long formed. This will give an ultimate capacity of 60,000 H.P., although at present only 20,000 is being installed. The generators will be of 3,000 k.v.a. each, driven by double runner turbines operating under 45 ft. head, at 164 revs.

per min. Two turbine driven and two motor driven exciters of 250 kw. capacity each will be installed. Generation is to be at 6,600 volts, stepped up to 66,000 volts by means of water-cooled oil-insulated transformers. The transmission line will consist of four three-phase aluminium circuits carried on two series of double circuit steel towers with concrete footings. Pin type insulators by the Locke Insulator Co. will be employed, made in four parts, including an inner shell entirely protected from the weather. These insulators have stood 120,000 volts under heavy rain.

On arrival in the city the power will enter a substation, where it will be stepped down to 11,000 volts, and distributed by underground cables to three or more substations, where it will be further reduced to 2,200 and 550 volts. The 2,200 volt current will be stepped down to 110 volts for house lighting by means of small transformers, according to the usual American practice.

The cost of the scheme based on the ultimate capacity is expected to work out at £12 per horse-power for the power station and equipment, including the cost of building a railway 24 miles long to the power house site, and a further £3 per horse power for the transmission line.

A short discussion took place, chiefly centring on the choice of 60 cycles as the frequency and on the cost of the scheme. The general feeling appeared to be that, given a clear field, 25 cycles would have been a more suitable frequency, but that local conditions might in this case preclude its use. In answer to questions as to whether any trouble was expected from the formation of "frasile" ice, it was stated that they did not anticipate any hindrance from this cause as the water behind the intake was quiescent, and although it would freeze over on the surface no ice would form underneath, and that in fact the surface ice would be rather beneficial than otherwise. "Frasile" and anchor ice only formed where the water, before reaching the intake, was disturbed by the passage over rapids.

Section A.

Prof. Rutherford's address to Section A, as our readers already know (from the abstract given in our issue of August 27th), dealt chiefly with the atomic hypothesis and contained a comparison of the various estimates made of the mass of an atom by various methods of experiment, showing what a close agreement was now obtained in measurements made of this quantity.

The vote of thanks was moved by Sir. J. J. Thomson (who referred to the fact that Prof. Rutherford's share in this work had been carried out at McGill University), and was seconded by Dr. W. N. Shaw, who remarked that Prof. Rutherford, as a physicist, had been among the first to rescue the atom of matter from the chemists and give to it a physical as well as a chemical interpretation.

Friday, August 27th.

Section G.

Friday, in Section G, was confined entirely to Papers on civil engineering subjects, dealing chiefly with the question of transportation in Canada, which is, of course, a very important point. They comprised Papers on "Improvements in the Navigation of the St. Lawrence," by Lieut.-Col. W. P. Anderson; "The St. Lawrence River, the Great Imperial Highway of Canadian Transportation," by Major W. G. Stephens; "A Summary of the Georgian Bay Canal Report," given by the President, Sir W. W. White; "An Account of the Engineering Works of the Panama Canal," by Colonel Goethals. The latter Paper was exceedingly interesting to all interested in the progress of this undertaking.

On Friday evening the members of the Committee of the Section were entertained to dinner by the local engineers, when a number of cordial speeches were made on both sides, and when those who came from the Old Country had an opportunity of gaining some idea of the way in which this new one is developing.

Section A.

A short Paper was given by Dr. Reichenheim on "Anode Rays and their Spectra." For the halogen compounds of the alkaline metals Dr. Reichenheim obtained rays having a characteristic colour and spectrum which he had studied. Tubes were shown at the meeting containing lithium, sodium and strontium, giving red, yellow and blue respectively. He had measured the value of e/m and found that it had the value corresponding to the mass of the atom of the metal employed.

Prof. Rutherford read a short Paper on "The Action of Alpha Rays upon Glass." He pointed out that Prof. Joni had suggested the origin of the halos in mica as being radio-active, as they generally contained at their centre a small particle of radio-active matter. He himself had found that a small capillary tube containing radium emanation had been affected to a depth equal to the radius of action of the alpha rays, a reddish colour becoming apparent and the refractive index of the glass being changed.

Two Papers were read by Prof. McLellan, one written by himself and the other by Mr. V. E. Pound, dealing with the "Secondary Radiation produced in different Metals by the α rays from Polonium," and on "Some Phenomena connected with the Radiations from Polonium" respectively. They seemed to show that the radiating power of polonium depended greatly on the metal on which it was spread.

Monday, August 30th.

Section G.

The electrical Papers were all down for reading on the Monday morning, and as they had many points in common the discussion of them all was taken together. Previous to this, however, on the Saturday, an excursion had been made to the new hydro-electric plant at Point Du Bois, so that any further discussion on this scheme could take place on the Monday morning. The civil engineering work was found to be well under way, and an excellent idea was gained of the arrangement of the scheme. Reference has already been made to the electrical features.

The Papers read on the Monday consisted of one by Prof. Thornton and Mr. O. J. Williams on "The Distribution of Dielectric Stress in Three-phase Cables" (The Electrician, September 3rd); one by Prof. E. W. Marchant on "The Calculation of the Charging Currents in Three-core Cables" (The Electrician, September 3rd); and one by Mr. E. A. Watson on "Losses from High-tension Overhead Lines due to Brush Discharge" (The Electrician, September 3rd).

In the discussion, Prof. L. A. Herdt, of McGill University, and consulting engineer to the Winnipeg supply scheme, asked why the effect of the earth had not been taken into consideration in Prof. Marchant's formulæ. In an actual transmission line one also had to allow for the increase in capacity of the line due to the proximity of the poles, and for the capacity and leakage currents at the insulators. Blondel had given a formula which took these into account and which checked very well with figures obtained from the Shawinigan transmission to Montreal, and the Ontario Electrical Development Co.'s line to Toronto.

Prof. Marchant replied that he had not taken the effect of the earth into account as it was only small, but that the allowance could easily be made.

Prof. Herdt said that the total effect of all the causes he had mentioned was to increase the charging current by about 22 per cent. The problem was one on which some experiments might well be carried out.

Prof. Thornton asked whether Mr. Watson had observed any extra loss off the wire when exposed to strong sunlight, as he understood that sunlight had a great ionising effect and might produce considerable leakage. He would also refer to some experiments made by Elster and Geitel, which showed that when sunlight fell on pine trees the air in the neighbourhood became strongly electrified, and he would like to know whether any tests had been made on this point.

Mr. Watson replied that the effect of sunlight, so far as he had been able to observe it, was very small and for engineering purposes negligible. The effect of pine trees he had for

obvious reasons not been able to investigate, but it was doubtless of importance.

Prof. MARCHANT asked Mr. C. B. Smith whether aluminium stranded cables were to be used, and what they anticipated would be the effect of stranding on the critical voltage. Also what lightning arresters were to be used.

Mr. CHASE replied that 19-strand cables would be employed having strands 0·12 in. diameter. Aluminium cell arresters would be used.

Prof. HERDT remarked that the lightning arrester was a very important problem, and that much needed to be done before it was settled. He did not think that any arrester could protect a line from a direct stroke.

SECTION A.

The feature of to-day's meeting was the discussion on Positive Electricity, opened by Sir Joseph Thomson, of which a report is here given. There was a large attendance at the

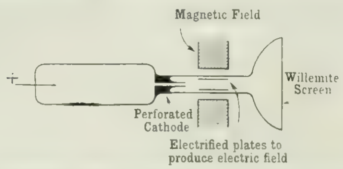


FIG. 1.—APPARATUS USED FOR MEASURING THE MASS OF THE CANAL *STRAHLEN*.

Section, including numerous distinguished visitors from both Germany and America.

In introducing the subject, Sir Joseph Thomson said that there were two fundamental questions requiring settlement; these were :—

1. Is there a definite unit of positive electricity?
2. If so, what is its size?

The first question is equivalent to asking whether from a pure gas it is possible to obtain a positively charged particle of smaller mass than the residue which is left when from a molecule of the gas a negative corpuscle is taken away. We know that we obtain the same negative unit from all gases. The question is whether the same holds for the positive one.

The study of positive particles has so far been chiefly concentrated on the phenomenon of canal *strahlen* and on the passage of positive ions through mixed gases.

The two types of canal *strahlen*, which have been chiefly studied, are those which are found behind a perforated cathode, and those which are projected from the cathode and move

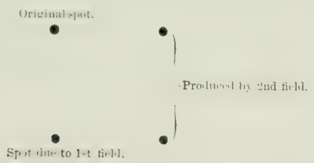


FIG. 2.

in the same direction as the cathode rays. This consists of a tube with a perforated cathode, as indicated in Fig. 1. The rays are allowed to fall on a fluorescent screen, coated with Willemite, where they produce a bright spot. Magnetic and electric fields are also arranged to deflect the rays.

A method of calculation was then given by which the deflecting effect of a magnetic field could be calculated. When the tube was working, but the deflecting magnet unexcited, a single bright spot was obtained on the screen. The effect of applying a magnetic field was not, however, to produce a simple shifting of the spot of light, as would be the case for cathode rays. The precise effect depended on the degree to which the tube was exhausted, but the general result was to spread the spot out into a ribbon of light which was often brightest at the end where the original spot was.

If the pressure is still further reduced, the ribbon becomes still fainter, and finally resolves itself into two spots, one displaced from the original position, the other quite undeflected.

The experiment was then tried of putting on a second magnetic field at right angles to the first. The effect then was to produce four spots of light, as shown in Fig. 2.

These spots lay at the four corners of a square. This seems to show that some of the uncharged particles which were undeflected by the first field have become charged during their passage between the first and second fields, and hence are deflected by the latter.

Moreover, the fact that all the particles which were deflected by the first field are not also deflected by the second shows that, in addition to the acquiring of charge by some particles other particles lose their charge during their progress. It would therefore seem probable that in canal *strahlen* we have uncharged particles which break up as they pass along and which have the same velocity after break up as they had before. It is suggested that canal *strahlen* consist of positively charged particles and neutral doublets, also that the positively charged particles during their flight may combine to form neutral doublets and that the neutral doublets may split up giving positively charged particles.

Particles were also found in the canal *strahlen* with a negative deflection and of a mass comparable to that of a positive particle. These give rise to a faint band of light on the screen, the brightness of which depends on the stage where we apply the magnetic force and also on the value of it. There is a certain value of the magnetic force at which the increase in brightness of the negative band is very rapid.

In the case mentioned where two magnetic fields at right angles are employed the brightest negative band is generally obtained from the original spot. The explanation of the negative band was believed to be due to uncharged doublets picking up negative corpuscles.

The speaker suggested that possibly the first stage in ionisation was not the production of positive particles but of neutral doublets.

The rays which moved forward from the cathode appeared to have approximately the same velocity as the backward moving canal *strahlen*. Experiments were made to measure the velocity of the canal *strahlen* when the electric force in the tube was made to vary as much as possible by using high or low vacua. Simultaneous measurements were made of the velocities of the cathode rays and of the canal *strahlen*, and it was found that although the velocity of the cathode rays varied in the ratio of 1 to 4 owing to the change in pressure, that of the canal *strahlen* was quite unaffected, which would support the neutral doublet hypothesis.

Measurements of the value of e/m were made for hydrogen, oxygen, neon, helium, sulphur dioxide, carbon tetrachloride, methyl iodide, and, in order to investigate the behaviour of a radio-active gas, the vapour of uranium chloride also. The values of e/m obtained from all these gases were exactly the same, provided the gas pressure was sufficiently low. The velocity obtained was about 2×10^8 cm./sec. It can be shown theoretically that this is the least velocity at which free charged particles can exist. If the velocity were less than this they would recombine.

The speaker had not obtained any particles moving at a faster rate than this figure. As a consequence of these experiments he would suggest that there was a positive particle independent of the gas from which it was derived, and that the first stage in the production of the particle was the formation of a neutral doublet.

The subject of the positive unit had lately been attacked by Wellisch, who had studied the motion of the positive ions produced by Röntgen rays on a mixture of dense gases. The ionisation by Röntgen rays of a dense gas such as methyl iodide or carbon tetrachloride is so great that if a mixture of these gases with, say, hydrogen is taken, even if it only contains 1 per cent. of the former, the whole of the ionisation produced is due to the methyl iodide.

Wellisch measured the velocity with which the positive ions

move through the mixture at ordinary atmospheric pressure. The speed of this motion in the residue left when a molecule of methyl iodide loses a negative corpuscle can be calculated. As the molecule is large this speed will be comparatively small. Actual measurement, however, shows that the velocity is the same as if no methyl iodide were present at all, the theoretical velocity being one-tenth of the observed.

If it is attempted to explain this on the assumpton that the charge is transferred from a methyl iodide to a hydrogen molecule, it must not be forgotten that this transference from a large body to a small one would involve an increase of the potential energy of the system, and would be therefore impossible.

The speaker further pointed out that if the intermediate neutral doublet stage existed the number of ions produced might be less than the number of doublets, which would have a bearing on the small number of ions produced by Röntgen rays in comparison with the number of molecules struck.

The maximum value of e/m which Wellisch had obtained was 10^4.

Some observers had found positively charged rays which were easily deflected by a magnet, and from which they had concluded that the value of e/m was higher than 10^4. He would point out in the first place that unless the magnet were carefully shielded it might quite alter the conditions in the tube. However, even if precautions were taken against this source of error there still remained effects which could not be thus explained, but it must be remembered that the deflection depended not only on the value of e/m but on that of the velocity, and if the velocity were small they could be easily deflected.

The small deflection of the canal *strahlen* was due both to the smallness of e/m and the largeness of their velocity. The slow moving easily deflected positive rays were probably secondary rays.

A reference was made to the magneto cathodic rays discovered by Bayard and Righi.

These are observed from a perforated cathode in a magnetic field. They consist of two rays lying along the magnetic lines of force, and which can be shown to be cathode rays moving very slowly and wound up into spirals along the lines of force. By adjusting the magnetic field these could be caused to open out. They could be collected and passed through a galvanometer, dispelling all doubt as to their polarity.

There were also two sets of rays moving at right angles to the magnetic field, and possessed of a very great curvature. One of these carried positive, the other negative charges, and they appeared to be slow moving secondary radiations.

The speaker was inclined to think that there might be smaller + particles given off from radio-active bodies, but they had not so far been detected.

Prof. Rutherford pointed out how necessary was a knowledge of the nature of positive electricity, and how important was the present discussion.

Dr. Goldstein, the discoverer of canal rays, expressed his satisfaction that his work in that direction had been of some use.

Dr. Reichenheim said that Prof. Dieselhorst and himself in carrying out some experiments on magneto cathodic rays had obtained results agreeing with those given by Sir Joseph Thomson, and had found that they consisted of negative electrons moving in spirals around the lines of magnetic force. Some part of the negative particles found in the canal rays appeared to be not negative ions but electrons, which dissociate out of the neutral canal rays after the positive charges had been deflected by a magnetic field.

Prof. G. T. Hull stated that experiments which he began in the Cavendish laboratory four years ago were in accord with the results reported by Sir Joseph Thomson. In these experiments the canal streams in tubes containing hydrogen or helium were observed. The electrical deflections of the luminous streams in the helium filled tubes were approximately the same as those in the tubes filled with hydrogen. Moreover some of the deflected luminosity appeared to be due to particles which acquired their positive electrical charge from 6 cm. to 10 cm. behind the cathode. This development of the positive charge on a particle along the line of the canal stream might be due to the breaking up of a neutral doublet, which had come through, or from the cathode.

Prof. Rutherford asked whether the fact that the value of $e/m = 10^4$ for a + particle was the same as that for the hydrogen atom could be taken as showing that these were identical. He also expressed interest in the factors governing the break up of the neutral doublets.

Sir Joseph Thomson said that he had no direct proof of the correspondence of the H atoms and the + particles. He had tried to collect these particles by obtaining a film which was transparent to them, but had not so far been successful. The break up of the doublets depended greatly on the pressure of the gas, and by altering the pressure the relative brightness of the spots could be varied.

Prof. R. A. Milligan said that he should like to ask Sir Joseph Thomson whether he had any notion as to whether his neutral doublets ever had a penetrating power which enabled them to get outside the tube. He asked the question because some experiments on the polarisation of the primary X-ray beam, which had just been finished at the Ryerson laboratory, seemed to show that the primary X-ray beam consisted of two parts, one of which showed considerable polarisation—*i.e.*, had a maximum intensity in a plane passing through the target at right angles to the line of force of the cathode beam, and fell off symmetrically on either side of this plane, while the other part was completely unpolarised—*i.e.*, had equal intensities in all directions. What might be the nature of these unpolarised rays they as yet had no notion. He wondered whether Sir Joseph Thomson might see any reason for identifying them with the neutral doublets.

Sir Joseph Thomson replied that he found no evidence thus far, that the neutral doublets had a penetrating power greater than that of the canal rays.

The next Paper of electrical interest was by Prof. A. W. Porter on "Electric Splashes on Photographic Plates," and comprised a number of very pretty effects produced by suddenly charging a metal point in contact with a photographic plate. The effect was tried of varying the gas surrounding the plate, and also of reducing its pressure. The appearance varied greatly with these factors. For example, in air at ordinary pressure it had a fan-like radial structure, while in coal gas it had a branching appearance. If the air pressure was reduced the structure changed, and central rays developed in the fans, broad at their base and tapering outwards to a sharp point. The explanation of these phenomena is at present obscure.

Another Paper of electrical interest was :—

RECOMBINATION OF IONS IN AIR AT DIFFERENT TEMPERATURES.

BY P. PHILLIPS.

Langevin has shown that McClung's original experiments on this subject were quite spoiled by diffusion owing to the electrodes being too near together, and to the intense ionisation which existed at the surface of the electrodes. L. L. Hendren has shown experimentally that diffusion is almost negligible at the temperature of the laboratory and at atmospheric pressure if the distance between parallel electrodes is at least 2 cm. and the ionisation is uniform between them.

In the present experiment Langevin's method of finding the recombination is adopted. The rays produced by a single discharge in a Röntgen bulb ionise a layer of air between two parallel electrodes, one of which is connected with a Dolezalek electrometer and the other raised to a definite potential.

The parallel electrodes are about 3 cm. apart, and the layer of ionised air about 1·5 cm. thick, thus leaving spaces of about 0·75 cm. between the surfaces of the ionised layer and the electrodes.

Under the circumstances, it is probable that diffusion may be safely neglected, but, in any case, more rapid diffusion would here make the recombination appear slower.

The electrodes are surrounded by a jacket, through which vapours from liquids boiling at known temperatures may be circulated.

In essence, the experiment consists in measuring the charges received by the electrometer when different fields are established between the electrodes. This is done first at the temperature of the laboratory and then at the temperature of the boiling liquid. From a comparison of the two series of readings the ratio of the coefficients of recombination at

*(Abstract.

the two temperatures may be calculated, the coefficient at the temperature of the laboratory being taken as unity.

The following results have been obtained up to the present, and they show that a decreases somewhat rapidly with a rise of temperature :—

Temperature.	a	Mr. Erikson's values.
15° C.	1·00	1·00
100° C.	0·50	0·51
155° C.	0·40	0·405
178° C.	0·36	0·38*

* (By extrapolation.)

Since completing the above experiments Mr. Erikson has published a Paper on the same subject. Using ionisation from radium, and with an entirely different method, he gets almost identical results which are given in the third column.

These figures differ from McClung's results in that they show a decrease in the value of a with increasing temperature, whereas McClung obtained an increasing value.

The reports on "Experiments for Improving the Construction of Practical Standards for Electrical Measurements" and "Magnetic Observations at Falmouth Observatory" were presented. The former is reproduced in part elsewhere in this issue, and the latter is given below :—

MAGNETIC OBSERVATIONS AT FALMOUTH OBSERVATORY.*

The results of the magnetic observations at Falmouth Observatory for 1908 have been published in the annual report of the National Physical Laboratory, as well as in that of the Royal Cornwall Polytechnic Society. The mean values of the magnetic elements for 1908 were :—

Declination	17° 54′·7 W.
Inclination	66° 31′·4 N.
Horizontal force	0·18798 C.G.S.
Vertical force	0·43279 C.G.S.

The accuracy of the work seems to be satisfactorily maintained.

Throughout the year Mr. Kitto has been regularly contributing particulars of the daily magnetic condition as regards disturbance to the international tables which are at present prepared at De Bilt, Holland. Dr. Chree has recently been engaged on a comparison of the magnetic disturbances recorded at the winter quarters of the National Antarctic Expedition of 1902-4 with those recorded simultaneously elsewhere, and has found the Falmouth curves very useful for the purpose. It is found that for purposes of inter-comparison, disturbances of comparatively small size, when of short duration, are in many respects simpler to deal with than the larger disturbances during which rapid oscillatory movements take place. But in handling the smaller disturbances, and in settling the exact times of their occurrence, it is of special importance to have curves whose edges are sharp and which are not blurred and indistinct through the disturbing effect of electric trams. Thus the undisturbed position of Falmouth proved of very material assistance. The comparison of magnetic disturbances is a subject to which increased attention is being given, as evidenced, for instance, by Prof. Birkeland's recent important work on the subject.

The committee learn that the progress of the magnetic work at Eskdalemuir has been further delayed owing to trouble with the underground chamber and the magnetographs, so that no opportunity has yet arisen for comparing the regular diurnal inequalities of the magnetic elements obtained at that station with those obtained in the south of England. For such a comparison records from Falmouth are likely to be of especial importance.

Tuesday, August 31st.

SECTION A.

The two following Papers, which we give in abstract, were read :—

EFFECT OF TEMPERATURE VARIATIONS ON THE LUMINOUS DISCHARGE IN GASES AT LOW PRESSURES.

BY ROBT. F. EARHART.

The apparatus used in this investigation consisted of a small glass bulb in which two parallel electrodes were sealed. These electrodes were 5 mm. apart. Suitable tubes permitted the bulb to be evacuated, the pressures being measured with a Macleod gauge. The bulb was contained in an electric furnace which could also be used as a container for carbon dioxide snow, when measurements for discharges occurring at low temperatures were taken. Potentials required to produce a luminous discharge for pressures varying from −78°C. to 325°C. The gases operated upon were air, hydrogen and carbon dioxide.

Potentials required to maintain the luminous discharge under similar conditions were also measured. Families of curves showing the effects of temperature and pressure for potentials required both to produce and to maintain luminous discharge are given.

They indicate that Paschen's law holds approximately for the discharge in air, until temperatures in the neighbourhood of 300°C. are attained. Here Paschen's law does not hold even approximately. The effect of temperature variation on the potential required to maintain the discharge is much less than for the production of the initial discharge.

* Report of the committee, consisting of Sir W. H. Preece (*Chairman*), Dr. R. T. Glazebrook (*Secretary*), Prof. W. G. Adams, Dr. Chree, Capt. Creak, Mr. W. L. Fox, Sir A. W. Rücker and Prof. Schuster.

SOME PROPERTIES OF LIGHT OF VERY SHORT WAVE LENGTHS.

BY PROF. THEODORE LYMAN.

This Paper contains an account of experiments made on the properties of light of wave-lengths of the order of 1,500 Angstrom Units. An attempt was made to obtain a substance more transparent than fluorite to these waves, but the results obtained were negative.

Light of such short wave-lengths is very easily absorbed ; in fact the millimetre of air at atmospheric pressure is quite sufficient to absorb most of the light of shorter wave-length than 1,700. Most of the absorption appears to be due to the oxygen of the air which has a strong absorption band extending from λ 1,800 to λ 1,300.

Hydrogen, argon and helium when examined in short columns all prove perfectly transparent while the absorption produced by nitrogen is extremely slight. Carbon monoxide and dioxide, however, each possess absorption spectra characterised by narrow bands.

The behaviour of oxygen appears to be important in connection with the production of ozone under the influence of light of very short wave-length.

Accounts are described in the Paper of an experimental investigation of the screening effect of a layer of air or other gas, on a plate of zinc exposed to rays of short wave-length.

A discharge tube had one end closed by a fluorite window. Outside this window was arranged a "screen chamber" which could be filled with gas under different conditions. This chamber was also closed by another fluorite window, and outside of this was a "condenser chamber" containing a zinc plate 9 mm. diameter which could be connected to an electroscope. The light from the discharge tube was arranged to fall on the zinc plate.

If the zinc plate was negatively charged and the screen chamber contained air at atmospheric pressure the rate of collapse of the gold leaves was only slow. If, however, the screen chamber was exhausted the collapse was almost instantaneous.

It is found that a layer of air 1 cm. thick at atmospheric pressure absorbs all rays shorter than $\lambda = 1{,}750$ very strongly, while at 1 mm. pressure it shows little absorption until $\lambda = 1{,}300$ is reached. Generally it may be said that the photo-chemical effects, such as the production of ozone, and the photo-electric effects such as the ionisation which is produced when the radiation falls on a zinc plate, increase as the Schumann region of most refrangibility is approached.

ELECTROCHEMISTRY AT THE BRITISH ASSOCIATION.

The subject of electrochemistry was not prominent at the recent meeting of the British Association. The chief papers of interest from this point of view were two by Dr. Fox and one by Dr. Lowry ; these are abstracted below, except the paper by Dr. Fox on "Mercurous Sulphate for Standard Cells," which appeared in our issue of September 3rd. The most important communication, however, was the report of the Committee on Electro-analysis, which we reproduce in full.

"*On the Constancy of the Hydrogen Gas Electrode*," by C. J. J. Fox.—The author has investigated the constancy of the hydrogen gas electrode in sulphuric and hydrochloric acids when gold, platinum and palladium coated with platinum black, and also with palladium black, are employed. Palladium when coated with palladium black gives both in 0·1 normal sulphuric and 0·1 normal hydrochloric acid a value which is from 4 to 5 millivolts too high, which is permanent even when the hydrogen is caused to pass for hours over the electrode. But gold and platinum coated with platinum or with palladium black give in a few minutes concordant values among themselves when immersed in 0·1 normal hydrochloric and 0·1 normal sulphuric acid. The electrodes need not be of platinum foil, as it was found that pieces of gold or platinum wire were quite as satisfactory. It has usually been thought that the hydrogen gas electrode in 0·1 normal hydrochloric acid is not so constant as in 0·1 normal sulphuric acid ; but this does not seem to be the case—at all events, if precautions against the possible presence of arsenic are taken. From Bredig's work it would appear that the smallest trace of arsenic would "poison" the platinum or palladium black. It is not possible to get a good coating of platinum black on a very pure specimen of platinum foil if the platinum chloride be very pure. A trace of lead acetate is usually added to the solution therefore, and it is necessary to remove every trace of this from the electrode after coating, or good values will be unobtainable. Heating in a solution of oxalic acid and then in nitric acid removes all the lead quite satisfactorily.

"*New Method of Producing a Cadmium Arc*," by T. M. Lowry.—In order to produce a cadmium spectrum of sufficient intensity for polarimetric work advantage is taken of the favourable properties of the silver-cadmium alloys. An alloy with 60 per cent. of cadmium melts at as high as 700 deg. In striking contrast to the behaviour of

the pure metal, the alloy gives a steady arc, which can be kept centred by rotating the electrodes in opposite directions. The spectrum shows the silver as well as the cadmium lines, but these are so far separated that even with a low resolving power the slit of a spectroscope can be opened to its full width without any overlapping of the brilliant "blocks" of light which take the place of the usual lines.

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON ELECTRO-ANALYSIS.*

During the year experiments have been carried out upon a new design of potentiometer, on the general simplification of apparatus and method for the electro-deposition of metals, particularly by means of graded potential; and in connection with the electro-deposition of mercury upon gold, silver, platinum, and mercury cathodes.

In connection† with the latter part of the subject it has been found when mercury is deposited on a gold electrode, that the results are invariably from 0·5 to 2·0 per cent. too high; the same applies also to electrodes of silver. The gold electrode employed was in the form of a flag, and had a total active surface of 0·5 square decimetre. As pure gold was found too soft for working purposes, an alloy containing 5 per cent. of platinum was used. Specially purified mercuric chloride, bromide, and sulphate were employed, but the results obtained were always too high. When a platinum gauze electrode was placed in series with the gold electrode and an identical solution employed, as a rule the metal deposited on the platinum was almost theoretically correct, although at times it was fractionally low. In order to get more rapid deposition the gold electrode was placed in the field of a very powerful electromagnet, but even though the time of deposition was reduced by one-tenth the results were still too high.

The silver cathodes consisted of coils of pure silver within which a platinum anode was rotated, but although the whole of the metal was frequently deposited in 45 minutes, the results were almost always too high. The exact cause of the high results obtained was not ascertained, although it was at first supposed to be due to occluded hydrogen; this was practically proved not to be the case. It was finally shown that the only really satisfactory method for depositing mercury was to use a cathode of mercury. A new electrolysing vessel of quartz was designed for this purpose. This apparatus is a small quartz beaker capable of holding about 80 cc. of solution, and has a syphon fused into it about 0·5 cm. from the bottom. Mercury is placed in the vessel so as to just reach to the bottom of the syphon, and electrical contact is made with it by fusing a piece of iridium wire into the bottom of the beaker. The solution to be electrolysed is placed above the mercury and the spiral anode rapidly rotated (500-750 turns per minute). The mercury can be completely deposited out in from 20 minutes to half an hour. The solution is then syphoned off by pouring in water which causes the syphon to act. The pouring in of water is continued until the ammeter shows zero. The whole of the waste water is then allowed to flow away and is replaced by 90 per cent. alcohol, then by absolute alcohol, and finally by two washings of dry ether. The surface is then dried by blowing dry air over it for about 10 minutes.

A very considerable amount of work has been done to make the apparatus described by Dr. Sand ("Trans." Chem. Soc. 91, 373 (1907) and 93, 1572 (1908)) more portable and readily set up without sacrificing any of its essential features. The stand has been made completely portable by providing it with a special cap which hinders the mercury forming the connection between the stationary and moving parts from being spilt during transport. A special clutch has also been designed which allows the moving parts to be readily thrown in and out of gear with the motor without stopping the latter. Such an arrangement becomes necessary when it is desired to actuate several sets of apparatus from a single shaft driven by one motor, or when a small motor-generator is employed for the double purpose of supplying the current and rotating the electrode, or lastly, when a water or hot-air motor is employed which cannot be stopped instantly while the electrodes are in a wet state. All the apparatus for measuring the potential of the cathode has been assembled in a single portable potentiometer-box, which is also arranged to show the P.D. between the anode and the cathode. For this purpose it became necessary to design a special new form of portable capillary electrometer. A full description of all the apparatus referred to will be published shortly. It was exhibited to Section 1 of the International Congress of Applied Chemistry.

Experiments are also in progress with anodes made partly of glass and partly of platinum, and with cathodes of metals other than platinum.

A very careful study has also been made of the composition of the deposit of lead peroxide obtained during the analysis of lead solutions. Results differing by more than 1 per cent. have been found in the laboratories of Hollard. (Analyse des Métaux (190) and Classen. Quantitative Analyse durch Elektrolyse. 5th edition. 1908. p. 125.) It has now been found that in a moist atmosphere lead peroxide will take up water at a temperature of about 200 deg., but will lose it exceedingly slowly at this temperature in a perfectly dry atmosphere. These facts are quite sufficient to explain the discrepancies observed. On the other hand, it has been found that lead peroxide deposited with a suitable current density at about 90-95 deg. contains only about ½ per cent. of water after drying with alcohol and ether. It is here desiccated as a result of electric endosmose, and this method of depositing is recommended as by far the most trustworthy and simple. These results will also be published shortly.

* This report was issued at Winnipeg. The committee consists of Prof. F. S. Kipping (*Chairman*), Dr. F. M. Perkin (*Secretary*), Dr. G. T. Beilby, Dr. T. M. Lowry, Prof. W. J. Pope, and Dr. H. J. S. Sand.

† F. M. Perkin, "Trans.," Faraday Society.

CORRESPONDENCE.

OPERATION OF ALTERNATORS IN PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Mr. Joseph W. Anson's interesting article on the above subject, contained in your issue of this week, there are one or two points which would appear to require some further elucidation.

Mr. Anson speaks of the evil effects of increasing the generator speed by "two or three revolutions" (presumably per minute). It would hardly seem that such a small increase as this could have any very marked effect on the working of the valve gear.

When dealing with the troubles accompanying low-power factors, Mr. Anson speaks of the system having a power factor of 0·6 or 0·65, while the power factor indicators on the generators only showed 0·9 or 0·92. I cannot see what possible combination of circumstances could produce so paradoxical a result. Of course, it is quite possible that the power factor shown by the instrument on any one generator might be quite different from that of the system, owing to the excitation of that machine being incorrectly adjusted, but if the power factors shown by all the generators are sensibly the same this power factor must be that of the system.

It is not quite clear, I think, what Mr. Anson means when he says that the cause of this "false power factor" will at once be clear when it is noticed "that the plant is running under false conditions, probably 5 per cent. too fast and with a very light field current." It is obviously impossible for any individual generator to be running 5 per cent. faster than the others and yet keep in step with them, and, on the other hand, no general increase of speed could effect the power factor of the station.

Possibly I have misunderstood Mr. Anson on these points.—I am, &c.,

Hendon, N.W., Sept. 11. KENELM EDGCUMBE.

We have submitted the above letter to Mr. Anson, from whom we have received the following reply:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Kenelm Edgcumbe's letter, I have to state that an increase in speed of two or three revolutions per minute undoubtedly makes a great difference to the steadiness and quietness in the running of large reciprocating engines of the type mentioned in my article. The wear on small valve gear parts, such as knife edges, dashpot springs, &c., increases quite out of proportion as the speed, at which the valve gear works, is increased above the normal.

In my remarks about power factor under the heading "Generators running on load with a false power factor," I would ask Mr. Edgcumbe to note that the whole of that statement refers to one engine-driven alternator supplying the night load on a system by itself, and without any other machines in parallel with it; and in no place in that paragraph have I referred to either the engine, generator, or meters in

the plural sense, whereas Mr. Edgcumbe in his letter has turned the actual statements contained in that part of the article into the plural.

The portion of Mr. Edgcumbe's letter which states that "the power factor shown by the instrument, on any one generator, might be quite different from that of the system," is simply a corroboration of the subject matter contained in that part of my article.

I must, however, quite disagree with his statement at the end of the third paragraph that "if the power factors shown by all the generators are sensibly the same, this power factor must be that of the system." This point does not follow at all, for it is quite possible to have three or four generators running in parallel with the same power factor, and yet that power factor need not necessarily be the true power factor of the system, for if the three or four machines are all running over speed, and the field is light, the power factor shown by all the power factor meters would be higher than the true power factor of the system, although the line voltage may be perfectly correct.

Again, in the last paragraph, referring to my remarks about the speed of the engine running on night load by itself, probably 5 per cent. too fast, Mr. Edgcumbe at once states that it is impossible for an individual generator to be running 5 per cent. faster than the others. I would again ask Mr. Edgcumbe to note that, in that portion of my article, I referred to one generator only, and presumably Mr. Edgcumbe will grant that it is quite in order to run an engine either faster or slower when the alternator, which is driven by that engine, is on load by itself. I am, of course, aware that it is not customary to run an alternator 5 per cent. higher in speed, in parallel with another alternator or alternators, having the same number of poles.

The words at the latter end of Mr. Edgcumbe's letter also require attention. He states that "no general increase of speed could affect the power factor of the station." I maintain that if the speed of all the running plants be increased, in order to maintain the correct line voltage at the station, it will be necessary to reduce the field, preferably a little on all the machines running, and, of course, the effect of this decrease in field current will be to raise the power factor on all machines, thus showing that the power factor of a station can be affected by alterations in the speed, above or below the normal for which the engines and generators are designed.—I am, &c.,

Greenwich, S.E., Sept. 14. JOSEPH W. ANSON.

ANTENNÆ.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to the fact that in your issue of July 23, 1909, there is contained an article by Mr. Pickard entitled "Antennæ," in which, amongst other things, he says in effect that the Stone wireless direction finder is limited in its application to the use of wave lengths equal to twice the distance between the antennæ, which limitation renders it commercially impracticable. This statement is wholly uncalled for in view of the fact that a very simple consideration of the devices published in my patents shows that the apparatus is not limited to any particular wave length and distance between the masts. This relation between the wave length and the distance between the masts was merely used in the descriptive portion of my specifications to facilitate the explanation of the operation of the device and to show that in the special case in which the wave length happens to be one half the distance between the masts, the operation of the direction-finder is exceptional.

Mr. Pickard in his Paper further makes a comparison between the precision with which the bearings of a distant station may be obtained by the use of my direction-finder and the precision with which such bearings may be determined by what he styles his unearthed loop, and he alleges that a greater precision is obtainable with his form of loop. I can authoritatively say that Mr. Pickard has never witnessed any official or other tests of my direction-finder, and that the errors which he attributes to it are greatly in excess of any that have been reported to me by those who have conducted both the official and unofficial tests of my direction-finder. Further, I wish to point out that what Mr. Pickard styles his unearthed loop is broadly covered by my patents, there being no invention, because there is no advantage, in removing the earth connection from the loop shown in my patent. In the latter connection I would say that my assistants have repeatedly reported to me that the removal of the earth connection which converts one of the forms of my direction-finder into what Mr. Pickard styles his unearthed loop markedly diminishes the efficiency of the system by diminishing the intensity of the received signals.—I am, &c.,

Boston, U.S.A., Sept. 2. JOHN STONE STONE.

COMMUTATION-POLE TRACTION MOTORS.

One of the latest novelties in electric traction has been the introduction of motors fitted with special commutation poles. For many years after the design of standard railway motors was worked out, it was considered that a final form had been arrived at on which any substantial improvement was a practical impossibility. It is true that the motor was by no means sparkless under certain conditions, but it was generally considered that the amount of sparking experienced in actual practice was unimportant and that any measures that could be taken to overcome the trouble would be worse than the disease.

Quite recently, however, large railway motors have been designed both for standard voltages and also for high voltages in which it was considered advisable to make special provision against sparking by

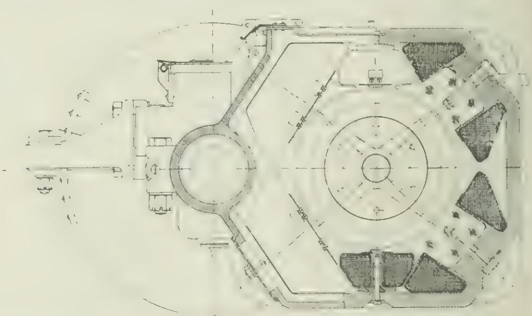


FIG. 1.—DIAGRAM SHOWING GENERAL ARRANGEMENT OF COMMUTATION POLE TRACTION MOTOR.

the introduction of commutation poles. The results obtained with these motors were found to be so satisfactory that it was considered worth while to apply the experience so gained to the construction of tramcar equipments. In this way a complete line of motors of this type has been evolved for outputs ranging from 22½ H.P. up to 150 H.P., and even larger units have been designed with outputs up to 250 H.P. For the smaller motors a special design has been worked out (the patent rights for which are held in this country by Messrs. Siemens Bros. Dynamo Works) by means of which the introduction of commutation poles causes very little extra expense and very little increase on the overall dimensions of the motors. The special feature of this design will be referred to subsequently.

The most obvious benefit gained by the use of commutation-pole motors is freedom from sparking and the consequent decrease in the cost of maintenance due to this cause. This property is especially valuable in cases where there are steep gradients. It is only necessary to state that the motors fitted with commutation poles will run without the slightest sign of sparking at any output up to 50 per cent. overload, for the importance of this advantage to be fully realised.

This, however, is by no means the only advantage, and in many cases it is not the most important. Traction motors of the ordinary type without commutation poles are naturally sensitive to sparking and for this reason the early attempts at some degree of control by varying the strength of the field in relation to the armature current were practically abandoned. As soon, however, as motors were introduced in which there was no fear of sparking, even when 50 per cent. of the field current was shunted, the objections urged

against this method of control were no longer valid. Messrs. Siemens Bros. Dynamo Works are now putting on the market a controller in which provision is made for shunting the field windings in varying degrees as may be suitable for any particular case, such, for example, as 25 and 50 per cent. In this way a controller is arrived at in which instead of there being as usual two economical running positions, namely, full series and full parallel, there are at least five, for example—

1. Full series, full field.
2. Full series, field shunted 50 per cent.
3. Full parallel, full field.
4. Full parallel, field shunted 25 per cent.
5. Full parallel, field shunted 50 per cent.

This system of control offers two important advantages, namely:—

(*a*) The driver has a more complete control over his car, having the choice of five different speeds under any given conditions.

(*b*) A considerable economy in consumption of energy is made possible.

In order to illustrate these advantages, the curves shown in Fig. 2 have been prepared. These curves relate to a 10-ton tramcar, equipped with two 38 H.P. commutation-pole motors. Two sets of performance curves for these motors are given, one for the motor geared with a reduction of 97 : 19 and the other with a reduction of 100 : 16, the diameter of the driving wheels in each case being 31½ in. In the first case the speed and pull curves are given for the full parallel position of the controller; in the second case speed and pull curves are given for the five running positions of the controller. With these two sets of curves a sample run has been worked out as shown in the diagrams, in accordance with the following particulars :—

Tractive resistance assumed to be constant, 20 lb. per ton.
Number of stops per mile, 8.
Average speed, including 5 second stops, 10 miles per hour.
Maximum speed, about 16 miles per hour.

The energy consumption has been worked out with the following results :—

With fields not shunted, 1·19 kw.-hour per car-mile.
With fields shunted, 0·96 kw.-hour per car-mile.

In this particular case, therefore, the change of gearing and the different method of control makes possible a saving of about 20 per cent. in the energy consumption.

This may possibly be regarded as an extreme case ; but the matter may be put in another way. The energy imparted to the car between standstill and the time when it reaches a speed of 12 miles per hour is in the one case 82 watt-hours and in the other case 68 watt-hours, so that on the assumption that this is repeated at regular intervals of 45 seconds—that is, 80 times per hour—the energy saved per car during that hour is 1·12 kw.-hour. Thus, quite apart from the question of the energy absorbed by the brakes, which may vary according to per particular circumstances of the case, there is a clear saving of 10 the cent. of the energy consumption in imparting to the car a speed of 12 miles per hour.

The flexibility of the modified system of control by means of shunting the fields is clearly seen in reference to the remaining diagrams. These two diagrams show speed-time curves for the two

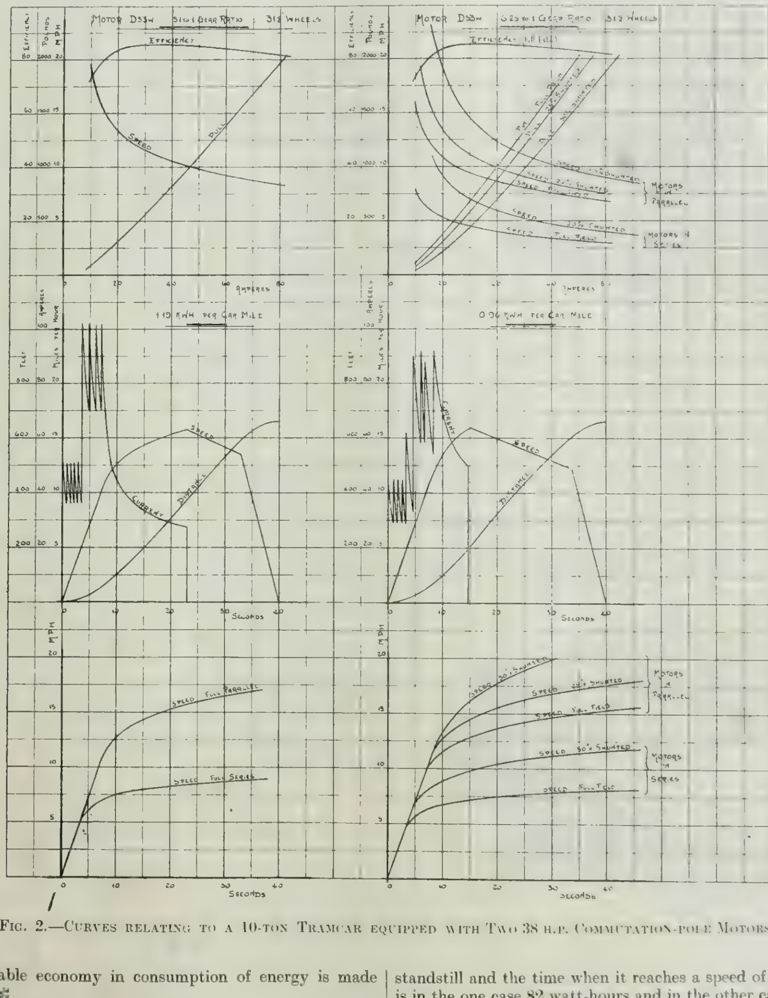


FIG. 2.—CURVES RELATING TO A 10-TON TRAMCAR EQUIPPED WITH TWO 38 H.P. COMMUTATION-POLE MOTORS.

cases. In the first case, there are only two speed-time curves, namely, that in which the motors are in full series and that in which the motors are in full parallel: in the second case, there are five speed curves corresponding to the five running positions of the controller. The comparison between the two sets of curves requires no explanation. The degrees of shunting assumed for the purpose of this calculation are not necessarily fixed but may be modified to suit each particular case for which the equipments are desired.

Referring now to the construction of the motor, the general features of the design worked out, especially for tramway motors, are shown in the general arrangement diagram, Fig. 1. In this figure it will be seen that there are the usual four main poles, and in addition two commutation poles, one between the main poles in the upper half of the motor and the other between the main poles in the lower half. In order to provide as much room as possible for these commutation poles and their windings, the main poles are given a special shape such that the magnet coils are not symmetrical about the centre lines of the poles, but are displaced sideways. The pole faces, however, are spaced symmetrically round the armature so that there is no interference with the proper distribution of the magnetic flux. The main field coils and the commutation coils are specially wound to such a shape as to fit into one another so that practically no extra space is required for the additional coils, as is the case with commutation pole motors by other makers.

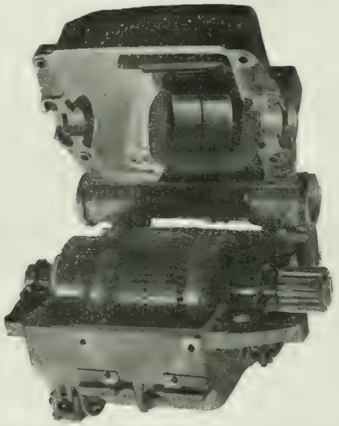


Fig. 3.—View showing Interior of Motor.

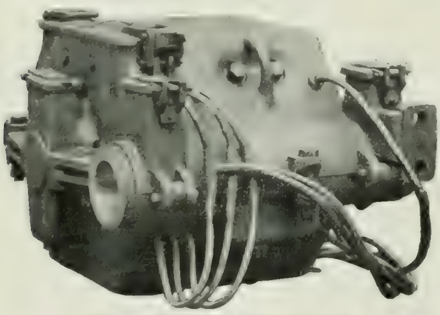


Fig. 4. Exterior View of Motor.

The general appearance of the motor will be seen from Figs. 3 and 4, in which are shown the exterior and the interior of the motor.

Ten motors of this type for an output of 38 H.P. have been supplied by Messrs. Siemens Bros. Dynamo Works to the Hull Corporation tramways. A number of motors of larger output (50 H.P. type D 58wa) have been supplied, or are now under construction at their Stafford Works for electric locomotives for the Harton Coal Co. in South Shields, for Brennan's experimental mono-rail car, and for the Adelaide Municipal Tramways Trust.

Messrs. Siemens Bros. Dynamo Works are making these motors in a number of sizes ranging from 25 H.P. to 145 H.P. on a one hour rating.

PARLIAMENTARY INTELLIGENCE.

NAVAL ELECTRICAL ENGINEERING CONTRACTS.

In the House of Commons on Tuesday, Mr. Renwick asked the First Lord of the Admiralty whether, in the case of contracts which had recently been placed for the electric light installations and searchlights in British warships now building, the contractors for such installations, &c., being British branches of German firms, it was made a condition of the contract that only British-made cables, machinery and fittings should be used, and only British subjects employed in the superintendence and fitting of same on board the vessels; and whether precautions had been taken to prevent the necessary plans of the ships supplied to the contractors being sent abroad or shown to foreigners.

In reply, Mr. McKenna said that in a contract of the kind referred to it was made a condition that only British-made cables, machinery and fittings should be used, and only British subjects employed in the superintendence and fitting of them on board the ships. With regard to the last part of the question, the following provision has been embodied in recent contracts:—"This contract involves an obligation of secrecy within the meaning of sec. 2 of the Official Secrets Act, 1889. The contractors shall at their own expense take all such measures and precautions to ensure secrecy in connection with the design, construction, equipment, and completion of the said vessel as may be necesaary, including therein all such measures and precautions as may be regarded as necessary by the Commissioners, and the contractors shall, if so required, at any time by the Commissioners afford to them such evidence as the Commissioners may consider satisfactory that all such measures and precautions have been, are being, and will be taken."

HOME OFFICE RULES FOR ELECTRICITY IN MINES.

In the House of Commons on Wednesday Mr. Markham asked the Secretary of State for the Home Department to say what was the definition of a "completely enclosed motor" in the Home Office rules relating to electricity in mines; and whether a flame-proof motor, not totally enclosed, was covered by the definition.

In reply, Mr. Gladstone said he was advised that the enclosure required by special rule 37 was total enclosure, and that, he understood, was the view generally taken in the industry. The case of a "flame-proof motor not totally enclosed" would not, therefore, be a compliance with the rule; but the point had been noticed for reference to the Committee on the rules which he was about to appoint.

Mr. Markham: Is the right hon. gentleman aware that a member of the Committee which drew up these rules stated that "completely enclosed" meant nothing to the mind of the Commissioners more than "totally enclosed"?

Mr. W. E. Harvey: In view of the loss of life which has occurred recently in mines, which is attributed to electricity, I wish to know if the Government are prepared to undertake some experiments with regard to electricity in mines.

Mr. Gladstone: As I have already stated, I am about to appoint a Committee, and it is extremely probable that Committee will extend its inquiries to this question.

Mr. Markham: In view of the second report of the Mines Royal Commission issued last week, recommending an immediate increase of inspectors, how many additional inspectors are to be appointed and how many of these would be men who had had a practical knowledge of working in the coal face?

Mr. Gladstone: The report and memoranda contained more than one proposal with regard to the creation of new classes of inspectors and a unanimous recommendation for the re-division of the country into districts. The recommendations were under consideration.

Telegraph Arbitration Bill.—This bill was read a second time in the House of Lords yesterday (Thursday).

LEGAL INTELLIGENCE.

Municipal Wiring in Aberdeen.

In the Aberdeen Sheriff Court on 8th inst. a petition for interdict was presented at the instance of the Electrical Contractors' Association against the Lord Provost, Magistrates and Town Council of Aberdeen for contravening sec. 25 of the Aberdeen Corporation Electricity Act, 1907. The Corporation have laid and are laying electric cables from the electric meters in the lodge at the City Hospital, Aberdeen, to the several buildings in connection with the hospital, and they have erected, wired and fitted, and are erecting, wiring and fitting electric lamps within the grounds of the hospital. The 1907 Act enables the Corporation to provide, let for hire, and fix, set up, alter, repair and remove, but not to manufacture lamps, meters, electric lines, fuses, switches, fittings, lampholders, motors and other apparatus, and things for lighting and motive power, and for all other purposes for which electric energy can or may be used, or which may otherwise be necessary or proper for the supply, distribution, consumption, or use of electrical energy, and may provide all materials and do all works necessary or proper in that behalf, and may require and take such remuneration in money or such rents and charges

for, and make such terms and conditions with respect to the letting, fixing, setting up, altering, repairing, or removing of such lamps, meters, electric lines, fuses, switches, fittings, lampholders, motors, and other apparatus and things as aforesaid. Provided (*a*) That it shall not be lawful for the Corporation to expend money (except through a contractor) upon the provision of the labour and materials required for the wiring for and fixing of electric light fittings upon the premises of their consumers, or prospective consumers, or upon the provision of lamps, fuses, switches, fittings, lampholders, and other apparatus and things for light purposes, but nothing in this sub-section shall prevent the Corporation completing the service line between their supply mains and their own apparatus upon the premises of any such consumer."

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The County Borough of Halifax Education committee require a lecturer in Electrical Engineering and Physics. Salary £180 per annum. Particulars and forms of application from the secretary, Mr. W. H. Ostler, Education Offices, Halifax, to whom applications should be sent by Tuesday, Sept. 28. See also an advertisement.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

A designer is wanted, with experience in the design of electric motors, also good college and workshop training. See advertisement.

A professor of chemistry is wanted for Patna College, Bihar, Bengal. Salary R500, rising to R1,000 per month. Particulars from the Secretary, Board of Education, Whitehall, London, S.W., to whom applications are to be sent.

Smethwick Education committee require a principal for their Technical School. Salary £250 rising to £350. Particulars from Mr. A. H. Sears, Council House, Victoria Park, Smethwick. Applications by Sept. 28.

Llandilo Council have appointed Mr. T. Bowen as resident electrical engineer.

Mr. W. T. Maccall, M.Sc., A.M.I.E.E., head of the electrical engineering department of Halifax Municipal Technical School, has been appointed head of the electrical engineering department of Sunderland Technical College. Mr. T. C. Joyce, B.Sc., is the assistant lecturer in the department.

Mr. W. B. Morgan, station superintendent at Avonbank, Bristol, has resigned in order to take up a position at Dawson City.

Mr. H. B. Saxby has been appointed electrical engineer to the Bombay, Baroda and Central India Railway Co., under a five years' agreement, at R600, rising to R800 per month.

EDUCATIONAL NOTICES.

University of London (University College).—The courses in mechanical, civil, municipal and electrical engineering begins on Monday Oct. 4. The College contains spacious electrical and mechanical engineering laboratories, workshops, drawing office, &c. Special and post-graduate courses on "Steam Turbines," "Recent Methods and Instruments in Surveying," and "On the Theory and Design of the Ideal Arch, Metal and Masonry" have been arranged. Further particulars may be obtained of the Secretary, Mr. Walter W. Seaton, University College, Gower-street, London, W.C.

Goldsmith's College (University of London).—The new session commences on Monday, 20th inst. Enrolling begins on 13th inst. There are complete courses of instruction in electrical, mechanical and constructional engineering. Students are also prepared for the B.Sc. in Engineering of the University of London, and for the examinations of the Institution of Civil Engineers, the Board of Education, and the City and Guilds of London Institute. The head of the Engineering Department is Mr. W. J. Lineham, B.Sc., M.I.C.E., M.I.E.E. Further particulars from the Warden of the College.

University of Bristol.—The session 1909-1910 commences on Oct. 1. There are full courses of instruction in the faculties of arts, science and engineering, and facilities are afforded for research and post-graduate work in all important branches of science and engineering. Prospectuses, &c., from the Registrar.

Merchant Venturers' Technical College.—The engineering departments of this college will, from the beginning of next session, include the faculty of engineering of the University of Bristol. The college has already special departments for electrical engineering (under Prof. Robertson) and motor car engineering (under Prof. Morgan), but the departments of civil, mechanical and mining engineering have hitherto been amalgamated, and they have been in charge of the vice-principal, Prof. Munro. The engineering staff will now be strengthened by the inclusion of those who have hitherto been engaged in teaching engineering at University College, Bristol, and a separate department of civil engineering will be inaugurated and placed in charge of Prof. Ferrier. Not only will this mean improved facilities for students in civil engineering, but it will also strengthen the departments of mechanical and mining engineering, which will remain in charge of Prof. Munro. As regards equipment, the Merchant Venturers' Technical College is already provided, in its new building, with the latest apparatus and machinery, and with laboratories and workshops constructed on the most modern principles. To this has lately been added the best of the machinery and apparatus formerly used in the engineering departments of University College. [A description of the new building appeared in THE ELECTRICIAN for July 30 and Aug. 6, 1909.]

We have received a copy of the calendar of this college for the 1909–10 session which gives full particulars of the courses of instruction, fees, &c. It is published at 6d.

University College of North Wales.—In the electrical engineering department of this college a systematic course of instruction is given in electrical measurement and practical electricity for students proposing to enter the profession of electrical engineer. The physics laboratory is well equipped. The course extends over two years. Prospectuses, &c., may be obtained from Mr. J. E. Lloyd, M.A., secretary and registrar.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Sir John Cass Technical Institute, London.—The new session commences on 23rd inst. There are classes in general physics and mathematics as a preparation for the final B.Sc. examination of London University, and special courses of general physics and electricity and magnetism for the honours B.Sc. on "Conduction in Gases" and "Radio-activity" and on the "Differential and Integral Calculus for Science Students." There are also evening classes in chemistry, metallurgy, physics and mathematics designed to meet the requirements of those engaged in the chemical, metallurgical and electrical industries, &c., and facilities are afforded for special and advanced practical work in well-equipped laboratories. Particulars from the Principal, Sir John Cass Institute, Jewry-street, E.C.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms.

The evening technical courses in all branches of electrical and mechanical engineering will commence on Monday, Sept. 27. The laboratories are well equipped for both alternate (single and polyphase) and continuous-current work, and for all kinds of electrical testing. Particulars as to fees, &c., can be obtained at the Institute or on application to the principal, Dr. R. Mullineux Walmsley.

Hackney Technical Institute, London.—The next session commences on Sept. 20. There are evening lecture and laboratory courses in electrical engineering, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses may be obtained from the Principal of the Institute, Dalston-lane, London, N.E.

Battersea Polytechnic (London).—In the engineering departments of this polytechnic there are day courses which prepare for the engineering degree, B.Sc. London, polytechnic diploma in mechanical, electrical and civil engineering. The entrance examination commences on Sept. 21. There are also evening classes which prepare for the B.Sc. in engineering, the associateship examination of the Institution of Civil Engineering all mechanical engineering subjects, electrical, structional and automobile engineering, telegraphy and telephony, architecture and building, &c. Prospectuses from the Secretary, Battersea Park-road, S.W.

Borough Polytechnic Institute.—Complete courses of instruction in electrical and mechanical engineering, chemistry, &c., are given at this Institute. The head of the electrotechnics department is Dr. John Henderson, and the course of instruction in electrical engineer-

ing is spread over four years. There are also special courses for electric wiring work, construction and design of electrical appliances and workshop fittings, and also in advanced electricity and magnetism. The next session commences on 27th inst. Further particulars and detailed syllabus of each course are given in the prospectus, which can be obtained from the principal, Mr. C. T. Millis, Borough-road, London, S.E.

Manchester Municipal School of Technology.—We have received a copy of the very complete calendar for the session 1909-10 of the Municipal School of Technology and Municipal School of Art, Manchester. The book, which consists of 534 pages, conveys a good idea of the excellent manner in which Lancashire industries are catered for at this up-to-date educational establishment, for there are carefully graduated courses of instruction in all branches of pure and applied science and technology, art, &c. There are day and evening classes, and facilities are granted for experimental and research work. The published price of the calendar is 6d., post free 10d. ; but an abridged calendar can also be obtained.

East London College.—We have received a copy of the calendar of this College for the session 1909-10. Particulars of the courses in engineering may be obtained from the Principal.

Daimler Works Scholarships.—The competition for this scholarship concluded on Sept. 3rd, when, as a result of a written and viva voce examination conducted by Dr. Hele Shaw and Prof. Morgan the following awards were made by the directors of the Daimler Motor Co.

Major scholarship, value £200 (£100 premium and £50 per annum for two years) to Harold Grinstead, B.Sc. (Hons.) of Horsham Grammar School and London University; Minor scholarships, value £140 approximately (£100 premium and about £20 per annum wages for two years) to Thos. Edw. Beacham, B.Sc. (Hons.), Bertram Rhodes, B.Sc., and Frank Edw. Salter. Information respecting the 1910 competition may be obtained on application to the pupils department, Daimler Motor Works, Coventry.

Accrington.—The recent electrical exhibition, organised by the Electricity department, was very successful as over 16,000 persons paid for admission, and it is anticipated that the result will be an increased demand for current for lighting, power and heating.

Amble.—The Council have decided to call in an electrical engineer to report upon their electricity supply scheme.

Australasia.—The "Australian Mining Standard" states that the Charlton (Victoria) Electric Lighting Co. is to be floated with a capital of £2,900.

Launceston (Tasmania) Council have decided to construct electric tramways, with car sheds at York Park, and a Tramway committee has been appointed. The city engineer and city electrical engineer are to visit Melbourne and Adelaide to inspect the tramways in those towns.

A successful experiment was made recently at Mr. C. E. Eldridge's Standard Quarries with electric fuses for blasting, in place of the fire fuses hitherto used.

Austria-Hungary.—The authorities of Holenfurt have arranged to construct an electric railway from Zartlesdorf to Lippnerschwebe. The cost is estimated at £125,000.

The communal authorities of Gloggnitz are arranging to erect electricity works. Power will be obtained from the Weissenbach waterfalls. The estimated expenditure is £11,000.

Bethnal Green (London).—A special meeting of the Council will be held on the 30th inst. to consider in committee the question of the supply of electricity in the borough.

Bexhill.—The L.G. Board have sanctioned a loan of £2,120 for condensing plant, cooling tower, &c., repayable in 21 years. The Council have applied for a further loan of £197 for small extensions of the public lighting system.

Buckfastleigh (Devon).—The Council have approached the owner of the local electricity works with a view to his supplying electricity for public lighting.

Burslem.—Owing to the standing orders, the Council have postponed until February consideration of the application of the electrical engineer (Mr. A. Bremner), for an increase of salary. The Electric Lighting committee will then recommend that an increase be granted to Mr. Bremner.

It is proposed to put down an additional Belliss-Siemens set at the electricity works.

Ceylon.—In order to carry out the recommendations of Mr. A. H. Preece (of Messrs. Preece & Cardew) it has been decided to replace the existing overhead method of construction of the Colombo telephone service by an underground system in the more congested portions of the service, and estimates for that purpose are in course of preparation. The cost is estimated at Rs.100,000. Mr. Preece's suggestion to construct telephone trunk lines between Colombo, Kandy and Nuwara Eliya is under consideration, and estimates have been prepared. The cost would amount to about Rs.220,000.

China.—The report of Consul P. F. Hausser for 1908 says the Swatow Electric Light Co., after a chequered career, finally collapsed, having lost more than 60 per cent. of its capital. It has been reconstructed with a capital of $140,000. New engines have been ordered from Europe. It is expected that the town will again be lighted electrically by July next. An electric tramway to the city of Cheng-Hai (10 miles distant) is projected. The prospectus puts the capital at $300,000, but (Mr. Hausser says) the shares are not being taken up readily.

Cowdenbeath (N.B.)—The Council have decided to oppose the proposed application of the Fife Electric Power Co. for a provisional electric lighting order for this district.

Customs Duties.—It has been decided that, under the New Zealand tariff, the import duty on medical transformers (consisting of transformer, coil, rheostat and switch) is 30 per cent. ad val. under the general tariff and 20 per cent. for British goods. Grove battery cells for educational purposes are admitted duty free.

Under the South African Customs Union tariff the duty on electric magnetos, or separate parts thereof, is 3 per cent. ad val. British goods are granted a 3 per cent. rebate, and are therefore duty free.

Darlington.—The Council have received sanction to a loan of £2,187 for a 500 kw. generating set.

Dundee.—Messrs. J. and A. D. Grimond (Ltd.) have commenced proceedings against the Town Council for the recovery of damages (estimated at £2,200), caused by the failure of the Corporation to give, in accordance with the terms of their contract, a supply of electrical energy for power to the firm. The Electricity committee, however, repudiate liability.

The damage done by the recent fire at the electricity station has been assessed at £1,588. 16s. 11d., exclusive of damage done to 23 transformers belonging to the British Thomson-Houston Co. The committee have agreed to sell four old boilers and two generating sets (which were scorched in the fire) to Messrs. William Kerr & Co. for £550.

Arrangements have been made for supplying electric current for lighting the Dudhope Museum building and also for working the models which have been installed. The wiring contract has been secured by Mr. T. C. Keay.

Edinburgh.—On Tuesday the Council decided (by 26 votes to 17) to adopt the recommendation of the Electric Lighting committee to apply the total surplus on the electric lighting department for the past year (£2,182) to relief of rates.

Electricity in Tunnel Boring.—The boring of the tunnel, 4½ miles in length, which is to conduct water from the Derwent Valley to the Rivelin Valley to augment the Sheffield Corporation's water supply, is now completed. Larmuth compressed air drills, driven by electric motors, were used, and the air and the bottom of the tunnel were kept in good condition by the use of a tramway worked by 25 H.P. electric locomotives, instead oj adimal traction, and the use of electric light also assisted in minimising the vitiation of the atmosphere.

Exhibition.—An "Everything for the Home" Exhibition will be held at Birmingham from Oct. 6 to 23. Particulars from the International Trade Exhibitions (Ltd.), Broad-street House, London, E.C.

Glasgow.—The sub-committee on Tramway Finance recommend that an experimental direct 15-minute service of cars for four months be given between Townhead district and the west end of the city.

Glasgow Telephone Service.—The Post Office authorities are equipping a new central exchange in Waterloo-street which will have provision for 10,000 subscribers, and will be ready about the end of the year. It is designed on the common battery system, which is already used by the National Telephone Co. in their Hillhead, Ibrox and Langside exchanges.

India.—"Indian Engineering" says plant for the electric lighting of the new shunting yard at Khargpur has been ordered from England by the Bengal-Nagpur Railway Co.

Llandudno-Colwyn Bay Tramway.—The Council have come to terms with the Llandudno and Colwyn Bay Electric Railway (Ltd.) as to the construction of the extension to Colwyn Bay, and the company's application for 12 months' extension for constructing the line will be supported by the Council.

L.C.C. Tramways.—On Tuesday the Lord Mayor of London performed the ceremony of opening the added portion of Blackfriars Bridge, which consists of 30 ft. of the width on the western or up river side. The Lord Mayor also acted (pro tem) as motorman on the first of the County Council's tramcars (with the exception of trial cars) to traverse the bridge. The public service of cars over the bridge was started on the same day. An illustrated description of the widened bridge and the works involved in the widening and tramway construction works appeared in our last issue.

The final portion of the Holborn to Hampstead (via King's Cross,

Great College-street and Camden Town) tramway route was opened to the public on Friday.

L.C.C. Tramways Guide.—We have received a copy of the 1909 edition of the Official Tramways Guide of the London County Council. The guide, which consists of two parts, runs into nearly 150 pages. The first part gives a list (arranged alphabetically) of places of interest in London, including the museums, exhibitions, theatres, hospitals, chief public buildings, parks and other places of interest in London, and in many cases an indication is given of the best means of reaching the place in question. The second part of the guide gives particulars of the routes traversed by the Council's tramways, and there is also a good map of the whole of the lines, with an index of the chief streets and localities served by the tramways. We congratulate the Tramways Department upon the completeness and accuracy of their guide, which must be of great service to all tramway passengers and a positive boon to visitors to London. The guide is published at 1d.

Local Government Board and Public Electric Lighting.—Yarmouth Electricity committee have received a communication from the L.G. Board with reference to the recent application of the Council for £2,000 for alteration of the public lighting from gas to electricity, in such streets as the Corporation may from time to time decide.

The Board stated that it was not their practice to sanction loans for undefined expenditure on public lighting, and they saw no reason to make an exception with Yarmouth.

The Council are communicating further with the Board.

London United Tramways Assessment.—Brentford Guardians have now paid £3,832. 19s. 5d. to the London United Tramways (Ltd.) for their taxed costs in connection with the appeal as to the assessment of the company's property within the Brentford area.

Long Eaton.—The Council have increased the discounts to be allowed to electricity consumers.

Lowestoft.—A supply of electricity for light and power is to be given to the shipbuilding yard, &c., of Mr. J. Chambers. Another feeder is to be laid at an estimated cost of £875.

Luton.—The salary of the borough electrical engineer (Mr. W. H. Cooke) has been increased to £400 per annum.

Marble Arch-Cricklewood Tramways.—Willesden Council have decided to oppose the scheme for the construction of a tramway from Marble Arch to Cricklewood unless the road through Kilburn is widened to 60 ft.

Metropolitan District Railway.—This company are about to introduce many improvements in their service. To relieve pressure at the booking offices and save the time of passengers an electric automatic ticket machine has been installed at the Mansion House station, and, if it is successful, similar machines will be placed on other stations. At present only 2d. tickets can be bought. Only copper coins with the same measurement and weight as a penny will make the required electric contact, and consequently foreign, silver or bad coins will not succeed. Unsuccesssful coins are returned. So far the device has, it is stated, proved very successful.

New Edition.—A new edition of "The Dynamo, its Theory, Design and Manufacture," by Messrs. C. C. Hawkins and F. Wallis, will be published immediately by Whittaker & Co. This book has been thoroughly revised and considerably enlarged, and deals exhaustively with the most recent practice in this important branch of electrical engineering.

Newcastle (Ireland).—The Council have been notified by J. W. Fraser & Co. of their intention to apply for a provisional electric lighting order.

Newport (Mon.)—The gas lamps in two thoroughfares are to be adapted for electric lighting.

Plymouth.—The new museum and art gallery and the Corporation laboratory are to be wired at a cost of £417.

Presentation.—Huddersfield Tramway staff have presented a Sheraton inlaid timepiece to Mr. Frank Smith, station engineer, on his marriage.

Quebec (Canada.)—The Canadian Light & Power Co., of Montreal, has made an arrangement with J. G. White & Co. for the engineering design and supervision involved in the construction of a hydro-electric plant on the St. Lawrence River, near St. Timothee, Quebec. The present initial development provides for 21,600 H.P., with such further development as may be required in the near future. It is estimated that the present initial development will cost about $4,000,000. The Canadian Company purposes to do the work by contract, on the basis of unit prices.

Spain.—A concession for the construction and working of the Metropolitan (Electric) Railway at Valvidrera has been granted provisionally to Don C. E. Moutañés. The work, which includes the boring of a tunnel, is to be completed in two years.

Toronto (Canada.)—For some time there has been considerable discussion on the scheme of the Hydro-electric Commission for the transmission and supply of electric energy from Niagara Falls to Toronto for power and lighting, and now a citizen (Major J. A. Murray) has issued a writ for an injunction against the Municipal Council and other parties

To restrain them from proceeding with the construction of transmission lines, transformer houses and other electrical appliances for the transmission of electrical energy generated by the Ontario Power Co. from the Niagara River, and from acquiring property for the location of the said transmission line; and also from expending money and further pledging the credit of the Province of Ontario and the credit of the Municipal Corporation in connection with the carrying out a of certain contract pretended to have been made by defendants with the Ontario Power Co. for the purchase from the said Ontario Power Co. of electrical energy developed from the Niagara River.

An injunction is claimed because (1) the Niagara River is a navigable river, forming part of the boundary between the Dominion of Canada and the United States of America, and the waters of the said river are within the exclusive control and jurisdiction of the Dominion of Canada; (2) the Ontario Power Co. are assuming to take water and to develop power from the waters of the said river without the sanction or authority of the Government of the Dominion of Canada, and the action of the said Ontario Power Co. in so doing is illegal and ultra vires; (3) the defendants have assumed to enter into a contract with the said Ontario Power Co. for the purchase from the said Ontario Power Co. of a quantity of electrical power developed from the waters of the Niagara River, illegally taken from the said river as aforesaid, and have agreed with the said Ontario Power Co. to expend sums of money in the erection of transmission lines, transformer houses and other electrical appliances, &c; and (4) the said pretended contract being illegal and ultra vires of the said Ontario Power Co., is, in fact and in law, no contract at all, and defendants are acting wrongfully and illegally in spending money and in pledging the credit of the province and of the said municipalities in furtherance of the said pretended contract.

Torquay.—The L.G. Board recently asked the Council for their observations on a communication they had received complaining of alleged nuisance caused by vibration by, and smoke fumes from the electricity station, and requesting that no loan should be granted for new municipal buildings until the station was removed to another part of the town. The matter was referred to the Electric Lighting committee, with instructions to consume only smokeless coal at the station.

Trade Union Congress.—The 42nd Trade Union Congress was held at Ipswich last week, when 495 delegates attended, representing 1,701,000 trade unionists.

In his presidential address, Mr. D. J. Shackleton, M.P., referring to the legislation of the present Parliamentary session, said that while the Budget had taken up most of the time of Parliament opportunity had been found to pass into law two important trade union Bills—the Trade Boards Bill and the Labour Exchanges Bill. It was gratifying to know that the Government Bill contained within it the methods which they had from time to time advocated as to the treatment for the evils of sweating. The Bill was confined to a few trades as an experiment, but they had confidence that the experience gained would prove the wisdom of adding other trades to the list. As to the Labour Exchanges Bill, the President and officials of the Board of Trade had been made fully aware of the ideas of the congress and the decision of the recent special conference on the subject, and they had confidence that the regulations when issued would be found to be fair and equitable to all the interests concerned. The question of insurance against unemployment would in all probability form part of the work of the next session of Parliament. The Government in those proposals were taking the first practical step to deal with the greatest evil of modern society—an evil not by any means confined to these islands. They would give the proposals of the Government their earnest and sympathetic consideration, and the congress might rest assured that the position of the organised workers of the country would be safeguarded. He drew the attention of the congress to the case of "Conway v. Wade," which would be brought before them by way of an appeal for financial support. The real point arising in that case was whether the act done by defendant (who was a trade union official) was an act done during a trade dispute. On the facts of the case the Lords of Appeal had decided that it was not, and however much they might differ from that opinion their decision had to be accepted. The question had naturally been raised how far the Trade Disputes Act of 1906 was efficient for the purpose for which it was passed. On the facts of that case, and on the findings of the House of Lords, he had no hesitation in saying it stood unshaken for the objects which they had in view. The lesson to be learnt from that case was that, in taking any action which the Act clearly contemplated might be taken, it should be done with the consent, and, as far as possible, on the instructions of the trade union concerned; and had that been more clearly shown in the case under review, he believed the decision would have been in favour of defendant.

Ministry of Labour.—A resolution was passed to call upon the Government to appoint a Minister of Labour, with Cabinet rank, under whose supervision all departments of labour should be co-ordinated, including a statistical department which should enumerate the number of persons engaged in industrial occupations in the United Kingdom, and prepare

monthly statements dealing with the wages of those employed permanently, casually, or irregularly.

Labour Exchanges.—It was unanimously resolved "that no system of labour exchanges will be satisfactory unless boards of administration be composed equally of representatives of recognised trades unions and employers, with a neutral chairman appointed by the Board of Trade; that provision be made to prevent these exchanges being used to undermine the trade union rates and conditions of working by the supplying of labour at less than the union rate: that under no circumstances shall these exchanges be used as agencies for the supply of labour to assist any firm who may have a dispute with their workpeople. Further, in view of the large and growing extent of unemployment in women's trades, this congress affirms the belief that adequate provision should be made in the labour exchanges for women workers; also that the Parliamentary Committee be instructed to urge upon the Government the necessity of providing accommodation for trade union meeting rooms in the labour exchange buildings."

Miscellaneous.—A resolution was passed in favour of observing the 1st of May in each year as Labour Day, as in other countries. Another resolution demanded the institution of a legal eight-hour day. A resolution was passed approving of direct employment in all Government departments. The congress also approved a resolution affirming that certain industries were injuriously affected by the competition of prison labour, and instructed the Parliamentary Committee to urge the Government to so amend the Workmen's Compensation Act as to make it definite who are dependents in any case of loss of life, in order that the liability might be equal for single and married men.

Industrial Insurance.—This question was raised by the President, who (on behalf of the Parliamentary Committee) moved that "Having regard to the serious nature of the illegal practices connected with industrial insurance, which have led to widespread gambling in human lives, this congress calls upon his Majesty's Government to institute an inquiry by means of a Royal Commission or a committee with a view to legislation to prohibit such illegal practices."

Underground Telegraph Wires.—The Postmaster-General has decided to extend the underground telegraph wires from Chatham to Dover, and contracts for the work have been let.

Watford.—Herts County Council are about to construct tramways in the Watford area, and the Urban Council are negotiating for the supply of electricity to the trams.

The electrical engineer (Mr. F. W. Purser) has been instructed to ascertain the names of owners and occupiers outside the area who desire a supply of electricity, as an application had been received for the supply of electricity on Lord Essex's property.

West Houghton.—It is proposed to light the public offices electrically, and the Lancashire Electric Power Co. have been asked to submit terms for supplying current.

Weymouth.—The salary of the borough electrical engineer (Mr. J. H. Bolam) is to be increased from £250, by two annual increments of £25, to £300 per annum.

Wolverhampton.—The Victoria-street and Lea-road extension of the Corporation tramway system has been opened for traffic.

Worcester.—81 gas lamps are to be replaced by 12 arcs and 57 Osram lamps at a cost of £250 per annum, against £229. 4s. 6d. for gas.

Yarmouth.—The Electricity committee have resolved that the price of electric current for motors taken from the tramway supply be charged at the rate of ¾d. per unit, plus cost of coal per unit sold.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Ayr.—The annual report of the tramways manager (Mr. W. Grant) states that

The revenue for the past year was £15,081, against £15,322 for 1907-8. Receipts per car-mile were 8·87d., compared with 9·13d. The number of passengers carried was 3,610,537, decrease 49,501. The surplus for the year was £62. Capital expenditure now stands at £82,169; the depreciation and renewals fund amounts to £13,110, and the reserve fund stands at £5,000.

Bradford.—The chairman of the Finance and General Purposes committee (Mr. D. Wade) made his annual statement as to the trading departments of the Corporation on Tuesday.

The total income of the electricity department was £110,242 and the working expenses £52,131, leaving a trade profit of £58,111. Interest and sinking fund charges amounted to £55,964, so that the net profit was £2,147. The unappropriated profit at the beginning of the year was £3,223, to which had been added the net profit of £2,147, making £5,370. Against that there had been charged £1,200, which had been allowed for rebate to tramways for electricity supplied for traction. Also a transfer of £2,000 to revenue account with other sums amounting to £4,692, leaving an unappropriated profit at the end of the year of £678. The renewals account (£3,699) had been increased by £200 transferred from unappropriated profits, and there had been expended upon the renewal of engines, mains, &c., £2,399, leaving to the credit of renewals a balance of £3,300.

There are 2,439 consumers, and the equivalent of 387,737 30-watt lamps is connected. 18,564,301 units were generated. 17,062,455 units were sold, including 2,777,386 units for private lighting, 132,911 for public lighting, 2,401,482 for power, 9,421,368 for traction and 143,300 for lighting tramway sheds, &c. The maximum simultaneous load on feeders was 6,884 kw. (5,044 kw. for lighting and power and 1,840 kw. for traction), and the capacity of the generating plant is 6,844 kw. There are 69 public arc lamps and 12 incandescents, and there are 1,510 motors (808 of 3,511 H.P. on hire) of a total of 7,209 H.P. connected. The Bradford Dyers' Association, a consumer on bulk supply, are under contract to take current not exceeding 1,000 kw.

The traffic revenue of the tramways department was £231,475, and miscellaneous revenue £12,760, making a total of £244,235. The working and management expenses were £170,196, leaving a gross profit (exclusive of allowances for renewal of permanent way) of £74,039. Interest and sinking fund charges amounted to £58,721, leaving to be carried forward to the renewals fund the balance of £15,318, compared with £17,238. The balance to credit of renewals fund at the beginning of the year was £52,229, and at the end of the year £44,461. Out of this sum the Council had voted £20,000 towards relief of rates during the current year, leaving £24,461.

Bridlington.—The accounts of the electricity department for the year ended March show capital expenditure £35,996 (increase £1,363).

Revenue was £4,870, working and general expenses £2,607, and gross profit £2,263. After meeting capital charges the net deficit was £188 (compared with £275 in previous year). Units generated were 330,262. 151,764 were supplied to public lamps and 138,826 to private consumers. The total maximum demand was 694·8 kw.

The report of the borough electrical engineer (Mr. A. J. Beckett) states that for the first time the revenue for private lighting, &c., has exceeded that from street lighting. Revenue has increased by £388 and units sold by 34,007. Working costs are down 0·014d., although expenditure of £136 was incurred for repairs to battery, &c. During its four years' existence the undertaking has not had to call upon the rates for assistance.

Horsham.—The accounts of the electricity department for the year ended March show capital expenditure £31,713 (increase £482).

Revenue was £4,019 (against £3,789 in previous year) and total cost were £1,978 (£1,908). The gross profit was £2,041 (£1,881) and net profit £10 (against deficit of £148). Total costs were 2·265d. (against 2·34d.) per unit. There are 520 (444) consumers and 15,416 (14,018) equivalent 33 watt lamps connected. The units sold were 208,613 (195,341).

The report of the engineer (Mr. J. B. Morgan) states that a 32 c.p. lamp formerly represented a connection of four 30-watt lamps—total 120 watts; but with the metal filament the same candle-power is obtainable for the equivalent of 1¼ 30-watt lmps. Coal cost is down 0·1d., partly due to improved methods of stoking, and works costs have dropped from 1·72d. to 1·67d. Consumers are beginning to realise the extreme handiness of electric laundry irons, hot water jugs and kettles, as well as heating appliances for trade purposes. Units sold per lamp were reduced from 14·6 to 14·2 (total 8,830), or a loss to the department of £165 through the use of metal filament lamps.

Shoreditch (London.)—Last week the Lighting committee reported to the Council that for the year ended March 31 the gross profit on the electricity undertaking was £21,335. 4s. 8d., against £19,547. 17s. 6d. in 1907-8, although there was a reduction in the total income of £644. 3s. 2d.

The reduction in income was mainly due to the reduction in the number of lighting units sold, through the increased use of metal filament lamps. After meeting interest (£10,793. 12s. 6d.) and repaying capital to the extent of £5,951. 19s. 4d., also paying bank interest, &c., the net profit was £4,117. 15s. 2d., which has been used to wipe off the deficiency brought forward last year and the annual contribution to change of pressure account, leaving a small deficiency of £328. 8s. Works costs showed a reduction under every head.

The destructor accounts show that the total refuse dealt with during the year was 41,369 tons, against 35,531 tons. The borough refuse amounted to 28,905 tons, compared with 29,434 in 1907-8, the cost being £5,896. 4s. 8d. (including loan charges), against £6,331. 3s. 3d.

South Shields.—The accounts of the electricity department for the year ended March show capital expenditure £182,268 (increase £4,830).

Revenue was £25,559 (compared with £25,608 in the previous year), working and general expenses £13,004 (£13,538), leaving gross profit £12,555 (£12,070); interest and sinking fund required £11,371 (£10,711), and net profit was £1,184 (£1,358). The maximum load was 1,653 kw. (1,776 kw.) and the load factor 21·59 (18·99). The units sold were 3,127,039 (2,954,990), including 1,434,875 (1,515,495) for lighting, 358,551 (102,620) for power and 1,333,613 (1,336,875) for traction.

The report of the borough electrical engineer (Mr. J. H. Cawthra) states that the result is satisfactory, taking into consideration trade depression and the advent of the metal filament lamp. The lamps and motors con-

nected are equivalent to 99,481 35 watt lamps (compared with 89,537 at March, 1908). The average revenue per equivalent 35-watt lamp was 3s. 7d. (against 3s. 11d.). Lighting units have decreased 5 per cent. and traction units 2 per cent., while power units have increased 249 per cent. ; works costs have been reduced from 0·71d. to 0·62d., and total costs from 1·099d. to 0·998d.

Wimbledon.—The capital expenditure of the electricity undertaking for the year ended March was £198,565 (increase £14,535).

Revenue was £31,831 (against £28,926 in previous year), working and general expenses £29,321 (£26,222) and net profit £2,510 (£2,704). Total costs were 1·502d. per unit sold (against 1·448d.) and capital charges 1·310d. (1·163d.). 2,944,520 units were generated, 620,600 supplied to public lamps (average price 2·342d. per unit) and 1,722,689 to private consumers (3·284d.). There are 1,110 metal filament and 89 arc lamps for public lighting (=4,449 8 c.p.) and 150,022 equivalent 8 c.p. lamps connected for private customers, the number of consumers being 3,602. The maximum supply demanded was 1,507 kw.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Directors of the METROPOLITAN RAILWAY Co. invite tenders for the supply of general stores during the 12 months' ending Oct. 31, 1910. Manufacturers and others desirous of tendering should apply to the Secretary, Mr. W. H. Brown, for forms. The company's requirements include electric wires and cables, lamps, carbons, switches, fuses, telephones, &c., and electrical insulating materials. Patterns and samples will be on view from the 27th inst. to Oct. 2 inclusive, and tenders must reach the Secretary by 10 a.m. of Monday Oct. 4. See also an advertisement.

Tenders are invited for supply of 100,000 porcelain insulators to the Postmaster-General's Department, VICTORIA. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-st., London, S.W.

Tenders are invited for the supply to the Postmaster-General's Department, New South Wales, of a common battery switchboard for the NORTH SYDNEY telephone exchange. Tender form, specifications, &c., may be obtained from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

LONDON County Council invite tenders for (1) the manufacture, delivery and erection in certain of the Council's substations of two 500 kw. and one 150 kw. motor generators, and (2) the manufacture, delivery and erection of h. and l.t. switchgear for Woolwich and other substations. Tenders, on forms to be obtained from Mr. G. L. Gomme, County Hall, Spring Gardens, S.W., by 11 a.m., Sept. 21.

BRISTOL Education committee require tenders by noon, Sept. 21, for electrician's work at the new school at Alexandra Park, Fishponds, Bristol. Forms of tender, &c., from Messrs. Rodway & Dening, Gaunt House, Orchard-street, Bristol.

Tenders are required by noon, Sept. 27, for the electric lighting of new asylum buildings, Purdysburn, BELFAST. Specifications from Messrs. Watt, Tullock & Fitzsimons, 77A, Victoria-street, Belfast.

YORK Corporation want tenders by 9 a.m., Sept. 24, for a traction switchboard. Specification, &c., from the City Electrical Engineer, Foss Islands-road, York.

MANCHESTER Tramways committee want tenders by 10 a.m., Sept. 21, for supply of steel girder tramway rails. Specifications from Mr. J. M. M'Elroy, 55, Piccadilly, Manchester.

FULHAM (London) Council require tenders by noon, Sept. 22, for supply of 150 electricity meters. Forms of tender, &c., from the Borough Electrical Engineer, Townmead-road, Fulham, S.W.

SALFORD Tramways committee want tenders by 10 a.m., Sept. 20, for supply of 500 tons of steel tramway rails. Specification, &c., from the General Manager, 32, Blackfriars-street, Salford.

CORUMBA (Brazil) Municipality want tenders by Oct. 5 for the erection and equipment of electricity supply works.

CAPE TOWN Municipality want tenders by Sept. 29 for supply o about 2,500 dry cells during the year commencing July 1 next.

The Turkish Government want tenders for the installation and working of a telephone system in CONSTANTINOPLE and the vicinity. An agent on the spot is practically essential. Tenders to the Minister of Finance, Constantinople, by Oct. 14.

The Public Works Dept., Madrid, want tenders by Sept 22 for a concession for the construction and working of an electric tramway in VIGO and suburbs, in competition with an application by Don J. C. Fernandez.

Tenders will be opened at the Public Works Dept., Madrid, at noon Nov. 3 for the construction and working of an electric tramway from Calle de Villanova to Calle de Wad-Ras, BARCELONA. The Sociedad Anonima Tranvias de Barcelona á San Andrés y Extensiones will have certain preferential rights in the competition.

TENDERS RECEIVED AND ACCEPTED.

Bristol Electrical committee have accepted the following tenders : Electrical Co., a.c. meters for 1909-10, £762. 8s. ; General Electric Co., carbons for 12 months ending April 30th, 1910, £366. 12s. 4d. ; Siemens Bros. Dynamo Works, arc lamp globes for 1909-10, £31. 2s.6d.

Swansea Electric Lighting committee have accepted the following tenders :—Callender's Co., cables ; London Electric Firm, arc lamp pillars, brackets, raising and lowering gear ; W. Lucy & Co., switch pillars and joint boxes ; Veritys Limited, arc lamps.

Melbourne Council have accepted the tender of the Midland Machine Trust for supply of electric current to 26 tantalum lamps at 15s. each for the lighting season and at £4 each for arc lamps.

Plymouth Council have accepted the tender of the National Telephone Co. for connecting the residences of firemen with the central station and maintaining same for three years.

Messrs. Maguire & Gatchell, of Dublin, who have recently executed a number of country house electric lighting contracts, have obtained a contract for the electric lighting of the Viceregal Lodge, Dublin.

Bradford Council have accepted the tender of G. A. Steinthal & Boydell for motors for the conditioning house at £209.

Worthing Council have accepted the tender of the Beck Flame Lamp Co. for Beck lamps at £638.

The tender of Turner & Atherton has been accepted for an electric hoist and an X-ray equipment for the Stockport infirmary.

Burslem Education committee have accepted the tender of Evans & Sons for wiring Middleport schools at £86. 15s.

Lowestoft Council have placed an order with the Shipley Fan Co., at £15. 10s., for a fan for the generating station.

A contract has been signed for the supply by McLean & Co. (Melbourne) of electric lighting plant for Korumburra (Victoria), comprising gas producer, 75 B.H.P. multiple cylinder vertical gas engine, and 45 kw. generator, and a Hart battery, giving 360 amperes, at one hour rate of discharge. The initial capital outlay will be £2,160.

Storage Battery Contracts.—During the past week the D.P. Battery Co. received orders for the supply and erection at Howrah of a storage battery having a capacity of 800 kw.-hours for the East Indian Railway Co., and another for New South Wales. In the home trade the company have secured contracts for 13 batteries for country house lighting installations for the purpose of Government tests, and metal depositing work, as well as sundry renewal orders.

Admiralty Contracts.—The Paterson Engineering Co. have received from the Admiralty a repeat order for oil eliminating plant with quartz sand filter for H.M. Dockyard, Chatham, together with steel carrying structure and pipe work. The capacity of the Paterson purifying plant at this station will now be 10,000 gallons per hour. Paterson oil eliminators are also installed at several other dockyards.

The British Electric Calibrated Fuse Co. have received the Admiralty contract for all fuses required up to Dec. 31, 1911, from 3 to 30 amperes.

BUSINESS NOTICES.

Mr. T. R. Wilton, B.A., A.M.I.C.E., who was for many years an assistant to Mr. A. G. Lyster, engineer-in-chief to the Mersey Docks and Harbour Board, has commenced practice as a civil engineer at 18, Westminster Chambers, 1, Crosshall-street, Liverpool.

The Electrical Apparatus Co., Queen's-road, Battersea, S.W., announce that in future they will be the only manufacturers of the "Koolark" enclosed fuse, and all inquiries and orders for same should be addressed to the company.

Sale by Auction.—Messrs. Fuller, Horsey Sons & Cassell will include in their sale at H.M. Dockyard, Devonport, on Tuesday, Oct. 12, at 11 a.m. quantities of scrap brass and borings, white metal and manganese bronze, zinc ashes and bottoms, lead skimmings, foundry ashes, iron and steel, 21 tons electric cable, electrical gear and stores, boat's engines and boilers, lathes, tools, &c. May be viewed three working days before, and on morning of sale. Catalogues (6d. each) at the Dockyard and of the Auctioneers, 11, Billiter-square, London, E.C. See also an advertisement.

Plant for Sale.—Rhyl municipal electricity department advertise for sale a 165 kw. d.c. steam dynamo (Alley & MacLellan engine and Lancashire dynamo). Particulars from the electrical engineer, Mr. Ernest H. Wright.

Patents Development.—The proprietors of the following patents wish to enter into negotiations with firms in Great Britain for the sale of same or for the grant of licences to manufacture under royalty:

No. 23,429/1901, relating to "Electric locomotives." Applications to Messrs. Hyde & Heide, 3, Broad-street Buildings, Liverpool-street, London, E.C.

No. 18,408/1906, for "Improvements in electric insulators for high-tension conductors," and No. 18,125/1905, for "Improvements in electric motor control systems." Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton Buildings, Chancery-lane, London, W.C.

"Metfil" Lamp.—A striking showcard, in colours, has been issued by the Edison & Swan Co., a reproduction of which we give below. The card is neat and of considerable artistic merit, while it is also a striking advertisement. The desire has been to emphasise the fact that Royal Ediswan "Metfil" lamps are British made. A copy of the card, which is eveletted for hanging and varnished to prevent soiling, and which measures some 21 in. by 15 in., can be obtained from the publicity department of the company by any electric lighting contractor sending his trade card.

Electric Flasher.—An electric flasher has recently been designed in which the time taken for flashing can be regulated, whilst the apparatus is said to possess the additional advantage of being sufficiently interesting to attract attention, apart from the flashing of the lights. The principle of the flasher is as follows:—

A zinc tube is wound with a coil of high-resistance wire, the latter being insulated from the tube. When a current passes through the wire the tube is heated, expands and operates a lever, giving a great amplification of the movement and causing an arm to tip over and fall on to a contact, whereby the lamps are caused to light up. The closing of this contact, however, short-circuits the resistance coil, with the result that the tube cools down until the arm is caused to fall into its original position, when the process is repeated, the lamps being automatically illuminated and extinguished. By an adjustment of the contacts the frequency of the operation can be varied from 7 seconds to 2¼ minutes. The apparatus has been designed by Mr. C. H. Jukes-Browne, of 76, Weston-road, Strood, Kent.

CATALOGUES, &c.

Underground Mains, Cables, &c.—Messrs. Pirelli (Ltd.), 45, Basinghall-street, London, E.C., have issued a new catalogue, in which particulars are given of paper-insulated lead-covered cables for electric light and power work, air space telephone and telegraph cables, all types of rubber and gutta-percha insulated cables, along with wires and flexibles for every purpose. The catalogue is an exhaustive one, ranging from large armoured cables to instrument wires, yet it is interesting to notice that everything described is of Messrs. Pirelli's own manufacture. Accessories, such as tapes, ebonite sheets, &c., are also included, in addition to bell wires, &c., whilst attention may be called to the extra high-tension cables. One, of which particulars are given, made by Messrs. Pirelli for laying across the Lake of Garda, withstood a pressure of 100,000 volts between the conductor and sheath, although the working pressure was only specified as 13,000 volts, whilst a cable made for the Milan Exhibition, 1906, broke down on test at over 200,000 volts, the working pressure in this case being specified as 150,000 volts alternating.

Motor Converters.—A pamphlet has reached us from Messrs. Bruce Peebles & Co. dealing with the La Cour motor converters. This pamphlet should prove welcome, as it deals with a type of machine which during the last year or two has become of increasing importance. The success of the motor converter is no doubt due to its specially valuable features, including absence of transformers, simplicity of the switchgear, efficiency, power factor, &c. The comparison made on p. 16 of a motor converter, a rotary converter and a motor generator is particularly interesting and instructive. The station engineer will be impressed by the fact that over 100,000 kw. of Peebles motor converters have been installed or are under construction.

Electrically Driven Tools, &c.—From the Witton-Kramer Electric Tool & Hoist Co. we have received a further batch of leaflets describing their specialities: Leaflet K6, electric polishing machines; K7, standard types of electric winches, made in all sizes from 1 h.p. to 50 h.p.; K8 shows two types of electric grinders; K12 the "Witton-Kramer" flexible shafts.

"Richardson" Series Adaptor.—Mr. Chas. W. Richardson, Patricroft, Manchester, is issuing a four-page pamphlet which gives illustrated particulars and prices of his series adaptor for placing metal and other high-efficiency lamps in series, any distance apart, in any position, on existing circuits, without re-wiring of circuits, electroliers or fittings. The inventor claims that by this piece of apparatus installations are changed over without interference with business in a cheap and effective manner.

Eclipse Electric Cooking Apparatus.—From the Electric & Ordnance Accessories Co., Aston, Birmingham, we have received a copy of a catalogue dealing with electric cooking and heating apparatus constructed on their system.

The units consist of a special resistance material insulated with mica and enclosed in a thin metal casing. We are given to understand that this resistance material is well able to withstand a temperature of 2,500°F. without risk of breakdown. That these units are suitable for the purpose is proved in that the makers inform us that a number of kettles were placed in circuit for periods varying from 500 to 1,250 hours, and at the end of these periods not one of the units had broken down, nor were they the worse for wear to any appreciable extent. These periods correspond to an ordinary use of at least five years. The apparatus the company are prepared to supply at present consist of kettles, jugs, glue pots, hot plates, plate warmers, flat irons, curling tong heaters and cigar lighters. These latter consist of a miniature arc lamp which is brought into action by pulling the chain at the side, and it should be useful for entrance halls of hotels, clubs and for tobacconists' shops. Most of the apparatus listed is capable of adjustment to give from one to four different heats by a slight manipulation of the plugs.

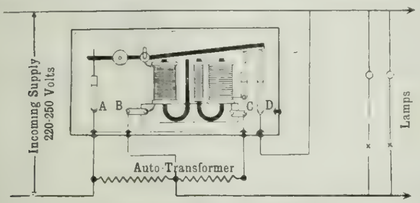
In addition to the usual information concerning the apparatus the company have also prepared a very useful table showing the cost of operating their apparatus. From these figures it would appear that the "Eclipse" apparatus is well within the reach of all electric light consumers from the standpoint of operating cost. The prices also appear to be reasonable.

In addition to the apparatus listed in the catalogue the company are shortly bringing out a series of apparatus for cooking by incandescent heat, such as grills, ovens, toast racks, &c. In these, the units will consist of resistance material prepared specially for the Electric & Ordnance Co., and capable of being run at red heat for a considerable period. The company have been testing some units made up from this material and inform us that up to date they have run for 1,100 hours without yet showing signs of giving out. In addition to being simply run in circuit, quantities of water and grease have from time to time been poured on these so as to realise as far as possible actual working conditions. The result of this pouring on of water and grease is merely to cool down the units temporarily until the foreign matter has evaporated and has no injurious effect whatever. The company will send a copy of this catalogue to anybody inquiring for same.

Electrical Fittings and Accessories.—Messrs. Baxendale & Co., electrical supply manufacturers and merchants, of Miller-street, Manchester, have forwarded a copy of their illustrated catalogue for 1909, in which a great variety of fittings and accessories are listed and priced, including electric bells, indicators, door contacts, pushes, wires, casing, jointing materials, overhead line material, batteries, staples, screws and terminals, induction coils, speaking tubes, piping, &c. Very full indexes, connection diagrams and the general information given concerning the articles listed should make this catalogue of great service to wiring contractors, bell fitters, &c.

Electric Radiators.—We have received from Messrs. Veritys Limited copy of a new catalogue of radiators. Several new designs are included.

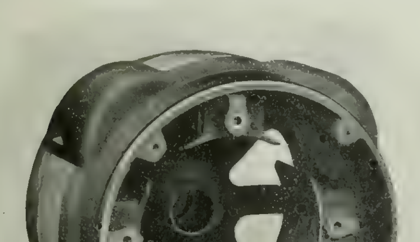
AUTOMATIC TRANSFORMER SWITCH.—Messrs. D. Burr & Son, 85, Gracechurch-street, London, E.C., have placed on the market a new automatic transformer switch, specially designed for use in connection with small installations where a large outlay is not warranted. The function of the apparatus is to cut in the transformer automatically when the first lamp is switched on and cut it out when the last lamp is switched off. The general design of the switch and arrangement of connections are shown in the accompanying illustration.



AUTO-TRANSFORMER SWITCH.

The switch is built up on an oiled slate slab and mounted in a cast-iron case with glazed front, having porcelain bushes for the incoming leads. No special wiring arrangements are necessary with the apparatus, which will operate when a single 16 watt metal filament lamp is switched on or off. It can be supplied to work on circuits of the usual voltages and frequencies, and no special type of auto-transformer is required for use in connection with the switch. It is claimed that the apparatus is strong, not likely to get out of order, silent in working and absolutely reliable, and it is also cheap.

J.-L. MOTORS AND DYNAMOS.—From the J.-L. Mfg. Co.,of Southall, we have received a copy of a new catalogue describing Johnson-Lundell laminated field motors and dynamos. The outstanding features of these motors are the use of a laminated magnetic circuit in the field magnet yoke, and of a double carbon brush holder; the use of a laminated field results in the J.-L. motors being of exceptionally small over-all dimensions and of light weight, whilst possessing the same rigidity as a solid casting. The patent double carbon



FRAME SHOWING LAMINATED FIELD AND METHOD OF HOLDING POLE PIECES.

brush gear is of advantage where a very wide range of speed variation is required without the use of interpoles. Other advantages claimed for J.-L. motors are: Sparkless commutation at all loads with fixed brush position, large overload capacity, low temperature rise, perfect utilisation of all materials employed in the construction, and adaptability for meeting exceptional structural conditions. The illustration herewith shows the laminated field of a J.-L. motor and the method of supporting the pole pieces.

CAMP CONDUIT.—MM. L. Dens & Co., Antwerp, forward a pamphlet which gives particulars of the Camp vitrified clay conduits, for which they are general agents for the Continent.

OKONITE AND MANSON TAPES.—We have received from Wm. Geipel & Co., a copy of a new price list of Okonite and Manson insulating tapes. Okonite tape is intended to take the place of ordinary Para rubber strip, and has the advantage, it is claimed, of being sold at a much lower price, whilst Manson tape is a protective tape for covering joints insulated either with Okonite or rubber tapes, or for covering joints in paper or bitumen insulated cables. From a sample of this tape which we have examined we can testify as to its adhesive properties.

PEEBLES CONTINUOUS-CURRENT DYNAMOS AND MOTORS.—We have also received from Messrs. Bruce Peebles & Co. a new pamphlet dealing with their C type continuous-current dynamos and motors. In all cases the machines described are fitted with "commutating poles. The pamphlet gives all the necessary information regarding the machines, and as very complete details of the dimensions of the dynamos and motors listed are given, it should prove useful to prospective customers. We may also mention that the technical details given as to the performance of protected, semi-enclosed, and totally-enclosed machines are very complete, including horse-power, kilowatts, speed and efficiency, a large choice being offered in the way of speed. The machines are manufactured in all standard sizes, and conform both to the Home Office and Fire Insurance Rules.

BANKRUPTCIES, &c.

Herbt. J. Burdett, electrical engineer and contractor, 16, Regent-street, Rugby, and 32, Earl-street, Coventry, has been adjudicated bankrupt.

The official receiver (Mr. H. E. Burgess) has issued his report to the creditors and shareholders of the Uxbridge & District Electric Supply Co. (Ltd.).

The assets are valued at £75,038 to meet debenture claims and interest (£52,579) and unsecured liabilities (£6,622). There is a surplus of £15,748 in assets after discharging liabilities, and a loss of £10,526 to shareholders. The official receiver remains liquidator, with a committee of inspection.

The first meeting of creditors of Herbt. John Burdett, electrical engineer, and contractor 16, Regent-treet, Warwick, and 32, Earl-street, Coventry, will take place on Sept. 20 at 8, High-street, Coventry, and the public examination on Oct. 11 at County Hall, Coventry.

The examination of Herbert Shuttleworth, electrical engineer, Cross-court, Briggate, took place at Leeds on Tuesday. Liabilities £465, deficiency £391. Debtor started business as an electrical engineer and contractor in 1906. Failure attributed to depression of trade.

A receiving order has been made against Ernest Fenwick Jones, electrical engineer, &c., 132, York-road, West Hartlepool.

An application for the discharge of Harry P. Allison, electrical engineer and contractor (trading with Joseph G. S. Cunnington as Laing, Wharton & Cunnington), 7, Great Newport-street, London, W.C., will be heard on Oct. 13 at Bankruptcy-buildings, London,W.C.

A meeting to receive an account of the winding up of the Poole & District Electric Traction Co. (Ltd.) will be held at Electrical Federation Offices, Kingsway, London, W.C., on Oct. 11.

A meeting will be held at Norfolk House, Norfolk-street, London, W.C., on Oct. 14, to receive an account of the winding up of the International Telescriptor Synd. (Ltd.).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications [illegible] inspection until after acceptance of Complete Specification. [illegible] inspection 12 months after the date attached to them [illegible] in the ordinary course. Names within [illegible]* *When complete Specification accompanies application, an asterisk is affixed.*

August 3, 1909.

17,909 GEIGER. Arc lamps.*
17,917 THOMPSON. Electrical terminals.
17,932 KAROLYI, KLUPATHY & BE[illegible]. Wireless [illegible] apparatus at a distance [illegible] 12/5/09.)*
17,960 FELTEN & GUILLEAUME-LAHMEYERWERKE AKT.-GES. [illegible] (Date applied for, 4/1/09.)*†

August 4, 1909.

18,005 SIEMENS BROS. & Co. [illegible] & HALSKE AKT.-GES. [illegible] Electric control of clocks.*
18,007 REINER. Trolley [illegible].
18,012 ZEE. Switches.*

August 5, 1909.

18,036 JEV[illegible] & GREE[illegible] [illegible].

August 6, 1909.

18,221 FIELD & FERRANTI. Electric switches and the like.

August 7, 1909.

18,224 HOEDT. Double-bulb incandescent electric globe lamp.
18,228 CONRADI & CONRADI. Electric connector plug.
18,268 DANNATT. Automatic electric switches and electricity meters.

August 9, 1909.

18,310 CLEMENTS. Electric advertising signs.
18,326 SIEMENS BROS. & Co. [illegible] (Addition to No. 9,592/09.)*

[illegible] Siemens Schuckertwerke G.m.b.H. Flame arc lamps. (Date applied for, 11 8/08.)*†
[illegible]
August 10, 1909
18.405 Hope-Jones. Electric clocks.
[illegible]
[illegible] (Date applied for 1 4/09.)*
[illegible] Bellamy & Jane. [illegible] movers.
[illegible] Siemens & Halske Akt.-Ges. [illegible] (Date applied for [illegible])*
[illegible] Lewis. E[illegible]

SPECIFICATIONS PUBLISHED.

1908 Specifications

[illegible] Thorpe. Electrolytic meters. (Post-dated 14/7/08.)
[illegible] Lohay. Electrical control of mechanism from a distance. (Date applied for, 16 7/07.)
[illegible] Schauli. Galvanic batteries.
[illegible] Siemens Bros. & Co. & Siemens & Halske Akt.-Ges. Electric [illegible] single line railway.
14.897 Breslauer. Compounding alternating-current generators. (Date applied for, 15 7 07.)
15.031 Bianco. Electrolytic galvanising process.
16.183 [illegible] Telephony and telegraphy.
16.462 O'Neil. Electric telegraphy.
16.546 Marconi & Marconi's Wireless Telegraph Co. Wireless telegraphy.
16.620 Parsons, Greaves & Hemsted. Electrical conductors.
16.704 Parsons & Law. Dynamoelectric machinery.
16.863 Hann. Electric or like conduit jointing.
16.911 Parsons & Parsons. Commutators for dynamoelectric machinery.
16.997 B.T.-H. Co. & Carter. Control of dynamoelectric machines.
17.159 Postans. Electric ignition devices.
17.211 Shears. Magnetic brakes for tramway and other vehicles.
17.283 Gray. Electric conductors.
17.315 Cox. Electrical switches.
17.505 Marconi & Marconi's Wireless Telegraph Co. Apparatus for wireless [illegible]

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

DIOPTRIC SIGN CO. (LTD.) (104,860.)—Reg. Sept. 6, capital £1,000 in £1 shares, to acquire from E. L. Warren, the benefit of certain existing inventions relating to an improved sign and to carry on the business of electrical engineers, metal workers, &c. Private company.

ELECTRICAL TROLLEY HEAD CO. (LTD.) (104,886.)—Reg. Sept 8, capital £6,000 in £1 shares, to adopt an agreement with J. T. Cherry and E. H. Clive for the acquisition of certain patents, and to carry on the business of electrical engineers, manufacturers of and dealers in electrical trolley heads, &c. First directors S. J. Harris and J. Griffin.

INTERNATIONAL FILAMENTS (LTD.) (104,923.)—Reg. Sept. 11, capital £20,000 in £1 shares, to acquire from Sir John W. Ottley, C. F. Call, H. Reynolds, J. Metcalfe, W. Stewart and M. Gregory, foreign and colonial rights and secret processes and inventions relating to the manufacture of metal filaments and electric incandescent lamps, and to carry on the business of electric, telegraph, telephone, mechanical and consulting engineers, manufacturers of and dealers in electric incandescent lamps and filaments, &c. Private company. First directors, W. Stewart and J. Metcalfe. Reg. office, 34-6, Gresham-street, London, E.C.

R. LASCELLES & CO. (LTD.) (104,853.)—Reg. Sept. 4, capital £1,000 in £1 shares, to adopt an agreement with R. Lascelles, and to carry on the business of mechanical, electrical and general engineers, manufacturers of and dealers in electric, telephonic and other apparatus, &c Private company. First directors, R. Lascelles and T. Figg.

NATIONAL ELECTRIC SIGNS CO. (LTD.) (7,267.)—Reg. in Edinburgh on Sept. 8, capital £2,000 in £1 shares, to acquire the rights to erect and use in Great Britain the German invention "Universal Licht-Reklame," and to carry on in the U.K. or elsewhere the business of general advertisers and contractors. First directors, F. Land, J. Barr and D. Graham. Reg. office, 112, Bath-street, Glasgow.

UNIVERSAL TRANSMISSION SYND. (LTD.) (104,894.)—Reg. Sept. 8, capital £71,000 in £1 shares, to adopt an agreement with Universal Transmission, F. H. Clergue and W. L. Harrison for the acquisition of the Williams-Janney-Waterbury tool patents and applications for patents in reference to certain inventions and improvements in power transmission devices, and to carry on business as manufacturers and suppliers of and dealers in machinery, plant, engines, appliances and apparatus, &c. Private company. First directors, H. S. Sugden and W. H. Lynch.

MORTGAGES AND CHARGES.

BRITISH ALUMINIUM CO. (LTD.)—Two mortgages, dated Aug. 20, to secure £73,930. 19s. 10d. each, supplemental to indentures dated July 17. Property charged, company's undertaking and property, including uncalled capital. Holders, (1) Wernher, Beit & Co. and (2) W. Morrison, H. Morrison and J. A. Morrison.

CHURCH STRETTON ELECTRIC SUPPLY CO. (LTD.)—Charge dated Aug. 28 to secure £100 (supplemental to charge dated March 17). Property charged, certain land at Church Stretton, Salop, with the generating works and other erections thereon, and a provisional order relating to the Urban District of Church Stretton, &c., assigned to the company under date May 18, 1904, by Church Stretton (Ltd.) Holder, E. Bond.

LODGE MUIRHEAD WIRELESS & GENERAL TELEGRAPHING SYND. (LTD.)—Particulars of £10,000 debentures created Aug. 20, 1909, filed, the amount of present issue being £7,6 0. Property charged, company's undertaking and property, including uncalled capital. No trustees.

REGENT ELECTRIC CO. (LTD.)—Particulars of £100 debentures, created Aug. 20, have been filed, the amount of present issue being £75. Property charged, company's property, including uncalled capital. No trustees.

RECEIVERSHIPS.

HEADLAND'S PATENT ELECTRIC STORAGE BATTERY CO. (LTD.)—G. D. Price ceased to act as receiver or manager on Sept. 6.

HUGGETT & WORTHINGTON (LTD.)—Notice of the appointment of B. Silcock, C.A., 6, Egypt street, Warrington, as receiver and manager by order of court dated Aug. 31, 1909, has been filed.

SIMPLIFIED UNDERGROUND CONDUCTOR CO. (LTD.)—J. A. S. Hassal ceased to act as receiver or manager on Aug. 31.

THOMAS R. MARTIN & CO. (LTD.)—Mr. C. Gray ceased to act as receiver and manager on Sept. 3.

CITY NOTES.

MEMORANDA (Sept. 16).—**Bank rate** $2\frac{1}{2}$ **per cent.** (since April 1, 1909). Price of silver, $23\frac{1}{16}$d. per oz. Consols $88\frac{7}{16}$—$88\frac{9}{16}$ for money and for account. Consols Pay Day, Oct. 1; Stock and Shares Continuation Days, Sept. 27 and Oct. 12; Ticket Days, Sept. 28 and Oct. 13; Pay Days, Sept. 29 and Oct. 14; Mining Shares Carry Over Days, Sept. 24 and Oct. 11.

Prices of Metals (London).—*Copper*, cash, $58\frac{5}{8}$; three months $59\frac{1}{8}$. *Lead*, English, $12\frac{15}{16}$—$13\frac{1}{4}$; foreign, cash, $12\frac{11}{16}$—$12\frac{3}{4}$; three months, $12\frac{7}{8}$. *Spelter*, cash, $22\frac{15}{16}$—23; three months $23\frac{1}{8}$—$23\frac{1}{4}$. *Tin*, English, 133—135; foreign, cash, $136\frac{3}{8}$; three months, $137\frac{3}{8}$. *Iron*, Cleveland, cash, 51/1, and three months, 51/10. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BRITISH ELECTROMOBILE CO. (LTD.)—The accounts for the year ended March 31 show an adverse balance of £204.

BRITISH THOMSON-HOUSTON CO.—At the meeting on Tuesday Mr. Geo. Franklin, who presided, moved the adoption of the report, which appeared in our last issue. The report was adopted.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)—The directors have declared an interim dividend at the rate of 4 per cent. (2s. per share) on the ordinary shares for the past half-year.

CANADIAN GENERAL ELECTRIC CO.—The directors have declared a dividend of $1\frac{3}{4}$ per cent. on the common stock for the three months ended 30th inst. (at the rate of 7 per cent. per annum).

POOLE & DISTRICT ELECTRIC TRACTION CO. (LTD). (in Liq.)—The report of the liquidators states that the liquidation of the company was commenced in July, 1905, but owing to the delay occasioned by the litigation with Bournemouth Corporation the liquidators have been unable to convene the final meeting. The total proceeds from the realisation of the assets amount to £137,880 and the disbursements to £136,600, or £3. 3s. per share, making £19. 3s in respect of each £10 share. The balance (£1,280) has been retained by the Board of Trade, £30 to meet outstanding dividend warrants, and £1,250 as remuneration of the liquidators, including payments to the British Electric Traction Co. for services and accommodation rendered during the four years over which the liquidation has extended and legal costs.

ROSARIO ELECTRIC CO. (LTD.)—Dividends have been declared of 3s. on the first and second (Nos. 1 to 1,500) preference shares and 34·3d. on Nos. 15,000 to 20,000 of the second preference shares.

SHAWINIGAN WATER & POWER CO.—A dividend of 1 per cent. has been declared for the quarter ended Sept. 30.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Sept. 22 a special settling day in and have granted a quotation to a further issue of £500,000 $4\frac{1}{2}$ per cent. perpetual consolidated debenture stock of the *British Columbia Electric Railway Co. (Ltd.)*, and have also ordered to be quoted £150,000 6 per cent. cumulative preference stock of the *Melbourne Electric Supply Co. (Ltd.)* (in lieu of preference shares of the Electric Lighting & Traction Co. of Australia, Ltd.), and £1,250,000 6 per cent. 50 year mortgage bonds of the *Mexico Tramways Co.* (in lieu of scrip now quoted). The committee have been asked to grant a quotation to a further issue of £175,000 5 per cent. mortgage debenture stock of the *British Aluminium Co. (Ltd.)*.

TORONTO RAILWAY CO.—A quarterly dividend of $1\frac{3}{4}$ per cent. has been declared.

UNITED ELECTRIC CAR CO. (LTD.)—Mr. Geo. Richardson stated at the meeting on Wednesday that the output, owing to the continued slackness in their special business, had been considerably below the capacity of the works and plant. Nevertheless, the net profit was £1,800 more than last year, and with the substantial amount brought forward, the directors felt justified in declaring a dividend of $2\frac{1}{2}$ per cent. on the ordinary shares, and £5,333 would be carried forward, against £6,187 last year. As to the prospects, he could only say they were obtaining a fair share of the orders given out, although such orders were small, and he regretted he could not see any immediate prospect of improvement. They were trying their best to dispose of the Hadley and Old Trafford premises, but trade had been so bad that no suitable offer had yet been received.

URBAN ELECTRIC SUPPLY CO. (LTD.)—The directors have declared a dividend of 2s. 6d. per share.

WINNIPEG ELECTRIC RAILWAY CO.—The directors announce a dividend of $2\frac{1}{2}$ per cent. for quarter ending 30th inst.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount. £	Inc. or Dec. (a) £	Aggregate No. of weeks.	Aggregate Amount. £	Aggregate Inc. or Dec. (a) £
Aberdeen Corporation	Sept. 8	1,491	+ 87	14	22,440	– 513
Airdrie	" 3	218	– 1	35	7,629	– 101
Anglo-Argentine	" 9	40,593	+ 2,724	36	1,403,092	+ 87,351
Ayr Corporation	" 11	330	+ 28	17	6,873	– 164
Baker St. & Waterloo Ry.	" 11	2,885	– 205	10	28,880	+ 415
Barnsley	" 3	173	+ 4	35	5,918	– 312
Barrow	" 3	257	– 16	35	8,162	– 621
Bath Electric Trams, Ltd.	" 8	900	+ 58	36	28,199	+ 1,358
Birmingham Corporation	" 11	6,434	+ 101	24	154,442	+ 3,786
Birmingham & Mid.	Aug. 27	830	– 37	34	28,613	+ 299
Blackburn Corporation	Sept. 8	1,152	+ 70	24	27,201	– 918
Blackpool and Fleetwood	" 11	1,504	+ 266	...	...	...
Bolton Corporation	" 12	2,369	+ 287	24	56,797	– 287
Bombay	Aug. 12	R38,529	+ R2,551	32	R1,200,485	+ R69,248
Bournemouth Corporation	Sept. 8	2,079	+ 25	23	42,541	+ 290
Bradford Corporation	" 11	4,896	+ 273	23	117,476	+ 2,750
Brighton Corporation	" 12	1,168	+ 116	24	25,591	+ 1,235
Bristol Trams & Carriage	" 10	5,546	+ 471	16	95,145	+ 4,509
Burnley Corporation	" 11	1,367	+ 128	24	30,985	+ 81
Burton Corporation	" 12	266	– 2	24	6,475	– 172
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	" 11	R51,036	+ R3,820	10	R495,668	+ R28,976
Camborne-Redruth	" 11	121	– 25	37	4,538	– 157
Cardiff Corporation	...	...	...	...	...	...
Cavehill	" 3	92	+ 8	35	3,151	– 129
Central London Railway	" 11	4,968	– 3,319	10	49,167	– 21,864
Charing C., Euston & H'stead	" 11	3,595	+ 205	10	36,285	+ 4,320
Chatham & Dist. Lt. Rys.	" 10	918	+ 16	39	29,618	+ 1,706
City & South London Rly.	" 12	3,203	+ 27	10	30,529	+ 1,197
City of Birmingham	" 3	2,789	+ 114	35	97,981	+ 989
Colchester Corporation	" 8	220	– 11	10	2,076	– 861
Cork Electric Trams Co.	" 9	511	+ 40	10	15,993	– 727
Croydon Corporation	" 3	1,714	+ 433	22	35,098	+ 1,682
Devonport & Dist. Trams	" 3	384	– 112	35	12,981	– 3,183
Dover Corporation	" 11	250	– 6	24	5,510	– 373
Dublin & Lucan Railway	" 10	138	– 12	10	1,699	+ 43
Dublin United	" 10	5,417	– 163	10	62,045	+ 962
Dudley-Stourbridge	" 3	892	+ 6	35	28,800	– 721
Dundee Corporation	" 8	1,207	– 84	†17	20,107	– 514
East Ham Council	" 11	1,011	+ 104	§23	24,129	+ 3,322
Exeter Corporation	" 10	363	– 8	24	7,974	+ 590
Gateshead & Dist. Trams	" 3	995	– 22	35	34,880	– 317
Glasgow Corporation	" 11	17,504	+ 402	‡15	248,976	– 2,976
Glossop Trams	" 11	119	– 13	37	4,516	– 134
Gravesend—Northfleet	" 3	245	+ 18	35	7,378	– 121
Great Northern & City Rly.	" 11	1,308	+ 7	10	12,436	– 41
Gt. Northern, Piccadilly, &c.	" 11	4,955	– 85	10	48,015	+ 540
Greenock & Port Glasgow	" 3	632	+ 84	35	19,361	+ 609
Hartlepool Tramways	" 3	265	– 6	35	8,242	– 229
Hastings Elec. Trams Co.	" 9	1,441	– 15	10	14,336	– 150
Hong Kong	" 11	$8,214	+ $125	...	...	...
Huddersfield Corpn.	" 11	1,685	+ 158	23	39,605	+ 1,155
Hull Corporation	" 11	2,639	+ 202	23	59,708	+ 1,892
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	" 8	136	– 6	23	3,205	– 199
Ipswich Corporation	" 11	482	+ 33	24	10,268	+ 172
Isle of Thanet Co.	" 11	1,143	– 1	§41	29,771	+ 481
Jarrow	" 3	123	+ 16	35	4,165	+ 335
Keighley Corporation	" 9	173	+ 20	23	4,080	+ 136
Kidderminster & District	" 3	143	+ 21	35	3,897	– 200
Kilmarnock Corporation	" 11	146	– 3	17	2,622	– 91
Lanarkshire Trams Co.	" 9	1,431	+ 252	36	46,225	– 449
Lancashire United	" 8	1,467	+ 169	36	48,085	– 403
Leamington	" 3	223	+ 42	35	6,200	+ 224
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	" 11	2,162	+ 32	10	22,657	– 177
Leith Corporation	" 11	621	+ 121	17	11,148	+ 1,439
Lincoln Corporation	" 11	116	...	24	2,998	+ 104
Liverpool Corporation	" 4	10,703	– 59	‖35	378,033	– 2,435
Liverpool Overhead Rly.	" 12	1,419	+ 28	‡11	16,206	+ 118
Llandudno & Colwyn Bay Ry	" 10	598	+ 141	41	11,982	+ 2,048
*London County Council	Aug. 28	36,667	+ 3,501	§21	784,193	+ 29,701
London United	Sept. 11	6,479	– 1,178	‖21	223,065	– 21,967
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	" 11	217	– 3	23	4,572	– 287
Manchester Corporation	" 11	15,631	+ 334	24	358,737	– 2,871
Mersey Railway	" 11	1,946	+ 116	10	19,092	+ 686
Merthyr	" 3	219	– 4	35	7,539	+ 99
Metropolitan Dist. Railway	" 11	9,253	+ 40	10	93,446	+ 5,540
Metropolitan Elec. Trams	" 3	7,017	+ 1,078	35	216,785	+ 17,613
Middleton	" 3	368	+ 13	35	11,996	– 936
Nelson Corporation	...	...	...	...	...	...
Newcastle-on-Tyne Corp.	" 11	3,750	+ 2	23	91,940	– 1,159
Newport (Mon.)	" 11	634	– 7	24	16,065	– 314
Northampton Corporation	" 10	485	+ 16	§24	11,778	+ 308
Oldham, Ashton & Hyde	" 3	597	– 22	35	19,703	– 1,240
Oldham Corporation	" 12	1,735	– 130	†25	46,276	– 3,403
Perth (N.B.) Corporation	" 8	156	+ 1	§16	2,802	+ 2
Perth (W.A.) Elec. Trams	" 10	1,318	+ 61	36	50,582	+ 330
Peterborough	" 3	128	– 7	35	4,171	– 337
Portsmouth Corporation	...	...	...	...	...	...
Potteries	" 3	1,828	– 2	35	61,892	– 1,287
Preston Corporation	" 8	783	+ 18	10	7,740	– 39
Rotherham Corporation	" 9	582	– 43	23	13,867	– 635
Rothesay	" 3	371	+ 42	35	8,411	– 87
Salford Corporation	" 13	4,553	+ 90	‡24	110,304	– 3,333
Sheerness	" 3	67	– 3	35	1,820	– 234
Sheffield Corporation	" 12	5,500	+ 79	§24	137,258	– 1,157
Singapore Trams	" 11	$10,321	+ $674	...	...	...
South Metropolitan	" 3	942	+ 144	35	28,170	– 250
South Staffs	" 3	859	– 25	35	29,359	– 1,470
Southend Corporation	" 8	709	+ 76	23	14,301	+ 2,190
Southport Tramways	" 3	355	+ 16	35	10,430	– 295
Stalyb'dge, Hyde, &c., Jt. Bd.	" 11	791	+ 32	§23	18,593	– 650
Sunderland Corporation	" 12	1,091	– 74	24	28,240	– 1,014
Sunderland District	" 8	473	+ 23	45	20,759	– 892
Swansea Trams	" 3	1,087	+ 94	35	33,921	+ 679
Swindon Corporation	...	...	...	...	...	...
Taunton	" 3	57	+ 11	35	1,417	– 44
Tynemouth and District	" 3	368	+ 88	35	9,098	+ 652
Tyneside Trams Co.	" 8	437	+ 46	10	4,704	+ 268
Wallasey District Council	" 11	971	+ 36	§23	22,989	+ 560
Walsall Corpn.	" 11	514	– 16	36	18,470	– 1,192
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	" 2	2,412	+ 294	22	53,188	+ 3,377
Weston-super-Mare	" 3	363	+ 55	35	5,893	+ 319
Wolverhampton Co.	" 3	420	– 14	35	14,695	– 1,325
Wolverhampton Corpn.	" 8	776	– 13	10	8,163	– 335
*Worcester	" 3	319	+ 10	35	9,874	– 61
Wrexham	" 3	111	– 1	35	3,446	– 149
Yorkshire W.R. Trams	" 12	1,199	+ 7	37	43,971	...
Yorkshire Woollen District	" 3	1,022	+ 95	35	31,882	– 288

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shre.	Last Dividend	Name	Price Wed., Sept. 15.	Rate % Yielded £ s. d.	Dividend Due.	Business Week to Sept. 15 Highest	Lowest
		ELECTRICITY SUPPLY.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8½ –[illegible]	6 0 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½ –10	4 ? 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9½ –10	6 0 0	Feb, Aug	10.	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 –104	4 6 6	Jan, July	103	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½ –4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 –96	4 16 0	May, Nov	..	..
5	1/6	Brompton & Kensington Elec. Sup. Ord.	7¼ –7¾	6 ? 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7¾ –8	4 8 0	Mar, Sept	..	..
St.	4%	Central Elec Sup. Co. 4% Guar. Deb. Stock	97 –100	4 0 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4¼ –4½	5 16 6	Feb, Aug	4	–
5	2/3	Do. 4½ per Cent. Pref.	4¼ –4¾	4 10 0	Feb, Aug	..	–
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 –99	4 1 0	Jan, July	9?	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99½ –101½	4 ? 6	..	10?½	..
5	2/8	Do. City Undertaking 4½% Cm. Pref.	3¾ –4¼	5 2 6	Jan, July	4½	..
5	2/0	†Chelsea Electric Supply Ord.	3½ –4	4 10 0	March ..	3..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 –103	4 7 0	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord.	10½ –1?½	5 10 0	Feb, Aug	10½	..
10	6/0	Do. 6 per Cent. Cum. Pref.	1?½ –12	4 11 9	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 –124	4 0 ?	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 –103	4 7 6	Jan, July	102½	..
5	..	County of Durham Elec. P. D. Ord.	½ –2		April, Oct		
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 –3½	3 14 1	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7½ –8½	6 3 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½ –11	5 ? 0	Mar, Sept	10?	...
St.	4½%	Do. 4½% Deb. Stock (red.)	104 –107	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 –103	4 7 6	May, Nov	101½	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ –5	5 10 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 –100	4 ? 9	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7½ –7¾	5 11 6	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	6¾ –7¼	5 12 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	5¾ –6¾	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 –98	4 2 0	..	–	–
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 –101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85 –89	5 1 0	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞ –2⅛	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 –5¼	5 14 0	Mar, Sept	5	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 –97	4 2 ?	Jan, July	9?½	..
5	2/6	Metropolitan Electric Sup. Ord.	4¼ –4¾	5 13 0	April, Oct	4½	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¾ –5	4 19 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 –108	4 2 8	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ –85½	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Db.	96 –99	4 11 0	June, Dec	..	..
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	5¾ –6¼	3 12 9	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	8? –8?	5 4 5	Jan, July	..	..
5	..	Newcastle Elec. Supply Ord.	4½ –4¾		Feb, Aug	1¾	–
5	5%	Do. 5 per Cent. non Cum. Pref.	4½ –5	5 0 0	Feb, Aug	..	–
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 –98	4 1 8	Jan, July	..	–
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 –101	4 1 8	..	..	..
1	3%	Northern Counties Elec. Sup.	—		Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 –91	5 0 0	Jan, July	..	..
10	6/0	Notting Hill Electric Ord.	12 –13	5 8 0	March ..	12½	1
5	2 6	†Oxford Electric Ord.	6 –5½	5 8 0	March ..	..	–
St.	4%	Do. 4 per Cent. Deb. Stock	95 –98	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8½ –9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 –7½	4 13 4	Feb, Aug	–	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 –88	3 19 6	Jan, July	–	..
5	..	Smithfield Markets Electric Sup. Ord.	[illegible]		Feb	..	
5	4/0	South London Electric Supply Ord.	2⅝ –3	6 16 0	April	2¾	2¾
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 –103	4 17 0	–	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	–
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	1⅛ –1¼	5 12 0	Feb, Aug	.	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	102 –105	4 6 0	April, Oct	103	–
5	2/6	Urban Electric Supply Ord.	½ –1	–	April, Oct	–	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1⅞ –2	..	April, Oct	..	–
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	77 –81	5 11 6	April, Oct	..	
5	5/0	Westminster Elec. Sup. Ord.	8½ –9	5 11 0	Mar, Sept	8¾	8.
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 –5⅝	4 3 8	Jan, July	5⅝	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	99 –101	3 19 0	Jan, July	99½	..
1	..	Bath Elec. Trams Pref. Ord.	¼ –⅜	..	April	..	.
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	–
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	87 –91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	87 –90	5 0 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8 –8½	7 2 6	Feb, Aug	..	–
10	4%	Do. Cum. Pref. (fully paid)	8 –8¼	4 14 0	..	..	–
St.	4%	Do. 4 per Cent. Debs.	100 101	3 19 0	Feb, Aug	..	–
10	..	British Electric Traction Ord.	[illegible]	.	June, Dec	1	–
10	8/0	Do. 6 per Cent. Cum. Pref.	2 –2½	12 0 0	Feb, Aug	.	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	84 –87	5 15 0	April, Oct	85½	85
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 –67	6 14 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	61 –63	4 15 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	85 –87	4 12 0	Feb, Aug	85½	85
St.	2½%	Do. Deferred Stock	44 –45	5 11 0	Feb	.	..
100	4%	Do. 4 per Cent. Debs.	101 –103	3 18 0	Jan, July	103	102
St.	4%	Charing X, Euston & H'mpstd Per Db. Stk.	94 –96	4 3 6	Jan, July	95½	94½
5	2/6	City of Birmingham Trams. 5% Cum. Pref.	4½ –5½	4 15 9	April, Oct	..	.
100	4%	Do. 4 per Cent. 1st Mort. Debs	97 –101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	31 –33	4 15 0	Feb, Aug	3..	..
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	108 –110	4 11 0	Feb, Aug	..	..
St.	5%	Do. (1896)	104 –107	4 15 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100 –103	5 2 0	Feb, Aug	.	..
St.	5%	Do. (1903)	96 –100	5 0 0	Feb, Aug	100	–
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 –102	3 18 0	May, Nov	..	..
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12½ –13½	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ –1	..	Feb, Aug	..	..
10	–	G. Northern, Picc. & Brompton 4% G. Pf.	3 –3½	–	Feb, Aug	.	
St.	4%	Do. 4 per Cent. Deb. Stock	95 –98	4 2 6	Jan, July	95½	95
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¾ –2	..	Mar, Sept	..	..
St.	4½%	Do. 4½ Db. St.	76 –81	5 11 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 –4½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 –6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80 –83	5 10 0	Jan, July	..	–
5	1/3	I. of Thanet E. T. & Lt. 6 per Cent. Pref.	⅞ –1⅛	.	Mar, Sept	..	–
St.	4%	Do. 4 per Cent. Deb. Stock	58 –63	6 7 0	Jan, July	..	–
10	5/0	Lanarkshire Tramways	9¾ –10	5 15 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ –90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	–	–
10	5%	Do. 5 per Cent. Pref.	6 –5	8 6 8	Feb, Aug	–	–
St.	4%	Do. 4 per Cent. Deb.	82 –84	4 15 3	Jan, July	–	..
10	2/0	London United Trams. 5% Cum. Pref.	2½ –2¾	..	Jan, July	2½	2¾
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 –70	5 14 0	Jan, July	..	..
St.	–	Mersey Con. Ord. Stock	1 –2	–	Feb, Aug.	..	..
1	10⅝	Metropolitan Elec. Tramways Ord.	[illegible]	–	..		½
1	–	Do. Deferred	[illegible]	..	April..	8d.	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 1 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 –95	4 14 0	Jan, July	94¾	94
St.	1%	Metropolitan Railway Consolidated	37¾ –38¼	1 5 6	Feb, Aug	38½	37½
St.	2¾%	Do. Surplus Lands Stocks	65 –67	4 5 6	Feb, Aug	65½	65½
St.	3½%	Do. 3½ per Cent. Preference	89 –91	3 16 9	Feb, Aug	89½	...
St	3½%	Do. 3½ per Cent. "A" Preference	86 –88	3 19 0	Feb, Aug	87½	86½
St.	3½%	Do. 3½ per Cent. Convertible Pref.	85 –87	4 0 6	Feb, Aug	86	85
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 –94	3 14 6	Jan, July	93½	93

In calculating the yield allowance has been made for accrued interest but not for redemption.

* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shares.	Last Dividend.	NAME.	Price Wed., Sept. 15.	Rate % Yield-ed.	Dividend Due.	Business Week to Sept. 15 Highest.	Lowest.
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*		£ s. d.			
St.	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 3	Jan, July	92½	91¼
St.	..	Metropolitan District Railway Ord.	15½—16½	—	Feb, Aug	16	15
St.	..	Do. Extension Pref. (5 per Cent.)	48 —50	..	Feb, Aug	49½	48
St.	3½	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	66 —68	5 3 6	Feb, Aug	67½	67
St.	3½	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	..	..
St.	4½	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	3½	Do. Guar. Stock 4 per Cent.	94 —97	4 2 6	Mar, Sept	90½	90½
St.	6	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9	Jan, July	143½	..
St.	4	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	96	95½
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅛—⅜	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—⅜	—	April, Oct	..	—
1	1/6	Do. 5 per Cent. Cum. Pref.	⅝—⅞	6 14 0	Feb, Aug	..	—
St.	4½	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	—
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	..
St.	4½	Do. 4 per Cent. Deb. Stock	70 —74	5 8 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db.	81 —85	5 18 0	Jan, July	..	..
..	..	UndergdE.Rys.Lon.6 In.bds.with coup.3	36 —38	..	June, Dec	37	36
..	5	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103	—
..	4½	Do. 4½% Bonds with coup. 3	88 —90	5 0 0	..	89½	—
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	⅜—⅝	—	March ..	—	—
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	..	—	—
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
St.	..	Anchor Cable Co. 4½% Deb. Stock	102 —104	—	..	102	—
1	..	Aron Electricity Meter Ord.	⅛—¼	..	..	..	..
1	1/4½	Do. 6% Cum. Pf.	⅞—⅞	6 17 0	April, Oct	—	..
1	2/4½	Babcock & Wilcox Ord.	4⅛—4⅜	4 12 0	April, Oct	2⅛	2⅛
1	0/7½	Do. Pref.	1⅛—1⅜	4 0 0	..	..	..
5	4/0	†British Insulated & Helsby Cables Ord.	7½—7⅞	6 11 0	July, Feb	7⅞	..
5	3/0	Do. 6 per Cent. Pref.	6⅜—6⅝	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	89 —94	4 16 0	Mar, Sept	..	..
5	—	British Westinghouse 6 per Cent. Pref.	⅛—⅛	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0	..	98½	98
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	40	39½
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	41 —45	9 18 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con.Ord.	1⅝—11½	5 17 9	Jan, July	10⅝	10½
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜—5¾	4 7 0	Jan, July	5½	5⅜
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	2 —2¼	5 18 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	106 —109	4 2 6	Feb, Aug	—	—
	1 0/0	Chadburn's (Ship) Telegraph Ord.	1⅝—1⅞	6 11 9	March ..	..	—
	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	5 6 6	April, Oct	..	—
1	0/7½	Consolidated Electrical Co.	⅞—⅞	7 0 0	August ..	..	—
1	1/0	Consolidated Signal Co.	1⅛—1⅜	9 8 0	April, Oct	..	—
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1	6 0 0	April, Oct	..	—
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	⅞—1⅛	13 7 0	Jan, July	..	—
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	90 —93	5 7 6	Jan, July	..	—
1	0/7½	†Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1⅛	7 12 0	Sept	..	—
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	4 15 3	Sept	..	—
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	—
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅛	..	Feb, Aug	..	—
5	2/6	Do. (£5 paid)	1 —1¼	9 3 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	—
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	—
	..	Edmundson's Elec. Corp. Ord.	⅛—⅛	..	Jan, July	..	—
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	—
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 0 0	Jan, July	..	—
2	..	Electric Construction Co.	⅞—1⅛	..	Jan, July	⅛	—
2	2/9	Do. 7 per Cent. Cum. Pref.	1⅛—1⅛	9 16 0	July	..	—
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	65 —69	5 16 0	Jan, July	..	—
St.	5	Ferranti Ltd. 5 per Cent. (1900) 5% 1st Mt.Db.St.	71 —77	6 10 0	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅞—8¼	6 1 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.	12⅝—13⅜	5 12 0	Feb, Aug	13	..
5	2/3	Do. 4½ per Cent. Pref.	5½—6⅜	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14⅜—15⅜	6 9 9	Feb, Aug	14	..
10	5/4	Do. 5 per Cent. Cum. Pref.	10¼—10⅝	..	..	10⅝	..
100	4%	Do. 4 per Cent. Debs. (red.)	100 —102	3 19 0	April, Oct	..	..
1	—	National Elec. Construction Co.	⅜—⅝	..	April......	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	..	May, Nov	⅛	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	82 —85	5 5 0	Jan, July	82½	..
5	..	Simplex Conduits Ord.	1½	—	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	..	..	..
12	12/0	Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	35½	34⅞
100	4%	Do. 4 per Cent Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd. Ord.	2⅛—2⅜	4 7 0	—	2⅛	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1¼	4 0 0	—	1⅛	1⅛
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 —117	4 5 3	—	116	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102—104	3 16 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	105	—
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 6	..	107	106½
10	8%	J. G. White & Co. 6% Cm. Pref.	10—11	7 5 4	..	..	..
1	1/0	Willans & Robinson Ord.	⅞—⅞	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅞—3⅛	9 12 0	Apr, Oct	2½	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3⅜	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	95 —96	5 4 0	June, Dec	..	—
St.	15/0	Anglo-American	61—63	5 3 0	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	104—105	5 15 0	F,My,Ag,N	104½	103¾
St.	8/0	Do. Deferred	21—21⅞	1 17 6	F,My,Ag,N	21	20⅞
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	91	..
10	6/0	Cuba Submarine Ord.	5⅛—5⅛	6 9 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 9	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3 —3½	5 14 0	April, Oct	—	..
5	5/0	Do. 10 per Cent. Cum. Pref.	5⅛—5⅞	5 19 0	April, Oct	—	..
50	4½%	Do. 4½ per Cent. Deb.	100—102%	4 8 0	Jan, July	..	..
20	5/0	Direct United States Cable	13 —13½	6 6 0	Ja,Ap,Jy,O	13⅛	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	129 —132	5 6 6	Ja,My,Jy,O	130	129½
St.	17/6	Do. 3½ per Cent. Pref. Stock	84½—86½	4 1 0	Ja,My,Jy,O	86	85½
St.	4	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	105½	105
10	2/6	Eastern Extension	11⅝—12⅛	5 14 0	Ja,Ap,Jy,O	12⅛	11⅞
St.	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	..	..
20	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	4 8 0	May, Nov	..	..
25	7/0	G. N. of Copenhagen), with Coupon 77	26 —27	6 13 6	Jan, July	26½	26¼
100	4½	Halifax & Bermudas 4½% 1st Mt. Db. (red.)	100 —102	4 9 0	June, Dec	..	..
..	52/6	Indo-European etc. all	61½—63½	5 16 9	May, Nov	63	62½
..	$1	†Mackay Companies Common	80 —85	4 14 0	Ja,Ap,Jy,O	—	—
..	$1	Do. Preference	75 —77	5 4 0	Ja,Ap,Jy,O	—	—
1	..	Marconi's Wireless Teleg. Co.	⅞—⅞	..	April	⅞	..
100	..	Pacific & European Tel.4%Guar.Dbs.(red.)	100 —102	3 18 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	4 3 0	May	1⅛	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅛—⅞	..	May, Nov	⅛	⅛
10	6/0	Do. 6 per Cent. 1st Pref	8⅛—8⅞	6 15 0	May, Nov	8¼	8¼
10	6/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5	Do. 5 per Cent. Debs.	101 —108	4 17 0	Jan, July	..	..
1	3/0	Western Telegraph	13½—13¾	5 2 0	Mr,Jn,S,D	—	..
St.	4	Do. 4 per Cent. Deb. Stock (red.)	103 —105	3 16 0	June, Dec	—	..
—	4	Western Union Telegh. $1 000 4% Bonds	105 —107	3 14 9	..	..	..

Shares.	Last Dividend.	NAME.	Price Wed., Sept. 15	Rate % Yield-ed.	Dividend Due.	Business Week to Sept. High-est.	Low-est.
		TELEPHONES.		£ s. d.			
100	2⅝	Amer. Telephn. & Telegh. Cap. St.	147 —149	5 6 8	..	147⅞	1
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	96 —98	4 2 0	Jan, July	—	
St.	5%	*Anglo-Portug'se Tel. 6% 1st Mt. Db. Stk.	101 —103	4 17 0	Mar, Sept	..	
5	5 0	Chili Telephone	8 —8⅜	4 15 6	August ..	..	
1	0/7½	Monte Video Telephone Ord.	7⅛—⅞	6 17 0	Nov	⅞	
1	0/6	Do. 5 per Cent. Pref.	⅞—⅞	5 14 0	May, Nov	..	
St.	6%	National Co. Pref. Stock	106 —107½	5 11 6	Feb, Aug	107½	1
St.	6%	Do. Def. Stock	121 —123	4 17 6	Feb, Aug	122	1
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—10⅞	5 9 0	Feb, Aug	10⅛	
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10⅛—10⅞	5 9 0	Feb, Aug	..	
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅛	4 8 0	Feb, Aug	..	
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	99½	
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	
1	1/0	Oriental	1⅛—1⅛	5 6 0	April, Oct	..	
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	4 15 3	April, Oct	..	
St.	4%	Do. 4 per Cent. Red. Deb. Stock	83 —85	4 11 0	Jan, July	85½	
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100½—100½	4 8 6	Jan, July	..	
5	5/0	United River Plate	6 —7	5 10 0	July	7	
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	June, Dec	..	
St	4½%	Do 4½ Deb. St. Red.	104 —106	4 5 6	Jan, July	105½	
		FINANCIAL INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..	
10	5/6	Globe Telegraph & Trust	10⅛—10⅜	6 7 0	SpDcMrJu	10⅛	1
10	3/0	Do. 6 per Cent. Pref.	13⅞—14⅛	4 4 0	SpDcMrJu	14	1
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	131	
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	—	Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅞	5 2 6	April, Oct	4⅛	
5	—	Do. 6% Cum. 2nd Pref.	4⅛—4⅜	5 4 0	Jan, July	..	
St.	4%	Do. 4% Deb. Stock	93½—93¾	4 5 6	June, Dec	93½	
St	..	Do. 4½% Deb. Stock	97 —99	..	..	98½	
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	102½	
5	3 6	Brisbane Electric Trams. Invest. Ord.	6⅞—7	4 6 0	May	6⅞	
5	2 6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	..	
St.	8%	Brit Columbia El.Ry.Df. Ord. ex rights	142 —147	5 9 0	Mar, Sept	143	
St.	6%	Do. Pref. Ord. Stock ex rights	114 —119	5 1 0	May, Nov	117½	
St.	5%	Do. 5% Cum. Perp. Pref. Stock	105 —109	4 11 9	Jan, July	108	
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	
100	4½%	Do. Vancouver Power Debs.	102 —106	4 5 6	Jan, July	103	
St.	4½%	†Do. 4½% Perp Con. Deb. St.	101 —103	4 2 6	..	104	
St.	6%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	—	
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	91 —95	6 6 0	Feb, Aug	..	
5	2/0	Calcutta Tramways (1 to 137,610)	4⅞—5⅛	3 16 0	Mar, Sept	6	
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5	5 0 0	Jan, July	..	
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	—	
St.	..	Cape Electric Tram Shares	⅛—⅛	..	..	..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅛	4 1 6	F,My,A,N	5⅛	
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..	
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	92 —96	5 4 0	Feb, Aug	—	
1	..	Kalgoorlie Elec. Trams Sh.	⅛—⅜	..	..	..	
100	5%	Do. 5 per Cent. "A" Deb. Stock	91 —94	5 6 0	Jan, July	..	
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 12 0	Jan, July	..	
5	1/0	Lisbon Elec. Trams. Ord.	⅞—1⅛	4 4 9	July	..	
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 1 0	Jan, July	—	
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	98 —102	4 18 0	Jan, July	—	
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	92 —95	5 2 0	Jan, July	..	
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 3 0	Feb, Aug	..	
100	$1½	Mexico Trams Co Com. St.	125 —128	3 18 0	..	129½	
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	90 —93	5 7 6	..	94⅛	
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	
St.	4½%	Do. do. (Nos. 1 to 4,000)	102 —104	4 6 6	..	..	
1	0/6	Perth Elec. Trams Ord.	⅞—⅞	8 0 0	May	—	
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	101½	
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅞—5⅞	5 4 8	..	..	
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	—	
100	..	Rio Janeiro Tram. Lt. & P. Co.	91 —93	..	..	93½	
..	5%	Do. 30 yr. Gold Bnds.	94 —96%	5 4 6	..	95½	
100	5%	Do. 50 yr. Mt. Bnds.	86 —87	5 16 0	—	86½	
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —150	6 6 9	..	—	
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103%	4 17 0	June, Dec	102½	1
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	99½	
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅞—5⅛	5 17 6	Mar, Sept	..	
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9½—10	6 0 9	..	—	
St.	4½%	Do 4½ per Cent. Deb. Stk. (red.)	94 —96	4 14 0	Jan, July	95	
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	93½—95½	..	..	94½	
5	4/0	Calcutta Elec. Supply Ord.	6⅛—6⅜	6 1 0	April, Oct	6⅛	
100	$1½	Canadian Gen. Elec. Co. Com. St.	122 —127	5 13 0	..	128½	1
100	$3½	Do. 7% Cm. Pf. Stock	119½—121½	5 15 0	..	120½	
100	6%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	
500	5%	Elect. Development Co of Ontario	84 —86	5 16 0	..	84⅛	
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	—	
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	
10s	1/-	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—⅛	..	..	—	
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—5⅛	6 18 3	April, Oct	—	
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	76 —80	6 5 0	April, Oct	—	
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	80 —82½	6 2 0	..	83	
St.	$1	Mexican Lt. & Power Co. Com. St.	69 —73	6 2 6	..	72½	
500	5%	Do. 5% 1st Mort. Gold Bnds.	85 —88	5 19 0	—	85⅛	
100	$1	Montreal Lt. Ht. & Power Co. Cap. St.	127 —131	4 15 0	F,My,A,N	..	
1	1/⅛	River Plate Electricity Co. Ord.	1⅛—1⅞	5 11 0	April	..	
1	1/2⅞	Do. 6 per Cent. non-Cum. Pref	1 —1⅛	5 6 6	May	..	
St.	5%	Do. 5 per Cent. Deb. Stock	103 —106	4 14 0	Jan, July	..	
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⅞—5⅞	5 5 3	April, Oct	..	
5	3/0	Do. 2nd Pref.	5⅛—6	5 0 0	—	5⅞	
100	$1	Shawinigan Water & Power Co. Ca	97 —99	4 1 0	—	99	
..	5%	Do. 5 per Cent. Bds.	105 —107	4 13 6	Jan, July	106½	
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	98½—99½	4 10 6	—	99½	
St.	4½	Toronto Power Co. 4½ Db. St.	99½—100½	4 9 6	..	99½	
..	6d.	Victoria Falls Power Co. Pref.	2⅞—3⅛	5 14 9	Jan, July	..	
1	..	Do. 16/- paid	1⅛—1⅜	..	—	..	

* In calculating the yields allowance has been made for accrued interest but not for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote the

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.

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Accumulators and Power Work

THE history of the application of the accumulator to serious electrical engineering work is not without its element of romance, for while at its birth great things were expected of it, it long suffered a period of almost complete eclipse, and it is only in recent years that the importance of the role which it can play in modern power-station design has become fully recognised. This state of affairs has not been reached without a good deal of hard work on the part of the battery makers, and it will doubtless be conceded that they have, by patient laboratory experiments and attention to the purity of the raw material, succeeded in eliminating the majority of the drawbacks to the use of the accumulator. And the question of the installation of accumulators in stations where the load fluctuates between wide limits, and where to instal generators to deal with these peaks would mean the sacrifice of economy, is worthy of serious consideration.

As an illustration of these remarks, we may give some figures supplied us by the D.P. Battery Co., of Bakewell, which exemplify the saving in fuel resulting from the installation of batteries in a station that had been running several years. This plant consisted of Diesel engines direct coupled to 100 kw. generators, and the battery was of the D.P. make, and capable of discharging 240 amperes for three hours. The load was formed by a tramway, the mean being 150 amperes, with peaks of 400 amperes. It was found that without the battery 10·2 units could be generated per gallon of oil used, while after the battery had been installed this figure became 12·3 units, or an increase of 20 per cent. in output for the same fuel. The reduction of the fuel bill amounted to 18 per cent. over the course of a year after the battery had been installed, the output of the station being practically the same.

Such an example is by no means unique, and we are informed by the D.P. Battery Co. that a proportionate saving can be effected in any station under similar conditions of working. Further, a large field for the use of accumulators is to be found in sub-stations, where the installation of a battery means, it is claimed, a reduction in the size of the feeders, or with the same sized feeders power can be transmitted over proportionally longer distances. The installation of batteries in sub-stations may, in fact, postpone for some years the necessity for feeder extensions.

The application of the above considerations in practice is well illustrated in a plant which has recently been installed at Southampton. The installation consists of electrical cranes, which have replaced the hydraulic cranes previously employed. They are equipped with grabs of a special type, with a capacity of $1\frac{1}{2}$ tons, and are capable of loading and unloading at an average rate of 1 ton per minute. The cranes, when working simultaneously, take an average current of 250 amperes, at a line voltage of 500 to 525 volts. The consumption per ton is about 0·5 unit.

The current fluctuations are necessarily severe with this type of work, and vary from 0 to 800 amperes. With the aid, however, of a D.P. battery and reversible booster this load is very successfully dealt with by one 150 H.P. producer gas engine, another similar engine being in reserve. The engines are direct coupled to generators capable of an output of 192 amperes at 520 volts, with a 15 per cent.

Fig. 1.—Cranes Working in Connection with a D.P. Battery at Southampton Docks.

overload for half an hour. The coal consumption with the engines working at full load is 1·5 lb. per kilowatt-hour.

The battery consists of 245 cells of the D.P. Battery Co.'s standard "L.S." 15-plate type, in wood lead-lined boxes, capable of discharging at 500 amperes for one hour or at 1,000 amperes for short periods. The positive plates are about ½ in. thick, and are very solidly constructed to stand the heavy rates of charge and discharge. The formation of the plates is effected by the D.P. Battery Co.'s special Planté process, and consists of a thin hard skin, which is practically proof against disintegration—a very necessary qualification with a load such as the one in question. The battery is erected on single-tier stands, mounted on concrete blocks. The booster, made by the Lancashire Dynamo & Motor Co., is so adjusted that the engines can be set at any desired load, and all variations above or below this load are taken up by the battery and booster. From the records taken at this station the value of the services rendered by the battery and reversible booster can be clearly appreciated, as, with the line load fluctuating from zero to 800 amperes, the variation in the generator load is only about 15 amperes above and below the mean.

The connections of the switchboard are so arranged that (1) the battery can be put on the line by itself; (2) the battery and booster can take the load without the generators, the booster being adjusted so as to give an over-compounding effect; (3) the battery and booster can be put on to the line in parallel with one or both engines, one engine being the normal running condition of things. In the unlikely event of both sets being temporarily disabled, the battery could keep all the cranes going for over three hours; thus the station is amply safeguarded against an interruption of supply.

The cranes and generating plant described above are shown in the accompanying illustrations.

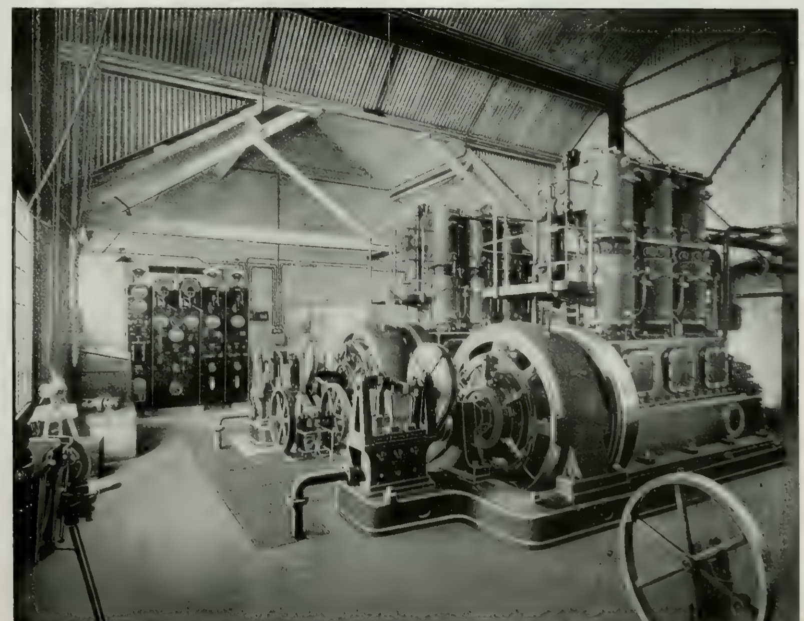

Fig. 2.—Generating Sets and Switchboard at Southampton.

The Eyquem Electric Lighting Set. . . .

THE persistent use of the motor car under a number of various conditions practically requires that some form of artificial illumination should be installed. And in this luxurious age it is not surprising that electric light should be requisitioned, and that special apparatus should be designed to make its use possible. The installation under notice, which is named as in the title, and which is made by the United Motor Industries of London, consists of a dynamo driven off the engine and a battery of accumulators with a pressure of about 12 volts. The fittings comprise a combined ammeter and voltmeter, two parabolic head lights, two side lights, a tail light, a roof light for an enclosed car, an electric signal for the driver, a lubricator and pressure gauge light, a Wagner horn, and last, but by no means least, a cigar lighter.

The dynamo is of sound design and is arranged to run sparklessly, while a regulating device on the governor principle is carried on the shaft and runs at the speed of the armature. By the use of this regulator it is claimed the success of this system is assured as the accumulators are charged whenever the speed of the engine exceeds a certain predetermined limit.

The lamps used on this equipment are of the metallic filament type, and owing to the fact that special parabolic reflectors are used the light obtained is ample; and naturally much better control is obtained over them than if acetylene or oil were employed. The cost of this set, both at first and for upkeep, is small, while the weight of equipment, including the battery, is only 52 lb.

The ammeter fitted should be of special interest. It has two scales showing the discharging and charging currents respectively, so that exactly what is going on at any particular time can easily be seen.

Sun Switches and Fuses.

SOME interesting apparatus in the way of switchgear has recently been placed on the market by the Sun Electrical Co., of London. These new switches, in fact, combine all the detail of this firm's well-known apparatus with a very useful cheapness. Their neat and compact appearance will be gathered from the accompanying illustrations

The "Sun" Ironclad switch, which we illustrate in Fig. 1, is of an improved pattern and has been introduced to meet the pressing demand for a good ironclad switch at a low price. It must not be thought, however, that this cheapness is obtained by skimping the material used, or by careless work. It is in fact obtained by simplifying the design and thus reducing to a minimum the number of parts required. The switch is of the double-pole knife pattern, and is suitable for use on circuits whose pressures do not exceed 500 volts. It is made in five sizes, having capacities of 20, 30, 50, 75 and 100 amperes respectively. An extremely quick and long break is obtained by the use of a strong pull-off spring, which comes into action as soon as the blades leave the jaws of the top contacts. By means

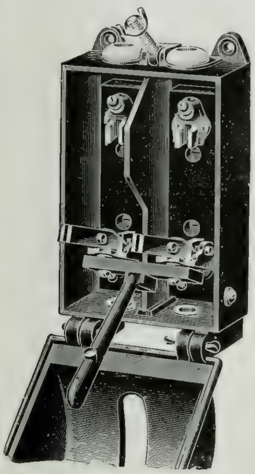

Fig. 1.—"Sun" Ironclad Switch.

of this arrangement it is claimed that the switch under any conditions cannot be left in an intermediate position. All the working parts are well insulated and the case is asbestos lined. The poles through which the cables are

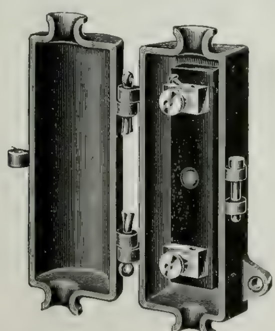

Fig. 2.—"Sun" Ironclad Service Fuse.

introduced to the terminals are fitted with insulating bushes, and an earthing terminal is provided.

Fig. 2 illustrates a piece of apparatus known as the "Sun" ironclad service fuse. This fuse is designed to compete with a number of other similar pieces of apparatus that are at present on the market. It can be used with fuses of the strip or wire type on circuits whose pressure does not exceed 250 volts, or with cartridge type fuses on circuits with pressures up to 500 volts. The terminals are large, containing plenty of metal, and of ample capacity, and are mounted on slate bases. The iron case is asbestos lined and is fitted with a sealing pin and earthing terminal.

Another similar piece of apparatus which the Sun Electrical Co. are manufacturing is an interlocked ironclad double pole fuse. This fuse box is so arranged that it is impossible to get at two fuses at one and the same time. The opening of the door of one fuse automatically locks the door of the other fuse. These fuses are made in sizes capable of taking currents up to 25 amperes at a voltage of 500.

Crane Motors and Controllers

To design an efficient crane motor it is necessary to take into account a number of opposing factors, and though it might at first be thought that this type of motor had a very easy time, it must not be forgotten that, while it is only actually working for, say, 10 minutes in every hour, when it is at work it is liable to constant overload and to operation under the most exacting conditions. It will therefore be seen that to design satisfactorily a crane motor is quite a special job. It is a job, however, which Messrs. Dick, Kerr & Co. have successfully undertaken, and the experience gained by them of heavy power work over a number of years has enabled them to offer a motor which is particularly well adapted for cranes, hoists, and purposes where the demands are severe yet intermittent.

The motor supplied by them for these purposes is of the enclosed ventilated type with very small apertures, and is manufactured with either series, shunt or compound winding. It is claimed to be very efficient over the whole range of its output. The magnet frame is octagonal in form and is made of cast steel of high permeability. The frame is cast in one piece, and two end plates are provided for supporting the armature bearings. The pole pieces themselves are so constructed that free ventilation of the armature is secured. They are made up of sheet steel punchings and are bolted symmetrically round the inner surface of the magnet frame, an arrangement which ensures equal distribution of the magnet field and perfect commutation.

Before being placed in position the field coils are machine

wound upon formers, high conductivity copper wire being used throughout. The wire is insulated with asbestos paper, and cotton covered. After being wound the finished coils are immersed in insulated compound and dried. They are then covered with a thick layer of mica paper and finally taped over with strong braided webbing. The complete coil is then waterproofed with a special compound, which, it is claimed, renders it quite impervious to moisture.

The armature core is built up of thin sheet steel laminations which are securely keyed to the shaft in sections, each plate being covered with "Insuline" to prevent eddy currents. Free circulation of air through the core is secured by inserting distance pieces between every few laminations. Like the field coils the armature coils consist of high conductivity copper, and are laid together and encased with mica, press-spahn and linen. The coil is then taped throughout its length, and finally dipped and baked.

The commutator of these Dick-Kerr crane motors is supported on a separate hub, which is keyed directly to the armature shaft. The commutator bars are of hard-drawn copper, the insulation being of mica. The commutator, after being built, is placed in a heated drying box for 24 hours, after which the end rings are again tightened to prevent the possibility of any movement of the bars due to expansion and contraction after machining. Two brush-holders are provided, each carrying carbon brushes. They are securely bolted to a special yoke at an angle of 45 deg. on either side of the vertical plane on the upper half of the commutator. Inspection of these brushes is easily obtained through two special doors fitted in the motor frame.

In connection with this motor an interesting brake, specially designed for crane work, is used. It is formed by an extension of the commutator bearing, an annular space being provided in which is carried an exciting coil. On the extended hub is carried a conical cast-steel ring which is free to move laterally, and in this ring are carried steel springs which normally tend to push it away from the face of the magnet. At the extreme end of the motor shaft a malleable iron crown is keyed. When the motor is not working the spiral springs thrust the steel ring into the crown. Directly the current is switched on the magnet coil becomes energised and, overcoming the thrust of the springs, attracts the ring facing the magnet, thus leaving the crown, and consequently the shaft, free to revolve.

Certainly one of the most important parts of crane work is the controller, whereby it is possible to obtain a good regulation of the speed which the load is lifting or moving from place to place. Messrs. Dick, Kerr & Co. consider that a crane controller should be so designed as to meet adequately all the conditions of the load during the period of operation. It should be sound both mechanically and electrically, as it is frequently handled by men who know nothing whatever of the apparatus, and therefore do not always realise that they are treating it badly. To meet these conditions, Messrs. Dick, Kerr & Co., have designed a special form of controller, which, it is claimed, is a distinct advance upon the ordinary magnetic blow-out type, for it not only contains important modifications of the blow-out principle but in other respects it shows improvement, particularly as regards simplicity of construction and ease of operation.

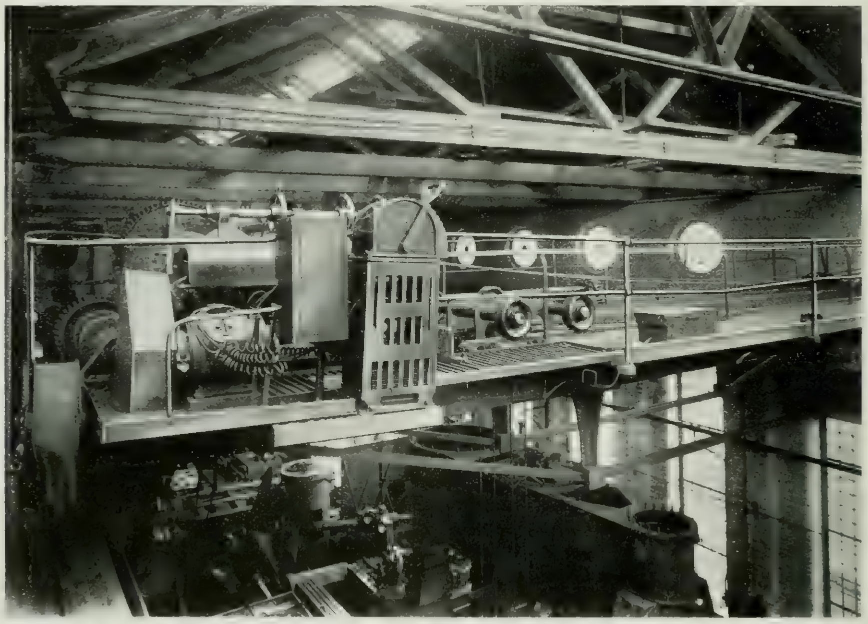

Fig. 1.—Travelling Crane for Shop Work fitted with Dick-Kerr Equipment.

This controller is known as the metallic shield blow-out controller. In it metallic shields are used and the blow-out can be swung clear of the fingers and segments when necessary to inspect them. The effect of this arrangement is said to increase in direct proportion to the strength of the current, so that the more powerful the arc the greater the blow-out available for suppressing it. The operation of the ordinary magnetic blow-out depends upon driving the arc in a direction parallel to the axis of the controller cylinder

In the metallic shield blow out the arc is lifted directly away from the cylinder in a direction at right angles to its axis. The insulated portions are never in a direct line with the arc, and it would therefore be impossible for one arc to reach another because a solenoid effect is produced between each one individually. The development of this arrangement has only been arrived at after careful observation of arcs under varying conditions.

The coil is placed in a shield of copper or other non-magnetic material and can be brought directly into the sweep of the arc. The external magnetic field created round the shield of non-magnetic metal attracts the arc to the shield and divides it in two. These two arcs travel rapidly in opposite directions round the copper shield and finally become united again in the air but round the coil and shield. The arc at this stage has become so attenuated as to break, and may, in fact, be extinguished before it has actually encircled. It may be mentioned that the copper ring suffers to no extent from the discharge, for it has been found, after several years' continuous use, to show no material depreciation either on the shield or the partitions.

The Dick Kerr controllers for crane work are made in various size and forms. One is a vertical controller, and it has been found this design is most generally preferred. The controller and resistance are, in this case, supplied as separate units. This controller is made in all sizes up to 1,000 amperes, and in the larger size the construction has been so designed as to provide adequate sub-division of the arc breaking points. In order to reduce the wearing surfaces a minimum number of contacts are provided. This is accomplished by arranging two rows of contact fingers opposite one another at a distance of two ordinary running notches. It also comprises splitting up the resistance leads at one side, being connected to one row of contact fingers, while the resistance leads of the other side are connected to the opposite row of contact fingers. Another type of controller, which is specially designed for hoisting gear is fitted with an electric brake for lowering loads. This is arranged by shunting the armature of the motor through a resistance, thus causing the former to operate as a generator, and consequently producing a powerful braking effect.

Fig. 2. - Wharfside Crane fitted with Dick-Kerr Equipment.

THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.

ISSUED MONTHLY (GRATIS) WITH "THE ELECTRICIAN"

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Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms ; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations ; to any firm of Merchants or Agents ; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings ; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Assisted Electric Generating Plants. In considering the questions involved in central station practice an observer cannot help being struck by the way in which centralisation of plant and equipment is carried out to the utmost limit. For instance, we find all the plant for supplying one area concentrated in one place. Such centralisation has, in fact, been considered from the economical point of view to be the best arrangement, for thereby standing and capital charges are reduced to a minimum. It therefore comes as rather a shock to our orthodoxy on this question to find that there exist certain persons who consider that there are other and better ways of solving the problem. One of these has recently supplied a contribution with the above title to the "Manchester Guardian," in which he advises power consumers to instal their own generating plant, or, rather, just sufficient plant to ensure that it shall always be possible to run on full load, whatever operations are being carried on, using energy from the supply authorities' mains to make up any deficiency there may be. The object of this scheme is to raise the load factor of the private generating plant; but in our opinion the idea is unsound. In the first place supply authorities would probably object to having their stations turned into a sort of stand-by, and would doubtless refuse to connect such consumers to their mains unless a guarantee were given that a certain number of units would be taken per year. And this number would probably be such as to prevent altogether the operation of the 100 per cent. load factor idea. The author of the article thinks that central station engineers will scarcely welcome the idea, and with this view we agree. On the other hand, he thinks it will increase their power load ; but this is an opinion which we do not hold. In fact, our opinion is that the whole idea is radically wrong. Under ordinary conditions, with a public supply available, the power consumer need never consider the installation of his own generating plant. By following the course of taking a supply from the mains he avoids a large amount of capital expenditure and standing charges, only having to pay his share of those incurred at the generating station. His responsibility is less, and his repairs and maintenance costs are also much reduced. The only possible excuse for a mixed system would be found in the case where a manufacturer had originally installed his own plant, but wished to meet increased demands for power by taking energy from the mains. As his own plant became out-of-date or worn out he would place more and more reliance on the supply from the public mains ; but to employ these mains continually as a stand-by, and even to instal automatic boosters so that they can be used to take up and drop the load as required, is a novel idea and one that we hope will not find general acceptance. On paper the scheme looks good to the uninitiated, and it is for this reason a pity that such an article should have appeared in a journal which has a large circulation among manufacturers who are not engineers, and in a district where the Corporation power supply leaves nothing to be desired ; and is quite capable of meeting any demands, however large, that are likely to be made upon it

An Economical Factor in Motor-driven Installations. In the above note we criticise an idea that has been mooted for raising the load-factor of a private plant by an "assisted" method. To increase the load factor at what may be called the generating station—that is at the main fuses of the installation—is, however, apart from other considerations, not going far enough back ; and it is worth while to retrace our footsteps still farther and to consider how the load factor and efficency generally of the machines may be increased. For it is here that much improvement is required. It is not forgotten that to determine exactly what is the right size of motor for driving a machine whose load varies greatly, and practically continuously, is not an easy matter. But, on the other hand, it is a problem that is not seldom solved by putting down an over-sized motor, which is only likely to be fully loaded during a portion of the working hours, and thus performing an operation which in other circles is, we believe, known as "playing for keeps." This, though a simple method, is uneconomical and predicates extra fixed charges, waste of power, poor load-factor, and in the case of alternating current installations, reduced power-factor. Further, it is not unlikely to react on the whole system and interfere with the voltage regulation and the quality of the light obtained.

It is, therefore, evident that the point at which we must seek to improve the load factor is the machine itself and to do this is only possible by considering the actual conditions under which each piece of equipment operates. For instance, a well-designed motor is capable of standing quite a heavy overload for a short time without damage, so that it would be quite feasible, and economical, to drive a

machine running on a fluctuating load which occasionally increased suddenly for a short period, by a motor of rated output well under the maximum thus set up; and by obtaining a load diagram of the machine to use a motor which was as nearly as possible always working on full load. This operation could be carried still further by studying the way in which the loads on the various machines in a shop worked in together and so to arrange them, in groups if necessary, that the whole series worked as economically as possible. And the idea need not be confined to single shops, but the power requirements of the whole works might be studied and the sequence of operations modified, if necessary, to obtain a load factor as satisfactory as possible.

A Condition of International Depression.

To belong to the electrical engineering profession or industry at the present time is not a pleasant occupation, even for a confirmed optimist. That things are pretty bad, in this country, at all events, is quite evident without resort to figures, and there is much hard thinking now taking place regarding methods which should be employed to improve this state of affairs. Some consider Tariff Reform the panacea, others are of the contrary opinion. And without encroaching upon any political ground we may point out that as regards the electrical industry the depression is by no means confined to this country. In the United States, in spite of the fact that much new work is being done, the electrical industry is not flourishing, and exports are in fact falling. In Germany, though several large firms have done well, many others have done badly, the exports are not what they were and the internal state of the industry is not likely to be improved by the proposed tax on electricity consumption. It would, therefore, appear that the present disastrous state of affairs is due rather to economic than political causes. And what is the remedy? The same state of affairs has occurred in other industries, and we may, therefore, be able to take advantage of their experience. When railways were first started in this country many small concerns rose and flourished for a time, but when the constructional work on these lines was finished the inevitable reaction set in and great depression was the result. The same course of events is noticeable in the career of the electrical industry, and only by a process of evolution can the present state of affairs be altered. The first great constructional period in the electrical industry is now over and in future the development will be more slow and steady, the consequence being that the next few years will see something in the nature of retrenchment—*i.e.*, a pruning operation will have to be carried out, with resulting advantage to the tree as a whole. Until that time arrives a permanent lifting of the present cloud cannot be expected. When it occurs the industry will be again set on a firm foundation.

Since the above lines were written there has been certain signs present that the clouds were lightening, that business was picking up and that industrial life, on the electrical side at any rate, was quickening. It is to be hoped that these signs are but forerunners of a permanent improvement in the industry.

"THE ELECTRICIAN" TABLES OF

No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max-demand Kw.	H. mot (i an
1	Aberdeen Corporation	J. Alex. Bell	Granite quarries, eng. works, shipyards, ice factories, fish-curing and preserving wks., paper wks., woollen and jute wks.	400	220, 440 three-wire 230 2-wire	4,043 31/5/09	681	104	780 at 11.0 a.m.	
2	Acton Council	J. Martin Blair	Laundries, motor works, dyeing and cleaning, printing	...	230, 460 three-wire	606 31/5/09	61	170	174	..
3	Aston Manor Corporation	R. Foster	General	400 3-phse. 50 ~	460 three-wire	4,365¾ 1/6/09	210	500	1,600	.
4	Ayr Burgh Council	Roland Marshall	Principally residental, building trades, laundries, small eng.-works, shipyard, carpet works, boot factory	100, 200 Single phase	250 500	345 30/4/09	101	30	...	..
5	Barnes Urban District Council	C. S. Davidson	Gas mantle works, sawmills, brewery, golf-club making, laundries, printers	..	210, 420 three-wire	639 31/3/09	60	60	470	..
6	Barnsley Corporation	E. A. Barker	Foundries, laundries, builders and joiners, linen manuf'ters, paper mill, &c.	...	230 460	685	118	30	849	.
7	Barrow-in-Furness Corporation	H. R. Burnett	Shipbuilding, iron, steel and engineering works	220, 440	970	150 30/9/08	50	...	...	.
8	Bath Corporation	Francis Teague	Engineering, cabinet-making, clothing and corset factories	110 single-phase	220, 440 three-wire	476 31/3/09	141	72	..	
9	Battersea Borough Council	F. A. Bond	Soap and candle works, engineering works, millers, railway goods yards, stone yards	...	230*, 460†	2,191 20/7/09	..	40	500 day load *	
10	Belfast Corporation	T. W. Bloxam	Shipbuilding, spinning and weaving, ropeworks, handkerchief making	...	220, 440 three-wire	5,141 31/7/09	620	70		.
11	Birkenhead Corporation	W. Wyld	Shipbuilding and ship repairs, laundries, leather works and foundry	...	230, 460 three-wire	906 31/3/09	Approx. 132	120	675·8*	.
12	Birmingham Corporation	R. A. Chattock	Metal, cycle and jewellery trades	5,000	220, 440 three-wire	16,798 31/8/09	2,131	350	8,645 l. & p. 5,040 tr	3 3
13	Blackburn Corporation	P. P. Wheelwright	Cotton manufacture and general industries	220	220 440	2,324 25/3/09	580	50	..	.
14	Blackpool Corporation	C. Furness	Joinery works, bakeries and bottling stores and laundries	200	500	1,231½ 30/8/09	163	80	...	.
15	Bolton Corporation	Arthur A. Day	Cotton spinning and engineering works	100, 200* 400†	230, 460	9,219¼ 31/3/09	816	300	4,925	.
16	Bootle Corporation	T. Dawson Clothier	Timber, engineering, dyeing, pumping and general	...	220, 440 three-wire	1,989 31/3/09	...	40	1,252	.
17	Bournemouth & Poole Electricity Supply Co.	E. Ll. Lugram	Boarding-houses and hotels	100,200,400 three-wire	250, 500 three-wire	452 22/6/09	169	25	...	.
18	Bradford Corporation	Thomas Roles	Textile works, dye works, mechanical and electrical engineering, miscellaneous	230, 400 50~	230 460	*7,481 18/8/09	*1,577	110	2,174	
19	Brighton Corporation	J. Christie	Engineering works, breweries, sawmills, laundries, foundry, &c.	...	230, 460	2,366 21/8/09	437	100	..	.
20	Bristol Corporation	H. Faraday Proctor	Tobacco, cocoa, printing, leather, confectionery and clothing	105 & 210 93~ 210-50~, 360 3-phase 50~	250 500	10,179	1,118	120	2,130	No
21	Burnley Corporation	Jas. E. Starkie	Cotton weaving, foundries, &c.	...	220, 440	591 20/3/09	195	30	440	N
22	Burton-on-Trent Corporation	P. J. Pringle	Breweries, timber mills, engineering works	200, 100	500 (tramways only)	869·5 21/8/09	138	45	505*	
23	Bury Corporation	S. J. Watson	Textile, engineering, paper, &c.	...	220, 440	2,642 31/8/09	306	80	...	.
24	Carn Brea, R.S.O. (Urban Electric Supply Co.	L. A. Hards	Mining and foundries	...	240, 480 three-wire	1,719 Dec., '08	121	30	758	N
25	Canterbury Corporation	C. A. Blascheck	None	...	220, 440	297 31/3/09	74	50	390	.
26	Cardiff Corporation	Arthur Ellis	Ship-repairing yards, engineering works, foundries, laundries, printers, brewers, millers, cold storage, &c.	200 400	200, 400 three-wire	2,854 30/6/09	455	80	...	N
27	Carlisle U.D.C.	S. T. Allen	Cotton factories, tinplate printers, engineering works and railway shops (7 companies)	...	L. & P. 230 460, 3 wire, traction 500	561 30/8/09	73	57	L. & P. 433 traction 250	
28	Charing Cross, West End & City Electricity Co.	H. W. Kingston J.M. Gatti (*Mn. D.*)	Printing	10,000	100, 200, 400, 1,000	Ex. bulk sup. 11,213, 31/7/09	...	250	...	.
29	Chester Corporation	S. E. Britton	Engineering, flour mills and printing	...	210, 420 three-wire	503 27/5/09	119	25	1,320	.
30	Chesterfield Corporation	R. L. Acland	Printing, brewery, furniture-making, foundries	...	240, 480 three-wire	716 31/12/08	150	30	...	.
31	Clyde Valley Electrical Power Co.	D. A. Starr	Steel works, rolling mills, collieries, paper mills, brickworks, foundries, shipyards, &c.	11,000 trans. to 400 for power	...	22,559 31/7/09	..	500	5,000	..
32	Colne Corporation	A. G. Cooper	Weaving, spinning, loom making, foundries, fell-mongering and electric crane making	...	240, 480 three-wire	366 15/2/09	138	20	...	
33	Cork Electric Tramways & Lighting Co.	H. H. Nalder	Breweries, butter factories, laundries, bacon curing, feather purifiers, printing, tanneries, milling, &c.	...	460	2,123 27/8/09	304	40	...	N
34	County of Northampton Electric Power & Traction Co	W. J. S. Jones	Boot factories, engineering works and joineries	...	230, 460 three-wire	120	26	15	...	.
35	Coventry Corporation	George Tough	Cycle and motor cars, toolmaking, weaving, watchmaking	200 two-phase.	...	5,029 31/3/09	545	120	2,101	.
36	Darlington Corporation	J. R. P. Lunn	Engineering, yarn spinning and school furniture	...	230, 460	1,682 31/8/09	192	125	790	.
37	Derby Corporation	T. P. Wilmshurst	General engineering, foundries, motor cars, silk mills	200	460, 230 three-wire	1,860	360	75	850	..
38	Derbyshire & Nottinghamshire Electric Power Co.	A. E. Loos	Iron works, collieries, lace and hosiery works, engineering works, brick-works, &c.	440	500 550	2,323 1/4/09	...	200	600	.
39	Dewsbury Corporation	R. H. Campion	Woollen manufacturers, rag grinding, printing, laundries, clothing manufacturers, wool shaking, iron cutting	...	220 440	526 1/2/09	106	30	100	.
40	Dublin Corporation	M. Ruddle	Saw mills, factories, elevators in stores, &c.	200 S.P. 3-phse. 346	...	1,620 1/4/09	364	20	...	.

ELECTRIC POWER SUPPLY.

No.	Method of Driving: Group. H.P.	Method of Driving: Indiv. H.P.	Rates: Per unit.	Rates: Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g=Gas. sg=Suction Gas. s=Steam. H.P.	Remarks. (NOTE.—Inst E.E. Wiring Rules for Motors generally apply in all districts.)
1	...	...	$2\frac{1}{2}$d. and 1d. M.D.	...	...	...	Long hour consumers, $\frac{1}{2}$ hour M.D. Short hour consumers, 1 hour M.D.
2	.	...	$1\frac{3}{4}$d. flat $2\frac{1}{2}$d.&1d.M.D.	Under consid'n	..	150g, 220sg, 200s	Includes new scheme of electric pumping at Council's sewage works, auto. plant; in operation one month
3	...	...	*2d to $\frac{3}{4}$d. according to load factor	On application	...	...	* Sliding scale.
4	200	100	2d. to $1\frac{1}{2}$d. Load factor basis	...	200	150g, 50sg, 200s	Shipyard agreed to take supply for 400 H.P. of motors. Supply not commenced yet.
5	89	550	$1\frac{1}{2}$d. with dis to $33\frac{1}{3}$ p.c.	On application	*	55g 500s†	* Most of our consumers are new to the district. † Includes plant at sewage works
6	...	...	$1\frac{1}{2}$d.-1d. motors, $3\frac{1}{2}$d. flat, lighting 7d. & $1\frac{1}{2}$d. D.I.	...	..	...	Discount (lighting only) 5 per cent. Sliding scale for motors.
7	...	...	3d. & 1d. M.D. 2d.-$1\frac{1}{2}$d. F.R.	...	...	...	....
8	..	...	$1\frac{3}{4}$d. to 1d.	...	...	*	* Isolated plants using gas, suction gas and steam are in operation, of which there are no particulars.
9	...	...	Flat rate 1d. ‡	Terms by arrangem't	...	...	* Up to 3 H.P. † Above 3 H.P. ‡ Or £4 per kw. per annum and $\frac{1}{2}$d. per unit.
0	...	...	$1\frac{1}{2}$d. & 1d. M.D., accord. to cons.	On application	.	...	* Lighting and power 3,443, traction 3,300.
1	..	...	2d. for 1500 units $1\frac{1}{2}$d. next 3500†	...	...	...	* Motor load only. † Exceeding 5,000 units per quarter at 1d.
2	...	...	1·35d. to 1·10d.	1d. to 0·7d.	11,000	...	....
3	...	...	Sliding scale	Sliding scale	...	...	Total B.H.P. does not include traction.
4	...	...	3d. and 1d. M.D.	...	...	..	....
5	...	...	2d. 1st 1,000, 1d. after less 10%.	...	..	...	* Single-phase. † Three-phase.
6	...	...	2d. to 500 per qtr., 1d. after	...	1,000	1,500g, 80sg, 4,510s	....
7	...	.	$2\frac{1}{2}$d. flat.	On application	...	...	....
8	...	...	2d. to 1d. 2d. to $\frac{3}{4}$d.	£3 per kw.†	...	..	* These figures do not include the following:—3 500 kw. motor-gens. used for converting current at 6,600 volts, 3-phase, 50 periods, to d. cur. at 230 and 460 volts. Also bulk supply 250 kw. at Messrs. Ripley's branch of the Bradford Dyers' Assn. † Plus $\frac{1}{2}$d. per unit, less disc.
9	...	...	1d. restricted hours, $1\frac{1}{2}$d. unrestricted	...	...	...	Special terms to large users.
0	...	...	$1\frac{1}{2}$d. & dis., $1\frac{1}{2}$d. and $\frac{3}{4}$d. *M.D. with discount	On application	...	800sg	*. To avoid as far as possible the use of max. demand indicators a flat rate is usually agreed upon.
1	1,990	..	Lighting $3\frac{1}{2}$d. flat Pwr. $1\frac{3}{4}$d. 1st 39 hrs. per $\frac{1}{4}$, 1d. aftr	None	...	...	....
2	195·5	674	3d. & 1d. also 2d & $1\frac{1}{4}$d. 1d.-$\frac{3}{4}$d.†	...	266	30sg	67·5 per cent. of total power is on restricted hour system. 80 per cent. of total power units sold on restricted hour system. * Includes lighting. † Restricted hour.
3	About $2.246\frac{1}{2}$	About $395\frac{1}{2}$	$1\frac{3}{4}$d., 1d. and $\frac{5}{8}$d.	On application	1,280	About 40,000	....
4	...	126	4d. & 1d. M.D. or $2\frac{1}{2}$d. flat	...	...	50g, 10sg	Power supply includes driving stamps, pumps and other mining machinery.
5	...	297	$1\frac{1}{2}$d. flat 5 p.c. dis. cash 28 days	...	..	...	Max. demand during year ended March 31, 1909, 390 kw. on feeders, includes light and power.
6	...	...	$1\frac{1}{2}$d. flat, 4d. & 1d. M.D.	Spl. rates to large consumers	...	...	Most of the engineering works on private property, from which Corporation are at present debarred from entry.
7	68	447	1d. and $3\frac{1}{2}$d. Also £7 kw. per ann. of M.D. 1d. unit cons'd	Special terms	40	...	Power supplied to tramway company, also to Council for sewage pumping.
8	...	...	3d. to $\frac{3}{4}$d.	On application	...	...	... ..
9	164	339	$1\frac{1}{2}$d. 1st 200 units per qtr., 1d. after	Above 25,000 p.a. 1d. flat rate	...	...	.
0	...	...	$1\frac{1}{2}$d.—1d.	...	...	...	. .
1	...	...	On application	On application	...	...	....
2	62	76	$2\frac{1}{2}$d. flat, 3d. and 1d. M.D.	On application	195	...	Several of $\frac{1}{4}$ H.P. and less not included in return. Motors let out on hire.
3	1,323	800	d, $1\frac{1}{2}$d., $1\frac{1}{4}$d., 1d. sliding scale	None	500 steam 450 gas	500g, 200sg, 2,000s	Competing gas 2s. 8d. per 1,000 c.f. with 25% disc. when annual bill exceeds £50.
4	...	...	$1\frac{1}{2}$d. flat and spl. agreem'ts	..	100	...	...
5	300 about	246 about	$1\frac{3}{4}$d. 2,500 units per quarter and 1d. after	...	4,000	...	... . .
6	...	...	$1\frac{1}{2}$d. to $\frac{3}{4}$d.; £4 kw M.D. and $\frac{1}{2}$d. unit	...	...	...	... .
7	...	...	1d. for all day use	...	800	...	....
8	...	...	$1\frac{3}{8}$d. to 0·4d.	...	...	...	Two large electric pumps being installed in place of an existing steam pump. Steam engine at present driving ventilating fan being displaced by an electric motor. Total H.P. about 250.
9	Both		$2\frac{1}{2}$d.(1)—1d.	Two Tramway Companies.	...	..	Maximum demand system or 1d. restricted hour.
0	Both		$1\frac{1}{4}$d.	...	2,200	...	Large additions in hand.

"THE ELECTRICIAN" TABLES OF

No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max. demand Kw.	H.T. moto[rs] (if any)
41	**Dundee Town Council**	H. Richardson	Jute mills, shipbuilding, foundry	...	400	1,950	404	65	...	...
42	**East Ham Corporation**	W. C. Ullmann	Printers for motors, otherwise district is purely residential	...	240, 480	Pte., 269, *Stn., 13½, 1/6/09	Private, 97 Station, 5	15	...	...
43	**Edinburgh Corporation**	F. A. Newington	Printing, joiners, masons, engineers, brewers	...	230, 460	9,400 15/5/09	2,250	50	...	...
44	**Fulham Borough Council**	Arthur J. Fuller	Engineering works, woodworking machinery, laundries, paper mill	200 two-phase above 5 H.P.	...	1,265 31/3/09	166	80	540	...
45	**Frome U.D. Council**	F. H. Merritt	Cloth, silk and india-rubber mills, iron foundries, engineering and motor works, breweries, mill furnishing, dairies, bacon curing, printing	...	240, 480 three-wire	715 30/3/09	191	35	150 approx	...
46	**Glasgow Corporation**	W. W. Lackie	Engineering, clothing, printers, butchers and bakers	6,500	250/500 three-wire	29,925 31/7/09	4,330	250	...	...
47	**Govan Council**	T. C. Parsons	Shipbuilding and engineering	...	500, 250	4,929 15/8/09	...	165	1,485	...
48	**Grantham Urban Electric Supply Co.**	J. E. Edmundson	Brickwork, foundries, timber merchants, engineering works, blouse factory, malting	..	240, 480 three-wire	346 31/12/09	98	13½	...	...
49	**Greenock Corporation**	J. A. Robertson	Shipbuilding, engineering, sugar refining	...	500	5,149 31/8/09	371	545	1,500 Appx.	...
50	**Grimsby Corporation**	W. A. Vignoles	Docks, timber yards, foundries and engineering works	...	230, 460 three-wire	1,026 5/8/09	156	90	1,065	..
51	**Guernsey Electric Light & Power Co.**	C. Lakin-Smith	Laundries, stoneworks and quarries, joinery works, foundry	...	210, 420	2,200	150	80	800	...
52	**Hammersmith Borough Council**	G. G. Bell	Engineering works, electric lamp works, small laundries, &c.	110, 220, 440 2,300 H.T.	...	2,614 19/12/08	336	200	...	3 20 2 12
53	**Hanley Corporation**	C. H. Yeaman	Brickworks, *potteries, iron works, collieries, *earthenware and china manufactories	Single-phase 100 ∿, 100-200, 400	50*	1,004 31/8/09	134	60	1,107	1 6C
54	**Heckmondwike Council**	G. H. Carter	Woollen manufacturers, rag grinders, foundry, boot and shoe, factory, coachbuilders, &c.	...	230, 460 three-wire	988 31/8/09	117	150	...	..
55	**Hereford Corporation**	W. T. Kerr	Cider making, breweries, mills (flour), farm work, joinery	...	220, 440	335 5/6/09	90	50	355	...
56	**High Wycombe Electric Light & Power Co.**	W. E. Brandreth	Chair and cabinet making, paper mills, engineering	. .	420 210	592	158	30	...	...
57	**Hove Electric Lighting Co.**	C. B. Smith	Purely a residential district excepting shops	...	220	321	113	12	...	...
58	**Huddersfield**	A. B. Mountain	Cloth manufacturers	Three-phase One-phase	... ...	1,723 1,404	62 401	150 35	800 2,000	..
59	**Hull Corporation Electricity Department**	H. Bell	Engineering, shipbuilding and oil mills	...	220, 440 three-wire	6,366 6/9/09	572 Consumers	75	4,513	...
60	**Ilford Urban District Council**	A. H. Shaw	Photographic apparatus, chemical works, paper mills	...	230, 460 three-wire	605 31/3/09	99	60	...	...
61	**Islington Borough Council**	Albert Gay	Bakers, brewers, builders, clothiers, coach and van builders, engineering works, confectioners, printers	Single-phase 50 ∿ 100 200 and 400	...	2,275½	453	50	3,600	
62	**Kettering Council**	W. A. Walker	Boot and shoe and clothing factories	...	230, 460 three-wire	713½ 31/8/09	150	30	250	
63	**Kidderminster & District Electric Lighting & Traction Co.**	A. Charlton	Carpet manufacture	..	460	1,010	...	26	520*	
64	**Kirkcaldy Corporation**	O. F. Francis	Linoleum, engineering, furniture, malting works, linen, &c.	..	230 460	786 15/5/08	...	130	811	..
65	**Lancaster Corporation**	W. A. Tester	Timber yards, builders' yards, foundry, linoleum works	...	230, 460	425 1/12/08	105	50	200	
66	**Leeds City Council**	H. Dickinson	Numerous	200 400	...	12,020 31/8/09	1,870	100	6,470	..
67	**Leith Council**	A. Peden Rutherford	Engineering and general	.	230, 460	3,297 31/8/09	420	100	672	..
68	**Liverpool**	Alfred Clough	...	...	230, 460	10,299 31/7/09	2,503	80	...	..
69	**Lincoln Corporation**	Stanley Clegg	Engineering works		230, 460 and 500	1,216½ 6/9/09 excld. traction	174	45	425	.
70	**Loughborough Corporation**	W. H. Allen	Hosiery and engineering	.	220, 440 three-wire	370 30/10/08	67	43	120, for pr. only	..
71	**Luton Corporation**	W. H. Cooke	Straw hat making, motor cars and lorries, hydraulic and general engineers, foundries, printing works	...	500	1,612 10/12/08	268	65	759	..
72	**Maidstone Corporation**	E. E. Hoadley	Building, brewing, paper making	...	230, 460	1,245 30/5/09	174	60	...	.
73	**Mansfield Corporation**	E. Holcombe Hewlett	Boots, hosiery, cotton doubling, founding, tin box, motor bodies, sand and stone quarries, coal mining	...	240, 480 500-600	260 15/6/09	80	12	...	
74	**Metropolitan Electric Supply Co.**	J. S. Highfield, *En.* J. Conacher, *Gn. M.*	Ordinary shops	200	200	3,546 27/7/09	961	60	...	..
75	**Middlesbrough Corporation**	H. M. Taylor	Iron and steel works, shipyards, joiners shop	..	220, 440 three-wire	1,694	303	50	450	.
76	**Motherwell**	S. Williams	Engineering and steelworks	..	230, 460	About 3,000	...	3 of 120	943	
77	**Newcastle and District Electric Lighting Co.**	W. D. Hunter	Engineering and shipbuilding, steel and lead works, &c.	100	240, 480 three-wire	8,643 25/9/08	..	150	4,300	
78	**Nelson Corporation**	D. Helme	Cotton manufacturing	...	230, 460 three-wire	280 1/4/08	63 On hire	40	...	..
79	**Newport Corporation**	H. Collings Bishop	Coal, iron, clothing, nails, brickworks, mills, ship repairs, &c.	Not permitted	230, 460 three-wire	1,838·5	229	100	Cannot give	No

ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g Gas. sg Suction Gas. s=Steam. H.P.	Remarks. (NOTE.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
41	500 approx.	1,450 approx.	2½d. downwards	On application	...	...	....
42	...	..	2d. All units over 600 per ¼ at 1½d.	...	...	...	*Motors used in gen. stn. for cooling towers, artesian well, driving machinery, &c.
43	...	...	1½d. flat, ½d. Stch R., 1d. 5hr. M.D.	...	...	..	... .
44	...	...	1d. flat	...	...	...	Power and lighting on same mains, 540 kw. day-load motors only.
45	43 approx.	672 approx.	2½d. flat; 4d. and 1d. M.D.	On application	150, also 365 private electric plant	50g, 20sg, 900s, 10 water (approx.)	....
46	...	...	1½d. & ¾d. M.D. 1d. flat rate for restricted hours	¾d.	...	...	....
47	...	...	Sliding scale 2d.—¾d.	...	...	290s, 200s, 4,000s	.. ..
48	.	...	4d. and 1d. M.D. 1 2½d. flat.	Special rates	...	No record.	....
49	...	...	2½d. to 1d.	1d.	..	...	....
50	..	...	2¼d. to 1¼d. with dis., 1·025d. T.S.	...	...	...	Number and horse-power of motors does not include the docks or Admiralty supply.
51	...	...	*	To sub-stations	1,00	...	* Lighting: 7d.-3d. M.D.. 6d. flat 5½. Power 4d. and 1½d. M.D., 2d.-2½d. flat.
52	...	...	1½d. with dis. to a max. of 33⅓ p.c.	...	...	...	....
53	...	...	3d., 1d., ⅝d. and ½d.	On application	..	. .	Power load rapidly growing and especially favoured with the many small and diverse trades subsidiary to staple industries of district. *Local for magnetting.
54	...	...	2d. to 1d. Sliding scale	Special terms	...	...	. ...
55	50	285	*3d. to 1d.	...	..	20g, 160sg, 300s	* With discount on hours of running.
56	...	...	4d.—1d. M.D system, 2½d. flat rate or on 2 rate meter	..	. .	16g, 200sg	All motors are hired out by this company, and are maintained and inspected.
57	...	...	3d. two hrs. 1½d. after	...	...	...	Radiators are at power rates but are not included in this return.
58	...	...	2d. and 1d. less discount	...	...	...	....
59	...	...	2d.—1d. per sliding scale*	On application	.	..	Hired motor system in operation. About 450 H.P. connected. * Subject to 2½ per cent. dis., for payment within 14 days.
60	..	...	2d. & 1d. M.D. 2d. to 1d. sliding scale	...	.	...	1d. power rate for large consumers.
61	...	...	1d. flat	Nil	1,220	...	....
62	683½	30	2d. to 1d.	On application	571	...	... .
63	...	...	1½d.	...	...	No information available	*This is a combined figure for lighting and power.
64	...	..	2¼d. to ¾d. sliding scale	...	...	...	1 large engineering works, 1 large colliery, 1 large malting works received entire power supply from Corporation.
65	...	105	2½d. sliding scale to 1d.	By contract	425	330g	... .
66	...	...	0·8d. to 1·75d. less 5 per cent.	...	...	..	.. ..
67	. .	...	1½d. to 1⅛d.	...	...	...	....
68	...	...	*2d., 1½d., 1d.	...	..	...	* 2d. up to 3,000 per qr., 1½d. from 3,000 to 10,000 per qr. 1d. all units in excess of 10,000 per qr.
69	...	...	2½d., 2d. & 2d. & 1d. M.D	On application	...	...	....
70	219	151	1d. flat	...	158	49g, 25sg, 492s	Two private plants, total 1,200 kw., running.
71	About 1,312	About 300	*2d., 1½d., 1d.	...	About 400	About 200g 100sg, 250s	*2d. first 1,000 per qr., 1½d. second 1,000 per qr., 1d. remainder.
72	Both		Various......		500	...	....
73	...	...	4d. & 1d. M.D. 1d. daylight	..	214	450s*	Town gas sold at 1 6 1,000 for power. Tramway supply 1,200 H.P. not included. * Not including collieries.
74	...	. .	3d. and ¾d. M.D.	.	..	...	......
75	...	...	2d. & 1d. M.D. Sp. on app'n.	..	1,500	...	Largest installation, shipyard, max. demand 400 kw.
76	...	...	1d. and ¾d.	...	...	...	....
77	...	...	Max. 1½d.	According to load factor, &c	...	.	Largest consumer, Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick Works.
78	Both		*	...	...	...	* Motive power—2½d. for 1st hour per day, 1½d. every subsequent hour, less 5%.
79	About 600	1,238	2d. and 1d. acc. to quan.	On application	...	...	One dry dock being converted to electric from steam.

"THE ELECTRICIAN" TABLES OF

No.	Supply Authority	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit.	Max. demand. Kw.	H.T. motor (if any)
80	Northampton Electric Light & Power Co.	G. H. Jackson ...	Boot and shoe factories, printers, motor car works and tanneries	...	210, 420 three-wire	1003 31/12/08	...	50	891	...
81	North Wales Power and Traction Co.	G. K. Paton (Chief Elec. Eng.)	Slate quarries	500 3-phase	..	3,050 6/09	60	200	1,000	...
82	Norwich Corporation	F. M. Long	Boot and shoe, mustard, printing, breweries	...	220, 440	2,704 30/6/09	495	50	750 at station	...
83	Nottingham Corporation	H. Talbot	Lace, hosiery, tobacco, engineering, leather	...	200, 400 three-wire	4,000 31/8/09	957	60	...	...
84	Nuneaton Corporation	S. C. Gibson	Hat making, hosiery wool, cotton, elastic web, foundry, quarries and collieries	...	220, 440 three-wire	229 2/6/09	56	60	120	...
85	Partick Council	W. Sillery	Shipbuilding and engineering works	...	240, 480	2,660 15/8/09	262	60	1,984	...
86	Peterborough Corporation	J. C. Gill	Engineering, brickworks, railway	...	200, 400	259 31/12/08	65	15	468	...
87	Reading Electric Supply Co.	E. Rowley Hill ...	Printers, engineers and iron founders, saw-mills	200	200, 400	1,711 4/6/09	258	65	1,377	...
88	Redditch Urban District Council	Wm. J. Ferguson	Needle trade, fishing tackle, cycle factories	200	...	775 17/11/08	97	40	...	...
89	Rochdale Corporation	C. C. Atchison ...	Textile and engineering	3,000 220	220, 440, 500	1,489 31/8/09	236	50	...	55 H.P.
90	Rotherham Council	E. Cross	Iron, steel and brass works	...	230 460	583 20/5/09	81	33	436	...
91	Salford Corporation	V. A. H. M'Cowen	Textile and engineering	200	220, 440 three-wire	9,766 31/3/09	955	300	...	...
92	Sheffield Corporation	S. E. Fedden	Steel and iron works, cutlery works, foundries, general engineering works	2,000, 400, 200	...	11,545 25/3/09	1,219	350 H.P.	6,593	One 35 80, 12 50 kw
93	Shoreditch Borough Council	C. N. Russell	Printing, shoemaking, cabinet and furniture manufacture	...	240, 480 three-wire	3,900 31/12/08	800	...	...	...
94	Shrewsbury Corporation	C. M. Johnston ...	....	...	210 420	158 31/12/08	70	20	383	...
95	Smithfield Markets Electric Supply Co	Edgar Dowling ..	Cold storage	...	100 200	515 8/12/08	33	130	736	...
96	South Shields Corporation	J. H. Cawthra ...	Shipyards, docks and marine engineering works	110, 220	550	1,420	73	50	...	...
97	Stalybridge, Hyde, Mossley and Dunkinfield Electricity Board	Robert Blackmore	Textile, paper mill boiler works, bleach works, engineering works, iron works	400 230	460 230	6,500	250	375	4,250	...
98	Stamford (Urban Electric Supply Co.	J. E. Edmundson	Brickworks, laundry, foundry, engineering works, flour mills, printing works, timber yard	..	240, 480 three-wire	532 8/6/09	...	35	...	...
99	St. Helens Corporation	E. M. Hollingsworth	Chemical, glass and bottle works	...	230, 460 three-wire	1,670 30/6/09	248	60	300	...
100	St. Marylebone Borough Council	A. Hugh Seabrook	Printing, building, small workshops (various trades)	...	240 480	2,534 6/5/09	629	110	7,406 whole supply	...
101	Stockton-on-Tees Council	J. J. Smith	Shipbuilding, engineering and ironworks	...	230, 460 three-wire	986 31/3/09	123	50	...	...
102	Stoke-upon-Trent Corporation	P. J. S. Tiddeman	Potteries, engineering works	None	240, 480 three-wire	825 30/4/09	75	60	387	...
103	Sunderland Corporation	A. S. Blackman ..	Shipbuilding, marine engine and boiler makers, coal mining	5,000 220	220	10,887 30/8/09	725	110	4,032	...
104	Swansea Corporation	C. A. L. Prusmann	Metallurgical, coal exporting &c.	220, 440 three-wire	220, 440 three-wire	1,789 31/8/09	...	60	1,067	..
105	Uxbridge and District Electric Supply Co.	A. Randall Bell...	Flour mills, printing, engineering, brickmaking	200	...	429 30/6/09	52	60	320	...
106	Wakefield Corporation	H. A. Nevill	Engineering, woollens, coal, printing, laundries	200	...	1,264½ 31/3/09	163	110	...	...
107	Walsall Corporation	A. S. Barnard ...	Saddlery, harness, leather, clothing, iron founding, tubes, brushes and rolling mills	..	105 210	634 31/5/09	141	35	...	...
108	Warrington Corporation	F. V. L. Mathias..	Wire mills, printers, saw mills, tanneries, engineers, corn mills, gas stove manufacturers, builders, min. water mfctrs, &c	380 3-phse. 50 periods	460	5,000	...	215	...	...
109	West Bromwich Corporation	W. A. Jackson ...	Spring works, steel rolls, hollow ware foundries, edge tools, tubes, school furniture, corn mills, wire nails	...	230, 460	1,352 31/7/09	141	110	About 400*	...
110	West Ham	H. H. Couzens ...	Chemical, engineering, flour mills, ink mills	100,200,400	500	6,908 kw. 31/8/09	890	115	...	...
111	West Hartlepool County Boro'..	H. F. Friederichs	Blast furnaces, steel wks., ship yds., engine wks., paper mill, saw-mills and joinery wks	...	230, 460 three-wire	1,785 31/8/09	212	120	500	...
112	Whitby (Yorks) District Council	L. H. King	Fishing	...	460	175	32	18	400	...
113	Whitehaven Corporation	B. Sankey	Tannery, flour mill, printing and machinery works, &c.	...	420, 210 three-wire	136 31/12/08	31	20	234	...
114	Wigan Corporation	Jas. Slevin	Coal mining, cotton mills, engineering works	...	230, 460 three-wire	1,614 31/11/08	220	50	921	...
115	Windsor Electrical Installation Co.	A. E. Farrow	Brewing	220	220	320 31/8/09	92	13	75	5
116	Wolverhampton Corporation	C. E. C. Shawfield	Ironworks, edge tool works, corn mills, paint works, cycle and motor works, saw-mills, &c.	6,000, 400	440, 220 three-wire	4,641 30/6/09		100	...	...
117	Worcester Corporation	C. M. Shaw	Porcelain, glove, leather, flour, engineering, various, buttons, confectionery, printing, horse-hair cloth, &c., works	100, 200	230, 460 500	825 31/3/09	146	2 40's	954	...
118	York Corporation	J. W. Hame	Confectionery, printing, railway works, flour mills	...	230, 460 three-wire	1,117 30/4/09	242	35	1,002	...
119	Yorkshire Electric Power Co.	W. B. Woodhouse	Textile mills, iron works, collieries, calcium carbide factory	2,000, 400	500	13,000 25/5/09	350	140	3,400	1 100 H.P.

ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group. H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors	Isolated Plants at present Operating. g = Gas. sg = Suction Gas. s = Steam. H.P.	Remarks. (NOTE.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
80	About 803	About 200	2d. to 1d. sliding scale	On application	About 800		... ..
81	575	2,475	1½d.—⅞d. and under sliding scale	...	3,050	...	Slate quarry load mostly winding, pumping, air compressor and mills. Transmission at 10,000 volts three-phase, all overhead, bare wire and 20,000 volt.
82	..	...	2d. to ¾d.	.	...	...	A 150 B.H.P. motor-driving sewage pump will shortly be installed.
83	...	...	1¼d.	...	...	.	. ...
84		196	2½d to 1d. on sliding scale	On application	...	50sg, 100s, 20 *oil*	....
85	.	...	1d. flat rate	...	...	...	....
86	..	...	1½d. flat.	...	..	...	Quarterly accounts
87	About 1,400	300	1½d. flat	...	400	50*g*, 125*sg*	....
88	...	...	2d. to 1d. sliding scale.	...	...	...	....
89	Practically all group driven.	...	2d. to 1d sliding scale*	On application	Steam 804 Gas 187	333*g*, 20*sg*, 190*s*	Isolated plants on present route of mains (approximate only). *Special terms for special conditions.
90	...	...	1½d. and 1d.	On application	458	...	....
91	...	...	*	...	...	...	* Flat rate.—1½d. first 1,000 units per qr. 1d. all in excess. Fixed charge system £1 per qr. per E.H.P. demanded and ½d. per unit consumed
92	...	..	Lht 4d., Heat 1d., Power 2d. to $\frac{6}{10}$d.	...	5,000	...	Great expansion of use of power supply in rolling mills and cutlery works.
93		...	¾d.*	...	...	. .	* Plus £3 per E.H.P. demanded.
94	...	...	*6d., 4d. & 2d. or flat 5d.	...	...	...	* Power—3d., 2d. and 1½d., 5 and 10 per cent. discount.
95	...	...	1½d. and 1d.	...	..	...	....
96	Both		1½d. 1st 5,000 per qr. 1d. after.	...	...	...	Also traction supply.
97	...	..	2½d.—·45d.	On application	2,000	300*g*, 1,700*s*.	... .
98	...	...	2½d. flat, 4d. and 1d. M.D.	On application	..	...	.. ..
99	...	...	2d. and 1d. with disc'nts	...	1,000	100*sg*	....
100	...	...	2d. and 1d. M.D.	...	220 since Aug., 1905	703*g*, 10*sg*, 1,109*s* 160 *oil*	....
101	...	..	Sliding scale 2d. down to 1½d.	On application	...	...	One works take about 250,000 units per annum, and the total amount sold per annum for power purposes amounted to 371,738 units.
102	Both		1½d. to 0·8d.	...	...	...	The potteries all require steam for heating, and this is generally the drawback to electric driving.
103	...	...	2½d. (dis. to ⅞d.) 2½d. & 1¾d. M.D.	On application	..	...	A large flour mill owned by E. O. Robson & Sons, Ltd., at present being converted to electric driving.
104	...	...	2d. (1st hr.) & 1½d. M.D.*	...	...	...	Motor hiring scheme in operation. * 200,000 per annum and over special rates.
105	300	126	2½ to 1½ flat or 3 & ¾ M.D.	...	...	50*g*, 1,200*sg*, 500*s*	....
106	...	...	2d. to 1d.	...	700	...	....
107	257	377	(*See* remarks)	On application	...	...	2d. up to 100, 1¾d. up to 200, 1½d. up to 500, 1¼d. over 500; 10 per cent. discount for over 10,000 per annum, 12½ per cent. discount for over 15,000 per annum.
108	...	...	0·6d. to 2d. according to conditions	...	7,000	...	....
109	About 710	About 642	1½d. to ¾d.	...	About 700	...	72 motors on hire = 477 H.P. Applications in hand for 100 H.P. * Motors only.
110	Partly	both	1d. max.	On application	4,645 kw.	...	....
111	100	1,600	2d.—1½d. flat with disc.	1d.—¾d	1,650	510*g*, 230*sg*, 5,375*s*	Flat rate for less than 50,000 per annum, 2d.-1½d.; over 50,000, under 500,000, 1½d.-1d.; from 500,000 to 600,000 and over, 1d.-¾d.
112	115	60	£5 per kw. per an. at 1d. unit	...	...	...	....
113	...	...	1½d. and 4½d. or 2 rate, 2d. for small motors	...	...	...	....
114	564	About 1,050	Up to 1,000 units per annum 2d., over 1,000 1d.	...	300	...	....
115	...	...	£3 per H.P. installed per ann. and 1d. per unit	None	100	35*g*, 120*sg*, 40*s*	....
116	...	...	1d.	Various	...	...	....
117	572	253	2½d. & 1d. M.D. ¾d. sewerage P. 1d. & 1¾d. restricted hour	...	900	200*g*, 450*sg* 1,889*s*	Power load arisen during last three years.
118	...	...	1¼ downwards	On application	...	..	... .
119	...	...	Sliding scale	...	...	...	....

Single-Phase Motors for Industrial Work. . . .

IN this country we enjoy from time to time a discussion on the relative merits of continuous-current and three-phase motors for industrial work. But in these discussions the claims of single-phase motors are generally overlooked, and, except to a very limited extent, they are not used in this country for driving machinery and other apparatus.

Things are, however, different in America, and it may, therefore, be of interest to describe some of the various ways in which this type of motor is used, and to give some details of its characteristics. In this article we describe more particularly the single-phase motors of the Century Electric Co., of St. Louis, and give some illustrations of their standard types of motors.

These motors are self-starting under full load, and the only device necessary for starting or stopping them is the ordinary double-pole knife switch. No transformers or other similar devices are used. The motor starts as a repulsion motor, but on reaching full speed the governor weights are expanded by centrifugal force. This short-circuits every commutator bar to one common ring, and at the same time releases the tension on the carbon brushes and pushes them away from the commutator, the motor then running as an induction motor. This governor is entirely automatic, and when the motor is stopped the device returns to its original starting position. As the commutator is only in use at the period of starting, wear upon it is practically negligible, and as the motors are entirely automatic and can be started from a distance, either by closing the primary or secondary circuit of the supply,

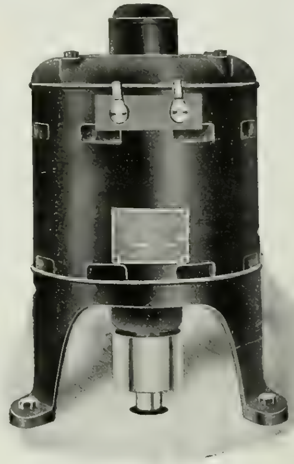


Fig. 1.—Single-phase Vertical Motor.

it makes them specially suitable to the operation of pumping equipment, air compressors or other machines, which work in conjunction with a float switch or pressure regulator, or any other automatic device for closing the current supply circuit.

The Century Electric Co.'s standard motors are wound for voltages of 104 or 208 volts. These pressures are selected as being a good average of the various voltages

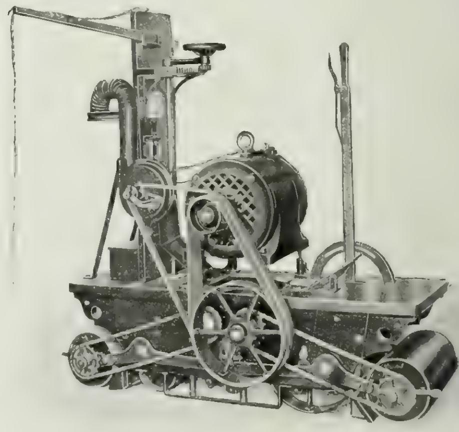


Fig. 2.—5 H.P. Motor on Floor Surfacing Machine.

found in the United States, and the motors can be operated at either of these voltages by simply changing the connections on a terminal board placed inside the motor. It is found, however, that these motors work satisfactorily on all voltages between 100 and 150, and 200 and 250 respectively, and they can also be wound for any frequency between 25 and 140.

These motors, being purely of an induction type, and having a high efficiency and power factor, will not, it is claimed, cause any more appreciable fluctuations of the circuit voltage than a similar load of incandescent lamps

Fig. 3.—½ H.P. Motor driving Soda Water Carbonator.

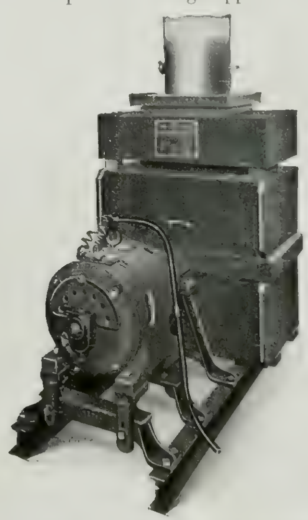


Fig. 4.—Slow-speed Motor connected to Organ Blower.

installed at the same point, provided the transformer is one having a good regulation on an inductive load.

The adjustment of the governor spring mentioned above depends on the frequency of the circuit, and it is, therefore, important that this should be known with accuracy beforehand.*

They develop at starting approximately 2½ times full load torque, and take approximately 2½ times the full load current, but by the time the motor has reached

* Century motors, it is claimed, are fully capable of bringing up to speed a load equal to 1½ times their normal rated capacity.

¾ speed the torque will have increased to approximately five times full-load torque and the current decreases to double the full load current. From that speed both torque and current gradually drop as the speed increases. The starting torque and current may be materially reduced by varying the position of the brushes on the commutator relative to the field. It is claimed that these constant speed motors are adapted to the operation of all machinery requiring frequent stopping or speed variation of the motor. In cases where it is necessary to alter the speed, or to stop and start the motor frequently, the installation of tight and loose pulleys is recommended, and the motor should then be allowed to run continuously. Flywheels should be provided where frequent overloads are placed on the motors. These motors can be equally well run on one-phase of a two or three-phase circuit as on an ordinary single-phase circuit, and it is claimed that in this case they do not create so much disturbance in starting as with an ordinary three-phase induction motor.

The illustrations given herewith indicate sufficiently the form of construction employed by the Century Electric Co. It will be noted that these motors are well protected, and at the same time sufficiently ventilated to permit of the motor carrying heavy loads continuously without an abnormal temperature rise. The very best material and workmanship are employed in their construction, and all parts will be found of heavy design for their rated capacity. The bearings are exceptionally large, the best phosphor bronze being used in their construction, and the oil wells are of ample capacity to hold sufficient oil for several weeks' run, and are of such design as to prevent the possibility of "pumping" oil out of the bearings. The shafts will be found of sufficient size for the most severe service, and are finished in a grinder. These motors can be mounted on the side wall or ceiling, by turning the end plates 90 deg. or 180 deg., to keep the oil wells in a vertical position. Vertical, enclosed and reversible motors are also supplied, while varying speed is obtained by altering a resistance in the field circuit.

It will be seen from the above that this type of motor is finding a wide application in the United States for industrial work. In many ways no doubt its use is an advantage, and where a constant speed is desired or is necessary, it should be exceedingly useful.

The Adnil Electric Co. are the sole agents for Century motors in Europe, and carry a stock in London. Further particulars of equipment may be obtained from this firm.

Oerlikon Dynamos and Motors for Small Outputs. . . . .

BOTH the dynamo and motor have of recent years become such standardised machines that one is apt to think that their production is more or less automatic, and to forget the care which must of necessity be expended in their design and manufacture. That care is

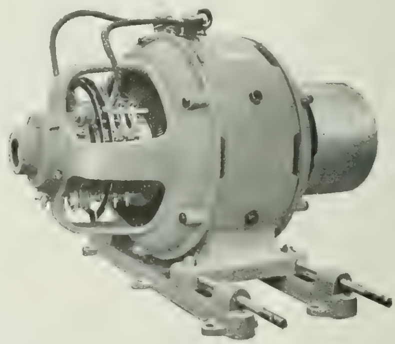


Fig. 1.—Oerlikon D.C. Standard Motor.

expended there is no reason to doubt. In confirmation of which statement we may call attention to the machines built at the Oerlikon works, whose London offices are at Oswaldestre House, Norfolk-street, Strand, W.C., the manager being Mr. G. Wüthrich, and which are designed in accordance with the most recent experience, and the latest developments and principles of construction. The efficiencies of these machines are very high throughout, and the overload capacity is considerable, whilst the temperature rise is kept within very reasonable figures. The design of the machines can claim also to satisfy all requirements from the æsthetic point of view. Special attention has been paid to the interchangeability of all the parts of the machines, all having been manufactured to limit gauges. The stores are so equipped as to be capable of supplying spare materials and of replacing any parts at a moment's notice, with the positive assurance that they will fit properly.

All Oerlikon direct-current dynamos and motors of small output capacity have a frame of cast steel, to which the laminated magnet poles are bolted by means of steel screws. The terminal block is fitted to the top of the frame and the terminals are protected. Ventilation slots on both sides of

the frame permit proper air draughts to pass through the machine.

The shield bearings are of specially robust design, and are so arranged that they can be turned round 90 deg. or 180 deg. for the purpose of facilitating the erection of the machine either on a bracket, on the wall, or on the ceiling of a workroom. The bearings are equipped with lubricating rings. The smaller machines have brasses of phosphor-bronze and the larger machines of cast iron lined with anti-friction metal. Proper access to the brasses and to the lubricating rings is provided for.

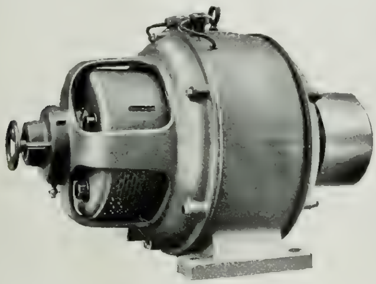


Fig. 2.—Ventilated Enclosed D.C. Motor.

The field coils are former wound, and carefully insulated from the frame by means of well-made insulation cylinders, and the armature coils—according to the voltage either wire or bar wound—are also former wound and well insulated. They are embedded in open slots. Small machines are generally equipped with series windings, whilst larger machines for low voltage have parallel windings. The press rings of the armatures are fitted with ventilators to ensure proper cooling of all parts of the machine. The commutator is built up of segments of hard-drawn copper insulated from the bush by means of mica. The degree of hardness of the mica is such that its wear and that of the commutator copper exactly correspond, thereby ensuring that the commutators run always true and smooth. The brush-holder ring is centrally arranged with the bearings so that it can be adjusted.

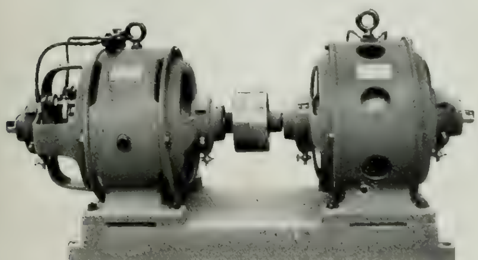


Fig. 3.—Oerlikon Motor-generator.

All machines, either of the series, shunt-wound or compound-wound type, running either as generators or motors, at all loads between no load and full load, run absolutely sparkless without shifting of the brushes. Normally the machines have an open magnet frame. Wherever it is necessary to have the machines made splash and rainproof, the enclosed ventilated type of machine is employed. The openings in the frame and in the end shields are closed by means of well-finished perforated sheet-iron covers, so as to provide the cooling air proper passage through the machine.

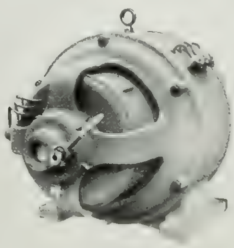


Fig. 4.—Ventilated Enclosed Three phase Motor.

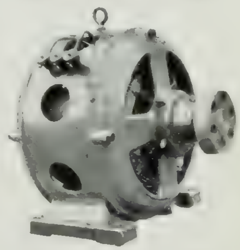


Fig. 5.—Three-phase Motor with Short-circuit Rotor.

The totally enclosed motors are built at special request for mining purposes, or for industries where the machines have either to be submerged in water or where the risk of fire has to be specially guarded against.

As regards overload capacity, temperature rise and insulation, the Oerlikon machines are designed on the most liberal lines and satisfy the requirements of the rules of all British Corporation engineers as well as those of the Institution of Electrical Engineers. As a rule, the Oerlikon machines show a temperature rise of about 54°F. to 90°F. on the iron parts, and 36°F. to 54°F. on the windings, and about 54°F. on the commutator, although engineers generally agree that much higher rises are permissible. For this reason it is clear that the overload capacity of the Oerlikon machines is invariably very considerable.

For starting up direct-current motors the Oerlikon Co. builds, according to the industry for which the machines are to be used, either metallic starters or starters immersed in oil. The metal starters are built into a cast-iron casing.

and the resistance material, of a very high temperature coefficient, is insulated from the frame by means of porcelain insulators. The switch contacts, according to the voltage, are either mounted on slate, marble or other efficient insulating material. The oil-immersed starters are dust and watertight, and the resistance material is completely immersed in oil. The contact switch and the resistance segments are fixed to the cover of the case, so that easy dismantling is ensured. The oil starters are of special advantage for fixing in damp rooms, and on account of their compact design they require relatively very little space, a feature to commend them to users. The generated heat is at once transferred to the oil, whilst the transference of the heat to the air by radiation is rather slow. For this reason ordinary oil-immersed starters are specially adaptable for motors which are not started oftener than, say, five times an hour. For intermittent working and repeated starting special starters are built to satisfy the requirements of all industries. They can be built to start the machines either against full load, half load or one-third load as desired. For intermittent working, however, the starters are invariably built to run up the machines on full load.

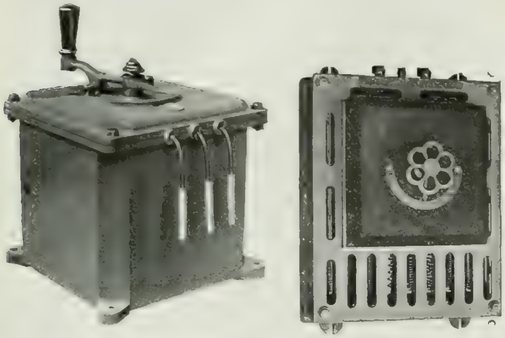


Fig. 6. Examples of Oerlikon Motor Starters.

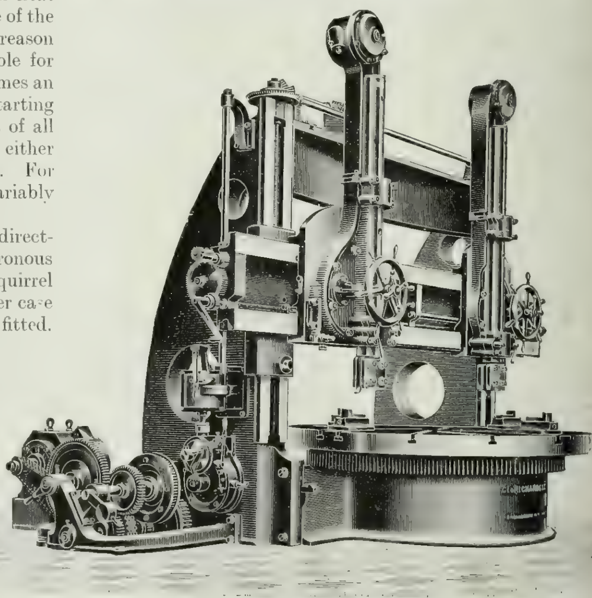
The same general idea as that outlined above for direct-current machines is also followed in the case of asynchronous motors for single, two or three-phase circuits. Both squirrel cage or wound rotors can be supplied, and in the latter case a special short-circuiting and brush-lifting device is fitted. The special feature of this device is that the contact poles, which represent the links between the rotor windings and slip-rings, remain in a fixed position, whilst the slip-rings and brushes can be shifted in such a manner that the outer slip-ring short-circuits the contacts. The short-circuiting of the rotor windings and the lifting of the brushes are done by means of one lever, and the starting up of the machine is, therefore, extremely simple.

The accompanying illustrations give a good idea of the general appearance of the Oerlikon motors and other apparatus.

Motor-Driven Boring and Turning Mill.

It is becoming more and more recognised every day that by employing the electric drive great economies can be effected in machine shops, and this is especially the case in those shops where extra large machines are erected. In such cases a motor is direct coupled to the machine, which thus forms a complete unit by itself.

Messrs. George Richards & Co., of Broadheath, have long made a speciality of manufacturing machine tools of many kinds. An interesting machine made by them is shown in the accompanying illustration It consists of an 8 ft. boring and turning mill, and is illustrative of all sizes of Richards' mills which are arranged for the motor drive. The motor is mounted on an extension bed, cast to the driving head-stock bracket, and the drive from the motor to the machine can be by either silent driving chain or spur gearing, as desired. Intermediate gear is provided so as to give two speeds to the driving shaft of the machine to any one speed of the motor, thus reducing the speed variation in the motor that would otherwise be required, and forming, it is claimed, a very efficient drive. The weighted lever shown in the illustration is the one for operating the intermediate gear, and one movement of this lever engages one wheel



Richards' Boring and Turning Mill.

at the same time as it disengages the other, and *vice versa*. It is therefore impossible for any accident to occur, as both wheels cannot be in gear at the same time. The gearing nearest the motor is the ordinary back gear, and a range of six speeds is given to the table through the gearing alone. A variable speed motor with a reduction in speed of 2 to 1 is recommended for use with this machine, as it provides a full range of speeds.

The elevating motion to the cross slide is driven from the same motor, a chain pinion being placed on the opposite end of the shaft and the drive through chain, horizontal shaft bevel gears and vertical shaft connected to the elevating motion at the top of machine.

Siemens Continuous-Current Variable-Speed Motors. . .

THE continuous-current variable-speed motors manufactured by Messrs. Siemens Bros. Dynamo Works are in all cases fitted with commutation poles; while further to reduce the distortion of the field and to ensure sparkless commutation at all loads, a long air-gap is provided. For wide speed variations compound winding is adopted.

All standard machines are capable of giving 25 per cent. overload for half an hour, or 50 per cent. for three minutes, and run practically sparklessly at all loads from no load to full load with fixed position of brushes. Under normal conditions the temperature rise for protected type motors does not exceed 70°F., and 80°F. in the case of the ventilated type. The power is transmitted either by direct coupling or by belt or toothed gearing. Fig. 1 illustrates a standard protected type motor for direct or belt driving, and in Fig. 2 is shown a ventilated type motor fitted with reduction gearing.

As an example of a motor of large size with wide speed variation may be mentioned a 100 B.H.P. motor working at

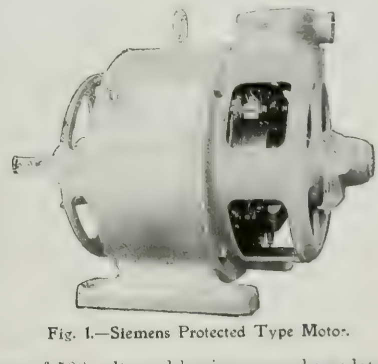


Fig. 1.—Siemens Protected Type Motor.

a pressure of 500 volts and having a speed regulation from 100 to 600 revs. per min. This machine is of the ventilated type, fitted with gauze covers. The speed variation is obtained by shunt control, and the motor is perfectly stable and absolutely sparkless under all conditions from no load to 100 per cent. overload. At the end of a five hours' run at full load at a speed of 350 revs. per min. the maximum temperature rise in no part exceeded 37°F., and

after six hours' full load at the highest and lowest speed the temperature was quite within normal limits.

Fig. 3 is an illustration of a Siemens class F.C. motor driving a high-speed lathe with 18 in. centre. This motor develops 35 H.P. at a pressure of 500 volts, the power being transmitted through reduction gearing. The motor

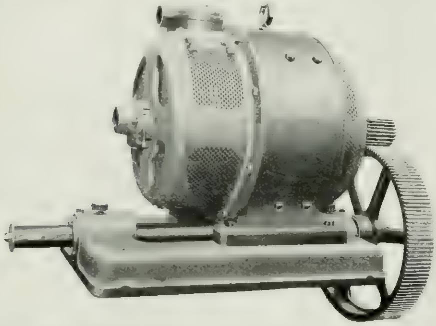


Fig. 2.—Siemens Ventilated Motor, with Reduction Gearing.

speed can be regulated from 400 to 1,400 revs. per min. by a rheostat with 26 steps, and the face-plate can, by means of change gears, be run at two speeds for each motor speed, so that the face-plate can be run at 52 different speeds ranging from 4·5 to 58 revs. per min. The motor is fixed on an extension of the lathe bed, and is readily accessible for inspection, oiling, &c.

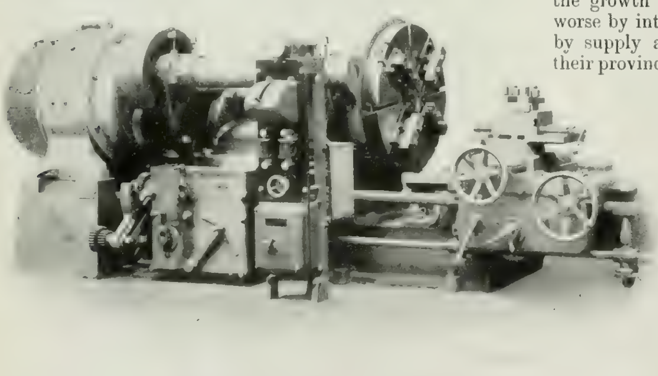


Fig. 3.—Siemens Motor and High-Speed Lathe

Methods of Generating Business. . . . . .

THOUGH at the time of writing meteorological conditions would seem to indicate that summer has taken its final departure, yet we are not without hopes that there is still some fine weather in store for us, and that we have yet time to consider and consolidate our policy for the winter months; during which it is to be hoped an increased demand for lighting, heating, and cooking apparatus will do much to bring about an improved state of things in the industry.

The legal restrictions against hiring out of apparatus do not prevent a supply undertaking from inaugurating a suitable publicity department or from opening a show room where the apparatus of approved makers could be exhibited in actual working order. Having instituted such a show room, engaged a man who can give imformation intelligently, and ensured that only the best material shall be used, the supply authority can do little more in the purely commercial direction, except that it might easily get into closer touch with contractors, with a view to setting on foot closer working arrangements than exist at present, and a discontinuance of anything in the shape of the Kilkenny-cat policy which is now too often pursued with disastrous results for the industry in general. Legislative operations have already produced a bad enough effect on the growth of the industry, without it being made any worse by internal strife or by the arrogation to themselves by supply authorities of work which truly lies outside their province. This is certainly a matter worth considering.

On the other hand, the electrical contractor in general might, we feel sure, do much more than he is doing at present by bringing before the general public the benefits of electricity for heating and cooking; and, having acquainted them with these benefits, consolidate the position by improving the design of the apparatus, both by introducing details which his own experience tells him are necessary and by adopting ideas which his customers may let fall, as regards the purely domestic side with which they are not unlikely better acquainted than he.

We cannot see, for instance, where the supply authority is debarred from hiring or selling apparatus why a contractor should not take the matter up. Shopkeepers in other branches of industrial work do advance so far and even meet their uncapitalised customers by instituting hire-purchase or pay-by-instalment systems. In such cases, however, it should not be forgotten that a pioneer struggle is being undertaken in what is not seldom an enemy's country, and that every allowance should be made for the awe in which electrical questions are held and the mystery which surrounds the apparatus in the eyes of the uninitiated. Care should therefore be taken that all apparatus sold is suitable for the work it has to do, while the consumer should have a clear idea of what the operation of the equipment will cost him. It would be better, in fact, to overstate than understate the case, for while the latter method may bring a new consumer on the mains he is more than likely on receiving his first quarter's bill to go off in high dudgeon. On the other hand, should the bill come to less than he expected, the resultant good humour is all to the benefit of the electrical cause and may not improbably lead to fresh consumers. If articles are hired out by contractors, it should be distinctly understood by the consumer that the price paid includes all repairs and renewals, an undertaking that should be loyally observed. It is improbable that much wilful damage will be done, but even in this case as long as the operation is not too often repeated, it is worth while to do repairs free. Moreover, when slight defects arise in the apparatus or parts wear out, care should be taken that these details are immediately put right without expense to the consumer.

The instalment or hire-purchase system, too, seems to offer a distinct opening for the further propagation of electrical apparatus. For the benefits thus obtainable are made evident at a very small cost, and their advantages can be disseminated through a larger proportion of the population. We cannot help thinking that a business of this kind carried on on commercial principles, and less with the idea of making large profits than of setting the industry on a firm foundation, would lead to ultimate success. Electric heating in general is essentially a new problem and must be tackled as such. New ideas must be formed and new apparatus designed in order that advantage may be taken of the system to the fullest extent and a hard and winning fight put up against its competitors.

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NOTES.

Tramway Matters.

In his presidential address to the Municipal Tramways Association, Mr. A. L. C. Fell dealt with a number of interesting tramway questions. Considering the constant competition in London between tramcars and motor omnibuses, it is not unnatural that he should touch upon the question of maintenance of paving by tramway authorities and the paying of rates on the earning capacity of the lines. There is certainly much to be said in favour of Mr. Fell's contention that all forms of public carriages should bear a share of the cost of maintenance of thoroughfares. At present the owners of omnibuses simply have to pay rates on the rateable value of stables or depots, whereas the tramway undertaking, in addition to bearing the first cost and maintenance of the paving, has to pay rates based on practically the earning capacity of the line.

It must be remembered, however, that in arriving at the rateable value of a tramway an allowance is made for repairs (including track), renewals, insurance, &c., so that the net rateable value is only a small proportion of the net receipts; and against this charge must be set the special privileges granted to the tramway authority. In considering the best use of a thoroughfare, the opinion is expressed that the installation of a tramway does not increase the congestion in the street, and a very favourable case is made out for the tramcar, as compared with the motor omnibus, in regard to the space it takes up. We think that this section of the address includes a little special pleading, but considering that Mr. Fell looks forward to the time when tramways will predominate, and when only "rare specimens of an extraordinary vehicle which was called a motor omnibus will be found in South Kensington Museum," difficulties as to competition will, no doubt, slowly cease to exist. In these days of friendly competition between undertakings of the same kind it would, no doubt, be a very great advantage for officials to become fairly familiar with undertakings other than their own, and we do not doubt that much benefit would result by facilities being given to officials to inspect other undertakings, as suggested by Mr. Fell. We hope that this suggestion will bear fruit. Among the many subjects on which opinions differ must be included the use of trailer cars. Apparently, most tramway managers prefer the double-deck car now so generally used, but, nevertheless, there is a large minority who hold that the use of trailers would facilitate the handling of traffic during rush hours. It is interesting to note that Mr. Fell is a strong believer in trailers, and before long we shall have the opportunity of seeing how they work on the lines of the London County Council.

Single-deck v. Double-deck Tramcars.

The Paper read by Mr. A. R. Fearnley, manager of the Sheffield Corporation Tramways, at the Conference of the Municipal Tramways Association this week, gives an interesting comparison of electric tramway practice in this country and on the Continent. The main features in which our tramways differ from those abroad are well known to engineers in this country, but the author's detailed analysis of the advantages and disadvantages of the different methods adopted should prove valuable. This applies particularly to the use of single-deck cars on the Continent and double-deck cars in this country. The present almost universal adoption of double-deck cars in Great Britain.

in striking contrast with tramway practice all over the world, would seem, however, to be justified on all grounds. In this connection it is surprising to learn that the latest type of single-deck car being used in Vienna actually weighs over 12 tons and provides seats for only 26 passengers, whereas the standard double-deck car in this country weighs about 11 tons and furnishes seating accommodation for 56 persons. The striking difference between these figures is largely accounted for, however, by the fact that in the case of the Vienna cars 24 passengers are allowed to stand, so that provision has to be made in designing the cars for this additional load. Although by no means in favour of over-crowding, we think that the present stringent regulations on the London County Council and other tramways, in regard to carrying passengers for whom seats are not provided, might be somewhat relaxed where there is definite standing room. The difficulty of collecting fares would not be materially increased, and might be facilitated by allowing passengers to obtain "strip tickets," as is at present the custom on the "Tubes."

The Overhead Trolley.

THERE is little doubt that on an electric tramway the weakest feature from an engineering point of view, and one which causes much trouble, is the arrangement for collecting current. In this country the trolley boom and trolley wheel are almost universally employed in the case of overhead wires, the main exception being the Sheerness tramways, where a Siemens bow is used. On the Continent, however, the bow collector finds great favour, and it certainly seems a mechanical improvement on the trolley. Mr. A. R. FEARNLEY, in his Paper mentioned above, supports the claims of the bow collector, but it is noticeable that details as to its cost of operation are difficult to obtain. The wear of the trolley wire should also be taken into account, since where a rubbing instead of a rolling contact is employed considerable difference in the amount of wear might be expected. In this connection, however, Mr. PHILIP DAWSON pointed out in a recent article that Continental engineers claim for the bow collector no greater wear of the overhead wire than where a trolley wheel is used, some engineers even claiming less wear in the case of the sliding bow. As, however, it would be difficult to alter existing practice in this country, the trolley is likely to remain in favour on tramways, although in the case of railways the problem assumes a totally different aspect, in which foreign experience is likely to play an important part.

Steam Turbine Economies.

A GLANCE from time to time at our columns in which are given the weekly traffic receipts of the various electric tramways and railways shows that the undertakings associated with the Underground Electric Railways Company of London are experiencing a period of comparative prosperity. It is not surprising, therefore, that at the meeting of the Underground Railways Company this week the chairman, Sir EDGAR SPEYER, expressed unqualified satisfaction at the half-yearly report which was presented by the directors. A feature of the working of these railways is the reduced cost of operation which is now being recorded, and from an article which appears on another page of this issue it seems that further economies, amounting to £30,000 per annum, are to be expected in the cost of power. It must be admitted that the works costs at Lot's-road generating station have not, in the past, been as low as might have been expected, considering the size of the undertaking and the nature of the load; but as the new Parsons turbines now being installed consume only about 14 lb. of steam per kilowatt-hour, compared with from 20 lb. to 23 lb. obtained with the older plant, it is evident that considerable improvement in the costs is likely to be the result. This advance indicates what rapid progress has been made in steam turbines during the last few years, and also serves to draw attention once more to the necessity for providing, in connection with electricity supply, ample allowances for the depreciation and antiquation of plant.

The Electrical Engineers (London Division).—Capt. P. H. Campbell, R.E., has been appointed adjutant of this corps, and has entered upon his duties.

American Institute of Electrical Engineers.—The Western Electric Co. has presented to the library of this institute a most valuable addition in the shape of a collection of patent specifications. The gift constitutes the largest accession since the original creation of the library, and consists of 461 leather-bound volumes containing approximately 100,000 specifications, covering the period from May 30, 1871, to December, 1908. The value of the gift is estimated as nearly £1,000, and it is hoped that it will stimulate further generosity of the same kind.

Combination of Reciprocating Engines and Exhaust Turbines.—The question of effecting economies in generating practice by the connection of a turbine between the reciprocating engine and its condenser is one of great interest at the present time. A good deal has been written on the subject, and much has been done in the installation of such plants, as will be gathered by perusing a very complete account of this work which is given in an article by Eugen Eichel recently published in the "Elektrische Kraftbetriebe und Bahnen." The author gives an excellent summary of the present position of this work, both in this country and in the United States, the Papers by Mr. A. S. Blackman, read before the Municipal Electrical Association, and by Mr. H. W. Wilson on the "Electrical Operation of Textile Factories," both of which have appeared in THE ELECTRICIAN, being specially mentioned. Messrs. Willans & Robinson's work in this direction is also included.

Smelting Titaniferous Iron Ores in the Electric Furnace.—In a recent issue of the "Canadian Engineer," Mr. B. F. Haanel gives some figures on this subject, obtained as the result of experiments made by the Electro-Metals Co. The ore was from Wyoming and contained as high as 2 per cent. TiO_2. The principal figures are as follows: Length of run (deducting stoppages), 22 hours 45 minutes; mean volts on furnace, high-tension side, 10,800, low-tension side, 35·6; mean amperes on high-tension side, 25; power factor, 0·91; power used, 329 H.P.; pig-iron obtained, 3,317 lb.; output of pig-iron per 1,000 E.H.P.-days, 5·04 short tons; electrical horse-power-years per ton of pig-iron, 0·543. The output in pig-iron per 1,000 H.P.-days for this run must not be considered as the best result that can be obtained, as the furnace during the first seven hours of the run operated badly. To arrive at definite and reliable results as to output the furnace should run continuously for at least three days.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tangier—Cadiz	May 19, 1909	Sept. 21, 1909
Tourane—Amoy	June 17, 1909	
Assab—Perim	July 8, 1909	
Dakar—Conakry	Aug. 19, 1909	—
Sheik Seyd—Perim	Sep. 15, 1909	—

Personal.—The Council of the Association of Engineers-in-Charge have unanimously elected Mr. Henry Adams, M.Inst.C.E., M.I.M.E., &c., as their president, in succession to Mr. James Swinburne, F.R.S., M.Inst.C.E., and an attractive programme has been drawn up for the new session, including some good Papers and several social functions. Among the members of the Association Mr. Adams is one of the oldest of the engineers-in-charge, having so far back as 1865 been in responsible charge in the outdoor department of Sir W. G. Armstrong & Co. at Elswick.

Kaleidoscopic Electric Sign.—Electrical engineers in London should take an early opportunity of inspecting an interesting type of electric sign supplied by Messrs. Rashleigh Phipps & Co., one of these signs being in operation every evening in the window of their showroom at 147, Oxford-street, W. The sign can be best described by saying that it gives kaleidoscopic effects of the most beautiful nature. A large number of coloured electric lamps are employed, wired in circuits of four, each circuit being controlled by an automatic contact breaker of the well-known type in which the heating of the contact breaker by the current causes the former to elongate and break the circuit, so extinguishing the lamps, which are once again lighted when the contact maker has cooled sufficiently to close the circuit. As these contact makers are adjusted so that the periods during which the circuits are closed and interrupted vary very considerably, it will be seen that the combinations of lamps alight at the same time are practically innumerable, and most charming effects are produced. Several of these signs are already in use, and they should certainly prove a great attraction; indeed, much pleasure is obtained by noting the varying kaleidoscopic effects.

Portable Electrically Driven Concrete Mixer.—According to the "Electric Railway Journal" the shops of the Memphis Street Railway have recently completed a concrete-mixing equipment, which is designed especially for street railway work. The railway company built the car for carrying this mixer and the special propelling truck. The car which carries the mixer is supported on two axles with 24 in. wheels. These low wheels permit placing the mixing outfit so near the ground that materials can easily be shovelled into the charging skips. A 15 H.P. motor is used to operate the mixing drum and the charging skips. The movement of both is controlled by levers on the platform. The car is moved along the street by a motor mounted on a single axle and partly carried by a wrought-iron connection bar. The controller for this motor is mounted on the mixer car platform, near the switches and levers which control the mixing machinery. This separate pair of wheels for carrying the propulsion motor was necessary because of lack of room under the low platform of the mixer car due to the small wheels.

Report to the Board of Trade on the Lift Accident on the City & South London Railway.—The report of the Board of Trade Inspector, Lieut.-Col. E. Druitt, on the lift accident which occurred at the Oval station of the City & South London Railway on August 3rd last, has now been issued. It appears that one of the lifts, which is worked hydraulically, was descending with 44 passengers and the lift man when the copper pressure pipe connecting the working valve with the cylinder of the hydraulic lift suddenly burst, the cage being at that time about 12 ft. or 13 ft. from the bottom, with the result that the cage descended quickly and hit the bottom of the well fairly hard. The cage rebounded about 9 in., and the safety clutches coming into operation, as the ropes carrying the cage became slack, the cage remained in that position. Six passengers complained of cuts and bruises, but the remainder suffered only a drenching from the water. The lifts at this station have been working since December 18, 1890, when the railway was first opened, and the only occasion when a similar accident occurred was on the same lift nine years ago. Chas. Whyman, the lift man, James Farmen, the lift foreman, and Mr. C. O. Ridley, of Messrs. Sir W. G. Armstrong, Whitworth & Co., who supplied the lifts, gave evidence on the question, the last of them showing that the bursting pressure of these pipes is five times that of the ordinary working pressure. This ordinary working pressure may, however, be considerably exceeded, when the lift is descending full of passengers, at the point where the burst occurred. The inspector reports in accordance with the evidence, and the company propose to substitute for the present pipes some $\frac{1}{16}$ in. thicker and fitted with a relief valve set to work at 1,400 lb. This will, it is hoped, minimise the effect of any sudden shock.

Electrically Driven Power Shovels.—The "Engineering an Mining Journal" gives a description of what, it is claimed, are the largest electrically operated power shovels ever constructed. They have buckets of 4 cubic yds. capacity and are used for mining limestone rock. The hoist movement of these two 110-ton machines is actuated by a 200 H.P. 220 volt series-wound direct-current mill motor, running at 415 revs. per min. The thrust motor, controlling the movement of the dipper handle, is an 80 H.P. machine of similar type, while the swing boom is operated by an 80 H.P. motor. Each motor is controlled independently by an automatic magnetic switch controller, which secures the greatest nicety of operation of the heavy bucket. This form of control protects the motors from any heavy overloads, which may result from the bucket striking solid rock or other obstruction, by opening switches that introduce resistance into the motor circuit. The control panels and resistances are mounted in the rear of the cab, while the controller handles are conveniently placed under the hand of the operator. The hoist and swing-boom motors are mounted within the car. The thrust motor is placed out on the boom, communicating its motion to the bucket staff through reduction gearing connected to a pinion engaging a rack on the staff. The power circuit to the shovel is completed through a cable, carried on a reel on the frame and through the rails on which the equipment advances. The shovel may also be fitted with a standard trolley for obtaining the necessary energy and for propulsion on an ordinary electrified track. The machine may then attain a speed of 5 miles an hour. Compared with the steam shovel, the electric-driven excavating apparatus has been found to present the advantages of simplicity, economy and ease in operation. The hauling of water and coal is avoided, fewer operators are required to handle the machine, and an appreciable saving of time is effected. In one case an electric shovel with a 75 H.P. hoist, 30 H.P. thrust and 30 H.P. swing-boom motors was operated at a cost of ½d. per cubic yard of gravel, clay and sand removed. Similar work performed by steam shovels often costs from 1½d. to 2d. per cubic yard.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, September 24th (to-day).

Municipal Tramways Association.

10:15 a.m. Business Meeting of the Association in the County Hall.

1:55 p.m. Special train leaves Waterloo Station (L. & S.W. Rly.) for excursion to Windsor.

4:55 p.m. Reception in the Guildhall by the Mayor and Corporation of Windsor.

SATURDAY, September 25th.

JUNIOR INSTITUTION OF ENGINEERS.

3 p.m. Visit to the Imperial International Exhibition, Shepherd's Bush, for inspection of engineering, scientific and other features of interest.

MONDAY, September 27th, to FRIDAY, October 1st.

IRON AND STEEL INSTITUTE.

Meetings at the Institution of Civil Engineers, Great George-street. [A list of the papers of electrical interest was given in our issue of September 3rd, p. 817.]

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

Monday, Sept. 27th, "A" Company	Technical drill, 7:0 p.m. to 9:30 p.m.
Tuesday, Sept. 28th, "B" Company.........	Technical drill, 7:0 p.m to 9.30 p.m.
Wednesday, Sept. 29th.	Gymnasium, 6 30 p.m. to 9:30 p.m.
Thursday, Sept. 30th, "C" Company	Technical drill, 7:0 p m. to 9.30 p.m.
Friday, Oct. 1st, "D" Company	Technical drill, 7:0 p.m. to 9:30 p.m.

SOME COMPARISONS OF CONTINENTAL AND BRITISH METHODS OF OPERATING TRAMWAYS.*

BY A. R. FEARNLEY.

Summary.—The author first considers the advantages of the double-deck car compared with the single-deck car and gives some interesting details of the cost of operation of the two types. He then discusses the use of trailer cars and the vestibule type of car, the latter being much in favour on the Continent. He believes the bow collector is a better arrangement than the trolley boom, and finally refers to the railless electric trolley car, which he considers will play in the future an important part in tramway business.

The most striking differences which at once impress one when inspecting Continental tramway systems are the rigid adherence to the single-deck type of car; the carrying of a large number of standing passengers, especially on the front and rear platforms; the almost universal use of trailer cars; the large and increasing number of vestibule cars (both motor and trailer cars); the bow collector, which is used in place of the trolley boom; and the provision of shelters or waiting rooms at important centres and junctions. A further difference is now being introduced—viz., the provision of railless electric traction systems for developing ultra-suburban traffic, such as is catered for at present in this country only by the horse or petrol 'bus or by railways, until the population warrants laying down tramway track.

Type of Car.—Seeing that the double-deck has almost all the good points of the single-deck car without its many limitations, I am at a loss to understand why, even at this date, some of the Continental lines do not give the double decker another trial, especially when we remember that two or three of our large British municipalities commenced electric traction with single-deck cars, but almost at once reverted to the double-deck cars. The most frequent objection that I have heard or seen to the use of double-deck cars on the Continent is that a great deal of time is lost in passengers entering and leaving the cars at the stopping stations, to which statement I anticipate few British managers will attach much importance. The most serious objection advanced is the one referring to the continued and lengthy absence of the attendant from the platform.

The best suggestions in favour of the single decker are that it can be readily coupled to a trailer and worked in this way without danger and inconvenience, and, what is equally important, the only additional attendant required may be a shedman or other employé of the department, not necessarily a regular traffic employé, the brakes being either magnetically or air-controlled on both cars by the motorman. An argument advanced against the use of the Continental type of single-deck car is that the passengers who stand on the platform expect to travel at a cheaper rate, and I think it will be agreed that this in itself would be a very strong argument against the adoption of a car of this type in this country.

In comparing actual working expenses of the two types of car it is astonishing to find that in many important points the single decker shows very little saving over the double decker. In Sheffield, where, owing to severe gradients and railway bridges, we are working 57 single-deck cars along with our double deckers, I find that the average current consumption per car-mile by the double-deck cars on our most hilly route is 1·64 units per car-mile, and on our most hilly single-deck car route 1·46 units per car-mile, being a difference in favour of the single-deck cars of only 0·18 unit per car-mile, whilst it is seen from diagrams attached to this Paper that the difference in the gradients of the two routes is not very serious. The seating capacities of the cars compared, each of the single-truck type with 6 ft. wheel base, are:—Double deck, 52 passengers, single deck 28 passengers; and I suggest that the double-deck car has a similar advantage on almost every point.

Another interesting comparison is in the mileage obtained from tyres. The average taken from the double-deck cars under certain conditions is 4,505 miles per $\frac{1}{8}$ in. wear, and for single-deck under similar conditions is 4,576 miles per $\frac{1}{8}$ in. wear, or only 70 miles per $\frac{1}{8}$ in. wear in favour of the single-deck, with 46 per cent. less carrying capacity.

On comparing the life obtained from brake shoes we find that double-deck covered-top cars average 4,520 miles per set of shoes, double-deck open-top cars average 4,643 miles and single-deck cars average 4,530 miles.

The traffic wages are the same, except in cleaning, where there is certainly a little in favour of the single-deck. Other important arguments in favour of the double-deck car, without repeating many well-known points, are smaller quantity of rolling stock required, considerably less car shed accommodation necessary, comfortable and very popular accommodation for smokers in all sorts of weather.

The standard double-deck car in this country provides comfortable seating accommodation for 56 passengers, and easy standing accommodation for from four to six passengers, and weighs about 11 tons. Compare this with the modern single-deck car in use on the Continent. One of the latest type now in use in Vienna weighs over 12 tons, with seating accommodation provided for 26 passengers, 24 passengers being allowed to stand in addition, showing that the single decker, with the very limited seating accommodation, is actually the heavier car, partly on account of the great strength and weight which has to be put in to accommodate the standing passengers. Whilst I do not suggest that this practice of carrying large numbers of passengers on the platforms should be followed in this country, at the same time I am of the opinion that the British passenger is inclined to attach too much importance to the little overloading of cars beyond the seating capacity which takes place.

Trailer Cars.—Judging by the way in which they are generally used, a trailer appears to mean additional accommodation for about 28 more passengers with each motor car. There are the increased wages and maintenance charges and the greater street area covered, together with the necessity for providing double track where the trailers are in use, also the extra current consumption (the Continental trailer appears to vary in weight from 3 to 6 tons), and the difficulty in placing depots in suitable positions to avoid a large amount of lost mileage in taking the trailer on and off. I think it will be generally agreed that the double-deck car suits the requirements, in this country at any rate, very much better than the combined single-deck car and trailer would do, and at considerably less working cost.

The question of coupling trailers to double-deck open-top or covered cars is a different problem from the one just referred to, and whilst it is difficult to understand why more experiments have not been made with this combination in this country, it must be at once admitted that unless certain special precautions are taken the danger in working would be considerably increased. For instance, in our last year's returns in Sheffield we had a total of 1,800 accidents of all classes reported, 656 of these being caused by passengers entering and leaving the cars when in motion. With trailers attached, it is reasonable to infer that a fairly high percentage of these would have resulted in more serious, and in some cases fatal, accidents, and it is a debatable point whether it would not be better for the whole of the tramways of the country at the present time to commence rigidly to enforce the by-law regarding the entering and leaving of cars when in motion, and to take proceedings when passengers are reported as having disobeyed this regulation. With this exception, I do not see that there is anything to prevent trailer cars being coupled to double-deck cars and used in this way. It may be stated that the Board of Trade is opposed to such additions or experiments, but I do not think that too much importance should be attached to such a statement.

Vestibules.—It is interesting to note that the use of the vestibule type of car is very general, and is rapidly on the increase on Continental tramway systems, and I believe that its adoption in this country will rapidly increase. After two years' experience of a number of these cars I shall certainly recommend any new rolling stock we obtain to be of the vestibule type.

Bow Collector and Trolley Boom.—I am of the opinion that the trolley boom, with its attendant overhead fittings, is the most unmechanical feature of the whole of our tramway equipment. The bow collector as used on the Continent is the better arrangement. It is much safer, and also very considerably simplifies the overhead fittings and construction work, although, on the other hand, it may shorten the life of the trolley wire. I am not in a position to say that the bow collector can be maintained as cheaply as the trolley boom, as, despite personal inquiries and considerable correspondence, the figures which I have been able to obtain regarding the maintenance of the bow collector are very limited. The cost of trolley upkeep in Sheffield for our last financial year amounted to 0·0336d. per car-mile. The cost on a line where the bow collector is in use was given to me as being 0·041d. per car-mile, and, in my opinion, the bow collector would be a considerable advantage if it could be worked with such a small difference in cost.

Waiting Rooms and Shelters.—This point, which is of considerable interest to the tramway passenger, has received very scant attention in this country. The number of towns which have made any provision at all in this respect form, I should say, a very small minority of the tramways represented in our association. Why this should be so it is difficult to say. Shelters of ornamental type are provided in many instances in the Continental towns, the average cost being probably not more than £30 to £40, and they are certainly a convenience to their passengers.

Railless Electric Trolley Cars.—In my opinion, if this system is

* Abstract of a Paper read yesterday at the Conference of the Municipal Tramways Association.

given a fair trial without unnecessary restrictions, it will, within the next few years, form an important addition to our tramway business. In comparing this method of dealing with suburban traffic, I would say that I think it is superior to any system of horse, steam, electric or petrol 'bus which, so far as my knowledge extends, is at work in this country at the present time. There is no doubt that if the old trouble on account of anticipated interference or damage to roads is not made too much of, many suburban districts which are to-day without any connection with our existing tramway systems, and in some cases without any convenient means of access to our cities, will be able to be linked up by a system of this description at a low capital cost, and yet obtain a satisfactory service. Also, the probability is that a system of railless cars would, in the case of thinly populated outside districts, be found sufficient for many years to come, and the laying down of tramway track, with the consequent heavy capital expenditure, might be delayed for a considerable period.

The reasons which a Committee in the House of Commons recently gave for striking out a clause empowering a tramway company, who were promoting a bill, to work railless electric cars, will be interesting. They were: (1) That they appeared to have no immediate intention of carrying out the experiment; (2) that the cases which they submitted where this system was in operation were not routes in streets of places where the traffic was as great as in the town referred to (*i.e.*, a town of about 126,000 inhabitants). These reasons may be of use to members as showing the attitude which may be taken up by a Parliamentary Committee when this matter is again brought forward in a Parliamentary bill.

Conclusion.—Another method which one notices in comparing the ways of working, and one which is frequently adopted on the Continental systems, is the placing of the tramway tracks at the side of footwalks. This method is rarely seen in this country, and then only where its adoption is compulsory, the Board of Trade usually viewing such work with considerable misgiving, and specifying low speeds for cars running on track in such positions. On the contrary, it seems to be accepted in many places on the Continent as a necessary arrangement for the convenience of the tramway passengers, and it does not appear to lead to any increase in accidents, and is certainly a very great convenience in the loading and unloading of cars.

In regard to the track, I find that we are adopting very similar methods to those in operation on the Continent. They appear to have had in use for a considerable time rails with wider groove and tread than the old English types, which are now rapidly being abandoned for the British standard sections. Speaking generally of permanent way construction, I should say that in few places on the Continent is it equal to the permanent way to be seen on the majority of our municipal tramway systems. The junctions, crossings and paving near the rails are certainly not kept in as good a condition as we are accustomed to see in this country.

With regard to the trolley wire, grooved wire is very largely used, and no doubt it has been found of equal advantage with the bow collector as with the trolley boom.

Comparisons of our methods might be carried considerably further, but it must be remembered that the climate and the conditions of living in the Continental cities vary considerably from our own, and in comparing the tramway systems these must also be borne in mind. Generally speaking, we must agree that their methods and system appear to meet the requirements of, and to give satisfaction to, their passengers. It is interesting to find that at their tramway conferences they are dealing with the same subjects and attempting to elucidate the same problems that have engaged and are engaging the attention of the members of our own association.

Attached to the Paper are the following technical data concerning the hub-motors as used on the Vienna municipal trackless trolley system:—

Each motor of the trackless trolley vehicle gives about 20 H.P., with current at 500 volts, at about 190 revs. per min., and the motors can take 100 per cent. overload for considerable periods without detrimental heating. They are designed so that the field magnet spindle is mounted and fixed on the axle as an internal pole star. The armature is placed outside, and forms part of the wheel itself. For this purpose it is carried on two ball bearings, one each side of the field magnet. The field magnet is of steel, and has 10 poles riveted together under a special process.

Each spool consists of a flat copper band of uniform section, but of variable width and depth. In this way the space between the spools is used to the best advantage, although these spaces get narrower towards the centre of the wheel on account of the radial disposition of the spools themselves. The armature is built in a similar way out of the best steel, and consists of a large number of spools, insulated by silk, which are built into the frame of the wheel, the latter being made of special gunmetal. The brush holder is arranged in a vertical plane, so that the vibration of the car cannot lift the brushes, which consist of special carbons, and only require very weak springs.

For overhead line purposes only four brushes are employed, which are fixed on one ring. It is sufficient to take off the cover plate to examine the whole motor, and this enables one to fix or tighten up any part. The motors are completely dust and water proof, and the design of the axle makes it possible to take off at one operation the whole wheel motor, and at the same time the radius rod, which is designed as the fixing point of the brakes. The motors are placed in the back wheels for trackless trolley operation, and in the front wheels for fire brigade work. Sometimes, also, on trackless trolley lines of heavy gradient, four motor wheels are employed, two at the back and two at the front, in which case the front wheels are fitted with a special design, securing perfect steering even in the case of a sudden breakdown of one of the front wheel motors. The general rule, however, for trackless trolley operation is a back-wheel drive, the brakes being fitted on separate air-cooled drums of very large diameter.

The efficiency of the electric motors on the brake is between 80 and 90 per cent., and if one considers that the power is directly brought to the motors in the wheel itself, and therefore no gearing or change of power or transformation of any kind is employed, this represents the efficiency at the wheel for a given current on the overhead line, which result, it is claimed, cannot be surpassed by motors of any other type.

ON MAGNETIC TESTING OF IRON WITH ALTERNATING CURRENT.*

BY A. CAMPBELL, B.A.

Summary.—The author has investigated the effect of widely different wave forms and various materials on the accuracy of the formula given by Roessler for the iron loss of a transformer. For certain materials the author finds that the hysteresis loss increases considerably as the frequency is raised, due probably to magnetic viscosity. Experiments are recorded to show the effect of the thickness of the sheets on the eddy current loss; and the effect of the dimensions of the stampings on the hystersis loss is also shown.

The introduction of high resistivity iron alloys with low hysteresis loss has made it more than ever desirable that sheet material for use in transformers, or alternating-current machinery, should be tested for hysteresis and eddy current loss by means of actual alternating current. The object of the present Paper is to describe the method by which these tests are carried out at the National Physical Laboratory, and to include some of the more interesting results obtained during the past year. Brief reference is first made to the work of Dr. G. Roessler,† Gumlich and Rose‡ and Lloyd and Fisher.§

Influence of Form Factor.—When an iron ring is magnetised by an alternating current of frequency $n \sim$ per second, the eddy current losses in the iron not only depend on n and the flux density, but also on the form factor f of the induced secondary voltage, where f is equal to V/v_{mean}, v_{mean} being the mean value of the induced voltage without regard to sign, and V the effective value of the same. According to Roessler, at constant temperature the iron losses in watts per cubic centimetre due to hysteresis and eddy currents respectively are given by the two terms of the expression $10^{-7}(\eta n B_{max}^{1.6} + \xi n^2 f^2 B_{max}^2)$, where B_{max} = maximum value of the flux density, η = Steinmetz's coefficient and ξ = eddy current coefficient.

If w = watts per kilogramme at frequency n, we have

$$w = \frac{10^{-4}}{D}(\eta n B_{max}^{1.6} + \xi n^2 f^2 B_{max}^2),$$

where D = density of the iron.

The main object of these investigations was to test the accuracy of this formula for various materials and widely different values of the form factor f‖—*i.e.*, for widely different wave-forms. As will be seen below, this led to a convenient method of separating the hysteresis and eddy current losses. Most of our results were obtained with frequencies quite near $50 \sim$ per second, and all of

* Abstract of an original communication to the Institution of Electrical Engineers, accepted by the Council for publication in the "Journal."

† THE ELECTRICIAN, Vol. XXXVI., p. 124, 1895.

‡ "Elektrotechnische Zeitschrift," pp. 403 and 503, 1905

§ "Bulletin Bureau of Standards," Vol. IV., p. 467, 1908, and Vol. V., p. 381, 1909.

‖ Gumlich has found it true with certain samples for small variation of f, and also for a considerable range of frequency. It is clear that it cannot be true for very high frequencies.

them were reduced to the standard. Also, except where otherwise mentioned, observations were made with $B_{max.}$ exactly 10,000.

Method of Test.—All the specimens were in the form of rings, usually of inner and outer diameters, 12 cm. and 15 cm. respectively; these were built up of stampings with paper insulation between them, and each was wound with at least two secondary coils of 10 and 30 turns respectively, and sometimes one of 100 turns was added. The primary windings were 30 or 100 turns. All the windings were evenly distributed over the ring. The method of test consisted in the determination of $B_{max.}$ and the form factor of the induced voltage by the help of a commutator as used by Sahulka * and Townsend,† while the corresponding power lost was measured by a sensitive wattmeter whose shunt circuit was connected to one of the secondary windings of the ring after the method of Steinmetz.‡ The connections are shown in Fig. 1. An alternator

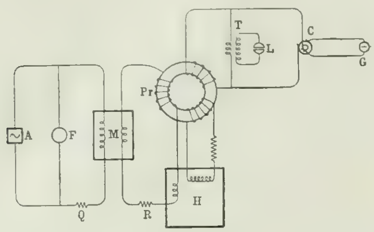


FIG. 1.

or rotary converter, A, working through the transformer M, supplies current to the primary of the ring D, the frequency being measured by the Campbell frequency teller F. The primary current passes through the series coils of the wattmeter H, and the shunt circuit of the wattmeter is connected through a high resistance to the secondary winding S. Another secondary coil, Z (of 10 turns) is connected through the high ratio transformer T to the 100 volt electrostatic voltmeter L, and also through the commutator C to the galvanometer G, which, by the addition of suitable high resistances, is arranged to read voltage directly. The commutator is run by a synchronous motor supplied with current from the alternator A; it reverses the connections to the galvanometer circuit twice per period, and, when, by shifting round a pair of movable brushes on C, the phase of the reversals is set to give a maximum reading on the

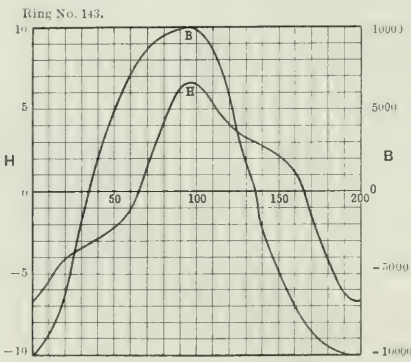


FIG. 2.
Secondary voltage form factor = 1·226.

galvanometer, this reading will measure v_{mean}, the mean value of the voltage induced in the winding Z.

The reading of the voltmeter L multiplied by the transformation ratio of T gives V, the effective voltage induced in Z, and hence f, the form factor, is immediately found. The galvanometer reading also gives B in the ring since $B_{max.} = 10^8 v_{mean}/4N_2 sn$, where s is the cross-section of the ring (in square centimetres), N_2 the number of turns in Z, and n the frequency. The temperature of the iron while under test was observed by the help of an iron-constantan thermo-junction inserted between the sheets before the ring was wound. The results obtained were corrected to standard temperature on the assumption that for such thin sheets (at the moderate frequencies used) the eddy current loss is inversely proportional to the resistivity.

Results Obtained.—In making the tests of total loss, in most cases it happened to be most convenient to keep the frequency nearly

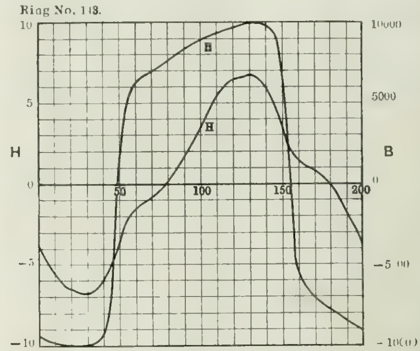


FIG. 3.
Secondary voltage form factor = 2·20.

constant and to alter the form factor (f). This was done in several ways, *e.g.*, by altering the ratio of transformation of M and the resistances Q and R, by omitting M and connecting directly to A through a resistance, or by altering the number of primary turns used on the ring. Although the conveter used gave almost exactly a sine-wave voltage, by these means it was found easy to obtain a wide range of form factor. This is illustrated in Figs. 2 and 3, which show two widely different cases with the same ring and the same machine, the curves for the magnetising current i_1 (and hence H) and the flux density B being drawn by Sahulka's and Townsend's methods with the commutator already mentioned. Complete curves of both i_1 and B can be drawn in about three minutes if the galvanometer is properly dead-beat.

From the observations were deduced the total watts per kilogramme—namely, 50 w/n for 50 ∾ per second and $B_{max.} = 10,000$; and the values found were plotted against nf^2. Fig. 4 shows the curves thus obtained for a number of widely different materials

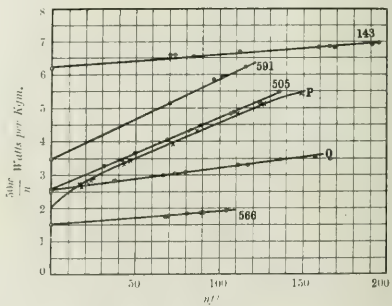


FIG. 4.

while Table I. gives for each of them the approximate thickness of the sheets, the resistivity, the permeability at B = 10,000 and the hysteresis coefficient η. It may be mentioned that No. 591 was ordinary tinplate, (P) had been annealed at 800°C., and aged at 100°C., while (Q) and No. 566 were high resistivity materials. To obtain the total loss at 50 ∾ per second for the standard conditions—namely, with induced voltage of sine-wave form (for which $f = 1·111$)—it is only necessary to read the ordinate of each curve for $nf^2 = 50 \times (1·111)^2$—*i.e.*, 61·7. As the curves are practically straight lines near this value, if we wish to determine total loss alone, it is only necessary to take readings for two different form factors (or frequencies) not very far apart, join the points obtained (by a straight line), and find where the ordinate at $nf^2 = 61·7$ cuts the join-

* "Zeitschrift für Elektrotechnik," p 4 (16), 1898.
† Am. Inst. Elec. Eng. "Trans.," Vol XVII., p. 5, 1900.
‡ Am. Inst. Elec. Eng. "Trans.," Vol. IX., p. 624, 1892. The method seems to have been used first in this country by L. W. Wild (THE ELECTRICIAN, Vol. LIV., p. 128, 1904).

ing line. This method of different form factors is very useful when the frequency cannot be varied.

Table I.

Sample.	Approx. thickness of sheets, mm.	Resistivity at 15 C., microhm-cm.	Permeability at B = 10,000.	Static η.
143	0·24	17·3	1,370	0 00384
591	0·46	12·6	1,868	0·00215
505	0·50	13·6	2,512	0·00158
P	0 43	14·0	2,878	0 00123
Q	0·40	43·0	1,873	0·00155
566	0·48	60·3	2,820	0·00090

Consideration of the curves in Fig. 4 leads to the following conclusions:—

1. For all the specimens except (P) the lines are practically straight, and pass through the "static hysteresis" points (the values obtained by the ordinary ballistic method). Hence over the range of nf^2 shown the hysteresis loss is constant, and the total loss per $\sim$ can be represented by the expression $F + Gnf^2$, the two terms representing the hysteresis and eddy current losses respectively.

2. The specimen (P), on the contrary, shows a curve which is by no means a straight line, but clearly bends in coming down to the static hysteresis point. It also falls slightly at the higher values of nf^2. Except for the intermediate part of its range, the total loss cannot here be represented by the expression $F + Gnf^2$. It is interesting to notice that (P) and (505) are very similar in total loss and also hysteresis, except at the upper and lower ends of the range.

3. The final conclusion is that, although some materials give excellent straight lines in the diagram of total loss for a wide range of frequency or form factor, other materials give lines that are distinctly curved, indicating that the hysteresis loss increases considerably as the frequency is raised from 0 upwards. There seems no doubt that this effect must be attributed to magnetic viscosity (*see* Lloyd, *loc. cit.*). In corroboration of this, if in the ballistic test of (P) an additional evenly wound secondary circuit was kept closed during the test, a quite distinct alteration was shown in the values obtained for the permeability and hysteresis for $B_{max.} = 10{,}000$. The slight drop in the (P) curve at the higher values is probably due to "skin effect," the higher frequencies causing B to be not quite uniform throughout the thickness of the sheet. Several other samples gave lines bent similarly to that of (P).

The above results appear to throw some light on an old standing controversy. Several observers have stated that hysteresis loss is practically independent of frequency (at the lower values) while others affirm that it varies with frequency and wave-form. Gumlich and Rose incline to the former view, and Lloyd appears to agree with them. It seems likely, however, that some of the experimenters have been testing specimens like (505) and (591), while others have had experience of more abnormal materials like (P).

Effect of Thickness of Sheets.—The experimental results for total loss at $B_{max.} = 10{,}000$ are only strictly valid when the thickness of the sheet is such that $B_{max.}$ has time to get practically uniform throughout the thickness in each half period. To investigate this point experimentally a set of specimens of different thicknesses, but of as nearly as possible similar material, were tested for total loss. The material was "electrical steel," made by Messrs. J. Lysaght. The results obtained are plotted in a diagram in the Paper, and also the theoretical curve calculated, on the assumption that the permeability is constant, by the formula of J. J. Thomson, as given by Russell.* The two curves agree as well as could be expected, considering the uncertainty due to want of uniformity of material. For the smaller thicknesses the eddy current loss is proportional to the square of the thickness of the sheet.

Dimensions of Ring Stampings.—In almost all magnetic tests there arise difficulties due to the alteration of the material due to the mechanical processes used in preparing the test-pieces, such as stamping, cutting or turning. The greater the width of the test-piece (whether ring or strip), the less the result will be affected by the edge hardening. In the case of rings, however, the radial width must not be taken too large in relation to the mean diameter, otherwise the magnetic force will not be sufficiently uniform over the width, being greater at the inner edge than at the outer. Thus, if it is not allowable to obliterate the effects of the mechanical treatment by annealing after stamping or cutting, the proportions of the test-pieces must be fixed by making a compromise between the two conditions—namely, maximum width of strip and greatest uniformity of H.

The amount of error in the usual energy determinations, due to the want of uniformity of H, has been very fully worked out by Richter† for rings of rectangular section, and lately his results for the simple case, where the permeability is constant, have been clearly tabulated by Lloyd,* who has also investigated the case of a ring of circular section. Lloyd points out that his results would be somewhat modified in practice because of the permeability not being constant. In a test of total loss it is the mean $B_{max.}$ that is observed, the mean being taken over the width of the ring, and the hysteresis loss corresponding to this value should be proportional to (mean $B_{max.})^{1·6}$, but the loss actually measured by the wattmeter is proportional to the mean of $(B_{max.})^{1·6}$. The ratio of the first of these expressions to the second is accordingly the correcting factor to be applied to the observed hysteresis loss.

* A. Russell, "Alternating Currents," Vol. I., pp. 360 and 362.

† "Elektrotechnische Zeitschrift, Vol. XXIV., p. 710, 1903.

As examples, I have worked out the correcting factor for two actual rings, one of very low, and the other of high hysteresis constant ($\eta = 0·00083$ and $\eta = 0·0042$ respectively). Each ring had an inner radius of 6 cm. and an outer of 8·5 cm. For $B_{max.} = 10{,}000$ the correcting factors come to 1·0008 and 1·002 respectively, showing that, for a mean diameter of 14·5 cm., in each case the error in hysteresis is negligible with a radial width of 2·5 cm. If the permeability had been assumed constant the correcting factor would have been about 1·011 in both cases. It must be remembered, however, that for lower values of $B_{max.}$ (*e.g.*, 5,000) the variation in permeability would often make the correcting factor *greater* than for constant permeability.

The effect of stamping has also been investigated, one experiment being as follows: From a batch of carefully annealed sheets two sets (1) and (2) of ring stampings were made, having radial widths of 1·5 cm. and 2·5 cm. respectively. On testing each set the ratio of their hysteresis losses was found to be 1·076. If we assume that the same width of edge is hardened in (1) and (2), then it is easy to show that the ratio of the loss for 2·5 cm. width to that for infinite width is 1·126. Thus even with a width of 2·5 cm. the stamping has increased the mean hysteresis loss by over 12 per cent., and it is evident that for widths of the order of 3 cm. the effect of stamping is considerable, and some allowance would have to be made for it if absolute and not merely comparative results are to be considered. The effect on the total loss will not be so great, as the eddy current part is not so much influenced.

THE CALCULATION OF SINGLE-PHASE COMMUTATOR MOTORS.†

BY J. FISCHER-HINNEN.

Summary.—Most of what has hitherto been written on single-phase commutator motors has dealt exclusively with theory. The present article treats the subject from a more practical standpoint and is devoted to the calculation and design of these machines.

I.—Introduction.

Though of late years much has been written on the theory of commutator motors, practically little or nothing has appeared which has been of direct service to the designer engaged in the calculation of these machines. In the following article, therefore, a number of examples will be given showing how the dimensions and windings of single-phase motors can be worked out without entering into long and tedious calculations.

In order to make the treatment as uniform as possible, the following symbols will be used:—

E = effective terminal pressure.
E_s = E.M.F. of self-induction.
E_r = E.M.F. due to rotation of armature.
I = effective current.
D = diameter of armature.
l = length of armature.
$\lambda = \frac{l}{D}$.
D_2 = diameter of commutator.
l_2 = active length of commutator.
γ_2 = thickness of a commutator segment plus insulation.
γ = brush width on commutator periphery.
b = polar arc ($b = \frac{\pi D}{p}$ in machines with winding distributed over whole surface, and $b = \beta \frac{\pi D}{p}$ in machines with salient poles).
p = total number of poles (*not* pole pairs).
p_2 = number of parallel circuits in armature.
Φ = maximum flux in main field.

* "Bulletin Bureau of Standards," Vol. V., p. 435, 1909.

† Abstracted from the "Elektrotechnische Zeitschrift."

$\bar{B}_l$ = maximum flux density in gap.
V_1 = leakage coefficient of field winding (= 1·1 to 1·15).
V_2 = leakage coefficient of armature winding.
N_1 = total number of conductors (*not* turns) in field winding.
N_2 = number of conductors on armature.
N_3 = number of conductors on compensating winding.
N_k = number of commutator segments.
a = ratio of total reluctance to reluctance of gap.
δ = single air-gap.
n = speed in revs. per min.
c_1 = primary frequency.
c_2 = secondary frequency.
100η = efficiency in per cent.
ρ = reduction factor (= 0·7 to 0·8) for taking slot openings, paper insulation, &c., into account.
β = ratio of wound to total circumference in machines with distributed windings and the ratio of polar arc to pole pitch in salient pole machines.
ϕ = angle of phase displacement between I and E.

II.—The Series Motor with Distributed Winding.

The general arrangement of this motor is shown in Figs. 1 and 2. The compensating winding may either be placed in series with the field winding or short-circuited. The following equations can then be deduced under the assumption that the cross field is completely neutralised.

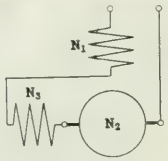


Fig. 1.

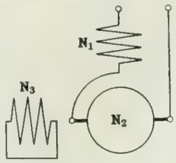


Fig. 2.

Flux density in the Gap—

$$B_l = \sqrt{2}\,\frac{4\pi}{10}\,\frac{IN_1}{p}\,\frac{1}{2\delta a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The coefficient a makes this equation quite general for all saturations. Up to densities of about 12,000 in the iron a is about constant and $\cong$ 1·1 to 1·2. For high saturations a may reach 1·6 or more.

Main Flux—

$$\left.\begin{aligned}\bar{\Phi} &= (1-0{\cdot}5\beta)B_l b l_p \\ &= 2{\cdot}8(1-0{\cdot}5\beta)\frac{IN_1}{p}\,\frac{Dl\rho}{\delta a}\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

E.M.F.s.—There are two E.M.F.s to be considered: E_r induced in armature by rotation in Φ, E_s induced in winding N_1 by static effect of pulsating flux Φ.

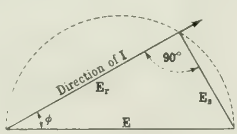


Fig. 3.

Referring to Fig. 3 we get

$$E_r = \frac{1}{\sqrt{2}}\,\frac{\Phi N_2}{60\cdot 10^8}\,\frac{np}{p_2} = E\cos\phi. \quad . \quad . \quad . \quad . \quad (3)$$

$$E_s = 1{\cdot}48\left(\frac{1{\cdot}5-\beta}{1-0{\cdot}5\beta}\right)\frac{c_1\Phi N_1 V_1}{10^8} = E\sin\phi \quad . \quad . \quad (4)$$

$$= 4{\cdot}14(1{\cdot}5-\beta)\frac{IN_1^2}{p}\,\frac{Dl\rho}{\delta a}\,\frac{c_1V_1}{10^8} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Also $$\tan\phi = \frac{E_s}{E_r} = 1{\cdot}04\left(\frac{1{\cdot}5-\beta}{1-0{\cdot}5\beta}\right)\frac{N_1p_2}{N_2}\,\frac{120c_1}{pn}V_1. \quad . \quad (6)$$

From (6) it is seen that the series motor can also work with a good $\cos\phi$ at synchronous speed, provided N_1p_2/N_2 is taken sufficiently small.

Equation (6) is also interesting, as it shows that the power factor is independent of saturation.

Pressure between Segments.—By this we mean the pressure between two segments undergoing short-circuit—this being the chief cause of sparking. In addition to this, the short-circuit currents exert a partially demagnetising effect, which leads to a rise of speed, and also add to the losses of the machine.

To keep this pressure a minimum it is well to keep the brush-width γ less than the width of a commutator segment γ_2. In general the pressure between segments is:

$$e_k = \frac{2{\cdot}22\,N_2}{10^8\,N_k}\,\frac{p}{p_2}\,c_1\,\Phi\,\mu \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where
$$\mu = 1 \text{ for } \gamma <= \gamma_2$$
$$= 2 \text{ for } 2\gamma_2 < \gamma > \gamma_2.$$

Substituting from equation (3)

$$e_k = 188\,\frac{Ec_1\mu}{nN_k}\cos\phi - 1{\cdot}57\,\frac{Ep\mu}{N_k}\cos\phi. \quad . \quad . \quad . \quad (8)$$

Since e_k must not exceed a certain value for sparkless running, this equation enables us to calculate the least number of commutator segments that can be used. Similarly it can be used as a criterion whether a motor for a given pressure, speed and frequency can be built as a series motor, or whether a repulsion motor must be used.

When resistance is used for starting it is possible to keep the starting current equal to the working current, in which case the value of n corresponding to normal load must be inserted in the above equation. For starting with twice normal torque, the current rises to about 1·4 times its normal value (since torque = flux × current and the flux is nearly proportional to the current), so that the right-hand side of equation (8) must be multiplied by 1·4.

The Commutator.—The dimensions of the commutator can be fixed from equation (8). Let i denote the permissible current density per square centimetre under the brushes; then, assuming there are as many brushes as poles, we have:

Current: $$I = \frac{736\text{HP}}{\eta\cos\phi}\cdot\frac{1}{E} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Diameter of commutator:

$$D_2 = \frac{N_k\gamma_2}{\pi} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Active length of commutator:

$$l_2 = \frac{2I}{\gamma i p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Armature and Armature Winding.—Multiplying both sides of equation (5) by I and writing

$$N_1 = \frac{1}{1{\cdot}04}\left(\frac{1-0{\cdot}5\beta}{1{\cdot}5-\beta}\right)\frac{N_2}{p_2}\,\frac{pn}{120c_1}\,\frac{1}{V_1}\tan\phi,$$

also* $$\frac{IN_2}{p_2} = K\,.\,D \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

and $$IE = \frac{736\text{HP}}{\eta\cos\phi};\ l = \lambda D.$$

we get $$D = \sqrt[4]{\frac{22{,}200\times10^8}{1-0{\cdot}5\beta}\times\frac{\text{HP}}{n}\times\frac{\delta a p}{\lambda K^2\eta\rho}\left(\frac{N_2}{N_1p_2}\right)} \quad . \quad . \quad (13)$$

$$= 100\sqrt{2{\cdot}77\times10^6\,\frac{1{\cdot}5-\beta}{(1-0{\cdot}5\beta)^2}\,\frac{\text{HP}}{n^2}\,\frac{\delta a c_1 V_1}{\lambda K^2\eta\rho}\,\frac{1}{\tan\phi}} \quad (14)$$

This equation contains only known quantities, though in using (13) N_2/N_1p_2 must be first found from equation (6).

Knowing D, the armature length l and number of conductors N_2 can be found from $l = \lambda D$ and $N_2 = p_2\frac{KD}{I}$.

Field Winding.—The iron section depends on the maximum flux Φ, found from equation (3).

$$\Phi = \frac{\sqrt{2}\,.\,60\,.\,10^8 p_2 E\cos\phi}{N_2 n p}.$$

Further, from equation (6)

$$N_1 = \frac{1}{1{\cdot}04}\left(\frac{1-0{\cdot}5\beta}{1{\cdot}5-\beta}\right)\frac{N_2}{p_2}\,\frac{pn}{120c_1V_1}\tan\phi.$$

There only remains the compensating winding N_3 to be calculated. If this is connected in series with the armature (Fig. 1) then

$$N_3 = N_2/p_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Owing to the inductance of the short-circuited coils, it is well to make this 25 to 30 per cent. larger.

More convenient, but less effective, is the winding shown in Fig. 2.

* K = constant depending on winding space, the magnitude of which for continuous working is approximately:—

For 1,000 $\frac{\text{HP}}{n}$ =	0·5	1	3	10	30	100	300
K_{max} =	300	350	400	450	500	600	750

where the number of conductors can be chosen at will, though the copper loss must be taken into account. The latter can be checked from the current I_3 in the short-circuited coils.

$$I_3 = \frac{N_2}{p_2 N_3}\,\frac{1}{V_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Example.—Let us now determine the dimensions of the following railway motor:—

Maximum output	70 H.P.
Speed	900 revs. per min.
Pressure	220 volts
Frequency	$c_1 = 25$ cycles sec.
Number of poles	$p=6$
Power factor	$\cos\phi = 0{\cdot}88$
Efficiency	$\eta = 86$ per cent.

We will further take

$$p_2 = p = 6 \qquad \delta = 0{\cdot}15\text{ cm.}$$
$$\lambda = 0{\cdot}5 \qquad \rho = 0{\cdot}8$$
$$\beta = 0{\cdot}6 \qquad V_1 = 1{\cdot}1$$
$$a = 1{\cdot}6 \qquad K = 550$$

From equation (6) $\frac{N_2}{N_1 p_2} = 1{\cdot}52$.

From equation (13) diameter $D = 48$ cm.

Length $l = \lambda D = 24$ cm.

From equation (9), armature current $I = 310$ amperes.

From equation (12), total number of armature conductors $N_2 = 512$.

Take 128 slots with four conductors per slot. Assuming a current density of 4 amperes per square millimetre, the section will be $s = \frac{310}{6 \times 4} = 13$ sq. mm. For this a copper strip $1{\cdot}3 \times 10$ mm., insulated to $2 \times 10{\cdot}7$ mm. can be used, and this will require a slot of about 6×29 mm., with a slot opening of, say, 2·5 mm.

The number of commutator bars $N_k = \frac{N_2}{2} = 256$. With the width of commutator segment $= 0{\cdot}48$ mm., the diameter of the commutator is, from equation (10), $D_2 = 39$ cm. This gives a maximum peripheral

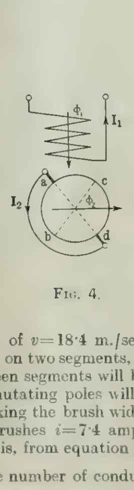


Fig. 4.

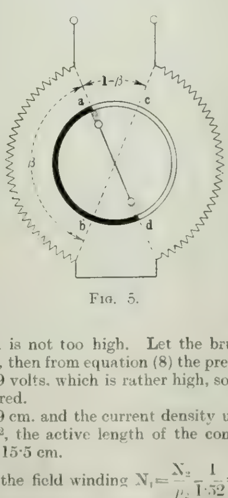


Fig. 5.

speed of $v = 18{\cdot}4$ m./sec., which is not too high. Let the brushes stand on two segments, *i.e.*, $\mu = 2$, then from equation (8) the pressure between segments will be $e_k = 7{\cdot}9$ volts, which is rather high, so that commutating poles will be required.

Taking the brush width $\gamma = 0{\cdot}9$ cm. and the current density under the brushes $i = 7{\cdot}4$ amperes/cm.², the active length of the commutator is, from equation (11), $l_2 = 15{\cdot}5$ cm.

The number of conductors in the field winding $N_1 = \frac{N_2}{p_2}\frac{1}{1{\cdot}52} = 56$. Winding one conductor per slot, there will be $56/\beta = 94$ slots, which we will round off to 96. Section of conductor with a density of 3·5 amperes/mm.² is $s = 89$ mm.² For this we can take a strip $5{\cdot}2 \times 16$ mm. or two strips $2{\cdot}6 \times 16$ mm. in parallel.

The *maximum flux* can be found from equation (3), $\overline{\Phi} = 3{\cdot}56 \times 10^6$. With a maximum density in the core of 15,800, the *depth of the core* will be $h = 5{\cdot}85$ cm.

The total number of conductors in the *compensating winding* (equation 15) is $N_3 = 85$, which we will round off to 84. The section is the same as for winding N_1. The main and compensating windings can be best arranged in two layers, whilst the commutating pole winding can be placed in the empty slots.

N.B.—In cases where standard patterns of three-phase machines are to be used for single-phase commutator motors, instead of D—which is known—we calculate K (from equation 13 or 14). In passing, it might be remarked that for outputs up to about 15 H.P. a three-phase motor of 2·5 to 3 times the output is required.*

The Non-compensated Repulsion Motor.—The repulsion motor differs from the series motor by having its armature winding short-circuited. The armature current is produced by induction, thus making the rotor pressure independent of the stator pressure. To obtain the exciting field Φ_2 perpendicular to the primary field $\overline{\Phi}_1$ it is only necessary to shift the brushes to $\overline{ab}$, say, in Fig. 4. The secondary field $\overline{\Phi}_2$ is produced by the winding $\overline{ac}$ and $\overline{bd}$, whilst the conductors between ab and cd act like a transformer.

In addition to the above symbols, we have now the following:—

E_1 = effective primary (terminal) pressure.
E_2 = secondary pressure at the brushes.
I_0 = primary magnetising current.
I_1 = effective primary current.
I_2 = effective secondary (armature) current.
$\overline{B}_1$ = maximum flux-density of primary field in gap.
$\overline{B}_2$ = maximum flux-density of secondary field in gap.
c_1 = frequency of primary current.
$c_2 = \frac{pn}{120}$ = frequency of secondary current.
$100\epsilon_1$ = percentage pressure drop in primary.

In order to obtain simple formulæ we shall assume—which accords well with practice—that the brushes are displaced, with respect to the primary field axis, at an angle equal to half the angle of the unwound part of the stator, as shown in Fig. 5.

Primary Flux.—Maximum density in gap.

$$\overline{B}_1 = \sqrt{2}\,\frac{4\pi}{10}\,\frac{I_0 N_1}{p}\,\frac{1}{2\delta a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Total flux

$$\Phi_1 = (1-0{\cdot}5\beta)\overline{B}_1 b l \rho$$
$$= 2{\cdot}8(1-0{\cdot}5\beta)\frac{I_0 N_1 D l \rho}{\delta a p^2} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Secondary Flux—Maximum density in gap,

$$\overline{B}_2 = \sqrt{2}\,\frac{4\pi}{10}\,\frac{I_2 N_2}{p p_2}\,\frac{(1-\beta)}{2\delta a} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Total flux

$$\Phi_2 = \frac{(1-\beta)}{2}\overline{B}_2 b l \rho$$
$$= 1{\cdot}4(1-\beta^2)\frac{I_2 N_2 D l \rho}{\delta a p^2 p_2} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Pressures.—Primary E.M.F.

$$E_1 = 2{\cdot}98\frac{c_1 \Phi_1 N_1}{10^8}\,\frac{1{\cdot}5-\beta}{2-\beta}(1+\epsilon_1) \quad . \quad . \quad . \quad . \quad (5)$$

whence

$$I_0 = \frac{E_1 10^8 \delta a p^2}{4{\cdot}15 c_1 N_1^2 D l \rho (1{\cdot}5-\beta) V_1} \quad . \quad . \quad . \quad . \quad (6)$$

Secondary E.M.F.s.—We have to distinguish between the following four pressures:—

Due to Φ_1—

1. E_2 statically induced by primary flux Φ_1.
2. E_r induced by rotation in primary flux Φ_1.

Due to Φ_2—

3. E'_r induced by rotation in secondary flux Φ_2.
4. E_s the self-induced E.M.F. due to cross flux Φ_2.

These E.M.F.s can be calculated as follows:—

$$E_2 = \frac{\beta}{1+\epsilon_1}\,\frac{N_2}{N_1}\,\frac{E_1}{p_2}$$
$$= \frac{2{\cdot}98\,c_1\Phi_1 N_2}{10^8\,p_2}\,\frac{(1{\cdot}5-\beta)\beta}{2-\beta} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$E_r = \frac{2{\cdot}84\,c_2\Phi_1 N_2}{10^8\,p_2}\,\frac{1-\beta}{2-\beta} \quad . \quad . \quad . \quad . \quad (8)$$

$$E'_r = \frac{2{\cdot}84\,c_2\Phi_2 N_2}{10^8\,p_2}\,\frac{\beta}{1-\beta} \quad . \quad . \quad . \quad . \quad (9)$$

and

$$E_s = \frac{1{\cdot}48\,c_1\Phi_2 N_2}{10^8\,p_2}\,\frac{(1-\beta)(1-2\beta)}{(1-\beta)} \quad . \quad . \quad . \quad . \quad (10)$$

E_r is perpendicular to E_2, and consequently serves to improve $\cos\phi$. E'_r is in phase with I_2.

As is known, the repulsion motor works best at synchronous speed.

* The series motor with salient poles and without compensating winding is also treated in an analogous manner and also the design of the commutating poles and other auxiliary devices for reducing sparking, but space forbids us to do more than merely to mention these.—Ed. *E.*

so that we can assume $c_2 = c_1$. If, in addition, we suppose I_2 to have the same phase as E_2, we get

$$E_r = E_s \text{ and } E_2 = E_r',$$

so that

$$\frac{E_r}{E_2} = \frac{E_s}{E_r'}.$$

Substituting the values in equations (7) to (10) we find with $\beta = 0.8$
$$\bar{\Phi}_2 = 1.05\Phi_1 \text{ approx.}$$

Further
$$E_r = E_2 = \frac{1.32 c_1 \Phi_2 N_2}{10^8 p_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Multiplying both sides by equation (4)

$$E_r' = \frac{0.665}{10^8} \cdot \frac{c_1 N_2^2 I_2 D l_p}{\delta a p^2 p_2^2} = E_2. \quad . \quad . \quad . \quad (12)$$

N.B.—Since at synchronism $\bar{\Phi}_2$ and $\bar{\Phi}_1$ are practically equal and displaced from one another in phase by 90 deg., a rotary field is formed which revolves synchronously with the armature. This field under these conditions has no influence on the coils undergoing short circuit, whilst the iron losses in the armature will also be zero at synchronism.

Armature and Armature Winding.—Equation (12) can be used directly for finding the dimensions of the armature. Since by assumption the armature current is in phase with the secondary pressure, we have

$$E_2 I_2 = \frac{736 \text{ H.P.}}{\eta} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Multiplying both sides of equation (12) by $I_2\eta/736$ and writing as before $I_2N_2/p_2 = KD$ and $l = \lambda D$ we get

$$D = 10^4 \sqrt{\frac{1110 \cdot 10^4 \text{H.P.} \delta a p^2}{\eta c_1 \lambda K^2 \rho}} \quad . \quad . \quad . \quad . \quad (14)$$

The smaller we take I_2 the greater E_2 will be, and since the pressure between segments e_k depends chiefly on E_2, we must see what this relation is. The most important case is starting under full load conditions, for e_k falls off as the speed approaches synchronism. For this case obviously

$$e_k = \frac{2.22}{10^8} \frac{N_2}{N_k} \frac{p}{p_2} c_1 \bar{\Phi}_2 \mu = 1.67 \frac{N_k \mu}{p E_2} \quad . \quad . \quad . \quad . \quad (15)$$

by substituting from equation (11).

It is therefore advisable after fixing on the armature dimensions to make a preliminary assumption for the commutator diameter and number of segments and from equation (15) find the maximum admissible value of E_2. From E_2 the current I_2 can be found (equation 13), and also the number of conductors N_2.

Commutator.—Diameter :

$$D_2 = \frac{\gamma_2 N_k}{\pi}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Active length (assuming as many brushes as there are poles)

$$l_2 = \frac{2 I_2}{\gamma i p}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Primary Field Winding and Flux.—Number of conductors (from equation 7)

$$N_1 = \frac{0.8}{1 + \epsilon} \frac{E_1}{p_2 E_2} N_2.$$

N.B.—Strictly speaking, in determining N_1, the demagnetising effect of the short-circuit current on the primary field ought to be taken into account. We can allow for this by taking N_1 some 8 to 10 per cent. less than equation (7) gives it.

Maximum flux (from equation 7)

$$\bar{\Phi}_1 = \frac{E_1 10^8}{1.74 \times c_1 N_1} = \frac{p_2 E_2 10^8}{1.39 \cdot c_1 \cdot N_2}.$$

Phase Displacement between I_1 *and* E_1.—The above formulæ have been deduced under the assumption that E_r' coincides with E_2 and consequently I_2 with E_2 (*see* Fig. 6). Neglecting leakage for the moment,

$$\cos\phi = \cos\alpha = \frac{\frac{\beta I_2 N_2}{p_2}}{\sqrt{\left(\frac{\beta I_2 N_2}{p_2}\right)^2 + (I_0 N_1)^2}}$$

$$= \frac{1}{\sqrt{1 + \left(\frac{I_0}{I_2} \frac{N_1 p_2}{\beta N_2}\right)^2}}. \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Now, from equation (7), neglecting ohmic losses :—

$$\cos\phi = \cos\alpha = \frac{1}{\sqrt{1 + \left(\frac{I_0}{I_2} \cdot \frac{E_1}{E_2}\right)^2}}. \quad . \quad . \quad . \quad . \quad . \quad (19)$$

Since, however, the leakage pressure $e_s = (\nu_1 - 1)E_1$ is fairly large, it cannot be neglected. Thus we write

$$\cos\phi = \cos(\alpha + \alpha_1)$$
$$= \cos\alpha \left\{ \sqrt{1 - (\nu_1 - 1)\cos^2\alpha} - (\nu_1 - 1)\sqrt{1 - \cos^2\alpha} \right\}$$

or
$$= \cos\alpha \left\{ 1 - (\nu_1 - 1)\sqrt{1 - \cos^2\alpha} \right\}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

where $\cos\alpha$ is obtained from equation (19).

Example.—To design a six-pole repulsion motor of 35 H.P. at 800 revs. per min. 40 cycles and 240 volts.

Assume $\cos\phi = 0.9$ and $\eta = 0.86$, and calculate on the basis of

$$p_2 = p = 6, \qquad \lambda = 0.4,$$
$$\delta = 0.075 \text{ cm.}, \qquad \rho = 0.7,$$
$$a = 1.2, \qquad \kappa = 550.$$

Armature diameter (from equation 14), $D = 46$ cm.

Length $l = \lambda D = 0.4 \cdot 46 = 18.5$ cm.

To find the secondary pressure take, preliminarily, the diameter of commutator $D_2 = 38$ cm., corresponding to a peripheral speed of 16 m/sec. With segments of 0.51 cm. width, the number of bars will be

$$N_k = \frac{38\pi}{0.51} = 234.$$

Taking further the admissible pressure between segments $e_k = 8$ volts, under the assumption that resistance connections between

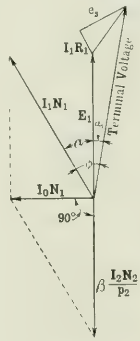


Fig. 6.

commutator and winding are used, and that the brushes cover two segments (*i.e.*, $\mu = 2$), we have from equation (15)

$$E_2 = \frac{N_k e_k^2}{1.67 p \mu} = \frac{234 \cdot 8}{1.67 \times 6 \times 2} = 92.5 \text{ volts},$$

and from equation (13):—

$$I_2 = \frac{736 \text{HP}}{\eta E_2} = \frac{736 \cdot 35}{0.86 \cdot 92.5} = 324 \text{ amperes},$$

and
$$N_2 = \frac{p_2 K D}{I_2} = \frac{6 \times 550 \times 46}{324} = 468.$$

The armature winding therefore can be wound in 78 slots with six conductors per slot.

Conductor 1.5×10 mm., insulated to 2.2×10.7 mm. (3.6 amps/mm²). Slot 8.5×28 mm.

Commutator.—Diameter (assumed) $D_2 = 38$ cm. Brush width $\gamma = 1$ cm. Current density $i = 8$ amps./cm².

Active length
$$l_2 = \frac{2 I_2}{\gamma i p} = \frac{2 \times 324}{1 \times 8 \times 6} = 13.5 \text{ cm}.$$

Primary Winding and Flux.—From equation (7) the number of conductors on primary will be

$$N_1 = \frac{0.8}{(1 + \epsilon) p_2} \frac{E_1}{E_2} N_2 = 154.$$

As mentioned above, this may be reduced 8 to 10 per cent.; hence, $N_1 = 0.93 \times 154 = 144$.

Flux
$$\Phi_1 = \frac{E_1 \cdot 10^8}{1.74 (1 + \epsilon_1) c_1 N_1} = 2.29 \times 10^6.$$

Phase displacement between E_1 *and* I_1.—We first find the magnetising current I_0 from equation (6) $I_0 = 49.3$ amperes.

Then from equation (18) $\cos\phi = \cos\alpha = 0.93$, and more exactly from equation (20) $\cos\phi = 0.9$.

Comparison between Series and Repulsion Motors.—We have seen that the repulsion motor works best in the region of synchronism, whilst above this speed sparking increases rapidly. The series motor is just the opposite, and improves as c_2/c_1 increases. Thus the latter is much better suited to low frequencies, since it allows a much greater freedom in the selection of the number of poles. Take, for example, a motor for 1,100 revs. per min. at 15 cycles. Here a repulsion motor is out of the question, for even with a bipolar the synchronous speed is only 900, and apart from the sparking the flux and commutator become abnormally large.

On the other hand, cases may occur where the pressure between segments becomes inadmissible in a series motor, so that a repulsion must be used if the terminal pressure cannot be reduced.

It may happen, however, that the conditions appear equally favourable for both types, and the question arises, Which type ought to be adopted? We will assume, in both cases,

$$\cos\phi=0{\cdot}9,\ \frac{np}{120}=c_2=c_1,\ \beta=0{\cdot}8.$$

The diameter of the armature for the *series* motor will be

$$D=10^4\sqrt{850\frac{\text{H.P.}}{c_1}\ \frac{\delta a p^2}{\eta\lambda K^2\rho}}$$

whilst for the repulsion motor

$$D=10^4\sqrt{1{,}110\frac{\text{H.P.}}{c_1}\ \frac{\delta a p^2}{\eta\lambda K^2\rho}}$$

Taking the same number of poles, speed, gap and current densities the repulsion motor comes out 7 per cent. larger both in diameter and length than the series motor. As a set-off against this the series motor has to be provided with a compensating winding, and since this occupies much space, K must be chosen smaller for this machine than for the repulsion type, so that the above difference practically vanishes.

The repulsion motor possesses the following advantages over the series:—

1. Permits of a large range of speed regulation by merely shifting the brushes.
2. Is less sensitive to load fluctuations.

Whilst the series motor will "race" when the load is thrown off, the repulsion motor cannot exceed a certain maximum, as determined by equations (7) and (10).

To *reverse* the direction of rotation of a series motor it is only necessary to reverse either the armature or field.

In the case of the repulsion motor this can be accomplished either by shifting the brushes about the main axis or by shifting the main axis about a fixed brush axis.

ELECTRICITY AND WATER SUPPLY.

An interesting adaptation of electricity to the needs of the water supply of a town has recently been completed in Darlington; and the installation is also noteworthy since the supply of current for the motor in question is taken from the electric tramway feeders. For some time past, owing to the development of the town, difficulty has been experienced in maintaining sufficient pressure in the highlying parts around Harrowgate Hill, &c., without creating an unnecessarily high pressure in the remainder of the distributing mains. To overcome this a stand pipe adjoining the reservoir has hitherto been used, the water for the reservoir being supplied over the stand pipe. This has involved, however, a considerably increased coal consumption, since pumping has had to take place against the additional head, although only a small proportion of the total supply is used in the higher lying parts of the town, and to reduce this loss of power as much as possible, a sufficient supply for the Harrowgate Hill district has only been given during certain hours of the day.

A scheme has now been evolved, however, by Mr. G. Winter, the borough surveyor, whereby not only will a continuous supply of water be maintained at Harrowgate Hill, but it will not be necessary to maintain any higher pressure for the town supply than called for by its own requirements, and during the night when the general supply is at a minimum, the reservoir at Harrowgate Hill is filled up, as well as certain tanks in other portions of the town, which are filled only once a day.

A centrifugal pump capable of lifting 120,000 gallons of water per hour against a head of 35 ft. has been provided, the suction of the pump being connected with the reservoir and the delivery to a tank placed above the pump and capable of holding 60,000 gallons. The main supply pipe from the pumping station is also carried directly into this tank together with an overflow into the reservoir.

The centrifugal pump is direct coupled to a compound wound motor, having an exceptionally heavy series winding, in order that the quantity of water delivered may be maintained approximately constant with a supply pressure varying between 430 and 500 volts, the current being obtained from the traction trolley wire at a considerable distance from the generating station. The normal rating of this motor is 38 B.H.P., provision being made for fine speed adjustments by means of shunt regulation.

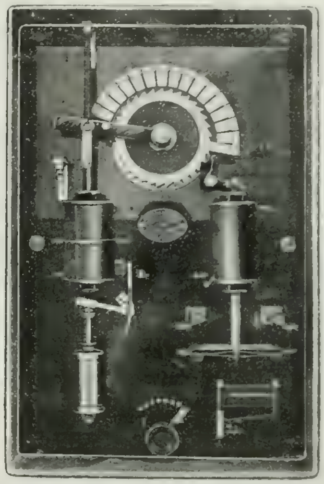


FIG. 1.—AUTOMATIC STARTING SWITCH.

A combined automatic main and starting switch (Fig. 1) with no-voltage release is provided, capable of starting up under full load. This switch, which is manufactured under Moule's patent, is of substantial design, with quick step-by-step motion, the time-limit between each forward movement being readily adjustable by hand. The current supply to this starting switch is controlled by means of a special pattern of iron-cased quick make-and-break float contact (Fig. 2), operated through a copper rope connected to a float in the tank.

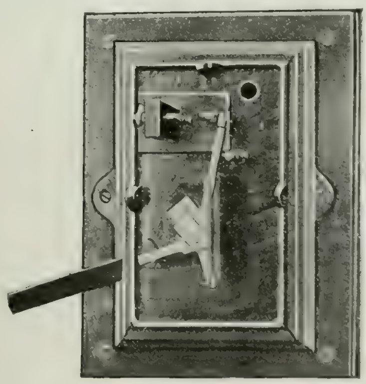


FIG. 2.—QUICK MAKE-AND-BREAK FLOAT CONTACT.

A further provision is made to prevent the motor from being started up automatically, should the pump from any cause have lost its priming. A pipe connected with the upper portion of the pump is coupled to a cylinder (Fig. 3) containing a copper float, which, when in its top position, completes the connection between the solenoid main switch and the tank contact; but if the water falls below a fixed level in the pump the circuit is broken, and the pump cannot be started until reprimed. This provision is necessary

as the plant is left unattended, and considerable injury could be done if the pump started up without water, though the special winding prevents the motor from running at an excessive speed.

The switchboard, in addition to the starting switch, contains an ammeter, overload circuit-breaker and main fuse, the whole being totally enclosed in iron, so that it is impossible to obtain a shock from any portion. This precaution is necessary since the plant is operated from the traction feeder with a pressure of approximately 500 volts to earth.

Provision is made, by means of a relay, operated from the electricity works through one of the tramway pilot leads, for breaking the circuit, when required for the purpose of testing the leakage current

Fig. 3.—Arrangement to prevent starting up without water in the pump.

on the traction system, or for any other reason. It is also interesting to note that heating units, consuming about 50 watts each, are provided inside the motor case and the switchboard, to prevent condensation and leakage on the surfaces of the apparatus.

The pumping plant was supplied and erected by Messrs. Cox-Walkers, of Darlington, and the whole of the switchgear, float contacts, automatic switchgear, &c., was designed and manufactured by them to meet the special requirements called for by Mr. J. R. P. Lunn, the borough electrical engineer.

ELECTRIC LIFT CONTROL GEAR.

The convenience of lifts under a number of very varying circumstances will not be denied by anyone. They are equally useful in blocks of flats or offices for purely passenger or goods work, while when they are required to deal with much heavier loads than would be met with in these circumstances they can also be designed to work very efficiently. Although we do not doubt that the hydraulic lift has certain advantages, we must confess that in one particular at least it falls sadly behind the equipment to which a motor is fitted. This is in the matter of control. It is a very great convenience in certain classes of lift work to be able to dispense with an attendant, and if the lift can be safely taken to any floor and then left to be called for from that floor by purely automatic means a very great step forward has been made, though, of course, it is sometimes more efficient to have an attendant. The electrically driven lift allows this to be done, and in the development of the arrangements for effecting it much ingenuity has been displayed. The necessary criteria which must be fulfilled are that the lift cannot be moved unless every gate is closed, and it should also be possible to control it both from inside the lift and from the various landings.

There are many ways of doing this, and in this article we may call special attention to electric lift control gear for continuous-current working, which has been developed by Messrs. Laurence Scott & Co., of Norwich. Apart from the electrical details, it is interesting from the fact that the controller itself is built up in skeleton form without the use of marble or slate panels, the whole of the apparatus being, in fact, carried on a metal framework which is insulated where necessary with micanite. This type of construction, it is claimed, eliminates the possibility of the controller being crippled by the breakage of a panel, and at the same time allows the whole arrangement to be easily adjusted or cleaned without it being necessary for the operator doing the work to be cramped up in a sort of "black hole of Calcutta," which is not infrequently made doubly uncomfortable by the fact that there is danger from purely electrical sources.

This arrangement appears to us to possess advantages from another point of view. When switchgear is mounted on panels of so-called insulating material, there is a tendency to rely on the latter for a certain amount of insulating protection. This reliance may be misplaced, for often metallic veins are found in both slate and marble panels, so that instead of such panels being insulators they are really acting as conductors of a peculiarly dangerous kind. On the other hand, if a metal frame is used, and the insulation carried out by material of high resistance properties, which is placed at certain

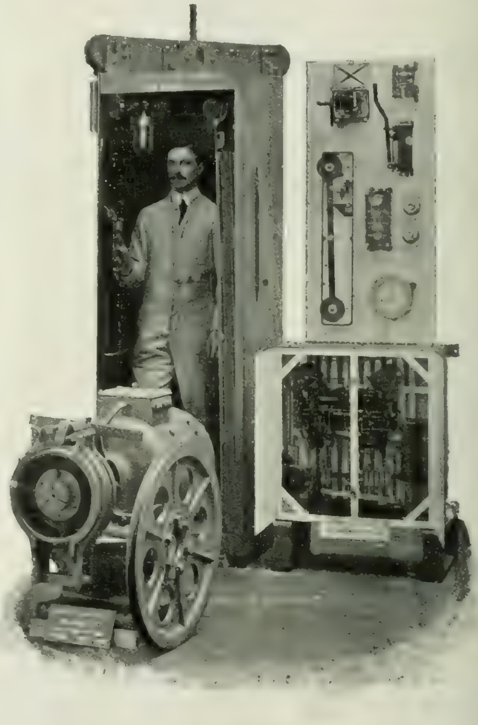


Fig. 1.—General View of Apparatus.

special points, it is known that if this breaks down the live parts are put to earth. In the controller which we are describing the solenoids and other equipment are mounted inside a box built up of angles and flat iron with sheet iron sides, doors being provided as shown in Fig. 1. This box is intended to protect workpeople from accidents, while at the same time it excludes dust and moisture, and it forms no impediment to the adjustment or repair of the apparatus. Fig. 2 shows the controller arranged for switch-in-cage operation. The two main reversing switches are fixed at the upper part of the gear and are connected in the main circuits. Their contactors are cross-connected in such a manner that the current flows through the armature in one or other direction, depending on which of them is closed. They cannot, however, be both closed at the same time. These contactors are operated by coils, the current through which is controlled by the cage switch. The throwing over of this switch into one or other position determines the direction in which the current shall flow through the armature, and therefore the movement of the cage up or down as the case may be. In the operating coil circuit worked by the cage switch are placed the limit and gate

switches, all in series, so that the cage cannot be started if any of the gates are open, while should it over-run its travel the main circuit is also broken.

An overload automatic device is fitted, and is shown in the diagram Fig. 2. It consists of a solenoid wound with two coils, one coil is in the main circuit, and on an overload lifts up the armature, which

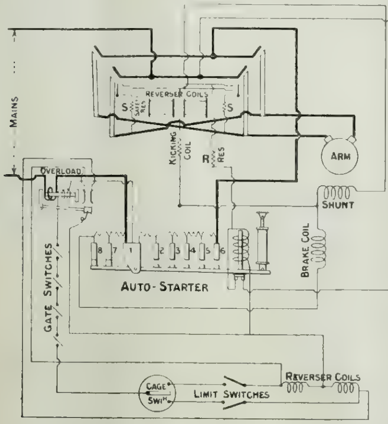


Fig. 2.—Connections for Lift. Cage Switch Control, Overload Release.

"shorts" the operating coil of the main reversing switch and breaks the circuit. The other coil is a shunt, and keeps the armature up after the main circuit is broken. The main reversing switch cannot be again switched on by the cage switch until the armature automatically drops, when the lift is ready to be restarted. The reason for this is that if only a series coil were used, and the cage switch was held in on a persistent overload, the armature would pump up and down and the desired effect would not be obtained.

The starting switch consists of a swinging arm operated by a solenoid, and is fitted with a number of carbon contacts. When all the resistance is cut out these carbons are short-circuited by a metal contact, so that they carry current during starting only. Further, as the main circuit is always broken on the contactors, it is claimed that these carbons will last indefinitely. The two extra carbon contacts which are fixed at the left-hand end of the starting arm allow an extra resistance to be inserted in the motor field, so that an in-

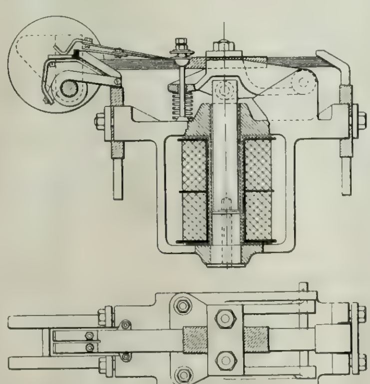


Fig. 3.—Contactor.

creased speed can be obtained after all the starting resistances have been cut out. This resistance is also used in connection with the slowing-down gear, which works in the following manner: The cage switch is fitted with extra contacts, and special leads are run to the resistance, so that when the switch is in the half-cock position the resistance is again short-circuited, and the lift slows down just before stopping. This arrangement makes it easy for the attendant or operator to bring the lift precisely to any desired position.

The contactors are shown in Fig. 3, which clearly indicates the method of insulation employed. A patented form of main brush is adopted in these switches, consisting of a number of rectangular copper laminations, which are each of the same length and which are riveted together, the whole being carried by a micanite sleeve. This device is, we understand, very carefully manufactured, and gives great flexibility and good contact. The lower end of the brush does not leave its contact when the switch opens, but the pressure between the brush and the contact is a maximum on the closed position. A magnetic blow-out is provided at the top of the switch,

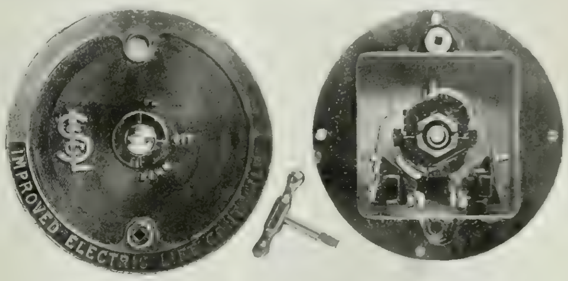


Fig. 4.—Cage Switch.

plenty of room being given for the arc to exhaust itself. Resistance coils of Eureka wire wound on iron tubes and insulated with micanite are used in connection with this equipment. The cage switch is shown in Fig. 4, and is of purely metallic construction with mica

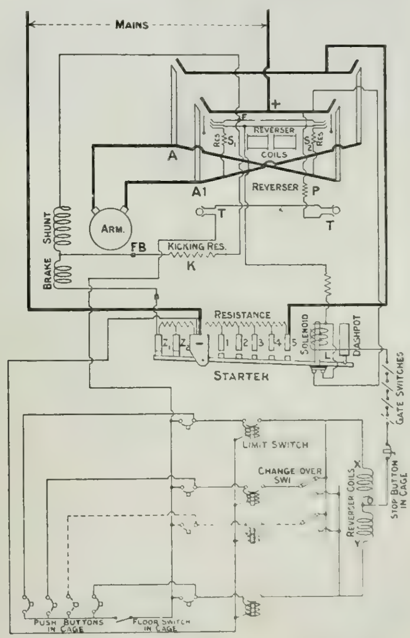


Fig. 5.—Connections for Lifts. Press Button Control.

insulation. It is provided with a removable key, and is so arranged that when the pressure on the latter is released the switch always returns to the "off" position. Further, the key has to be pressed into the switch and held in position during the travel of the cage

in other direction, the switch returning to the "off" position and locking itself as soon as the key is removed.

The arrangement we have just described is designed for those cases where an attendant accompanies the lift, but Messrs. Laurence, Scott & Co. have also paid attention to a push-button control arrangement. This is shown diagrammatically in Fig. 5. The controller itself is practically the same as that described above, though the overload coil is omitted, as in this type of lift it is usual to rely on fuses or circuit-breakers for protective purposes. One push-button is fitted at each stopping place and one in the lift for each floor. The pressing of the button on any floor brings the cage to that floor should the gates throughout the building be closed and the lift unoccupied. No gates can be opened except the one at which the cage is standing. The operation of the lift is entirely under the control of the passenger in the cage at any time, and the pressing of the button at any of the floors during a journey will not affect the travel of the lift to the floor desired by the passenger.

The operation of this arrangement is as follows: Pressing any of the cage or floor buttons energises and closes an electrically operated limit switch, which in turn energises the controller operating solenoids. The cage buttons, however, cannot complete the circuit until the floor switch is closed by a passenger standing in the cage, and all gates are closed. Stopping is effected by breaking the solenoid circuit at the limit switches, which are forced open mechanically by the passing cage. The change-over switches, shown in the diagram, are provided to determine the necessary motion of the cage to reach any floor. They are thrown over by the cage in passing.

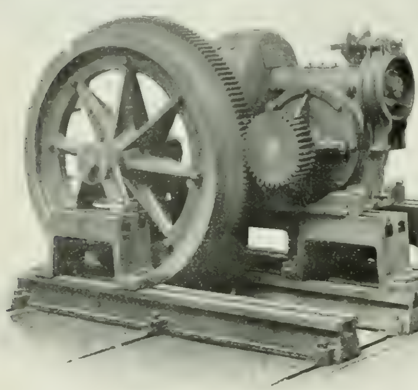


Fig. 6.—Lift Motor and Gear.

In connection with lift work generally, a standard type of machine for which is shown in Fig. 6, it is interesting to learn that Messrs. Laurence, Scott & Co. have provided a number of lifts of this class for use in the Navy. They are fitted in vessels of the "Dreadnought" class. For testing this apparatus Messrs. Laurence, Scott & Co. have also erected a special testing tower 50 ft. high. This tower has two cages which can be loaded up to 3 tons each, and by its use various lifting equipments can be tested under actual working conditions. The possibility of making such tests is an economical factor which cannot be overlooked, as it relieves the necessity for adjustment and alterations when the lifts are finally erected at the place where they are to work.

Electrical Production of Pig-iron.—According to the "Engineering and Mining Journal," the first pig-iron in the United States made in the electric furnace, and which has been put on the market commercially, comes from the plant at Héroult, in Shasta county, California. This plant uses furnaces of the Héroult type, and electric power is furnished by the Pitt river. The first regular shipment was 20 tons of pig iron delivered in Redding. The electric furnace in operation is turning out about 25 tons of iron daily, and delivering it at a cost less than the present price in California. Some few changes have still to be made before the process will be considered completely successful.

ELECTRICALLY-DRIVEN MACHINERY AT FISHGUARD HARBOUR.

By the opening of the Fishguard–Rosslare route on August 1, 1906, the Great Western Railway Co. provided an admirable means of access to the South of Ireland, so rich in interest from the tourist aspect. With an unrivalled train service in England, and boats which are second to none in cross-channel service, it is not surprising that the route is proving attractive, and is fast increasing in popularity. The boats themselves are magnificently equipped, and are really miniature liners, while the boat expresses on this side are all that could be desired. It is, however, not only to cultivate passenger traffic that the Great Western Company have taken this progressive step, but also to secure a very large amount of goods traffic between the two countries. In order to deal with this latter particularly, the station and quays at Fishguard had to be considerably enlarged and newly-equipped with harbour machinery. The purpose of the present article is to describe this machinery in as complete detail as possible.

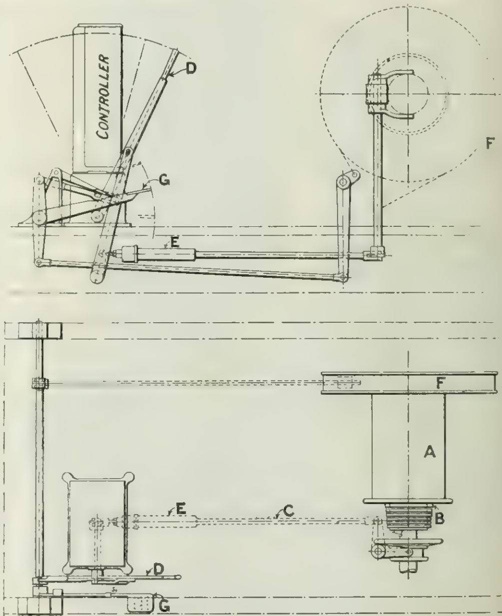


Fig. 1.—"Free-Barrel" Arrangement by Stothert & Pitt.

Beginning with the power house, which is situated at an extremity of the yard, its position is not an ideal one owing to the fact that rock-blasting operations are continually being carried on in its immediate vicinity. It is built directly at the base of a cliff, and experiences the full force of the extremely rough weather which is by no means uncommon at Fishguard. During the early days of the work, it frequently happened that large pieces of rock crashed through the roof and fell into the boiler house or engine room. On one occasion a fragment weighing several pounds struck the battery room door, penetrated it, passed between two rows of cells, striking one or two on its way, and finally left by way of another door, which it also penetrated. To guard against this sort of thing wire netting has been spread over the roof, and all the machines are protected by sheet-iron guards. The switchboard attendant also has an iron roof over his head while the switchboard itself is completely housed in iron.

In the boiler house are three marine water-tube boilers by Messrs. Babcock & Wilcox, each being provided with a short

iron chimney. They are fitted with internal superheaters and are hand-fired, the steam being superheated up to 500 F. The working pressure is 160 lb. per square inch. After passing through the engines the steam is taken through a Reavell oil separator, and from there to the condenser, which has a capacity of 9,000 lb. of steam per hour, and was built by Messrs. Belliss & Morcom. In conjunction with the condenser is an Edwards steam-driven air pump. Sea water is employed for circulating, and for pumping it an electrically-driven centrifugal pump has been installed. This pump is driven by a Siemens motor, to which it is directly coupled, the motor being of the enclosed type and developing 20 H.P. when running at 500 revs. per min.

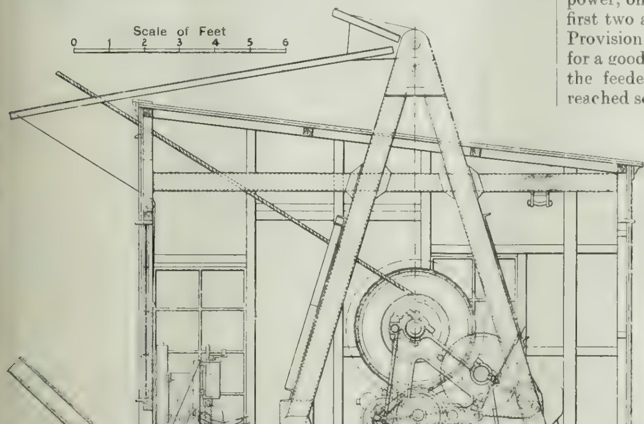


FIG. 2.—ARRANGEMENT OF 30 CWT. AND 3-TON ELECTRIC CRANES.

If necessary, the engines can exhaust into the atmosphere, and in this event the feed-water is obtained from a special storage tank; otherwise it is obtained from a hot-well. Duplicate feed pumps are provided, they being of direct-acting steam-driven vertical pattern built by Messrs. Weir.

In the engine room are four Belliss-Siemens continuous-current sets. The engines are of the two-crank compound type, and are directly coupled to four-pole shunt-wound generators. One set is provided with two 60 kw. machines in tandem, and is used as a steam balancer, each machine developing 60 kw. at 240 volts. The three remaining sets are each of 120 kw. at 480 volts. A hand travelling crane traverses the engine room and a booster is employed for battery charging. The latter machine consists of a motor connected between, and on the same shaft as, two dynamos, each of which is capable of developing 50 amperes at from 0 to 50 volts.

Situated over the stores is a spacious battery room containing 220 cells of the Tudor L.F. 9 type, having a capacity of 500 amperes at the low-discharge, or 10-hour, rate.

With regard to the switchboard, there is nothing of particular interest to note. It is of the conventional black marble type, and consists of the customary generator and feeder panels, due provision being made for extension.

Three sets of feeders leave the engine room, one being for power, one for lighting, and the third for the ocean quay. The first two are carried in a cast-iron conduit filled with bitumen. Provision of the trench for this conduit was not an easy matter, for a good length of it had to be blasted from the solid rock, and the feeders are not brought above ground until a point is reached some 200 yds. from the engine room. Up to this point paper-insulated lead-covered concentric cables are employed. After coming above ground they are entirely carried overhead with the exception of a short length in a subway. The overhead work consists of stranded and braided conductors, carried on insulators on square wooden posts with cross-arms. A main power distribution board is provided on the station platform, and enables the power feeders to supply 15 circuits.

The feeders for the ocean quay consist of two 0·2 sq. in. stranded and braided conductors. On leaving the station switchboard they pass through double-pole handle fuses and a double-pole switch, through the meter, and then up the engine room wall on brown porcelain insulators, afterwards passing through the wall on to channel iron arms, cemented into the wall. From this point they are carried overhead on lattice steel poles, 45 ft. high, as far as the beginning of the quay. Here rubber-covered cables are jointed on and run down the pole to straight-through joint boxes, from which concentric, paper-insulated lead-covered cables run to the main switchboard on the ocean quay. This board controls two cranes, there being two plug boxes for each crane. All cables on the ocean quay are carried by means of oak cleats under the decking. In addition to the power work there are also lighting cables consisting of a pair of 19/18 and a middle wire of 19/20.

At each end of the quay wall there is a Carbone enclosed flame arc lamp the centre of the arc being 13 ft. above the quay wall; these lamps are employed for navigation purposes and enable vessels of large draught to enter the harbour without danger, and to ascertain the safe berthing limits at night.

The roadway from the passenger station to the Fishguard Bay Hotel is illuminated by Westminster arc lamps, and electrically illuminated signs directing passengers to the various trains and boats are situated at convenient points on the platforms.

Owing to the nature of the load it is scarcely to be expected that the load factor would be high, and, as a matter of fact, it works out to 26 per cent. The works costs vary from 1·02d. to 2·17d., the lower figures being experienced in the winter, when the hours of lighting are longer, and the higher figure in the summer.

New marine repair engineering shops have been erected, and are lighted and driven throughout by electricity. The wiring is carried in Simplex screwed steel conduit, and each machine tool is provided with a portable hand lamp, connected to a wall plug by leads encased in flexible steel tubing. Six Westminster enclosed arc lamps are employed for lighting the shops, which contain numerous lathes, punching, shearing and blowing machines. There are installed two 10 H.P. and one 25 H.P. Siemens enclosed motors, which are arranged to drive separately or collectively on to two lines of main shafting.

By far the most interesting feature of the installation is the very fine collection of electrically-driven cranes erected on the quay wall and on the ocean quay. These were all supplied by Messrs. Stothert & Pitt. They consist of eight 30-cwt. cranes and two 3-ton cranes, all on the quay way, one 21-ton crane on the coaling wharf and one 3-ton crane on the ocean quay. The first eight are fed by flexible leads attached to connecting boxes on the station roof, while the remaining two on the quay wall are provided with sliding contacts moving along a bare-copper strip, supported on insulators also on the roof. Fig. 2 shows the general arrangements of the 30-cwt. cranes. The height from the centre of jib pulley to the ground is 37 ft., while the slewing radius is 35 ft. These cranes are known as the "half-portal" type, and are designed to raise a maximum load of 30 cwt. at a speed of 250 ft. per minute, the jib head speed of slewing being 400 ft. per minute.

The crane truck is carried on a rolled steel gantry, two wheels running on rails fastened to the top of station roof, while the other two are on the quay level, the former being 11 ft. 6 in. above the latter. Hand traversing gear is fitted, and the wheels are relieved of all pressure when the crane is at rest by means of screw jacks. Built into the top of the gantry framework is a cast-iron centre bed which carries a cast-steel roller path. A similar roller path is carried by the superstructure, and moves on a ring of steel rollers. A steel centre-pin secures the superstructure. Separate motors are employed for lifting and slewing, the former operation being effected by means of the patent "free barrel" arrangement designed by Messrs. Stothert & Pitt and shown in Fig. 1.

It consists essentially of a hoisting drum, A, driven by gear from an electric motor, the hoisting drum being loose on the shaft, and connected or disconnected by a friction clutch B. This friction clutch is thrown in and out of gear by the rod C, which is actuated by the controller handle D. When the controller handle is in the position shown, the clutch is disconnected and the motor stopped. On moving the handle forward, the controller is actuated, the motor is started, the clutch is thrown into gear, and the barrel commences to revolve and to lift the load. Further, motion of the handle increases the speed of the motor without altering the clutch, the motion being taken up by the spring box E.

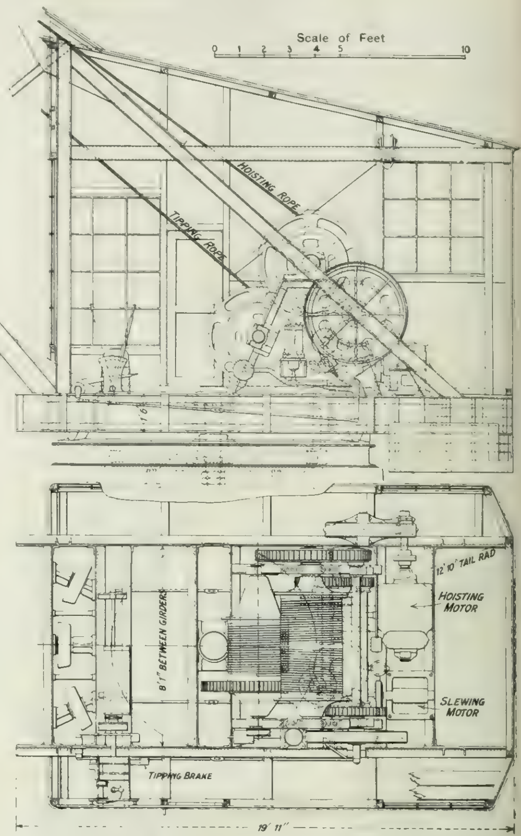


Fig. 3.—21-ton Electric Coaling Crane.

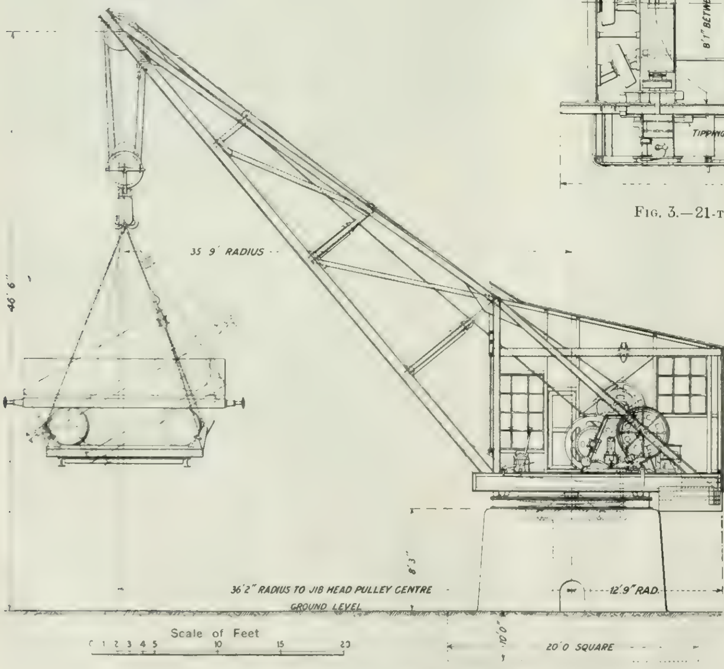


Fig. 4.—General arrangement of 21-ton Electric Coaling Crane.

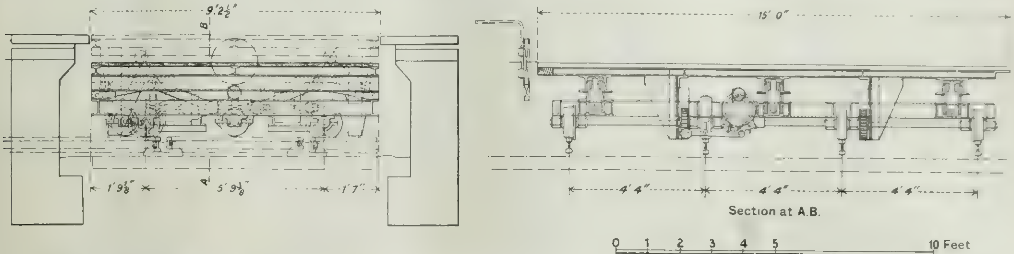
Lowering is performed by the mechanical brake F, which is actuated by the foot treadle G. There is a coupling rod or interlock between the treadle G and the handle D, so that depressing the treadle and putting on the brake throws back the handle D and stops the motor and disconnects the barrel, leaving the load suspended on the brake. This arrangement also prevents the motor being started until the brake is freed.

The advantage of the whole arrangement is that lowering can be performed at a very rapid rate, without reversing the motor, thus enabling the cranes to work at a very high speed and to compete successfully with hydraulic cranes.

There is also a great advantage in lifting, as lifting can be carried on, without stopping, to the top of the lift, when the clutch is instantly disconnected, leaving the motor spinning; thus no time is lost by waiting for the armature to come to rest. In cranes where the

motor is always in gear with the lifting barrel, the motion has to be checked before the top of the lift to prevent overwinding, but in practice with the free barrel arrangement it is found that a load can be lowered to the full depth before the motor has come to rest, and often there is a certain amount of momentum left in the armature to aid the next lift.

The motors in these cranes were supplied by the British Thomson-Houston Co., and are of their special crane type. Those employed for lifting are rated at 38 B.H.P. when running at 415 revs. per min., while the slewing motors are of 4½ B.H.P. at 635 revs. per min. The cranes are admirably constructed for convenience of working, and the arrangements are such that the driver can manipulate the load with accuracy and precision without the aid of a second person.



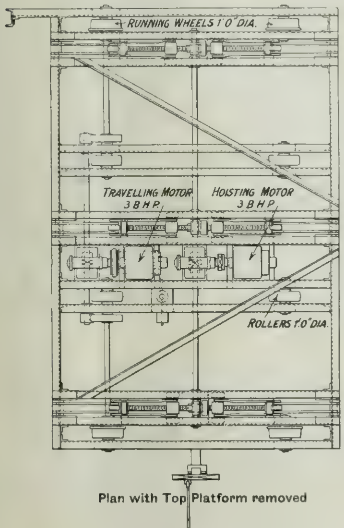


FIG. 5.—GENERAL ARRANGEMENT OF ELECTRIC TRAVERSER.

The 3-ton cranes are almost identical with those just described. The motors are of the same type while the speeds of hoisting and slewing are respectively 125 ft. per minute and 400 ft. per minute.

The 21-ton crane (Figs. 3 and 4) is designed to deal with entire trucks of coal, which it lifts and tips. Steel rollers are employed to carry the superstructure on the top of a solid masonry foundation, to which it is secured by a steel centre pin. Attached to the lifting gear are two barrels, one for lifting and the other for tipping. Tipping is effected by running one barrel and keeping the other stationary, while both are run simultaneously when hoisting alone is in progress. One 56 H.P. motor drives both barrels and raises a load of 21 tons at 25 ft. per second when running at 370 revs. per min. For slewing, an 8 H.P. motor is employed, the speed of slewing at the jib head being 250 ft. per second, when the motor is running at 540 revs. per min.

Next in importance to the cranes must be reckoned the "traversers," of which there are four. These are moving platforms which bridge the permanent way between platforms in the absence of trains, thus permitting passengers and goods to move from one platform to another without having recourse to the subway. Two of the traversers span a double line of rails, while the other two span only single lines. Normally they are housed under the platforms, but when required are driven out and raised by electricity, the traversing and raising being effected by separate motors. The illustrations show how these operations are carried out, the controllers being situated on the platform. As a measure of precaution the main switch feeding the controllers is interlocked with the signal and point levers in the signal box, so that no train can enter the section when the traversers are out and no traverser can be unhoused unless the section is blocked. The traversers, which were supplied by Messrs. Stothert & Pitt, are similar in all respects, except with regard to dimensions. Each is provided with two 3 H.P. motors, the long traversers running on 16 rollers of cast steel and the short traversers on eight. As will be seen, the lifting gear consists of toggle joints connected, through right and left-handed screws, with shafts driven by the hoisting motor. A framework of rolled steel sections carries the platform, which is of wood. It will be obvious, on a moment's consideration, that a somewhat complicated system of controllers and switches has to be employed in order to prevent

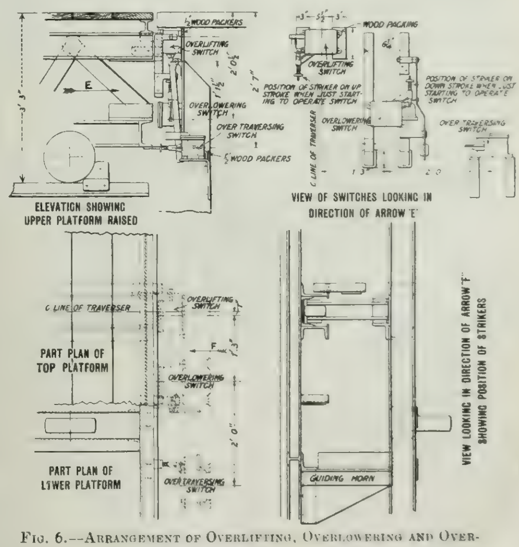


FIG. 6.—ARRANGEMENT OF OVERLIFTING, OVERLOWERING AND OVERTRAVERSING SWITCHES FOR ELECTRIC TRAVERSER.

mishap. For instance, it must be impossible to raise the platform of a traverser when it is housed wholly or partially, and it must be possible to raise or lower only when it is at its correct position over the lines. Assuming that it is raised it must then be impossible to cause it to traverse. These features are secured in the following manner. Referring to the diagram (Fig. 7) it must be understood that the parts marked "Travelling controller," "Forward," "Back," "Lifting controller," "Up,"

"Down" represent circular strips of metal forming part of the controller proper situated on the station platform. The parts marked U, D, F and B are switch contacts fixed on the traverser itself. When the traverser is housed it will be observed that current can only flow if the "Forward" contact is connected with the −main. Assume this to be done; the moment the traverser begins to move from its housing, B moves to the position 1 and 2 as below (Fig. 8). This has the effect of

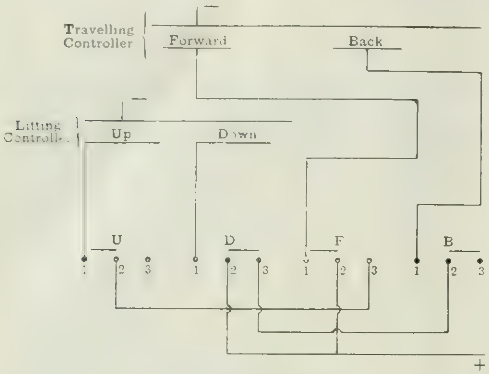


Fig. 7.—Traverser Housed.

making the "back" contact alive, so that, if desired, the controller can be immediately changed from "forward" to "back," and the traverser returns to its housing. Assuming, however, that this has not been done, but that the machine continues on its course, it will, on reaching the final position between the platforms, cause the switch F to change over and connect together contacts 2 and 3 breaking connection between 1 and 2. Thus the "forward" contact is cut out and will be observed that on F going over U_2 becomes alive, thus enabling the platform to be raised. The following (Fig. 9) therefore represents the existing connections on the traverser contact switches. If, now, the platform be raised D goes over to 1 and 2 as below (Fig. 10), thus breaking the circuit to B and making it impossible for traversing to be effected in either direction. When the platform reaches the top of its travel the switch U is caused to change over, breaking the circuit between 1 and 2, thus disconnecting the "up" contact on the lifting

Fig. 8.—Traverser Moving from Housing.

Fig. 9.—Traverser at Rest between Platforms.

Fig. 10.—Traverser Rising.

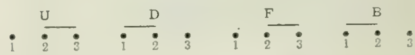


Fig. 11.—Traverser at Extreme Height.

controller but leaving the connections so that the platform can be lowered (Fig. 11). On lowering and housing the traverser these operations are reversed.

Situated at certain points in the station yard are three electrically-driven capstans (Fig. 13), used for shunting purposes. When overcoming a force equal to 1 ton weight each capstan winds normally at the rate of about 200 ft. per minute, and is driven by a 22 h.p. 440 volt motor. The motors are of Messrs.

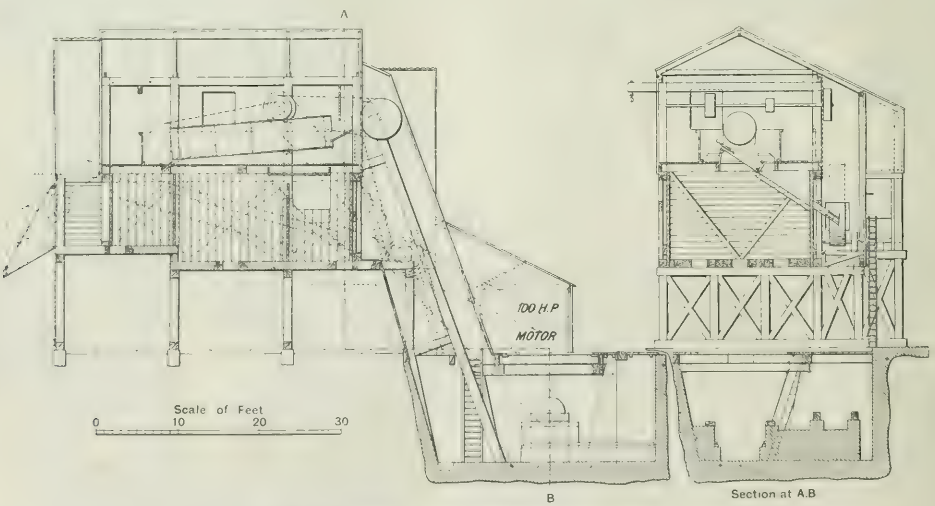


Fig. 12.—General arrangement of Stone Crusher.

the traverser cannot be worked any further forward; it can, however, still be brought back if desired. At the same time an electro-magnet in the controller is demagnetised and the controller barrel is thus released from the handle. A spring in the barrel carries the latter back to its zero position, thus ensuring a start being made under the proper conditions. Further, it Siemens' compound-wound four-pole totally-enclosed crane type, the controller being actuated by a foot plunger. Owing to the fact that the operation of these capstans often falls to inexperienced persons, a dash-pot is provided on the starting lever so that too sudden starting may not result. Variation of speed is obtained by depression of the plunger to varying

degrees. A drum is provided on the motor shaft, and this, in conjunction with a shunt solenoid, constitutes a brake.

The final feature of interest at Fishguard which we propose to describe is the ballast crusher (Fig. 12). This was supplied by the Allis-Chalmers Co. and consists of a gyratory breaker with elevator and rotary screens driven by a single continuous-current motor. The breaker is sunk in a pit so that its hopper is level with the rails along which the quarry waggons are brought to it. Being of the gyratory type it has two semi-annular openings for receiving the stone, each measuring about 14 in. by 52 in. The plant is capable of dealing with some 600 tons of hard rock per day of 24 hours. After having been through the crusher the broken rock is elevated and screened into three sizes, as follows :—(1) Under $\frac{3}{4}$ in. for use in making concrete ; (2) between $\frac{3}{4}$ in. and $2\frac{1}{2}$ in. for railway ballast ; (3) above $2\frac{1}{2}$ in. to be returned and re-crushed.

Each size is automatically discharged into a separate bin, and the bins are arranged on trestles with railroad tracks

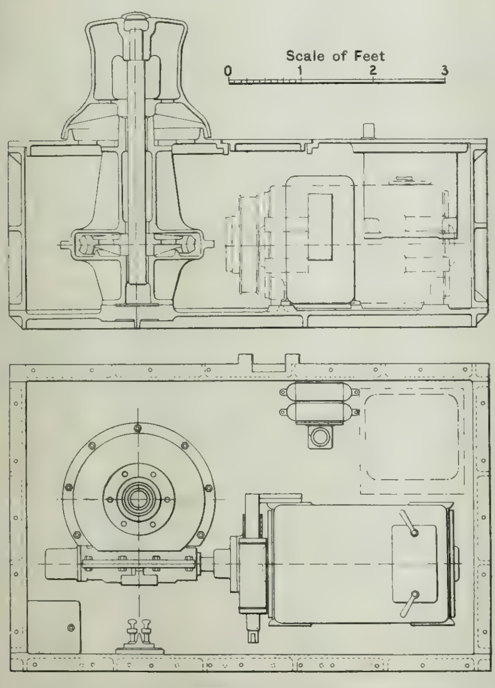


FIG. 12.—GENERAL ARRANGEMENTS OF 1-TON ELECTRIC CAPSTAN.

passing under them. The rock is thus crushed, elevated, screened and loaded into trucks mechanically, the only attention required being with respect to the rate at which the rock is fed into the crusher itself. From tests which have been made, it is found that the power required is as follows :—To drive plant when crushing at full capacity, *i.e.*, maximum to cover occasional peak loads, 200 H.P. ; to drive machinery light, 21·6 H.P. ; to drive motor light, 4·1 H.P.

In conclusion we have to express our thanks to the Great Western Railway Co. and to their electrical engineer (Mr. Roger T. Smith) for their courtesy in enabling us to view the installation ; also to Mr. H. C. Hollingsworth, resident engineer at Fishguard, and to Mr. G. Lambert Gibson, engineer to the Fishguard Harbour Construction Works, who devoted much time to our representative and placed a large amount of information at his disposal. Messrs. Stothert & Pitt kindly supplied many of the drawings.

INTERNATIONAL ELECTRICAL STANDARDISATION.*

BY ORMOND HIGMAN.

In several countries, and from time to time, rules and regulations for testing electrical machinery have been issued. The United States of America was the first to study the problem, and as far back as 1899 the American Institute of Electrical Engineers issued their first report. France, Germany and Great Britain followed with their respective rules, which, though dealing with practically the same subjects, contain differences, the result not so much of scientific reasoning as of national environment. It was in view of the growing divergence in the standard rules of the different countries that the Chamber of Government Delegates of the International Electrical Congress of St. Louis, held in September, 1904, adopted the resolution which led to the formation of the International Electrotechnical Commission.

The author then proceeds to describe the general organisation, the aims, and objects of this important movement. It will be remembered that a preliminary conference was held in London in June, 1906, at which the late Lord Kelvin was elected president of the Commission and Col. R. E. Crompton, C.B., first honorary secretary.

An account is next given of the proceedings at the council meeting of the Commission in London last October.† The work of the council was notable for the extremely cordial relations which existed between the delegates of the different countries. The unfailing courtesy displayed by one and all, the spirit of compromise which marked the attitude of the different delegates, and the general good-will augurs well for the future success of the Commission. If, at the preliminary meeting, the delegates were merely interested in the movement, the council meeting has certainly turned that interest into real enthusiasm for the high aims and objects of this world-wide movement. Mr. Balfour, in his opening address to the council, remarked that the general desire of the Commission, as he comprehended it, was so to arrange, by international agreement, the tests which are to be applied to different kinds of electrical machinery so as to describe the qualities of different machines that, whilst the man who buys and the man who sells will know exactly what each respectively is doing, there will yet be the freest initiative left to both—to the man who desires machinery to be constructed to carry out some particular design of his own, and to constructors of machinery, on the other hand, who desire to take advantage of the ever-increasing changes which growth in knowledge and increasing invention enable mankind to turn to account.

Before, however, any question of international agreement as to the tests of electrical machinery can be discussed, the different nations must agree upon the explanations of the terms in general use in the industry, and therefore nomenclature becomes a subject of great importance to the progress of the work. This does not, of course, prevent other questions being put forward for discussion, with a view to future agreement. The rating of electrical machinery, for instance, has already been considered in several countries, and, broadly speaking, the rules do not differ very greatly in their essential points, but rather in the details, which are dependent upon local conditions. At the same time, it is quite evident that simple rules for the rating of machinery, drawn up on a broad basis, without going into great detail, will be of great international utility. Another advantage will be that a system of physical and mechanical condition of tests can, and no doubt will, be established internationally. There is surely no reason why 1,000 kw. generators should not have the same rating in all countries ; there is no apparent reason why the efficiency or regulation of an alternator or transformer should not be reckoned on the same basis all the world over—that is to say, that the physical tests determining the output of electrical apparatus should be agreed upon internationally. Broadly speaking, the work of the Commission, as far as it relates to electrical machinery, must deal with conditions of tests which electrical apparatus shall fulfil, and not with the actual apparatus itself, every endeavour being thus made to guard against interfering with design or progress.

Standardisation in itself is nothing more or less than organisation of manufacture, and the question as to the course to be followed in order to obtain the best results is hardly more open to argument than the desirability of the final result, though in the earlier stages the work must be of more or less tentative nature. Such a work must be of benefit to manufacturer and to user alike, and for this reason, if for no other, both must be consulted before any decisions are arrived at. International trade in electrical apparatus and machinery is bound to be facilitated by the establishment of an international system of nomenclature of physical, mechanical and electrical conditions of tests, and it is very clear that to be successful this work calls for the intelligent co-operation amongst those who direct and in-

* Abstract of a Paper read before the British Association at Winnipeg.

† A full account appeared in THE ELECTRICIAN, October 30, 1908, p. 82.

fluence the industry throughout the world. It means more than ordinary co-operation; it means the coming together with the spirit of compromise, so clearly shown at the council meeting. International rules will tend towards uniformity in practice, because the consulting engineer in any country, when drawing up his specification, will naturally include the recommendations of the Commission in the matters touched upon in his specification. This will go a long way towards minimising the cost of tendering. Everyone knows only too well the amount of delay involved in preparing drawings and estimates to specifications drafted under regulations which, though similar, often differ in small details; regulations which might well be identical, and, in fact, would be so if they were drawn up by some well-recognised authority.

The adoption of an international system of nomenclature will minimise the difficulties of distance and language, and greatly assist in the comprehension of specifications, and, consequently, increase economy and rapidity in production. The fact that user and manufacturer alike are equally interested in the drawing up of any rules for the classification of electrical machinery is, undoubtedly, a cogent argument why countries which do not manufacture electrical apparatus should take as active a part in the deliberations of the Commission as that taken by those countries who do. For if a country does not manufacture electrical machinery it is, at any rate, a purchaser or a prospective purchaser, and it is quite evident that the purchaser must understand what he is buying as clearly as the manufacturer understands what he is selling. If any rules are to be international in the true sense of the meaning it is imperative that the particular conditions affecting any one country should receive adequate consideration before any decisions are finally arrived at. This is the more important in view of the so-called "international" congresses which have been held of late years, the labours of which are of questionable benefit.

CURRENT CONSUMPTION.*

BY R. S. PILCHER.

Summary.—The author believes that the remedy for preventing the increase in current consumption per car-mile on tramways is improved methods of driving. He shows the effect at Aberdeen of explaining to the motormen the saving to be obtained by careful driving, following this up by the installation of meters on the cars.

The cost of electricity to any tramway system may be the question of a profit or loss on the year's working. In Aberdeen the cost of current averages 1·10d. per unit, and the units consumed work out at 1·25 per car-mile, making a cost of 1·37d. per mile run. The proportion of this to our working expenses is 23 per cent., or more than half the cost of all our wages paid. In some of the largest towns in the country the power expenses are about 30 per cent. of the total working expenses, and in one town they are as high as 35 per cent. I think you will all agree with me that no effort should be spared in trying to prevent the systematic increases in current consumption which are to be seen all over the Kingdom. It is a fact, I believe, that the records of most towns in the United Kingdom and Ireland show an increase, year by year in the consumption of current per car-mile, and this is chiefly owing to track and car equipments becoming older, as well as to the great increase there has been in recent years in the number of top-covered cars in use.

Some tramway officials think there is a great deal of current wasted through defective motor fields, badly worn pinions and gears, bent axles, &c., and I believe that in systems which have only been running a few years, much of the increased consumption may be due to this. But most of our systems have now been running over five years, and have replaced pinions, and started to replace gears and field coils, in this way continually renewing the car equipments, so that I am inclined to think that the bringing forward of these causes of increased current consumption is rather apt to blind us to the true remedy, which, in my opinion, is to be found in the correct method of driving.

Five years ago I experimented on an English tramway system with a view to saving current, and by instructing the motormen in the series-parallel system of controlling motors, and by showing how it was possible to save current without decreasing the speed of cars, a reduction of over 7 per cent. was made. In Aberdeen I started a similar system three years ago, which has been very successful. In the first place, each motorman is brought into the office, and before a blackboard thoroughly instructed in the series-parallel system of control by means of diagrams. Each man is instructed how to use the momentum of his car to the best advantage, and he is shown how to keep up the same speed with less use of the power notches of the controller. He is shown how the careful driver can, after arriving at the top speed, maintain it off the series position, whilst the careless driver would have his controller on parallel all the time. The men are also instructed not to run their cars on parallel, unless they have sufficiently clear space ahead to get the full benefit in speed of extra consumption. All the motormen are informed of the cost of current and it never fails to impress them, because they previously did not appear to realise that electricity cost anything. Each motorman is put upon his honour to do the very best he can for the department, and he is informed of the reductions made. After having been thoroughly instructed in the office, he is given a printed instruction paper which shows where he should be running in parallel, and where in series, also where he should be coasting. I find that he soon learns the instructions, and gets into the habit of abiding by them. All our drivers are kept to their respective routes, otherwise I could not expect them to know the routes so well. A good inspector, who is tactful and not likely to ruffle the men, is put on the road to see that they carry out their instructions and to see that there is no rushing to and from the different termini.

Previous to this system being introduced into Aberdeen, the rise in current consumption each year had varied between 6 and 12 per cent. per car-mile, and immediately it was introduced there was a reduction. The first year the reduction was 6 per cent. on the year previous, or a saving of £640, in addition to which the gradual increase was checked. Since then we have maintained the same consumption per car-mile, *i.e.*, for three years, and as we have been adding to the number of top-covered cars, at the rate of six each year, I consider that this is equivalent to a gradual reduction.

The Aberdeen tramways system has now got all its service cars fitted with ampere-hour meters, and the consumption of current is lower at present with 41 top-covered cars than it has been for the last five years, although there were only three top-covered cars in use five years ago. These meters have already paid for themselves by the reductions made.

The consumption of current is shown each day and week against each man, a sense of healthy rivalry thus being created between the different men on each route in their effort to show the lowest consumption per car-mile. I find that our motormen like the cars with the meters on them; they become interested in watching the current consumption each trip and each day, and I do not think it is necessary to become arbitrary or too strict with the men. The average motorman is a little slow to understand the subject, but the explanation should be simplified. The main point is to get them interested in the subject, and when they understand they will certainly reduce the consumption of current.

I find that in Aberdeen the routes which use the most current are not always those routes which have the steepest gradients, but that the speed of the car and the number of stoppages have a material effect upon the current consumed. The cars which run the slowest, even although there are several fair gradients on these routes, use the least current, and on other routes where there is hardly any gradient the consumption is high, because of the high speed at which the cars have to travel, together with the greater number of stops. Theory would teach us that the faster the car travels the more economical is the current consumption per car-mile; in practice I find just the opposite. It is of no use to give the efficiency of a car running in parallel against a car running in series without taking into consideration the conditions of starting and stopping, combined with the fact that it is harder to keep time with a high average speed than with a low average speed, and a car will in consequence use more current when accelerating its speed. We have a route in Aberdeen on which seven cars operate. Some time back one car was taken off this route, but the six cars which were left used much more current than the seven cars had done, proving that in practice the faster the cars run the more current they will use per car-mile.

Sometimes mechanical controller regulators are advocated to save current, but I think that they are of little use except to prevent the abuse of the equipments by notching up too fast. My own impression is that any system of electric tramways which has no method of checking current consumption will use at least 5 per cent. more current per car-mile than a system which has a systematic check upon its drivers. Of course, I believe that in those towns where there are very many steep gradients and few level tracks there is not so much scope for this subject as in fairly level towns.

If current is to be saved without interfering with efficiency (and it can be saved), the first thing to do is to instruct your motormen specially on this subject, and follow this up by a direct check upon them. It matters little whether watt-hour meters, ampere-hour

* Abstract of a Paper read yesterday at the Conference of the Municipal Tramways Association.

meters or time meters are used. I believe the same effect can be obtained by any of these.

Different rail cleaners are often advocated for the purpose of reducing current consumption, but I think that most of them, although they clear the groove, leave a lot of dirt and dust upon the tread of the rail in dry weather, therefore, I think that the best rail cleaner is a water car. Although the current consumed on a wet rail is less than on a dry rail, I find that on rainy days the consumption of current is higher than on dry days, but this is owing to the greater number of passengers carried at rush-hours, and consequently the greater number of stoppages.

In Aberdeen, simultaneously with the introduction of systematic supervision of the drivers, I noticed a great improvement in the time-keeping of cars; also, which is very important, a great reduction in motor troubles, the number of armatures in for repair being greatly decreased. The car repairs for Aberdeen last year stood at 0·41d. per car-mile, and I believe this is largely due to the reduction in current consumed.

A diagram attached to the Paper shows the number of units per car-mile for 52 weeks (1905-6) previous to the system of instruction, for the year 1906-7 following the system of instruction, and for 1909 since the introduction of meters.

EFFECT OF A MAGNETIC FIELD ON THE ELECTRICAL CONDUCTIVITY OF FLAME.*

BY PROF. H. A. WILSON, F.R.S.

Summary.—The author gives an account of some measurements of the change in the conductivity of a Bunsen flame produced by a magnetic field, the direction of which was perpendicular to the current through the flame and to the motion of the flame gases. The velocity of the negative ions in the flame is calculated from the results, and the value of the velocity obtained agrees approximately with that found by other methods.

The flame used consisted of a row of 12 small Bunsen flames burning from quartz tubes. The centres of the tubes were 1 cm. apart, and each tube had an internal diameter of 0·5 cm. Each flame was about 6 cm. high, and the adjacent flames touched each other, so that a flame about 14 cm. long, 6 cm. high, and about 2 cm. thick, was obtained. Two platinum disc electrodes were supported in the flame facing each other about 10 cm. apart, and were connected through a galvanometer to a battery of secondary cells. Some potassium carbonate was put on the negative electrode to increase the current. The potential gradient along the flame was measured by means of two platinum wires which were supported horizontally in the flame perpendicular to the horizontal line joining the centres of the disc electrodes. These wires were connected to an electrostatic multicellular voltmeter. The capacity of the voltmeter was increased by connecting it to a $\frac{1}{2}$ mfd. condenser, and large amyl-alcohol resistances were put in the wires leading from the flame to the voltmeter, to prevent the small oscillations of the flame making the voltmeter needle unsteady. The flame was placed between the poles of a large Du Bois electromagnet, the conical pole pieces of which had been removed so that a fairly uniform field could be produced in a horizontal direction perpendicular to the line joining the disc electrodes.

It was found that passing a current through the magnet produced a gradual change in the conductivity of the flame, which remained when the current was stopped. This appeared to be due to the heating of the coils altering the draught of air to the flame. In addition to this effect there was a sudden change in the conductivity on turning the magnetic field on or off. It was easy to disentangle the two effects, but only rough measurements could be obtained. The ratio of the P.D. between the two wires to the current was taken as a measure of the resistance of the flame. It has been shown by several observers that this ratio is independent of the current.

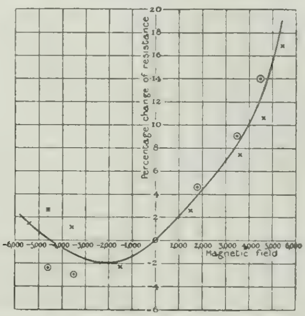
It was found that the percentage change in the resistance for a given magnetic field did not vary much with the current. Two sets of observations, one with P.D.s between the platinum wires of from 200 to 400 volts and the other with from 50 to 150 volts, gave nearly equal results. The distance between the platinum wires was 7 cm. The results obtained are shown in the diagram, the percentage change of resistance being plotted against the strength of the magnetic field. Each point represents the mean of several observations. The crosses are the results obtained with the higher potentials and the circles those obtained with the lower. It will be seen that with the field in one direction the resistance increased by an amount increasing more rapidly than the field, whereas with the field in the opposite direction the resistance was diminished with small fields, but slightly increased with fields above about 4,000.

Owing to the upward motion of the flame gases there is an induced electric force along the flame which opposes the current when the field is on in one direction and helps it with the field in the other direction. If, therefore, we take the mean of the effects for the two directions of the magnetic field, we shall get the value of the effect which would have been obtained with the flame gases at rest. A table in the Paper contains the values obtained in this way, and the mean value of σH^2, where H = magnetic field and σ = percentage change of resistance, is $3 \cdot 1 \times 10^{-7}$.

If it is assumed that the velocity of the positive ions in the flame is small compared with the velocity of the negative ions, then we may apply Sir J. J. Thomson's* theory of the effect of a magnetic field on the conductivity of metals to the flame. According to the theory we have $\sigma/100 = \frac{1}{3}H^2k^2$, where k denotes the velocity of the negative ions due to one electromagnetic unit of electric force. Hence $k = (3\sigma/100H^2)^{\frac{1}{2}} = 9 \cdot 6 \times 10^{-5}$ cm./sec. For 1 volt per cm. this gives $k = 9{,}600$ cm./sec.

Mr. E. Gold † measured the velocity of the negative ions in a Bunsen flame and found $k = 8{,}000$ by one method and 13,000 by another. The result just obtained is nearly equal to the mean of his two results. The velocity, of course, must vary to some extent in different Bunsen flames.

Half the difference between the effects with the magnetic field in the two directions gives the effect presumably due to the induced electric force in the flame. A table in the Paper contains the values of this effect, and σ/H shows that the effect is approximately proportional to the magnetic field, as was to be expected. If v denotes the velocity of the flame gases, we should expect the induced electric



CURVE SHOWING VARIATION OF RESISTANCE WITH FIELD.

force to be equal to Hv, and hence $\sigma/100 = vH/X$, where X denotes the strength of the electric force along the flame. This was not less than 10 volts per centimetre, so that we get $v = X\sigma/100H > 10^4$ cm./sec. Now, the velocity of the gases in a Bunsen flame is not more than 200 cm./sec., so that it appears that this effect is at least 50 times greater than was to be expected. In fact, if it had had the value to be expected it would have been negligible, and the change of resistance would have been independent of the direction of the magnetic field.

It appears, therefore, that the effect of the magnetic field on the resistance of the flame can be represented as the sum of two terms, one proportional to the square of the field and the other proportional to the field. The first term has the value to be expected, but the other term is much too large. The discrepancy would be removed if the negative ions moved *upwards* with a velocity proportional to the horizontal electric field and equal to 10^4 cm./sec. for 10 volts per centimetre, but there does not seem to be any reason for supposing that they do so. If the two wires in the flame are connected to a quadrant electrometer the induced electric force in the flame, when no current is flowing, due to the upward motion of the flame gases in the magnetic field, can easily be measured, and it is approximately equal to the product of H and the velocity. If H = 5,000 and v = 200 the induced force is 0·01 volt per centimetre, whereas to explain the observed change in the resistance it would have to be 0·5 volt per centimetre for a field along the flame of 10 volts per centimetre.

The author is not at present able to offer a satisfactory explanation of the magnitude of the part of the effect proportional to the field.

* Paper read before the Royal Society, slightly abbreviated.

* "Rapports Congrès International de Physique," Paris, 1900. Vol. III., p. 144.

† *Proc.* Roy. Soc., A, Vol. LXXIX., 1907.

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CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *accepted up to* **3:30 P.M. Thursday.**

CURRENT CONSUMPTION ON TRAMWAYS.

Apart from the rivalry between the managers of the various tramway undertakings in this country with a view to showing the lowest working costs, the increasing outlay necessary to maintain the undertakings in efficient running order, now that growth of traffic is small, is sufficient to cause tramway managers to keep down the cost of operation of their lines by every possible means. An examination of the financial returns of the various undertakings shows that a considerable proportion of the tramways of this country are being operated at the expense of the ratepayers or shareholders, according as the lines are municipal or company owned, whilst the absence of extensions to undertakings, and more especially of new schemes under construction, proves that under present conditions the margin of revenue over working expenses is very small. The question of lower costs of operation is, indeed, of great importance at the present time, when rolling stock and rails which have been in use for a few years are showing signs of requiring early renewal. When the subject is discussed in committee the cost of current is frequently the direction in which a reduction in working expenses is sought. Where the tramways and electricity undertakings are both municipally controlled, a reduced price for current is often the outcome, and the ultimate

result of such reduction on the records of the electricity undertaking is not easy to ascertain. With the price charged for electrical energy we do not, however, now propose to deal, since we have frequently referred to the subject; it is to the possibility of reducing the amount of current taken by electric tramways that we desire to draw attention. The energy consumption is certainly a considerable item in the total working costs—occupying somewhat the same position as does the fuel item in electricity supply—and in many cases it amounts to 30 per cent., or even more, of the total working expenses. The most noticeable feature, however, is the growth from year to year of the current consumption per car-mile; this is, of course, partly due to increased traffic, to the use of larger and heavier cars, in many cases with top covers, and no doubt to the wear and tear of rolling stock. Up to the present but little progress has been made by systems of regenerative control, although, theoretically, such systems appear to be nearly ideal from the tramway manager's point of view; and whilst believing that some system of regenerative control will eventually be largely adopted, we think that for the present a more extensive adoption of car meters and careful training of the motormen will bring about a much needed reduction in energy consumption.

On the Continent car meters are very largely employed; they are also being adopted, though to a smaller extent, in this country, and with apparently excellent results. Thus Mr. H. Mozley, in his report in connection with the accounts of the Burnley Corporation Tramways for the year ended March 31st last, mentions that the installation of time meters on the cars has resulted in a saving of 10·89 per cent. in the amount of energy consumed per car-mile. Similar savings of from 10 to 15 per cent. are also reported from other towns where experiments have been made with meters. Further evidence of the advantages resulting from drawing the attention of motormen to the effect of careful and skilful driving on the energy required per car-mile is provided in the Paper read by Mr. R. S. Pilcher, general manager of the Aberdeen Corporation Tramways, at the annual conference of the Municipal Tramways Association this week. From our abstract of the Paper elsewhere in this issue it will be noticed that, whereas an increase in current consumption of from 6 to 12 per cent. occurred each year previous to the introduction, some three years ago, of a system of instructing the motormen in the principles of series-parallel control of motors, a *reduction* of 6 per cent., equivalent to £640, was recorded in the first year subsequent to such instruction, whilst the current consumption per car-mile has since remained practically constant, notwithstanding that top-covered cars are continually being added to the rolling stock. The introduction of car meters naturally followed such a course of instruction, and Mr. Pilcher estimates that at least 5 per cent. saving in energy follows the checking of current consumption.

Another interesting point to which attention is drawn is the increase of consumption of energy with increased average speed. This is, no doubt, due to the greater loss of energy at each application of the brakes, together with the fact, pointed out by Mr. Pilcher, that it is harder to keep time with a high average speed than with a low average speed, so that there is less coasting. The question of the relation of the speed of tramcars and energy consumption is a very interesting one, and involves many factors. Thus, if the motormen endeavour to cut down the energy consumption to the best effect by coasting, the average speed of the cars will suffer, and it may be necessary to run additional cars, but, on the other hand, the cost of maintenance of both rolling stock and track would probably be much less. In this connection we think that misleading results may be obtained where time-meters are relied upon, since these encourage the motormen to accelerate their cars too rapidly with the object of reducing the length of time during which current is being taken, thus increasing the wear of rolling stock and track; ampere-hour or watt-hour meters, although more expensive in first cost, are likely to lead to more satisfactory results. There is no doubt, however, that great benefit results from instructing motormen in the elementary theory of the apparatus they control and showing them how to save current without necessarily decreasing the speed of the cars; and, apart from this, the possibility of checking the energy consumed on a car lends interest to the motorman's duties, and leads to a healthy rivalry between the men.

In conclusion, we wish to draw attention to the effect of dirty rails on energy consumption. We are pleased to notice that this subject is less neglected than formerly, more attention being now paid to the watering and cleaning of tramway rails. In this connection the car meters provide useful means of ascertaining the current consumption on various routes, and enable the state of the track to be roughly estimated. In view of the many advantages obtained by using car meters, it is, therefore, rather surprising to observe from our last Annual Tables of Electric Tramway Undertakings how few meters are being employed; but in view of the publicity which is being given to this question at the Conference this week we do not doubt that the car meter will receive a more recognised position in this country than hitherto.

THE NEW PARSONS TURBINES AT THE LOT'S ROAD GENERATING STATION.

As is now well known, it was decided some months ago to replace the existing steam turbines at Lot's-road generating station (of the Underground Electric Railways Co.) driving the 6,000 kw. alternators by others, of the ordinary Parsons manufacture, and it was hoped that a considerable saving in coal would result owing to the much lower steam consumption which was anticipated. Before condemning the original machines as failures, however, it must be remembered that this station has been in operation for five years, that the turbines were probably designed some seven years ago, and that since that time immense strides have been made in their manufacture. It is, therefore, not very surprising that it has been found advisable to replace them, and that the economy in coal costs will rapidly repay the expense involved by the change. Exactly the same thing has occurred in New York, where at the first station to be equipped with very large Curtis turbines (the Stuart-street station) some eight years ago all the machines have been taken out and others of the same type and size, but with a much lower steam consumption, installed, and it is probable that this policy will be followed in many of the large stations both here and in America. It is not necessarily a question of inefficiency of the original plant, but rather a sign of a marked advance in design and construction since its manufacture.

The turbines at Lot's-road, which have been running since 1904, are eight in number, each driving an alternator of 6,000 kw. normal output at 1,000 revs. per min. They are of the double-flow combined impulse and reaction type, the steam entering in the middle and flowing through the cylinder in both directions, with an exhaust at each end. There is thus no end pressure, and balancing pistons are unnecessary, though a thrust block is used. Double-flow turbines would be impossible if they were of the straight Parsons type, since the blades at the high pressure end would be very small (only half the ordinary height), and the overall length would be prohibitive. In these machines the first two rows in each direction are bladed to form an impulse stage, in which the steam expands through nozzles in the cylinder, and then passes through two moving rows of blades on the spindle, and one intervening row of guide blades, without further drop of pressure. This arrangement, combined with the absence of balance pistons, allows the length of the turbine to be about the same as a Parsons machine of equal power.

The new turbines had to be adapted to the existing bedplates and condensers, and it was decided that while adhering to the ordinary blading, it would be advisable to have separate high and low-pressure cylinders, which is very unusual even for turbines of this power, and has seldom been adopted since the famous Elberfeld machines were built in 1899. The steam is supplied by a 12 in. pipe, and enters the high-pressure cylinder at the end remote from the alternator, and flows towards the centre, whence it is taken through a 30 in. pipe underneath the bedplate to the entrance to the low-pressure cylinder next to the alternator. It passes through this in a direction opposite to that in the high-pressure cylinder, and exhausts practically at the middle into a large bridge pipe connected to the condenser below. The steam thus flows from the outside to the centre in both cylinders, in this way balancing the end pressure to some extent, and lessening the possibilities of distortion. Since the previous turbines had two exhaust pipes leading to the condenser, controlled by separate sluice valves operated by compressed air, those for the new turbines, which are 8 ft. by 5 ft., have two branches and the same valves are used. A further branch is taken off higher up to the atmospheric valve, which is used in case of emergency, the turbine being capable of developing 4,000 kw. when running on atmosphere.

In most of the constructional details the turbines do not differ materially from those of smaller size. The usual Parsons governing gear is employed with intermittent admission of steam through the relay valve, controlled by a cam on the governor spindle, which is driven through worm gearing from the end of the turbine shaft. The valve, however, instead of being opened by a lever, as is customary, on starting up the turbine, is operated by steam, which is admitted underneath the small piston fixed to the valve spindle. The emergency valve is similarly opened by means of steam pressure on the top of the dashpot piston, which prevents the valve closing too heavily. There is a very useful device for controlling the speed of the machine within small limits from the switchboard, which will be of considerable value in simplifying the somewhat difficult operation of paralleling two alternators. It consists of a pair of electromagnets with planed faces about 2 in. apart, between which a steel tongue piece moves centrally to and fro, this motion being imparted to it by an eccentric on the governor spindle. If either of the magnets is energised by means of a switch on the board, the tongue piece is attracted towards it, still retaining its outward motion, and brings a wheel with teeth on the inside into gear with another toothed wheel, causing the latter to rotate, and increase or decrease the pressure on the governor balls, and so vary the speed of the machine.

The oil for all the turbines in the power house is supplied from a central source, being pumped up to a height of about 30 ft., from which it is delivered to the bearings and returned to the cooling tanks. The main inlet and outlet valves for the new turbines are provided with a ½ in. hole through their seatings, so that there is always a circulation of oil through the bearings, even when the machines are not running, and no trouble can occur owing to the valves being inadvertently left closed.

The blades at the high-pressure end are just over 1 in. in height, and as only a very small clearance has been allowed (about 0·020 in. at the high-pressure end), and the balance pistons have been lined off not more than 0·010 in., there is little leakage of steam, and a high efficiency was expected. The old machines consumed anything from 20 lb. to 23 lb. of steam per kilowatt-hour, and as the guarantee for the new ones was a little over 14 lb., it is evident that the saving will be enormous. A trial has recently been carried out on the first of the turbines, and with a vacuum of 27·7 in., stop valve pressure of 180 lb. per square inch, and 140 deg. superheat, the excellent figure of 13·7 lb. of water per kilowatt-hour was obtained. When the eight existing turbines are replaced by the six new ones, which will be more than sufficient for the load, the coal bill will thus be reduced by at least one-third, and it is estimated that a yearly saving of £30,000 will result, since at present some 500 tons are used daily. Moreover, it has up to now always been found necessary to run the entire battery of eight boilers forming the complete unit for each turbine, which, therefore, was unable to develop its full power when one or more of the boilers was shut down for cleaning or repairs. With the lower steam consumption of the Parsons machines only five boilers out of the eight are required for normal load, and it is hoped to keep them in better condition, so as to prevent dirt coming over with the steam, which has hitherto caused considerable trouble, and would probably be even more serious in a single-flow machine, where the effect of the blades becoming partially choked up would be to cause an alteration in the end pressure, besides, of course, diminishing the output of the machine. The first of the turbines installed has now been running for nearly two months on loads varying from 2,000 kw. to 9,000 kw. without the slightest incident, and when the complete replacement has been carried out a remarkable change in the station costs may be anticipated.

THE CENTRAL REPAIR DEPOT OF THE LONDON COUNTY COUNCIL TRAMWAYS*

BY W. E. IRELAND.

Summary.—A description is here given of the various shops comprising the repair depot of the London County Council tramways. Details of the equipment of each shop, and the method of dealing with the repair and overhauling of cars, are given, together with interesting information in regard to the life of wheel-tyres, pinions, &c.

With the development of the tramway system of the London County Council, Mr. A. L. C. Fell decided to recommend the Council to erect a repair depot capable of dealing with the work of repair and renovation of the whole of the cars, besides providing for the future extension of the system. The difficulty of finding in London a suitable site centrally situated from a tramway point of view delayed the development of the scheme for some time. Several sites were from time to time considered as being more or less suitable, but owing chiefly to their high intrinsic value, rejected. The site which was eventually selected and purchased is situated close to the River Thames at East Greenwich, is some 6·9 acres in extent, and adjoins the Angerstein Wharf branch of the South-Eastern & Chatham Railway, from which it is proposed to construct a siding leading into the depot.

Fig. 1 shows the general plan arrangement of the buildings which will comprise the completed depot. The portion within the hatched lines covers 3·25 acres, is practically finished and has been in use some months. This consists of smiths', machine, wheel, truck overhauling, inspection, body and paint shops, and tool, finished part and general stores on the ground floor, with electrical repair, plough, tool, light machine and pattern shops on the galleries. The present building, which has a capacity for dealing with the overhaul of 600 cars per annum, has been planned with a view to future extension without in any way breaking up the continuity of the several shops, stores, &c. The first extension is now in progress.

The buildings are arranged on a definite scheme for dealing expeditiously with the cars during the two weeks each has to be in the

* Abstract of a Paper read on Wednesday at the Conference of the Municipal Tramways Association.

shops for its annual overhaul and renovation. The Metropolitan Police regulations require the body work and painting of each car to be thoroughly renovated once in every 12 months. Advantage is, therefore, taken of this regulation to overhaul systematically and put into first-class condition the whole of the mechanical and electrical equipments of the cars. The lay-out of the depot is arranged so that regular and synchronous progression of the work in the several shops is ensured.

Routine for Dealing with Cars.—The works superintendent issues forms, which are forwarded to the rolling stock superintendent, requesting the cars becoming due for renovation in any one week to be transferred from the several car sheds from which they operate in service to the repair depot on the Sunday night, each car after entering the gateway (*see* Fig. 1) sheds its plough by means of the special run-out arrangement shown. A small steam locomotive then draws the car into the depot through the porch-like entrance and on to a specially constructed shallow traverser, by means of which it is taken into the inspection shop. Here on the following morning an inspector carefully examines the car, noting the repairs required, and compiles a detailed list of the necessary work for the information of the superintendent. While the car is in the inspection shop the brake rigging and other parts of the trucks and equipments are disconnected, and bearing caps and bottom halves of the gear cases taken down ready for dismantling. The car is again drawn on to the traverser, a pneumatic jack placed under each side of both headstocks and the body lifted clear of the trucks. The traverser is then moved along the pit carrying the trucks from beneath the body to a point immediately under one of the lighting wells provided in the floor of the gallery above. Here the motors are lifted by an electric travelling crane running on a gantry above the gallery to the motor overhauling shop, and the trucks sent into the truck shop on the western side of the traverser pit. The body is then placed upon a temporary truck and taken into the body shop for the attention of body makers and wiremen.

The work required on the trucks, motors and bodies usually takes about four days to complete, at the end of which time the whole car is reassembled ready for the paint shop. The paint shop is cleared of its finished cars every Sunday, and the overhauled and reassembled cars placed in readiness for the painters to start their part of the work the first thing on the following morning. The painting and varnishing occupies a week, it being a rule that each week's output of renovated cars is ready for inspection by noon on the second Saturday following the day upon which they were received at the depot.

The Smiths' Shop.—This is at present 130 ft. long by 34 ft. wide, and contains eight 48 in. by 48 in. down-draft hearths, six 36 in. by 24 in. pedestal type ditto, two 5 cwt. motor-driven pneumatic power hammers, one Ryder forging machine, one drop hammer with ½ ton tup, one forging and annealing furnace, one double-head emery grinder, one punching and shearing machine, one 60 in. exhauster fan with a capacity of 22,000 cubic ft. of air per minute at 3 in. to 4 in. water gauge, and one 17½ in. blast fan with a capacity of 2,500 cubic ft. of air per minute at 8 in. to 10 in. water gauge pressure.

The form of hearth chosen is the down-draft type with exhaust mains. Stoneware ducts 30 in. diameter are laid in the ground and provided with suitable branches for connecting with the draft pipe of the hearths. These ducts terminate in a square brick chamber at the southern end of the shop, into which a 60 in. exhauster is built. This arrangement not only provides for the efficient extraction of the smoke, dust and fumes, but also ensures very satisfactory ventilation throughout the shop.

Wheel Shop.—This is 117 ft. long by 65 ft. wide, and is equipped with three high-speed tyre turning lathes, three ditto tyre boring mills, one 150 ton power wheel press, one wheel boring machine, one four-hole gas tyre heating hearth, with jib crane and pneumatic hoist, and half a dozen jig saws for cutting off tyres. The tyre turning lathes, of a special type, built by Tangyes Limited, are motor driven and capable of taking the heaviest cut on high carbon steel tyres that modern high-speed steel will withstand. In considering the power required for these machines, a cut 0·5 in. by 0·125 in. at 50 ft. per minute was taken as a good all-round average to aim for, and it was assumed that a cutting pressure for high-carbon steel tyres would be equal to about 80 tons per square inch, and taking the cut area as equal to 0·0625 sq. in. at a cutting speed of 50 ft. per minute gives approximately the horse-power required—viz., 33·9 H.P. Each lathe is, therefore, driven by a 36 H.P. polyphase motor, direct coupled to a change-speed gear box. The maximum purchase through the gears is 712·5 to 1.

While the cutting power of these machines was calculated upon turning at the rate of 50 ft. per minute, up to the present time it has not been found possible to get above 30 ft. per minute cutting speed on tyres of from 0·60 to 0·68 carbon, skin hardened by months of constant rolling on the track. It is hoped, however, that steel makers will so improve upon their tools that 50 ft. per minute, and even higher speeds, will soon be common for this class of work.

One of the most important points to consider when specifying for, or designing, a machine for turning high tensile tyres is the rigidity of the machine. Both tramway engineers and machine tool makers appear to have treated this point too lightly in the earlier types of lathes, with the result that the work took far too long to do, and owing to the vibration set up in the machine only light cuts could be taken even with high-speed steel tools. Tests have been made in the Council's shops on both types of machines, and it has been noted that the tools failed much sooner with a light cut on a machine which "chattered" than with a heavy cut on a rigid machine, and whereas in the earlier type of lathe from 8 to 10 hours were required to return a pair of tyres, or an average of six pairs per week of 54 hours, with the machines now in use the average output of each machine is six pairs per day, or 34 pairs per week of 54 hours.

The life of steel tyres made to the Council's specifications averages 56,000 miles for pony wheels and 50,000 for driving wheels; this gives an average rate of wear per ⅛ in. radial reduction of thickness of 5,090 miles and 4,545 miles respectively. Having regard to the heavy weights carried on these tyres, and the extra wear which is inevitable by reason of the high acceleration and the many stops made by cars in London, the mileage obtained may be considered fairly satisfactory.

At the present time some 430 new tyres and 575 pairs of wheels complete are handled in this shop per month, or an average of 5,160 and 6,900 respectively per year.

Machine Shop.—This is 143 ft. long by 43 ft. wide, and is equipped with one 3-ton overhead three-motor electric crane running the full length of the shop. The machines on the side adjacent to the western wall are three 8½ in. high-speed all gear headstock lathes, one 10½ in. ditto double-gap lathe, one centreing and facing machine, one

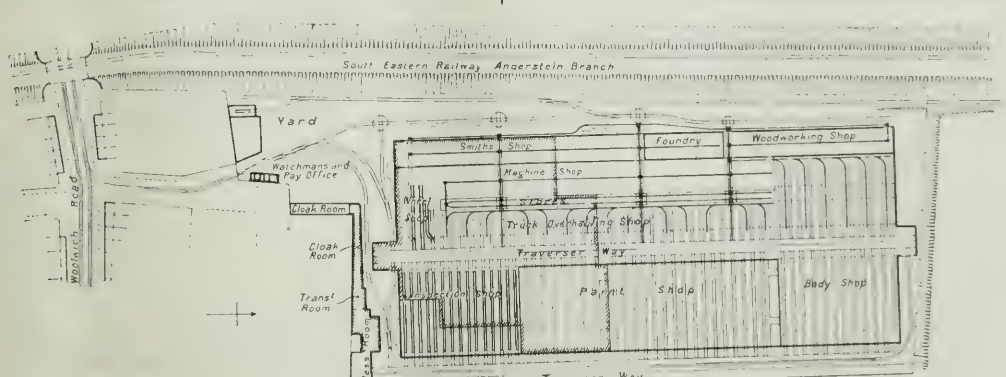


FIG. 1.—PLAN OF DEPOT.

capstan boring and chucking lathe, two special bearing boring capstan lathes and one power press.

The space at the northern end is occupied temporarily by an oil and waste saving plant, consisting of two turbo-centrifugal machines, one rotary washer and two oil filters. This, a most useful plant, is capable of dealing with all the wool waste from axle boxes and bearings, in addition to the ordinary cotton waste and wipers used at the car sheds and works. The plant is designed to handle about 20,000 lb. of wool waste and reclaim some 12,000 gallons of oil per year, and it is estimated that the saving due to this alone will be in the neighbourhood of £600 to £700 per annum, exclusive of the cost of labour, steam, power, &c., these probably not exceeding £150 per annum.

The western side of the shop has one milling machine, one four-spindle drilling and tapping machine, one special high-speed vertical plano-milling machine, one 14 in. slotting machine, one double-head and one single-head screwing machines, six power hack saw machines, six high-speed pillar drilling machines, one 4 ft. 6 in. and one 4 ft. radial drilling machine, and one 30 H.P. two-stage air compressor.

The centre of the shop between the machines is occupied by fitters' benches equipped with the usual parallel quick-action vices, and also a marking-off table. The line shafting is driven by five 36 H.P. polyphase motors, each attached to the upright stanchions. The shafting is divided into five sections coupled by means of claw couplings, so that any section may, if necessary, be run independently of the others. It should be noted that several of the machine tools in this shop have been built to the Council's specifications and are adapted for work of a special character.

Truck Overhauling Shop.—This shop is 195 ft. long by 46 ft. wide, and is equipped with two 5 ton three-motor electric cranes, and the usual fitters' benches, vices, pneumatic drills, hammers, chippers, &c. There are 14 working tracks, each capable of accommodating four bogie trucks or three single four-wheeled trucks. A narrow gauge industrial railway track runs along the full length of the shop on the side adjacent to the stores, with branch lines between alternate pairs of truck tracks. Two small battery power motor-driven service waggons are in course of construction for the purpose of transferring material from or to the stores and other parts of the depot and the men employed on truck overhauling.

Case-hardened steel pinions have been in use since 1906 and are now standardised. The increased life obtained with both pinion and cast-steel gear, compared with the life of unhardened pinions and cast-steel gear, more than compensating for the slightly increased cost. Case-hardened pinions were first tried on the single-deck steel cars when the Kingsway Subway was opened for service in 1906. The pinions then fitted are still in service, and the average mileage of the 32 pinions on these cars is to date slightly over 110,000 miles each, whereas the average life of unhardened pinions working under exactly similar conditions is from 19,000 to 20,000 miles each.

The life of ordinary cast-steel gear wheels meshing with the case-hardened pinions is also improved. This is probably accounted for by the fact that the hardened teeth retain their correct shape for a much longer period than unhardened teeth, with the result that they transmit a uniform rolling motion instead of the combined rolling and sliding motion transmitted by partly worn teeth.

Some difficulty was at first experienced in obtaining a suitable steel at a reasonable cost, and it was found, after several trials had been made with pinions cut from various steels, the steel which gives the best results from all points of view has the following percentage analysis: Carbon, 0·15; silicon, 0·02; sulphur and phosphorus each not to exceed 0·05 per cent. The pinions are specified to be case-hardened to a depth of not less than $\frac{1}{16}$ in. from the surface of the teeth, the centre being left soft.

Lubrication is also an important factor in the life of gears. A mixture which gives excellent results and is at the same time cheap has been in use for some four years. This is composed of black axle oil and sawdust mixed in the proportion of 42 gallons of oil to 216 lb. of sawdust, the cost of which works out at approximately 4s. 8½d. per cwt. The mixture is liberally applied, and found to quieten noisy gears to a remarkable extent, in addition to providing an efficient lubricant for the teeth

The Traverser Pit.—As shown in Fig. 1, this occupies a central position in, and extends the full length of, the building. B.S.S. No. 4 C track rails are laid at 13 ft. 6 in. gauge, with standard L.C.C. conduit work in the centre, the arrangement of electrical conductors, &c., being similar to that employed for street tracks. Power is supplied to the traverser motor from the conduit conductors by means of a standard car plough. Only one traverser has up to the present been installed, all the gears, pinions, wheel centres, tyres and electrical equipment being made interchangeable with similar parts of the rolling stock. Warping gear is provided, by means of which cars, trucks, &c., may be hauled either on to or off the tracks or traverser as required.

Inspection Shop.—This is at present 156 ft. long, 52 ft. of which is 37 ft. wide, and the remainder 75 ft. wide. There are 15 tracks with pits, and the gangways between the pits are 1 ft. 1¾ in. below the rail level. This shop is equipped with hydraulic pit jacks and a system of compressed air pipes with cocks at frequent intervals for connecting to pneumatic drills and other portable tools.

Painting Shop.—This shop is 104 ft. long by 112 ft. wide, and has eight tracks, each capable of accommodating three cars. Motor-operated roller shutters, all or any of which may be raised or lowered at will, separate this shop from the traverser pit. The shop is heated and maintained at a temperature of 60°F., when the outside temperature is at 30°F., by means of nine small steam heated units on the "Stanlock" system.

Galleries.—A small gallery is located immediately above the stores and between the machine and truck shops, and is reached by means of a staircase in the centre and an electric lift at the south end. A temporary patternmakers' shop, tool shop and a number of light machines are located on this floor. One 20 H.P. polyphase motor with auto-starter operates all the tools on this gallery.

The large gallery located above the traverser pit is 275 ft. long by 48 ft. wide, and is reached by two separate staircases from the south end, with a central staircase and an electric lift. This gallery is served by a 3-ton three-motor electric travelling crane, and one end is occupied by the test room. Here all re-wound and repaired armatures are placed in testing frames and run on load in both directions,

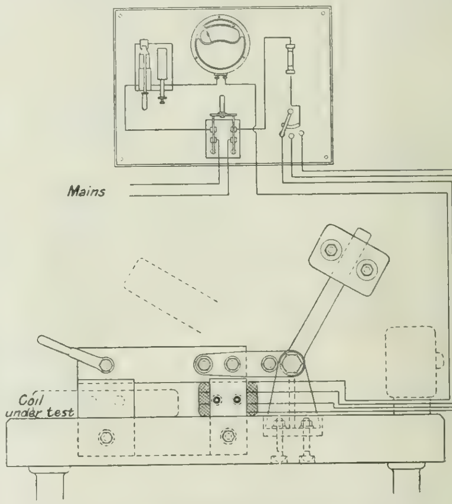


Fig. 2.—Testing Transformer.

the artificial load being absorbed by a Froude water dynamometer. Brake magnet and field coils are tested for continuity, internal short-circuits and ohmic and insulation resistance before being replaced on the cars after overhaul, and all repaired and new ploughs pass under the inspection of the test room attendant before being despatched to the car sheds for use on the cars.

The method of testing field and brake magnet coils for internal short-circuits presents some points of interest. A frame of Swedish transformer iron, shown in Fig. 2, has a hinged yoke across the top which is counterbalanced and made to lift clear of the front limb of the frame. The back limb carries a permanent coil which is excited from one phase of the alternating-current supply, and forms the primary coil of the transformer. The coil to be tested is placed on the front limb and the hinged yoke dropped into position. Just above the transformer is a panel containing the ammeter, which indicates the current flowing in the circuit. If the coil to be tested has no short-circuit, the current flowing in the primary circuit will be so small as to be scarcely readable on the ammeter; if, however, there is a short-circuit in the coil, even if but one turn, an appreciable current will flow and be indicated by the ammeter. A somewhat similar arrangement is in use in the shops of the St. Louis Transit Co., U.S.A.

With the exception of the space at the northern end of this gallery floor, occupied by the office block and the advertisement plate stove,

the remainder of the gallery is used as an electrical repair shop. Here the following plant is installed: Two commutator turning and grinding lathes, two armature banding lathes, and six coil winding machines. Here all ploughs, motors, armatures, controllers, field and brake magnet coils are dealt with.

The commutator grinding and turning lathes have in practice shown distinct advantages over the usual method of simply turning the commutators and finishing off with glass paper, in that the grinding wheel makes a truly cylindrical finish with a high polish, and in addition cuts cleanly on the mica segments, thus dispensing with the necessity of picking out the small particles of copper which bridge the mica when commutators are finished by turning only.

The plant installed for vacuum drying and impregnating armatures, field and brake magnet coils, &c., is heated by means of steam coils, and an inner cylinder of sheet steel is provided to keep the coils and varnish out of contact with the hot pipes.

All the ploughs are made and repaired at the depôt. There are two types in use, one of which is made with a solid hard rubber base and the other is made with a built-up wood base; in both cases the fittings are similar and interchangeable one with another. A full set of jigs and press tools have been made in the tool shop for the rapid and economical production of the detail parts. The steel frames for the rubber base ploughs are made and bolted together on a jig and sent to the rubber works for the bases to be moulded on, and to ensure accuracy of position of the base on the frame the rubber-makers' moulds are fitted with locating blocks which match those on the frame erecting jig. The steel frames for the wooden base ploughs are precisely similar to those for the rubber ploughs. The wood base is, however, made up and bolted on in the depôt.

The collector shoes of the ploughs are of cast iron and are fastened to a spring by a wedge. These shoes have an average life of 8,000 miles and cost about 3¼d. per pair. The friction plates on the web of the plough are of steel, have an average life of 3,000 miles and cost about 9s. per 100, including the cost of labour (1s. 10d.) in producing them. The total maintenance cost of ploughs, including all renewals during the last financial year, was 0·05d. per car-mile. A new rubber base plough costs about 107s.

Offices, &c.—The office block, consisting of a general clerical office, a timekeeper's office and a superintendent's office, is built of salt glazed bricks, the upper part being of framed glass. Rolling stock records are kept on the card file system, and the system on which works labour costs are kept is explained in the Paper, examples of the forms used being given. Details of the mess rooms, cloak rooms, &c., are also given by the author.

Lighting and Power Supply.—The depôt is lighted throughout, both inside and outside, with the exception of the paint and inspection shops and the offices, by 60 "Sunrae" Davy flame arc lamps arranged in series of 10 on the 500 volt direct-current supply. The power supply is by three-phase high-tension 6,600 volt current direct from the generating station at Greenwich to the transformer room, which is situated outside the depôt. Four 150 kw. single-phase transformers of the Berry type, one of which is a spare, have been installed. These transform the current from 6,600 volts to 220 volts.

A switchboard by Messrs. Spagnoletti has been installed for controlling the high and low-tension alternating current and the direct-current supply. The feeders from the panels are lead in underground ducts to various sections of the depôt, where they are connected to fuse distribution boxes, from which each motor circuit is taken. All feeders are of the three-core paper-insulated lead-covered type, the cables for the small ventilating fan motors are of the three-core V.I.R. type. The installation of the electric lighting, power supply, and telephones has been supervised by Mr. J. H. Rider.

Track Work.—The whole of the 4 ft. 8½ in. gauge track work within the building is made up of bullhead flat-bottom rails, spiked to transverse and longitudinal creosoted wood sleepers.

CORRESPONDENCE.

OPERATION OF ALTERNATORS IN PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have just had brought to my notice an interesting article on the "Operation of Alternators in Parallel" in your issue for September 10th, by Mr. J. W. Anson, which I think calls for a little comment.

I will take the paragraphs in sequence.

1. *Synchronising.*—I should like to know, first, what size reciprocating steam set takes 10 minutes to be brought up to speed, and how long would it be before the machine which was loaded to 75 per cent. of its capacity would have full load on it; surely Mr. Anson would not put another set in to help it with the 75 per cent. In describing an early morning experience, Mr. Anson says that by the time the second machine was in parallel the load on the loaded set was 5,000 kw. But what was the size of the loaded set?

Why should it be disastrous to synchronise with an electrically operated switch, when the synchroscope needle is revolving fairly fast? Granted that there is a slight time element in the electrically operated switch, compared with the direct mechanically operated switch, this is no reason why it is more difficult to synchronise with the former switch, as the time element can easily be allowed for, and I very much question if Mr. Anson could close a similar size hand-operated switch more quickly than an electrically operated one (say, of 3,000 kw. capacity), and I totally disagree that a quickly moving phase is difficult to take, as I know of a station where they have given up the hope of ever getting the synchroscope needle to go less than 90 to the minute. I have seen the operator closing the switch just after the needle had passed the mark to get the next phase and just got it, no damage nor disastrous effects resulting; and although the reverse relays are set to open at 100 kw. reverse, never under the most difficult synchronising conditions has the operator caused them to open. These relays were not wedged in, nor were they neutralised, always being tried for operation when taking the sets out of parallel—*i.e.*, letting the other sets "motor" the out-coming sets out.

I argue that it is more trustworthy to synchronise with a moving needle, but do not argue that the operator knows what position the needle will take up; it depends on what sort of load is on the sets. I have seen loads varying from 500 kw. to 15,000 kw., and the whole lot on and off about 20 times in as many minutes.

2. *Methods of Ensuring Steady Running.*—Why does Mr. Anson say that "there is far too much hesitation on the part of the operators in increasing the field current 30 or 40 per cent. of the full load field current," when in a previous paragraph he complains of the set having "somewhat over its full-load field current," and yet this field has only been on for a short while (the delay in getting a second set in)?

3. *Generators Running on Load with a False Power Factor.*—Under this heading I totally disagree with his reasoning.

In the first place there is no such thing as a false power factor unless the instrument is wrong. If an inductive load is being served by a generator, the load being assumed balanced, that load will give rise to a certain power factor; Mr. Anson gives this at 0·3 to 0·5, the load being asynchronous motors. From the same generator a synchronous load is being taken at 90 per cent. power factor, and Mr. Anson says he would expect to see a power factor of 0·6 to 0·65 on the generator and finds that it is 0·92; he will find, if he works it out, that is how it should be, the speed of the sets has absolutely nothing to do with the power factor. It is due to the field current, and it is the field current alone that controls the power factor in this case.

Surely Mr. Anson is aware that a synchronous set is the best means known for getting unity power factor at the generator, as if its field (the synchronous set) is increased enough a leading current will be taken from the generator, as it is a capacity effect, and this neutralises a lagging inductive load; by increasing the field current of the generator a lagging current will be taken. This is why Mr. Anson observes that when the speed of the set is decreased a further fall in power factor results when the increase in field current is made. A generator can not have two power factors at the same time, it must be the resultant of the apparatus which is on the line at the time.

4. *Parallel Running on Light Load.*—I fail to see that there is any difficulty in paralleling or running alternators on light loads. I have seen sets up to 3,000 k.v.a. capacity running perfectly in parallel, absolutely light, and no unsteadiness resulting, the sets having auto-expansion gear. The design of generators and engines of the present day leaves nothing to be desired in parallel running where heavy and varying loads are

dealt with. It is not wise nor convenient to keep the speed down, or a sudden load will make the set shut down altogether.

I would suggest that had Mr. Anson had more experience of large sets in heavy railway work a different article from his pen would have been the result, as it is only in stations which supply railways that anything in the nature of fluctuations can be properly seen and studied, where the load can be from zero up to the full capacity of the station at any instant and is so.—I am, &c.,

Deptford, S.E., Sept. 22. A. HAMILTON ELLIS.

P.S.—I see a letter by Mr. Edgcumbe in this week's ELECTRICIAN which also refutes some of the statements. I do not consider Mr. Anson's reply as being satisfactory.

We have submitted the above letter to Mr. Anson, from whom we have received the following reply :—

TO THE EDITOR OF THE ELECTRICIAN.

SIR : With reference to Mr. Ellis's letter, I consider that the time allowance, stated in my article, required to run a large reciprocating engine up to synchronous speed, namely, 10 minutes, is very moderate, as the moving parts of engines developing from 3,000 H.P. to 7,500 H.P. are very heavy, and these parts should be accelerated steadily in order to avoid undue strain in the metal. Furthermore, the internal cylinder surfaces in engines of the above size are of very considerable area, and, as there is certain to be a quantity of steam condensed into water during each stroke whilst running up to speed, it is not advisable to accelerate too quickly ; otherwise this water of condensation may be difficult to dispose of. If necessary, an engine of this size could be run up and synchronised in about four minutes, but this is not good practice, and should only be carried out in a case of great emergency. Again, there is the question of starting up the auxiliaries to the main engine, such as the barring motor, in order to get the engine in a position to take steam in one of the high-pressure cylinders, air pumps, &c., the circulating water valves for the condenser, or condensers have to be opened, and all these operations take time, so that the time stated in the article is very reasonable, and need not have caused any discussion. Mr. Ellis should note that my article deals with experience gained in the control of large alternating-current units as stated in the first paragraph, and all apparatus mentioned is suitable for combining with these large units.

Mr. Ellis mentions a 300 kw. electrically operated switch ; this must be a very paltry affair, as at a pressure of 6,600 volts across phases, in a three-phase system, the current carried by the contacts would be about 29 amperes per phase. All parts of this switch would be very light, and no electrical engineer with any common sense would specify it to be electrically operated unless required for very special circumstances. The switches I refer to are capable of carrying a steady load of 6,000 kw. to 7,000 kw., and of breaking the entire short-circuit current of a station developing 40,000 kw. if necessary, and I maintain that with switches of this type, having very heavy moving parts, it is extremely dangerous to attempt to take anything but a steady phase, and I know that engineers with actual experience of these switches will agree with me. Mr. Ellis's remarks about synchronising with the needle of the synchroscope revolving 90 revs. per min. are very clever and humorous, but it is quite impossible to take Mr. Ellis seriously, as at this speed it is difficult to distinguish the synchroscope needle at all, therefore the synchroscope and synchronising gear at once becomes superfluous in the station mentioned, and should be done away with at once. If the synchronising is usually carried out with the synchroscope needle revolving at the above speed, when an alternator is run up, the operator should simply walk up to the control panel and close the switch without troubling about the synchronising gear. The effect could not possibly be worse than using a synchroscope running at 90 revs. per min. I am of opinion that the electrical engineers in the station where they have given up hope of ever steadying the plant up sufficiently to make the synchroscope needle run less than 90 revs. per min. when synchronising, should not only give up hope, but should give up central station work as soon as possible.

I note that the reverse power relays on these generators, although only set at 100 kw., never operate under the most difficult synchronising conditions. I should like to know what these difficult synchronising conditions are like ; perhaps, however, they are better left to the imagination if the ordinary conditions are with the synchroscope needles revolving at 90 revs. per minute.

Mr. Ellis says that I complained of the generator, which had been running all night on load, having considerably more than full load field current during the delay in synchronising mentioned in the first part of my article. Mr. Ellis will find, if he reads the paragraph again carefully, that there is no complaint at all ; I merely made a statement.

My expression "false power factor" certainly seems to have aroused some indignation. Probably this is because it is a new term, but I see that both Mr. Kenelm Edgcumbe and Mr. Ellis are in agreement with me, for they both say that the power factor of a generator or generators can be adjusted at will by altering the field current and the speed ; of course, if the field current is altered it becomes necessary to alter the speed in order to maintain correct line voltage. Now, as Mr. Ellis says in his letter, the resultant power factor of all the electrical apparatus on the line must be the true power factor of the system, and if it is possible to vary the power factor of the generators by altering the field current, &c., it is obvious that some of the power factors which could be obtained by various combinations of field current and speed are other than the true power factor of the system.—I am, &c.,

Greenwich, S.E., Sept. 23. JOSEPH W. ANSON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In reply to Mr. J. W. Anson's letter on the above subject in your issue of September 17th, I would say that I assume, when he spoke of a generator showing a different power factor from that of the system, that this applied to one generator running in parallel with others, since this appeared to me to be the only possible case in which such a thing could occur. Mr. Anson's present statement, that he alluded to the case of a single generator, makes his meaning still more obscure.

In his letter of 14th inst., as also in the article in question, Mr. Anson speaks of a generator running "too fast, with a very light field" and thus "raising the power factor." But I think he overlooks the fact that a generator has no "correct" speed or "correct" field current at which it will give unity, or any other power factor. What Mr. Anson has in mind, I fancy, is the well-known fact that if two or more generators are running in parallel on the 'bus bars, and if the field of one of them is altered, the power factor of that particular machine will change, but only owing to interaction between it and the other machines. There will, even in this case, be no change in the power factor of the system, as shown by the station power factor indicators.

If there is only one generator running on the 'bus bars, a change of speed, or of field, will merely bring about a rise or fall of voltage, and no change whatever in the power factor, which depends, and can only depend, on the nature of the load, and has nothing whatever to do with the generator.

The same reasoning applies equally to the case of several generators running in parallel and all having their excitations so adjusted as to show the same power factor—*i.e.*, that of the system.

I think that if Mr. Anson fully realised that, by definition, the power factor of the system depends simply on the phase relationship existing between the 'bus bar voltage and the current flowing from the station, he would see at once that no possible manipulation of the generators could have any effect whatever on the power factor.—I am, &c.,

Hendon, N.W., Sept. 21. KENELM EDGCUMBE.

THE POWER CHARACTERISTIC OF THE TUNGSTEN FILAMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest Prof. Steinmetz's article on "The Power Characteristic of the Tungsten Filament," of which you give an abstract in your present issue. Our own observations at this Institute on Osram lamps practically confirm those given in the article, and are expressed by the equation $W=0{\cdot}0372V^{1{\cdot}58}$.

Now although, as Prof. Steinmetz points out, it is possible to predict the 1·6 power of the voltage by assuming the lamp is radiating according to the Stefan law, and that its resistance changes in direct proportion to the absolute temperature, it is unfortunately very probable that both these conditions do not hold for metal filament lamps, for most observers now agree that the radiation from these lamps is highly selective, and therefore does not follow the fourth power law; and, moreover, owing to the accidental presence of impurity from the processes of manufacture, the tungsten filament seldom gives a temperature resistance curve which passes through the absolute zero. On the other hand, tantalum which is produced in a high state of purity and mounted in the lamps as a wire gives the required temperature resistance curve. But if we plot power consumption against voltage for such a lamp we arrive at the relation $W=0{\cdot}0167\ V^{1{\cdot}7}$.

It would therefore seem that the remarkable agreement between theory and experiment in the case of the tungsten filament must be regarded as a coincidence and is not of universal application.—I am, &c.,

Northampton Institute, E.C., Sept. 21. A. C. JOLLEY.

THE POULSEN SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should be pleased, if you would kindly allow me, to correct a slight mistake in your article on "The Poulsen System of Radio-Telegraphy" in last week's issue

It is mentioned that a speed of 300 words per minute has been attained between Lyngby and Copenhagen. The fact is, however, that these tests took place between Lyngby and Esbjerg at a distance of about 200 English miles over land, whilst the Lyngby station is situated only just outside Copenhagen.

It will no doubt interest you to know that at the continuation of the demonstration on Saturday afternoon (the 11th) and Monday, the 13th, a speed of more than 100 words per minute was obtained between Lyngby and Cullercoats at a somewhat higher expenditure of energy (about 10 kw.) in Lyngby than mentioned in your article, with results at least equal to those at 50 words per minute there mentioned.—I am, &c.,

Cullercoats, Sept. 21. AAGE S. M. SORENSEN.

EIGHTH ANNUAL CONFERENCE OF THE MUNICIPAL TRAMWAYS ASSOCIATION.

For many years London, as a whole, suffered under the stigma of being without a tramway system worthy of its great name, the tramways which it had being small and somewhat out of date. This of late years has, however, been changed. First and foremost, the London County Council has a large and always extending system worked by very interesting methods, while two companies are also doing their part in dealing with the traffic problem. It is not unfitting, therefore, that the eight Annual Conference of the Municipal Tramways Association should be held in London, and that members should have the opportunity of inspecting the progress that has been made in this direction, even since 1905, when the Conference was last held in the metropolis.

Wednesday, September 22nd.

The Conference opened on Wednesday last at the County Hall, Spring-gardens, under the presidency of Mr. A. L. C. Fell, chief officer of the County Council Tramways, the members being welcomed by Sir Melvill Beachcroft, J.P., chairman of the London County Council.

In addressing the assembled members. Sir MELVILL BEACHCROFT said that the last occasion on which such a conference was held in London was in 1905, and he hoped that it would not be another five years before a conference of that character could be held in a building in London worthy of the Empire. In the name of the L.C.C. he extended a hearty welcome to the members of the Municipal Tramways Association. and expressed the hope that the meeting would help to solve many of the problems met with in the working of tramways. It was 40 years ago since the act was passed which enabled tramways to be run in London, and at present the tramway item had a very prominent position in the work of the Council. The problems met by the Council in London were the same that had been encountered in other cities. In conclusion, he gave some interesting figures of electric tramway development in London.

Mr. A. L. C. FELL (L.C.C.) said that, in accordance with the practice of previous years, he was not allowed to propose a vote of thanks to the chairman, Sir Melvill Beachcroft, for so kindly atttending the Conference. He therefore called on Bailie McFarlane, of Glasgow, to propose the vote of thanks.

Bailie MCFARLANE (Glasgow) said it was his pleasant duty to propose a vote of thanks to the London County Council and to Sir Melvill Beachcroft. No one could help being impressed with the dignity and bearing of the chairman, and with the very great abilities which had made him chairman of the Water Board, and which made him chairman of the great London County Council. In addition to his warm welcome, he had given them some most interesting information. He. the speaker, had great pleasure in proposing a vote of thanks to Sir Melvill Beachcroft, and hoped that he would be long spared to lead the destinies of that vast Council of the greatest centre of the world.

Mr. J. B. HAMILTON (Leeds) seconded the vote of thanks proposed by Bailie McFarlane. The Conference had already met in London on two previous occasions—viz., in 1902 and 1905—but on neither occasion had they had the pleasure of being received by the London County Council; he thought that the present occasion marked a very great advance for the Association, and he hoped that they would be able to maintain the high level which the chairman had set.

Mr. A. L. C. FELL said that he had been requested by the Executive committee to ask the Conference to approve that the Chairman of the L.C.C. and the Lord Mayor be made honorary members of the Association during the Conference. This proposal was passed unanimously.

Sir MELVILL BEACHCROFT said that he greatly appreciated the honour that had been accorded him, together with the Right Hon. Lord Mayor, in making them hon. members of the Association. He was thankful for the kind words by Bailie McFarlane and Mr. Hamilton, and he could safely say that no conference of more importance had been held in that room. He gladly took the opportunity when Mr. Fell asked him to attend to open the Conference. He hoped that all concerned would derive great benefit from the Conference, and that they would also be able to see some of the things that they had to show them. He thanked them all for the very warm reception that they had given him.

The president (Mr. A. L. C. Fell) then delivered his address, an abstract of the first part of which will be found on another page.

A vote of thanks to the president for his address was proposed by Mr. J. Aldworth, of Nottingham, seconded by Mr. C. J. Spencer, of Bradford, and carried with acclamation. Mr. Fell briefly replied.

A Paper on—

"The Medical Examination of Tramway Employés"

was then read by Councillor A. W. CHAPMAN, M.B., deputy chairman, Manchester Corporation Tramways. He thought that two questions should have an opinion expressed upon them by the Conference—viz., whether all employés should be medically examined before being received into service; and should there be periodical re-examination of men who had previously been passed as fit. The answer to both these questions, in his opinion, was in the affirmative, as the work on a tramway undertaking was trying and arduous, while illness, leaving its effects on the employés made periodical re-examination necessary.

The examination of candidates should follow the lines of that laid down by life insurance offices, while the questions of sight and hearing should receive most careful attention. Varicose veins and all allied conditions should also be absent in the candidate.

In considering who should conduct the examination the author thought that this should be carried out by a qualified medical man, and further one who had had experience in diseases of the eye and ear.

The paper concluded with the citation of some special cases in support of the above points, showing how necessary it was for a medical man to sit on the Tramways committee; while two forms now used in Manchester for registering the details of the medical examination, and which had been adopted as the result of the consideration of those used on other undertakings, were given. An appendix contained details of the candidates medically examined in Manchester from June, 1908, to May, 1909.

A vote of thanks to the author was carried, and the Conference then adjourned for lunch, discussion on the Paper being postponed until the afternoon.

On resuming work, a discussion took place on Councillor Chapman's Paper, an abstract of which we give below:—

Mr. A. Nance (Belfast) said that he wished to deal with the subject from a purely utilitarian point of view. He did not think that the examination of tramway employés by medical men was any saving, as a good deal of money had to be paid for this purpose, and the results obtained did not make it worth while. The sight and hearing of candidates could be tested without medical aid, and on his system reports were received every morning about the health of the men, so that a check was thus kept. He thought that all the advantages accruing from such an examination could be obtained without medical aid.

Dr. Collie (L.C.C.) spoke at great length on the system employed on the London County Council tramways, and thought that consideration of public safety should be the keynote in discussing these matters. He gave figures showing the results of sight tests on the Council's tramways, and described in detail the tests which were made. He had fixed perfect vision as being necessary for candidates for a motorman's position on the L.C.C. tramways, as so many came forward for these tests that they need only take the best men. It would be agreed that this point was of the greatest importance in a place where traffic was so dense as in London. He quoted a number of instances to show that medical examination of candidates was really very necessary, and controverted the last speaker's statements.

Councillor R. A. Smithson (Leeds) also testified to the good results obtained by a medical examination on the Leeds system of tramways. The medical officer's fees were a necessary expense, and he thought, in contradistinction to the author, that a general practitioner was the best man to conduct the examination.

Mr. J. Dalrymple (Glasgow) said that in Glasgow a preliminary examination of candidates was carried out by the staff, and the doctor then examined those that had been accepted by them. He thought that the Association ought to require compulsory medical examination of tramway candidates.

Mr. J. McElroy (Manchester) thought the Board of Trade ought to take action, and that the whole matter had been made much more serious since the introduction of the Workmen's Compensation Act.

Councillor A. W. Chapman (in reply) said, in answer to a question, that employés, other than motormen, might be allowed to wear glasses in the course of their work. He did not consider that a general practitioner was the proper man to conduct the medical examination, as, although he often had a better knowledge of human weaknesses, his pathological knowledge was not so good as that of the specialist.

A vote of thanks to the author for his Paper was then accorded and the next business, namely, a Paper by Mr. W. E. Ireland, on "The Central Repair Depot of the London County Council Tramways," was read. An abstract of the Paper will be found on another page of this issue. At the conclusion of the reading of this Paper the meeting was adjourned for the day.

Thursday, September 23rd.

The Association resumed its work this morning before a very good attendance. The first business taken was the discussion on Mr. Ireland's Paper on "The Central Repair Depot of the London County Council Tramways." We give an abstract of the remarks of the various speakers below.

Mr. H. E. Yerbury (Sheffield) was rather surprised that the author was unable to obtain a speed beyond 30 ft. per minute with cutting tools for turning tyres, even using high carbon steel. A speed of 60 ft. per minute could certainly be obtained. For high-speed work substantial machines were required, and more often the machine and not the tool limited the amount of work done.

Mr. C. J. Spencer (Bradford) thought there was nothing more important than the testing of field coils of the motors. The arrangement described in the Paper was similar to that at Bradford. It was not expensive, and easily fitted. At Bradford they also had a rough-and-ready method for testing field coils *in situ*. The cars were overhauled once every 13 weeks and each time the test was carried out. The resistance of field coils was so low that it was not possible to tell whether there was any fault by means of the ordinary resistance test. They therefore used a very low frequency alternating current. If a car was quite correct it would take a certain amount of alternating current on the test. If that current was exceeded then there was some fault in the coils.

Mr. E. S. Rayner (Doncaster) asked whether the case-hardening of the pinions was done by the L.C.C. at their own shops or by manufacturers.

Mr. W. E. Ireland, in reply to Mr. Yerbury, said that he had found that with the best Sheffield steel it was not possible to go beyond the figure for cutting speed given in the Paper. He did not claim any originality for the testing arrangement, which was effective and cheap, the cost being from £6 to £8. Mr. Spencer's rough-and-ready method for testing coils was a good one and would in all probability meet the case. Regarding Mr. Rayner's remarks they had not yet attempted to case-harden their steel pinions, as that was a matter for the specialist to deal with.

A vote of thanks having been accorded to the author, a Paper on "Some Comparisons of Continental and British Methods of Operating Tramways" was read by Mr. A. R. Fearnley, an abstract of which will be found on another page of this issue. An abstract of the discussion on this Paper is given below.

Mr. F. Ayton (Ipswich) did not think the wear with the bow collector on a trolley wire was quite so great as with the ordinary trolley system. He found that there was most wear at the ears, due to the covering effect of the trolley, and that with the bow collector a much smoother passage was obtained when passing under this point. There were also fewer breakages with the bow collector, and in addition, no time was lost at the terminals in turning the trolley. Regarding trailers, he asked the author whether it was necessary to have much more powerful motors where these were employed.

Ald. Smith (Liverpool) said that at Liverpool they had about 15 cars of the Hamburg type, and 15 of the American type. They found that at Liverpool, with trailers, accidents were more numerous, while with the double-deck car the difficulty of getting people off quickly had not been experienced, as he found they got off more quickly from the top of the car than from the inside.

Mr. H. Mozley (Burnley) said that slow speed was necessary when trailers were used, and he hoped that the Association would do nothing in the adoption of trailer cars that was not absolutely essential. He thought the bogey car, as adopted by the L.C.C., was what was required. The subject of vestibule cars was one he had been advocating for a number of years, because it afforded protection to the driver, and was much safer for the passengers. He also thought the glass in front of the driver was necessary, and in no way interfered with his view. The reverse staircase not only made room for the controller, but was also safer for the passengers. He noticed the author gave them the comparative consumption of energy of the single and double-deck cars on routes in Sheffield, but could he also give the earning capacity of the different cars?

Mr. A. Blaylock (Birkenhead) thought that the reasons why shelters had not been more extensively used was on account of the difficulty in obtaining sites, and that such shelters would probably be harbours for loiterers. They had provided many shelters in Birkenhead, but the estimated cost given by the author was only about half that at which he had found it possible to erect them.

Mr. J. B. Hamilton (Leeds) could not conceive why it was that, knowing all the advantages of double-deck cars, they still retained the single-deck car on the Continent. Passengers themselves preferred the double-deck car, especially those who smoked. The single-deck car was, of course, the simpler car to handle. He considered that the railless trolley system was a solution of many of the difficulties which beset tramway undertakings. The initial cost of this system was only about 20 per cent. of the ordinary tramway construction, and the service was quite as reliable. Moreover the cost of operation would be about the same as for the ordinary tramway. He thought that as soon as Parliament had decided upon the safeguards, &c., necessary, there would be a great development of the system in this country. He considered that tramways should have a freer hand, and he hoped that the Board of Trade would advise Parliamentary committees to allow this.

Mr. C. J. Spencer (Bradford) agreed that the excessive overcrowding of cars was not right, and he hoped that the authorities would take action in the matter. He asked the author why a double track was absolutely necessary where trailers were used. As to accidents to passengers entering the cars, he considered that it was absolutely out of the question to stop the car each time a passenger entered. If that was done the average speed would go down about 25 per cent. From statistics he had obtained from towns using vestibule cars he found that the sickness only amounted to about 6 per cent. of the total men working, and that covered a period of very bad weather. Waiting rooms and shelters would be a boon to passengers if they could be put down more cheaply, and he considered that it was necessary to have an attendant at such waiting rooms and shelters.

Bailie McFarlane (Glasgow) said that all the single-deck cars at Glasgow had now been replaced by double deckers. In such a city it was impossible to have single deckers, owing to climatic conditions. As to shelters, these were not required at Glasgow as they had such a quick service of cars.

Mr. S. C. T. Neumann (Bradford) considered that all undertakings should afford their managers an opportunity of inspecting the systems on the Continent and elsewhere, as Mr. Fearnley had done. He was of opinion that it was quite easy to provide a temporary shelter at a comparatively slight cost, and that there was absolutely no necessity for an attendant. He agreed that overcrowding and travelling on the platforms was a dangerous practice. He was afraid, however, that managers were apt to look upon tramways too much from the exchequer point of view, and therefore overcrowding was popular with them. The comfort of the public had to be considered, however. With regard to the stopping of cars for every person who wished to enter, that, he considered, was an impracticable suggestion.

Mr. P. Fisher (Dundee) said that on their system they had six waiting rooms of the character referred to in the Paper, but they also had four larger ones, looked after by an attendant, which cost from £150 to £350 each to erect. They, however, cost nothing to look after, as he found it the easiest thing in the world to get street hawkers to look after them free in return for a stand to sell papers, &c.

Mr. A. R. Fearnley (Sheffield), in reply, agreed with Mr. Ayton that with the bow collector there were fewer breakages. Larger motors were necessary on double deck cars. He agreed with Mr. Mozeley that trailer cars were dangerous. He considered that vestibule cars were very desirable both from the passengers' and the motorman's point of view. He agreed with Mr. Hamilton as to overcrowding on the platforms and that the cost of working the railless cars would be the same as the ordinary tramway. Although two years ago they obtained powers to run any kind of vehicle on specified routes, yet they were not able to run a trolley 'bus simply because of the overhead line. The only way to avoid overcrowding was to specify the number of passengers the car was to take and to stick to it. He considered the question of a double track for trailer cars a very important matter. It would be very awkward were the car to take the right points and the trailer the wrong ones. At Sunderland vestibule cars were in use and were spoken of very highly. Trolley trams, he considered, ought to be rated the same way as the ordinary motor omnibus. He also agreed that the overcrowding on the top deck of the cars in Bradford should not be allowed under any circumstances.

At the conclusion of this discussion the meeting was adjourned for the day, and the consideration of Mr. R. S. Pilcher's Paper on "Current Consumption" was postponed.

PRESIDENTIAL ADDRESS ON "TRAMWAY PROBLEMS IN THE FUTURE."*

BY MR. A. L. C. FELL.

In this short address I do not propose to deal with the history of electric traction from its inception up to date, but it is necessary just to give a few figures to show the position of affairs at the present moment. It appears from the latest Board of Trade returns that there are 305 undertakings in the United Kingdom, 177 of which belong to local authorities and 128 to companies and private individuals. The tramways open consist of 1,522 miles of double and 941 miles of single line, or a total of 2,463 miles, compared with 2,394 miles in the previous year. The total capital expended being £68,199,918, compared with £64,092,091 in the previous year. The total number of passengers carried was 2,625,532,895, compared with 2,454,807,487. The gross receipts were £12,439,625, compared with £11,849,175. The working expenses were £7,792,663, compared with £7,363,762 in the previous year. The returns clearly indicate that the rush with regard to the construction of electric tramways is over, and that the improved results are chiefly due to gradual development of existing systems and the reconstruction of horse, cable and steam tramways. For some considerable time no new large schemes have been brought before Parliament. Although the mileage of tramways opened during the past year has increased very little, the number of passengers carried has steadily increased, showing the great popularity of this means of locomotion. It will not do, however, for tramway men to feel satisfied that everything has been done that can be done, and simply sit down and await developments. We must keep in the forefront of the fighting line, and see that not only our special departments, but municipalities generally, are kept posted as to the true facts concerning tramway matters and the probable effect on the well-being of the community.

Many interesting papers are to be read and discussed during the conference, but it must be remembered that the consideration of papers is not the only benefit which the members of the Association derive from our conferences. Much of the most useful work is done in a very informal manner before and after our meetings, and the opportunity is given to all to extract information and obtain the best available advice without having to pay any fees. If municipalities would only look at the matter in this light they would realise that the small subscription paid to the Association is not adequate.

At our annual conference, and at the conferences of other tramway associations, it is often suggested that the time has arrived for the Tramway Act of 1870 to be revised. This may be so in some special instances, but as in the majority of cases the alterations would have very far-reaching results it is necessary that municipalities should settle the broad line of policy before Parliament is asked to take action. Take, for instance, the question of tramway paving. On the one hand, those responsible for tramway administration say that it is unfair that their undertaking should have to bear the first cost and maintain about 16 ft. of paving in the centre of the roadway, which is not worn out by their electric cars and which is used by general vehicular traffic, and in many instances by competing forms of locomotion. On the other hand, the road authority claims that the presence of tramway lines makes it necessary for paving repairs to be carried out much more frequently, and the tendency is for vehicular traffic, where the tramway service is very heavy, to be concentrated at the side of the road; or, in cases where the tramway service is light, for the vehicular traffic to concentrate on the tramway track and cut grooves in the paving outside the 18 in. margins. It is also argued by the road authority that the tramways undertaking is rightly charged with the cost of the paving and its repair in the tramway area as a small payment for the right to use the street; but it will be noticed that no suggestion is made that competing forms of locomotion should be charged for a similar concession.

Personally, I think that the most unfair points in connection with this matter are: (1) The local road authority can stipulate what paving is to be used; (2) competing forms of locomotion do not pay for the cost of installing or maintaining the paving; (3) the tramway authority has to pay rates on the earning capacity of its lines, whereas other competing forms of locomotion using the streets are not so rated. With regard to these points, it seems altogether wrong that where the tramway authority has to bear the first cost and also the maintenance of the paving in the tramways area, the road authority has power to stipulate the class of paving to be used, especially as the softest and the shortest life paving is generally selected. The fact that wood and soft granite paving require constant attention and renewal, and consequent interference to all classes of traffic, appears to be quite lost sight of. In half the cases I believe that wood paving is laid because it is an expensive luxury, and one which one district thinks it ought to have because another district has it. If it were not for the tramways, the local authority in certain cases could not probably afford to have it. With reference to the second and third points, I consider that it should be made obligatory for all forms of public carriage to pay a share of the cost of maintenance of all thoroughfares. Where a horse omnibus or motor omnibus service, however, at the present time uses the street, the owners simply have to pay rates on the stables or depots, whereas the tramway undertaking, in addition to bearing the first cost and the upkeep of the paving in the tramway area, has to pay rates based on the earning capacity of the line, and, although the omnibuses cut the roads to pieces, the one-half of the capital and maintenance charges falls on the ratepayers in general, a few of whom may use the vehicles in question, and the other half falls on the tramway authority, and indirectly on the tramway passengers. It really comes to this, that the ratepayers give a subsidy to omnibus companies so that they may compete with the tramway undertaking, which if owned by the municipality would relieve the rates, whereas the omnibus companies do nothing to assist in this direction. Until some agreement is come to between the tramway authority and the highways authority it is no use attempting to apply to Parliament for an alteration in the tramway act with regard to these matters, but the sooner the agreement is made the better it will be for all municipalities.

The Best Use of the Thoroughfare.—An important subject which should be dealt with by the local authority is the best use of the thoroughfare, and the special circumstances in each case should be taken into consideration. The popular fallacy has existed for some time that the installation of a tramway increases the congestion in the street. Under general conditions this is not the case, but, of course, the isolated cases, where tramways terminate in narrow congested streets, are always quoted, and in most instances by those people who have opposed the extension of the tramway, when the promoters have attempted to do away with the dead ends by the construction of a connecting link or loop line. Experience clearly shows that congestion of traffic is relieved by the introduction of electric tramways, one reason being that the vehicular traffic is formed up into straight queues, the slow traffic keeps more to the side of the road and the fast traffic follows the tramway. It has been proved beyond doubt that in handling large crowds of people entering theatres and other public buildings that if queues are formed they can be dealt with much more expeditiously and without danger. The

* Abstract of the Presidential Address to the Municipal Tramways Association.

same arguments apply even more forcibly in the case of traffic regulation, and where electric tramcars are introduced the speed of the traffic generally is increased and the liability to accident is minimised. Another fact is that a tramcar takes up much less space in the street per passenger seat than any other type of public street vehicle at the present time. It is necessary in designing carriages for public use to provide for the worst possible atmospheric conditions. The roof-covered cars afford complete protection in all weathers; in London, for instance, the latest cars carry 78 passengers. As the Police authorities in London will not allow roof covers on motor omnibuses, the seating capacity in wet weather will not accommodate more than 16 passengers under cover. It therefore follows that in wet and stormy weather one tramcar provides accommodation equivalent to that of five motor omnibuses. Even in fine weather three motor omnibuses under the latest regulations will be required to give the same seating accommodation as one large tramcar. With regard to the space occupied in the street, one electric car to seat 78 passengers is 33 ft. 10 in. long; the motor omnibus is 23 ft. long and only carries 16 passengers under cover. Between each of the motor 'buses a safety space of 6 yds. should be allowed; the space required, therefore, by the five motor omnibuses with the safety space between the vehicles will amount to no less than 187 ft., compared with 33 ft. 10 in. required by the electric tramcar. Even if the five motor omnibuses were coupled together they would take up a space 115 ft. long. These points should be specially taken into consideration when street widenings are thought desirable, and the vehicles which occupy the most space per passenger should bear the largest proportion of the cost.

Limitations of Tramways.—It is to be regretted that more friendly relations do not exist between railway and tramway authorities, as much more benefit would accrue from friendly co-operation than from antagonistic competition. A tramway is more suitable in every way for dealing with local short distance riders. The published returns of the large tramway undertakings in this country clearly indicate that the majority of passengers travel a distance of considerably less than 2 miles. Railway companies should, therefore, cater for the long-distance suburban passenger, and not attempt to deal with purely local traffic. Under the heading of railway companies I do not include the London tube railways, but I think that much might be done in connection with through booking between all railways and tramways, and suggest that this Association might take the initiative and endeavour to arrange a conference with the representatives of some of the railway companies. Our motto, as far as railways are concerned, should be co-operation, not competition.

I think that all municipalities should insist on their officials inspecting other undertakings, as it is impossible to keep up with the times unless this practice is allowed. An attempt has been made during the past year to see if arrangements could be entered into for this Association to come in closer touch with the International Tramways Union, but owing to the fact that under the constitution of that union of associations the subscription is based on the capital outlay of the various undertakings represented, the subscription from this Association, under these regulations, would be out of all proportion to the benefits received. It is, therefore, suggested that no further action should be taken in this direction, but that corporations should be recommended to occasionally send their officials and representatives abroad to investigate matters and report the result of those investigations to the corporations and to this Association. I venture to suggest that the Association should bear the cost of circulating the information to the members.

Railless Trolley Systems.—Many interesting reports have been issued during the past year on inspections which have been made by various deputations of the so-called "*trackless* trolley system" on the Continent. I am afraid that the *trackless* trolley system will not be seen until air ships are in general use, and I expect when this is the case the trolley wires will disappear, as there is every reason to suppose that it will be possible by that time to operate air ships by wireless transmission. An interesting example of a railless trolley system has been installed by the Metropolitan Electric Tramways Co. at Hendon, and arrangements have been made for this to be inspected. It is hoped that the members of the Association will take advantage of the invitation issued by the company. In special cases the railless system will have its uses. For instance, in London, I think it would be advantageous as a connecting link between the tramways which run to either side of the Blackwall and Rotherhithe Tunnels under the Thames. In these cases a tramway could not be satisfactory, but in ordinary service I am afraid the cost of maintenance of the railless system will be too high. It will be interesting to note the action taken by the authorities responsible for the up-keep of the roadway when any of these systems are installed in this country, and as to whether street improvements will be charged against the new form of traction. It is suggested that the railless system might be used for so-called "missionary work," to ascertain the best route for a tramway, but, in my opinion, it is a question as to whether this is really necessary. If people think that the route is only an experimental one, they will not settle down and take houses on lease, but if a well-thought-out tramway is installed they have a feeling of security, and the property in the vicinity of the tramway rapidly develops. This security of tenure is one of the chief advantages of a tramway route compared with an omnibus route, as the latter may be changed at a few hours' notice. Quite apart from the subjects of interest, such as the above, which can be studied under working conditions abroad, we have a large number of perplexing problems to solve at home. I would like briefly to refer to a few of these.

The president then dealt shortly with the work of the Association during the year on brakes, tramway, income tax and incorporation. The results of this work has already been published in THE ELECTRICIAN.

Standardisation.—Much has been said and written about standardisation in connection with tramway matters. Most of the large undertakings are doing everything possible to standardise their plant, but it is to be regretted that many smaller municipalities are still "discovering" electric traction, and are constantly changing the types of their cars and equipment. It is essential that, as far as possible, the working parts of all cars, trucks and electrical equipments should be interchangeable, not only to avoid having to hold an enormous stock of spare parts, but that the men who are responsible for the maintenance and operation of the cars may have a thorough knowledge of every part, and through this knowledge increase the safety of the public.

The necessity for standardisation does not apply to plant, cars and equipment only. Take as an example the information which is given in the annual reports of various tramway undertakings. It is a pity that the standard form of accounts which was prepared some time ago by this Association, in conjunction with the Municipal Treasurers' Association, is not strictly adhered to, and also that the comparative statistics quoted are not formulated on the same basis. As an instance, the well-known unit "car-mile" is most unsatisfactory as a comparable unit. One hears of the wonderful results per car-mile obtained on certain tramways where small light cars are used. These are published as comparative figures, and attention is not called to the fact that other cars in the same list had nearly twice the seating capacity. The term "car-mile" becomes still more ridiculous when applied to mechanically-propelled omnibuses with small carrying capacity. It is also very misleading in connection with power consumption, as it conveys no idea as to the relative size or weight of the cars, the average speed or the number of stops. Extraordinary results can be obtained from the car which seldom has to stop to pick up or set down passengers, or which runs empty for the greater period of the day. It is not possible to arrive at a reliable comparative unit based on the weight of the car and passengers, as the one depends on the ideas of the designer and the working conditions, and the other is a constantly varying quantity. What we really want to know is the cost per passenger per mile, or per "seat mile." In my opinion, the term "seat mile" should be given in all comparative figures. It is most useful to compare the number of passengers travelling with the seating capacity during the same period. Slight difficulty may be experienced on tramways where overcrowding is permitted, but I hope it will be another argument in favour of doing away with this, in my opinion, most undesirable practice. The ordinary conductor on a large tramcar has quite as much to do as he can possibly do properly at the present time, and overcrowding simply means that more fares will be missed and the whole of the passengers suffer much discomfort. I trust that the seat mile unit or some similar comparative unit may be adopted in the near future.

Through Running.—This matter has been before the Association on several occasions, but it has not been found possible to lay down any definite regulations, as each arrangement for through running depends on local conditions. Broadly speaking, I believe we all agree that it is desirable to connect up short lengths of tramway, but it is also recognised that it is unprofitable, and in many cases impossible, to run cars from everywhere to everywhere; it is, therefore, necessary to issue transfer tickets and book through. When once transfer arrangements have become necessary internally on a tramway route, it is extremely doubtful whether any advantage would be gained by a through running arrangement with an outside authority. In my opinion, in cases of this description, the disadvantages will be found to outweigh the advantages. The Municipal Tramways Association always has, and, I expect, always will, oppose any proposals for compulsory through running, but where the conditions are favourable there is no reason why through running should not be instituted on reasonable terms. One great difficulty in connection with through running will be with regard to labour conditions. In the majority

of instances the rates of wages are naturally higher in the large cities than in the outlying districts, where the cost of living is much less, and a grievance may exist if the men operating the cars over the same lines are not paid the same wages and do not work under the same conditions. This will be an interesting point to submit to a conciliation board. There should be no trouble of this description where inter-running is instituted between two large cities or towns, as in all probability the wages paid will be approximately the same.

The Use of Trailer Cars.—One of our tramway journals has recently published a series of expressions of opinion from managers in different parts of the country as to the use of trailer cars. From a perusal of these opinions I gather that there is a division of opinion on the subject, and that, whilst the majority of managers prefer the double-deck cars now so generally used, there is a large minority which holds that the use of trailers would facilitate the conduct of traffic at the "rush" periods of the day, and on other occasions, such as football matches, when crowds have to be dealt with in a very short period of time. Both these sets of views are entitled to every respect, and both are doubtless correct as far as they go, but probably a more satisfactory solution would be arrived at if both opinions were combined, and double-decked trailers were adopted. This would certainly minimise the space occupied in the streets for the seating capacity provided during the rush hours, and traffic at busy junctions would be held up for very much shorter periods.

The views expressed by a number of influential Continental managers fully demonstrate that they regard the use of trailers as being indispensable for their traffic purposes, and that they use them without in any material degree increasing the number of accidents. The Board of Trade and the Police authorities have recently agreed to trailers being run experimentally on one route in London, and I feel certain that the advantages will be speedily recognised.

(To be concluded)

SIEMENS BROS. DYNAMO WORKS, TANTALUM LAMP FACTORY AT DALSTON, LONDON.

The illustration below shows the large range of works premises which Messrs. Siemens Bros. Dynamo Works have equipped for the manufacture of the tantalum metal filament lamp. These premises are well situated on the outskirts of the city, within a stone's throw of Dalston Junction station of the North London Railway, and were formerly the works of Marconi's Wireless Telegraph Co. It will be seen that the factory is well situated for light, and this is a feature which it is becoming increasingly difficult to secure within immediate touch of the City of London.

New Lamp Factory of Messrs. Siemens Bros. Dynamo Works.

ROLLER BEARINGS.

Most machines have bearing surfaces which involve sliding one piece on another piece so causing friction. To obtain durability and a maximum load-carrying capacity,ait is obvious thet the roller is better adapted for hard working parts than the ball, simply because the roller can have any length of contact, while the ball must have an extremely small contact surface, a mere point; and the greater the contact surface of the friction-reducing element, the greater the load-carrying capacity must be. Three of the most important requirements of anti-friction bearings are: (*a*) The friction loss must be reduced to a negligible quantity; (*b*) the bearing must carry a maximum load per unit of the volume of the bearing; (*c*) either there must be no wear at all, or what wear occurs must be readily taken up without disturbing the characteristics of the bearing. Another desirable feature is that the bearing should withstand at one and the same time both load and end thrust.

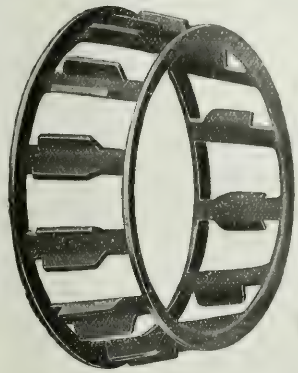


Fig. 1.—Steel Cage of "Timken" Bearing.

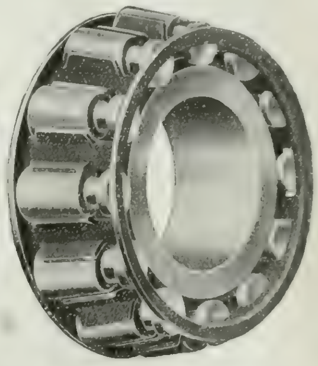


Fig. 2.—"Timken" Roller Bearing.

The "Timken" roller bearing has been a great success in America, particularly in connection with its application to motor cars, whilst for horse-drawn vehicles it has also been extensively adopted. There are doubtless many other fields in which this type of bearing would prove of advantage, so that our readers will be pleased to learn that it is being taken up in this country by the Electric & Ordnance Accessories Co., of Birmingham.

The new series of short bearings now offered are about the same length as bearings of the ball types, the space required being only $1\frac{1}{32}$ in. in the smaller sizes and $1\frac{9}{16}$ in. in the larger sizes.

The end or lateral thrust can only be eliminated or reduced to a minimum in roller bearings by the use of a conical or tapered solid roller, having ribs on the cone. Each cone of the "Timken" bearing has two ribs which engage the grooves in the rollers (see Fig. 2). These ribs serve the same purpose as the flanges on car wheels in keeping the car on the track; they also prevent the rollers from twisting and turning crosswise on the cone. The end thrust is sustained by the groove ends of the rollers abutting or pressing against the ribs on the cone. The rollers in revolving, roll or turn on the ribs, but do not slide, thereby reducing the end thrust friction to a minimum.

The line of contact between the rollers and the cones is entirely between the ribs on the cones. The groove in the rollers does not press or bear on the rib of the cone. The one-piece pressed steel cage.

shown in Fig. 1, retains the rollers as a unit on the cones only. It is claimed that the use of this cage ring insures more perfect alignment, holds the lubricant better, and is much neater in appearance than the old style cage. The feature of simplicity must also not be overlooked, as the use of this cage permits of a reduction in the number of parts forming the bearing.

All sliding surfaces wear, and so call for frequent adjustment and occasional replacement, so that the roller bearing has the advantage of durability, as opposed to the constant wear of the well-oiled plain bearing. The taking up of wear in the "Timken" roller bearings is provided for by forcing the cone, with its set of rollers, further into the cup or race-way, and their durability is not to be affected in the slightest degree by loose adjustment.

After exhaustive experiments it was decided that nickel steel, low in sulphur and phosphorus, was the best material for rollers. This special steel after being finished to shape and size, is then carbonised and allowed to cool slowly. The cups and cones are re-heated in hardening furnaces, the rollers being re-heated in special revolving furnaces and plunged in oil baths to give the best combination of hardness and toughness to resist wear.

PARLIAMENTARY INTELLIGENCE.

Sunday Telephone Facilities.—In the House of Commons Mr. Lloyd Morgan asked the Postmaster-General in view of the approaching transfer of the business of the National Telephone Co., whether the privileges at present enjoyed by the public of telephoning throughout the night would be in any way restricted when under the management of the Post Office, and whether it was proposed to make any change as to the use of the telephone on Sundays.

Mr. SYDNEY BUXTON replied that he did not anticipate that the present facilities for night telephone service, so far as they met an actual need on the part of the public, would be restricted after the transfer. The question of the extent of Sunday use would require careful consideration.

Electricity in Mining.—In the House of Commons on Tuesday, Mr. MARKHAM asked the Chanceller of the Exchequer for the reasons which caused him to refuse the request of the Mines Royal Commission for a grant to make experiments on the use of electricity in mines; and whether, in view of the further recent explosions (believed to be due to electricity), he would reconsider his decision.

Mr. HOBHOUSE said the Chancellor had not received any such request from the Royal Commission.

Edgware & Hampstead Railway Bill.—This bill, which has already passed the House of Commons, came before the Lord Chairman of Committees of the House of Lords on Wednesday, when it was ordered to be reported for third reading.

Wireless Telegraphy Act.—The Postmaster-General has announced that it is proposed to renew the Wireless Telegraphy Act to the end of next year by means of the Expiring Laws Continuance Bill.

Royal Assent.—On Monday last Royal Assent was given to the following acts of Parliament:—

Electric Lighting Orders Confirmation (No. 1) Act, 1909.

Glasgow Corporation Act, 1909.

Tramway Orders Confirmation Act, 1909.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The County Borough of Halifax Education committee require a lecturer in Electrical Engineering and Physics. Salary £180 per annum. Particulars and forms of application from the secretary, Mr. W. H. Ostler, Education Offices, Halifax, to whom applications should be sent by Tuesday, Sept. 28. See also an advertisement.

A chief electrical engineer is wanted for an electrical power station in the Federated Malay States. Must be accustomed to h.t. water turbines, generators, transformers, &c. See an advertisement.

An instructor in electrical and mechanical engineering subjects is required at Limerick Municipal Technical Schools. Commencing salary £130 per annum. Applications to the Principal.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

A resident electrical engineer is wanted for electric lighting plant (National engine and suction gas plant and storage battery). Must understand every branch of the work, and be able to drive motor, carry out small motor repairs, &c. Applications to Mr. R. H. Green, Estate Office, Willesborough, Kent.

An engineering workshop instructor is required at the Auckland (N.Z.) Technical College. Salary £200 per annum. Particulars from the High Commissioner for New Zealand, 13, Victoria-street, London, S.W. Applications by Sept. 30.

Mr. H. P. Stokes, assistant tramways manager at Burton, has been appointed manager of the Ilkeston tramways.

Brighouse Electricity committee have appointed Mr. A. Aspinall engineer and manager of the electricity department.

EDUCATIONAL NOTICES.

King's College (University of London).—The session 1909-1910 commences on Oct. 6. Prospectuses, &c., relating to the courses of instruction in the Faculty of Engineering and Applied Science and Division of Architecture may be obtained from the Secretary, Kings College, Strand, W.C. Evening classes are held in electrical and mechanical engineering, drawing, mathematics, physics, &c.

Two exhibitions of £25 each are offered for competition in the faculty of engineering in September. Applications to the Secretary.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 will commence on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Merchant Venturers' Technical College.—The engineering departments of this college will, from the beginning of next session, include the faculty of engineering of the University of Bristol. The college has already special departments for electrical engineering (under Prof. Robertson) and motor car engineering (under Prof. Morgan), but the departments of civil, mechanical and mining engineering have hitherto been amalgamated, and they have been in charge of the vice-principal, Prof. Munro. The engineering staff will now be strengthened by the inclusion of those who have hitherto been engaged in teaching engineering at University College, Bristol, and a separate department of civil engineering will be inaugurated and placed in charge of Prof. Ferrier. Not only will this mean improved facilities for students in civil engineering, but it will also strengthen the departments of mechanical and mining engineering, which will remain in charge of Prof. Munro. As regards equipment, the Merchant Venturers' Technical College is already provided, in its new building, with the latest apparatus and machinery, and with laboratories and workshops constructed on the most modern principles. To this has lately been added the best of the machinery and apparatus formerly used in the engineering departments of University College.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4. Entrance examination Sept. 29 and 30. These courses, which include periods spent in commercial workshops and extend over four years, also prepare for the degree of B.Sc. in engineering at the University of London. Fees £15 or £11 per annum. Three entrance scholarships each of £52 will be offered for competition at the entrance examination in September.

Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms.

The evening technical courses in all branches of electrical and mechanical engineering will commence on Monday next, Sept. 27. The laboratories are well equipped for both alternate (single and polyphase) and continuous-current work, and for all kinds of electrical testing. Particulars as to fees, &c., can be obtained at the Institute or on application to the principal, Dr. R. Mullineux Walmsley.

Borough Polytechnic Institute.—Complete courses of instruction in electrical and mechanical engineering, chemistry, &c., are given at this Institute. The head of the electrotechnics department is Dr. John Henderson, and the course of instruction in electrical engineering is spread over four years. There are also special courses for electric wiring work, construction and design of electrical appliances and workshop fittings, and also in advanced electricity and magnetism. The next session commences on Monday next, the 27th inst. Further particulars and detailed syllabus of each course are given in the prospectus, which can be obtained from the principal, Mr. C. T. Millis, Borough-road, London, S.E.

South-Western Polytechnic Institute, London.—A complete three years' course in electrical engineering is given at this Institute during the day and a four years' course in the evening. There are also courses of lectures and practical work in various electrical engineering subjects, including electrical design, alternating and polyphase currents, instruments and lamps, wiring and fitting, &c.

Hanley Municipal Technical School.—The borough electrical engineer of Hanley (Mr. C. H. Yeaman) will deliver at this school

on Friday evenings a course of lectures on Electrical Engineering, in connection with the course of instruction recommended in the City and Guilds programme.

College Calendars.—The calendar of Armstrong College (Newcastle-on-Tyne) for the 1909-10 session contains complete particulars of the courses of instruction in engineering and applied science, literature, art, &c., also fees, regulations for degrees of the University of Durham, and all information likely to be required by students. The published price of the calendar is 1s., post free, 1s. 4d.

The calendar of the City of Bradford Technical College for the 1909-10 session gives particulars of the courses of instruction in engineering and technology, &c. Local industries would appear to be well catered for by this college.

The calendar for 1909-10 of the Wigan and District Mining and Technical College is to hand, and contains information as to the courses of instruction, fees, &c.

Argentina.—The first section of the Cordoba electric tramways was recently opened.

Australasia.—The "Australian Mining and Engineering Review" states that Footscray and Williamstown (Victoria) Councils recently received a report by Mr. Sutherland and Mr. Ashman on the question of establishing electricity works, and that a decision to adopt such a scheme was anticipated.

A committee of Bairndale (Victoria) Shire Council are considering a proposal to adopt electric lighting, instead of the present gas lighting.

In the Federal Budget £10,000 is provided for the construction of wireless telegraphy stations.

Bath.—A conference is to take place between representatives of the City and Rural Councils as to the provisional order for the rural district.

Bermondsey (London).—The Electricity committee report having had under consideration a letter from the L.C.C. as to reserve and renewal funds in respect of wasting assets, where loans had been advanced for 42 years.

The committee point out that the Council have recognised the need of a reserve fund, and there is one in existence at present (with £3,807 to its credit), and after the current financial year it is intended to add to the fund until a limit is reached of 10 per cent. on the capital outlay.

With regard to the pending electrification of tramways in the borough the electrical engineer has been directed to see that the ducts are laid at a sufficient distance from the electricity supply cables so as not to restrict further extension.

Bolton.—Electric current is to be supplied to the Musgrave Spinning Co.'s mills for power and lighting.

Braunton (Devon).—Negotiations are proceeding between the Parish Council and the local representative of Messrs. Crompton & Co. in regard to public electric lighting. At present the Council spend over £50 a year on oil lighting, and, as Messrs. Crompton & Co. propose to form a subsidiary company to establish local electricity works, it is thought that an agreement can be made with the new company in regard to public lighting.

Brazil.—A report of Mr. M. Cheetham for 1908 states that electrical machinery imported into Brazil was valued at £543,850, against £707,054 in 1907 and £288,036 in 1906. The great increase in 1907 and 1908 was due largely to the work of the Light & Power Co. in Rio and Bahia, but apart from this there is a large and growing trade in electric light and power plant. Only three large British houses are represented in Brazil, and the agents for two of these are (it is stated) scarcely in a position to secure large orders in competition with German and American makers. There is a tendency on the part of the small interior towns to establish, either directly or by concession, electric light and power plants, and a fair share of this business might be secured by a more active policy on the part of British manufacturers, either by the establishment of local branches or by financial co-operation with local representatives lacking means but otherwise well qualified to do the business.

Bridgend.—The Guardians have decided to have the cottage homes wired.

Brumby and Frodingham.—The Council are proceeding with their scheme for the electric lighting of the public thoroughfares. Current will be taken from the Frodingham Steel Co. The present cost of street lighting is £166 per annum, and the charge for electric lighting will be £102.

Bury St. Edmunds.—The town hall and offices are to be wired, the work to be carried out by the electrical engineer with the assistance of a wireman.

Carlisle.—The Electricity committee have decided to give a supply of electricity to Messrs. Ferguson Bros., of Holme Head, by means of an overhead cable along the banks of the river Caldew, the estimated expenditure being £800.

An application has also been received from Messrs. Cowans, Sheldon & Co., engineers and crane builders, for a supply of electrical energy for power and lighting, and it has been agreed to lay a new feeder cable to London-road at a cost of £1,750.

The Council have been authorised by the L.G. Board to borrow £5,399 for extensions of plant, the loan to be repaid in 15 years. The amount applied for was £5,750, but the debt outstanding on automatic stokers abandoned (£251) has been deducted.

China.—Acting Consul G. W. Pearson says a small electric light installation might be a profitable venture in Hoikow and Kiungchow. It is possible a French firm may shortly undertake this.

Chippenham.—The local electric supply company has commenced the work of laying electric supply cables.

Corea.—It is stated that about 500 miles of new telephone lines are to be constructed in Corea at a cost of about 70,000 yen (£7,150).

Customs Duties.—It is stated in Supplement No. 3 to the Commonwealth of Australia Customs Tariff Guide that relay instruments, time elements, used in connection with electrical circuit-breakers, but being separate and distinct from them, are subject to duties of 17½ per cent., and 10 per cent. ad val. under the general and the U.K. preferential tariffs respectively. The duty on insulating strip—bitite (a preparation of oxidised and vulcanised oils, with asphalt or pitch but no rubber, used by electricians as an insulating tape)—is 5 per cent. under the general tariff, and British (U.K.) goods are duty free. Coin collectors, used in connection with telephones for signalling to telephone attendants that a coin has been placed in the slot, are duty free, whether British or foreign.

Dundee.—As stated in our last issue, Messrs. J. & A. D. Grimond, a local firm of manufacturers, have lodged a claim amounting to over £2,000 against the Corporation in respect of loss alleged to have been sustained by them, owing to the inability of the town to supply current to their works on Feb. 1, 1909, as per agreement between the parties. The cause of the delay in giving supply is not, it is stated, due in any way to the electricity department, but to the city architect's department in not having the buildings of the new station finished in time for the machinery which was lying ready to be erected. The supply was started on July 1 last.

Electric Lamps for the Police.—In future the Dundee police will be provided with electric lamps. The old oil bulls'-eye is to be discarded.

Electric Traction in Argentina.—The Chamber has adopted a bill authorising the construction of an underground electric railway running across Buenos Ayres from east to west.

Electrical Progress in Australia.—This is the title of a special number of the "Australian Mining Standard and Electrical Record" which contains a great deal of useful information regarding the progress made with electricity supply undertakings, electric tramways, &c., in the Commonwealth of Australia. Much technical and other particulars of the undertakings are given in the number, which is published at 2s. 6d.

Electricity in Collieries.—At the new Fife collieries of the Coltness Iron & Coal Co., at Blairhill, electric power plant is being installed, and electrical energy will be used for coal-cutting, pumping, &c.

Empire Cable Communication.—At the sitting of the Congress of the Chambers of Commerce of the Empire (at Sydney, N.S.W.) on Friday last Sir Albert Spicer moved the consolidated resolution embodying the purport of three resolutions put forward by the London, Sydney and Montreal Chambers respectively :—

This congress is of opinion that it is desirable to complete the Imperial route between the Motherland, Canada, Australia, and New Zealand by State-owned electric communication across Canada to Great Britain, and that the Postal Departments of the various Governments of the Empire should be requested to frame a combined scheme for substantial reductions in telegraphic rates, especially in the direction of cheapening Press cablegrams.

Fowey (Cornwall).—A generating station to supply current for lighting the Great Western Railway Co.'s jetties is being equipped.

Fraserburgh.—The Council, by six votes to five, have decided to purchase the local gas works. Provost Finlayson strongly opposed the motion. He contended that the proposed purchase would be a retrograde step. The Council should establish modern electricity works.

Fulham (London).—The Council have placed a contract with the Beeston Mfg. Co., of Leeds, for 288 special lanterns and brackets in connection with improvements they are making on the Fulham Palace-road tramway route. These brackets are specially designed for placing on tramway poles, and the new arrangement will replace about 48 arc lamps and posts. The necessary switches for these lamps have been ordered from the Reason Mfg. Co., Brighton. Contracts have also been placed for two water-tube boilers, stokers and accessories.

Germany.—The report of Consul General Sir Francis Oppenheimer (Frankfort), for the year ended April last, says the exports of electro-technical products from Germany in 1908 were valued at 185,219,000 marks (= £9,260,950), compared with 167,333,000 marks (= £8,366,650) in 1907.

Generally speaking, it is admitted that the electrical industry has been but little affected by the economic depression, although business cannot be described as satisfactory in comparison with the results of the immediate past. The check to the upward tendency which set in in the second half of the year was due to general economic depression, particularly in the iron and building trades and to the threatened introduction of a tax on electricity. The electrical industry, however, holds the record for the number of patents applied for during the year, viz., 2,721, and also for the number of patents granted. From 1877 to 1908 there were applications for 30,483 patents in this group and 11,749 were granted—nearly twice the number of the next highest group (motor carriages, coach building, cycles, &c., 6,036 granted). No technical innovations of an epoch-making nature were introduced. The piston machine is being more and more displaced by the steam turbine. Entirely satisfactory results were attained with high-pressure systems up to 15,000 volts. The orders for high-tension plants increased considerably. In telephony the central battery system did good service. The use of electricity for illuminating purposes on men-of-war and merchantmen is being widely adopted. A constant development also continues of electric power transmission by means of large electric motors in mines and smelting works. The experiments with electrical full gauge railways yielded satisfactory results—*e.g.*, the system adopted in Hamburg; in this respect important plans by the Baden and Prussian railway administrations are awaiting development. Various Confederate States—Baden, Bavaria and Wurttemberg—have drawn up petitions relative to the exploitation of the native water power. In the case of apparatus for electric illumination, transmission of power and electrolysis, the collapse in the price of copper had a favourable effect on the manufacturing costs of the finished article. The convention of porcelain manufacturers resulted in considerable increases in the price of various articles. The factories for insulating material were on the whole well employed, but in the manufacture of electrical measuring instruments depression made itself felt. The reports from the electric arc lamp works are not uniform, but the business results were on the whole satisfactory. The situation of the electric and galvanic carbon manufacturing branch was satisfactory. Owing to the good harvests and the high prices obtained for agricultural produce, electric light and power plants were introduced in increasing numbers in the country. Throughout this branch of industry there are complaints as to its labour conditions. It is necessary at the present day to employ more technical and supervising help than previously, because the workers no longer fulfilled the enhanced technical demands. As a capable staff of experts is still lacking, the Society of Electrical Installation Firms (Verband der Elektrischen Installationsfirmen) has given much attention to this question. The Co-operative Society for the Purchase of Electro-Technical Articles, founded by this society, has developed very satisfactorily. The number of light railways, which, according to the statistics for 1906, amounted to 176 electric lines with a total length of 5,534 km. (3,431 miles) and a value of over 850,000,000 marks (£42,500,000), has increased very considerably during the year. In connection with the development of large railway undertakings, chiefly high pressure, continuous and single-phase currents are to-day used. The use of three-phase current will, it is believed, decrease more and, more in consequence of the difficulty of erecting the conductors for transmission. The connections to the electric power stations were estimated at 1,100,861 kw. in 1907 compared with 655,427 kw. in 1905, and in 1908 the capacity of the stations has again considerably increased. There was a lively demand for capital in the last months of the year, which the more important works needed for preparing new undertakings. For new investments of existing undertakings capital of 39,030,000 marks was raised in 1907, and 39,165,000 in 1908; for new formations, 3,335,000 marks were raised in 1907, and 7,965,000 in 1908, while increases in capital were 31,200,000 marks in 1908, a total increase of 35,965,000 marks in 1908 over 1907. New power stations are not included in these sums, and if they be included, the new investments of the year 1908 would probably by far exceed 100,000,000 marks; against an estimate for 1907 of from 50,000,000 to 60,000,000 marks and for 1906 from 70,000,000 to 80,000,000 marks. The average dividend of 45 electric companies, controlling together a share capital of 573,245,000 marks, has been calculated at 8·1 per cent. in 1906-7 and 8·3 per cent. in 1907-8. The additions that had been made in 1907 to the prices of electrical apparatus, incandescent and arc lamps, insulating tubes, lighting pieces, &c., had either to be reduced or abandoned altogether, except in connection with low-tension work.

Glasgow.—The Tramways committee recommend that the Finnieston-street tramcar service be withdrawn at the end of the month, and that the Bilsland-drive service be reduced by half. The general manager (Mr. Dalrymple) has been asked to submit a full report with reference to the non-profit earning routes or portions of routes of the tramway system.

Greenock.—The electrical engineer (Mr. J. A. Robertson) recently reported that the demand for current for private lighting and power continued to increase.

During the last few months a temporary l.-t. supply has been given to Messrs. Scotts' shipyard, pending the installation of the h.-t. plant, which was expected to be ready by Jan. 15 next.

Mr. Robertson has been asked to prepare a report showing the methods of charging for current where electricity is supplied for lighting as well as for cooking and other domestic purposes.

An interesting exhibition of electric light fittings, lamps, motors and starters, cooking and heating apparatus, &c., is being held at the Town Hall this week. The exhibition has been organised by the burgh electricity department and the local contractors, and a great deal of local interest has been displayed in it. Nearly every electrical firm in the county is represented at the exhibition.

Hammersmith (London).—Application has been made by the Council to the Board of Trade to appoint a referee under sec. 33 of the Tramways Act, 1870, to determine the difference with the London United Tramways (Ltd.) in regard to the tracks.

A pump, supplied on trial by the Rees-Turbo Pump Co. is to be purchased for £102.

The electric mains are to be extended at a cost of £139.

Hindley (Lancs.)—The Council have authorised Messrs. J. Scowcroft & Co. to obtain a supply of electricity for lighting and power from the South Lancashire Tramways Co., but the Council reserve the right of supply when they are able to do so.

Inquest.—At Shildon on Friday last the inquest was resumed on a colliery fireman named Thompson, who was killed in the Shildon Lodge Colliery on Sept. 7.

Mr. Reg. Bell, manager of the colliery, described the working place and defined the duties of deceased. Thompson had charge of an electric pump, which pumped water up to the Harvey seam. Current was obtained from the Auckland Park Colliery. The duty of deceased was to switch off the current and to oil the bearings of the pump. From the position in which deceased was found, and from the evidence, witness had come to the conclusion that he had gone through the fence to adjust one of the terminals which had been sparking. Deceased had been employed for two years at the colliery, and for 10 months he had been engaged on that particular work. It was no part of his duty to go behind the fences.

Robert Hall said he found deceased behind the switchboard. The electric current was on. Deceased was lying on his face, and witness did not know but that he might be touching the cable.

H.M. Electrical Inspector of Mines (Mr. Nelson): In cases of electric shock the sooner steps are taken for restoration the better. Have you ever had the method explained to you?—No.

Have you had instructions as to dealing with electric plant if anything goes wrong?—No.

Supposing whilst working an electrical coal-cutter anything went wrong, what would you do?—Send for the electrician.

You would not attempt to do anything yourself?—No.

Mr. Hare: Did you see indiarubber gloves there?—Yes.

It did not strike you about putting them on?—Deceased appeared to be dead.

William Hepburn, electrician, said that one of the terminals was loose. There were electric burn marks on two fingers and thumb of deceased. Three of the terminals were dead and three were alive. In reaching up to tighten the loose terminals it appeared that deceased had touched one of the live terminals. He told how he instructed deceased in his work, and warned him that he was not to go behind the partition. It was not part of deceased's duty to do repairs at all.

Asked what he would have done under the circumstances, Hepburn said that he would have had the current switched off and the fuses taken out. Whilst repairs were proceeding there was a special danger board hung out.

The Coroner briefly alluded to the growing use of electric power in mines, and the need for exercising care. Apparently it had been a case of over-zeal. The Home Office representative was of opinion that no recommendation could be made.

The jury returned a verdict of accidentally killed whilst following his employment.

Italy.—The Societa Elettrica Comense A. Volta have secured a 60 years' concession for the construction and working of an electric tramway from Camerlata to Appeario and Mozzate. A State subsidy of £56 per kilometre (about £90 per mile) per annum for 50 years from the opening of the line accompanies the concession.

Leeds.—The Tramways committee have decided to promote a bill for the construction of a system of trackless tramways in the city. It is considered probable that power will eventually be sought to run such vehicles from the centre of Leeds to Drighlington, but the present proposal is confined to the City Square to Farnley route.

L.C.C. Tramways.—The section of the electric tramway between Nine Elms-lane and Queen's-road, Lavender-hill, has been opened for traffic this week, and the section from Queen's-road to Clapham Junction will probably be opened next week. The construction of the new line from Lavender-hill to Clapham Common has been commenced. The new line from Blackfriars-road through Southwark-street to the Hop Exchange is now open.

London Statistics.—We have received a copy of "London Statistics" for 1908-9, containing statistics of the Administrative County of London and of the public services carried on therein. The work is compiled by the Statistical Officer of the London County Council,

and though the present volume is not as bulky as the 1907-8 issue. it contains over 500 pages of useful statistics and information relating to the machinery of public administration in London, the work of the various committees of the County Council, &c.

It is interesting to note that there are 2.151 miles of streets in London, but in only 127 miles are tramways laid, and they cost £187 a mile to light. The L.C.C. tramcars carried 372,515,754 passengers in 1907, and the cars ran a total distance of 35.561.189 miles. Many tables and other information are given as to labour and rates of wages, poor law administration, education (elementary and technical), locomotion and transit facilities, electricity supply, local expenditure and revenue, rates, &c., and a very complete index facilitates reference. To officials of local authorities and all interested in public administration the book should prove valuable. It is published by Messrs. P. S. King & Son at 5s.

Maidstone.—On the recommendation of the Light Railways committee it has been decided that in lieu of providing demi-cars, three of the present cars are to be converted to regenerative control, at an estimated cost of £1.100.

Mexborough.—Sanction has been received to a loan of £3.986 for extensions of the electricity undertaking. £714 was deducted by the L.G. Board, including £271. 1s. 2d. for the cost of the provisional order, and the amount sanctioned is made up of the following amounts: £441 for excess expenditure, £1.645 extension of generating station, £300 for public lighting, £1,300 mains, and £300 services.

Oban.—The High School is to be wired. There will be about 400 35-watt. lamps, and current will be supplied from the Corporation mains.

Paris.—It is announced that the railways radiating from Paris to Versailles, St. Germain and Argenteuil are to be converted to electric traction at an estimated cost of £6.000.000.

Poplar (London).—Electric current sold to Stepney Council up to noon on 3rd inst. amounted to 629.299 units, or 129.299 units in excess of the minimum guaranteed to be taken in the quarter ending the 30th inst.

Portsmouth.—The Council have voted an honorarium of 100 guineas to the tramways engineer, Mr. V. G. Lironi, in recognition of the way in which the Goldsmith-avenue extension was carried out.

Presentation.—Mr. W. N. Brooks, traffic superintendent of the Brighton tramways, was presented on Tuesday with a travelling bag and various articles (the gifts of the office staff), on the eve of his marriage. Mr. Orchard, rolling stock superintendent, made the presentation.

Projected London Tube Railway.—It is announced that Parliamentary powers will be sought for the construction of a new tube railway between Victoria and Sydenham.

Recovery of Electric Lighting Accounts.—At Grantham Police Court on Monday the Urban Electric Supply Co. (owners of the local electricity supply works) sued Mr. John Beer for £11. 12s. 9d. due for electric light.

The magistrates asked why those cases came before them. Could not the company recover elsewhere?

The Clerk: They have power to recover here, or they can go to the County Court.

The Mayor thought it would be better if the company would take those cases to the County Court.

It was proved that the account, which covered five quarters and 48 days, had been applied for several times.

The magistrates made an order for defendant to pay the account by instalments of 10s. per month.

Reigate.—The Council have agreed to borrow £1,521 for extensions of the electricity undertaking.

Reward.—The Board of Trade have awarded pieces of plate to Capts. Russ and Freerk van Letten-Peterssen, masters of German steamships, and to Mr. Herbert William Bryant, an employé of the Europe & Azores Telegraph Co., stationed at Flores Island, in the Azores group, and a sum of money to Jose Baptista and Louis Ail, assistants to Mr. Bryant, in recognition of their services to the shipwrecked passengers and crew of the British ss. "Slavonia," which stranded off Flores Island on June 10.

Rotherham.—The Corporation's new refuse destructor adjoining the electricity works was opened last week.

Salford.—An inquiry was held here on Tuesday into the application of the Corporation for sanction to borrow, among other sums, £9.500 for extensions of the electricity undertaking.

The Town Clerk (Mr. L. C. Evans) said that £3,000 was required for the Prestwich scheme. It was necessary to borrow money for mains and services, as great progress had been made in the district. The sub-station had not yet been built, as they had had some difficulty about the site. Therefore that item should stand over for the moment.

The Inspector (Mr. H. Ross Hooper) asked for a statement of the Corporation's position in that matter before further expenditure was undertaken. So far they had had three loans. With regard to the first loan, there was an unexpended balance of £500. A third of the second loan was still unexpended, and of the last loan of £3,000 over £1,000 was still in hand.

The Town Clerk replied that they had not kept a separate profit and loss account for the Prestwich supply as against the Salford supply, as they had regarded it as one undertaking. They had, however, kept a separate revenue account, and could furnish particulars if necessary.

In regard to the application to borrow £6,500 for a storage battery and other improvements at the Frederick-road generating station, opposition was raised as to the smallness of the renewals fund, which stands at £18,632.

Mr. Billingham, chairman of the Electricity committee, said it would have been better for the undertaking if the profits had been used for the provision of better plant instead of being devoted to relief of rates.

South Shields.—An unopposed inquiry was held here last week into the Council's application for sanction to borrow £3.735 for the electricity undertaking.

Spain.—The Cia. del Tranvia Urbano, Bilbao, have been authorised to convert their horse tramways to electric traction, and to widen the gauge of certain lines.

The British Chamber of Commerce for Spain has received from Mr. Benet, of Adra, Almeria, a report recommending the advisability of constructing an electric tramway in that district.

Mr. Benet says no better investment could be found for British capital. The tramway is required for the transport of iron ore, about 25 miles from the mines to the port. Electric energy for the tramway could be generated by power obtained from a waterfall close by, or could be bought from the existing power stations.

The U.S.A. Bureau of Manufactures has received a report from Consul Winans (Valencia), stating that the Government's bill to authorise the construction of a subsidised railway from Valencia to Madrid has been passed by the Cortes, and tenders (to be in by April 29 next) have been invited for the construction work. The total cost is estimated at £1,200,000, and the Government subsidy will be £4,200 per mile, payable quarterly on all finished work. The use of foreign material is not prohibited, but no announcement has been made regarding remission of import duty upon it. Import duty was, however, remitted on the foreign material used by the Belgian contractors for the last railway constructed in this district. The Royal order as to the invitation of tenders mentions electricity as an alternative method of working. There are important sources of water power near the proposed route.

Switzerland.—The Compagnie du Chemin de Fer du Birsigtal, Bâle, have secured a concession for the construction and working of a metre-gauge single-track electric railway from Bâle to Rodersdorf, via Flüken.

Uruguay.—The "Review of the River Plate" says the Commercial Tramway Co. of Montevideo are about to add a 1,500 kw. set to their generating plant.

Venezuela.—The Cia. Anon. Tranvias Electricos de Caracas have been authorised to extend their system from Palo Grande to the Nuevo Matadero.

Whitefield (Lancs.).—The Council's electric lighting order has been transferred to the Lancashire Electric Power Co.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Harrogate.—The electricity supply accounts for the year ended March show capital expenditure £122.531 (increase £1.249).

Revenue was £17,082, total costs £8,781 and gross profit £8,301. Instalments of loans, sinking fund instalment and interest required £7.200, and £250 has been placed to reserve and £1.131 applied to relief of rates. 1,575,819 units were generated, 111.723 supplied to public lamps, 108.817 by contract and 933.083 by meter to private consumers. The maximum supply demanded was 840 kw.

Johannesburg.—It is reported that the Municipal Electric Supply department made a profit of £52.000 (instead of the £24.000 estimated) for the past year. No current was purchased from outside sources, and the cost of generation has been reduced from 1·07d. to 0·677d. per unit. Owing to the great demand for current additional plant has been ordered.

Profit from the tramways has increased from £22.800 estimated to £44.100 actual. The current year starts with a contemplated deficit of £17,500, but the chairman of the Finance committee (Mr. Greenman) anticipates that this will be extinguished in the same way as previous deficits. On capital account, £140,000 is about to be spent, of which £125,000 is for a new town hall, £67.000 power station improvements, and £60,000 tramway extensions.

Wednesbury.—The accounts of the electricity department for the year ended March show capital expenditure £20.148 (increase £5.524).

Revenue was £2,086, working and general expenses £1,648, gross profit £438. Interest and instalment for redemption of loans required £825, and writing off special expenses, new scheme, free wiring, &c., £339, leaving £184 to carry forward for renewals and contingencies. 19,500 units were generated and 223,760 sold to private consumers. The maximum supply demanded was 150 kw. The equivalent of 10,229 (against 8,448) 8 c.p. lamps is connected for lighting and 12,791 (4,036) 8 c.p. lamps for power and heating

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1909 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in handy book form. These are included in the 1909 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

Tenders are invited for the supply of 50 coin attachments, suitable for coins of different values, to the Postmaster-General's department in VICTORIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 100,000 porcelain insulators to the Postmaster-General's Department, VICTORIA. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-st., London, S.W.

Tenders are invited for the supply to the Postmaster-General's Department, New South Wales, of a common battery switchboard for the NORTH SYDNEY telephone exchange. Tender form, specifications, &c., may be obtained from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

The Directors of the METROPOLITAN RAILWAY Co. invite tenders for the supply of general stores during the 12 months' ending Oct. 31, 1910. Manufacturers and others desirous of tendering should apply to the Secretary, Mr. W. H. Brown, for forms. The company's requirements include electric wires and cables, lamps, carbons, switches, fuses, telephones, &c., and electrical insulating materials. Patterns and samples will be on view from the 27th inst. to Oct. 2 inclusive, and tenders must reach the Secretary by 10 a.m. Oct. 4.

GLASGOW Corporation want tenders by Oct. 4 for supply, erection, &c., of switchboard, distribution boards, mains, cables, switches, wiring, &c., for power and lighting purposes at Shieldhall outfall works. Specifications, &c., from the Office of Public Works, 64, Cochrane-street, Glasgow.

WALTHAMSTOW Council want tenders by noon Sept. 24 for supply of 695 yds. 0·75 sq. in. concentric cable. Specification, &c., from Mr. G. R. Spurr.

The Spanish Government, MADRID, invite tenders by April 29, 1910, for the construction of a steam or electric railway from Valencia to Madrid. A Government subsidy of £4,200 per mile is offered

The Director-General of Public Works, MADRID, will receive offers until Oct. 5 for a concession for the construction and working of an electric tramway from Avanzada to Algorta, in competition with an offer submitted by the Cia. Vizcaina de Electricidad.

The Junta de Obras of the port of VALENCIA, Spain, want tenders for supply of one 15-ton and two 1½-ton electric cranes. Tenders (in Spanish), accompanied by a deposit of 5,000 pesetas (£200), will be adjudicated on Oct. 29. The Junta also want tenders (of which the adjudication will take place on Nov. 1) for supply of one 50-ton and two 1½-ton electric cranes. Tenders (in Spanish) with 5,000 pesetas deposit (£200).

The Junta de Obras of the port of VALENCIA also want tenders for supply of six 1-ton electric winches. Deposit of 2,000 pesetas (£80). Tenders to be adjudicated on Nov. 2.

MADRID Municipality require tenders by 2 p.m. Nov. 12 for works in connection with the improvement of the Calle de Preciados extension and the joining up of the Plaza del Callao with the Calle de Alcalá. The total upset price is about £1,054,000, and the works include electric tramway construction, lighting, drainage, water supply works, &c. Deposit of about £18,200 required to qualify tenders. The "Madrid Gazette" of Sept. 2, containing full particulars, can be seen at 73, Basinghall-street, London, E.C. Local representation is necessary.

TENDERS RECEIVED AND ACCEPTED.

The following tenders have been accepted for Government departments:—

War Office: Siemens Bros. Dynamo Works, dynamos, arc lamps and tantalum lamps. *General Post Office*: W. T. Henley's Telegraph Works Co. and Johnson & Phillips, cable (indiarubber and cotton core); British Insulated & Helsby Cables, Johnson & Phillips and Western Electric Co., cable loop; British Insulated & Helsby Cables, W. T. Henley's Telegraph Works Co., Johnson & Phillips and Western Electric Co., cable (paper core); Bullers (Ltd.), cupholders (galvanised steel); Taylor, Tunnicliff & Co., insulators; Joshua Buckton & Co., machine testing; Bailey, Pegg & Co., c.-i. pipes; F. W. Cotterill (Ltd.), and Guest, Keen & Nettlefolds, insulator spindles; British L. M. Ericsson Mfg. Co., British Insulated & Helsby Cables, General Electric Co. and International Electric Co., telephones; Western Electric Co., transmitters and equipment at the P.O. central telephone exchange.

West Ham Education committee received 16 tenders (varying from £235. 16s. to £383) for an electric light installation at the Abbey School, and the lowest (that of Rowland and Hulton) has been accepted.

Contracts have been placed by Fulham Council with the Stirling Boiler Co. for two water-tube boilers, having a capacity of 14,000 lb. per hour each, and with the Underfeed Stoker Co. for two stokers and accessories, to work in connection with the new boilers. The Council have also placed orders with the Beeston Mfg. Co., for 288 street lanterns and brackets, and with the Reason Mfg. Co. for the switches.

Leyton Council have accepted the tender of H. J. Whitehead for wiring the public offices extension at £233.

Keighley Tramways committee have accepted the tender of Grace & Sutcliffe for two motor chassis at £1,303. 2s.

Wakefield Guardians have accepted the tender of the Wakefield Electrical Engineering Co. for electrical work for six months.

Rawtenstall Council have accepted the tender of the D.P. Battery Co. for the maintenance of the battery at the Hareholme works.

Power and Mining Plant Contracts.—Recently the power and mining department of the British Thomson-Houston Co., of Rugby, have secured several orders, including the following:—

Braidwater Spinning Co., 14 three-phase motors, main switchboard, &c.; Perex (Ltd.), one 56 kw. and one 20 kw. generators, six d.-c. motors, starting gear and lighting material; Corlett Electrical Engineering Co., five d.-c. motors and spares; Carrongrove Paper Co., one 300 kw. d.-c. generator, three three-phase motors, switchboard and wiring, &c.; Bennett Bros., 27 d.-c. and eight a.-c. motors and rheostats; Williams, Harvey & Co., five d.-c. motors from 6 to 30 H.P., switchgear, &c.; Walter Somers & Co., three 30 H.P. and three 15 H.P. d.-c. motors and rheostats; Steel, Peech & Tozer, 13 motors (from 5 to 100 H.P.); Scotts' Shipbuilding & Engineering Co., eight d.-c. motors (from 10 to 120 H.P.), with controlling and switchgear; Glasgow Corporation, three d.-c. motors (from 40 to 80 H.P.) and switchgear; Powell, Duffryn Steam Coal Co., 10 three-phase motors (from 5 to 30 H.P.); G. Whitehead & Co., two three-phase motors (25 and 110 H.P.), switchgear and wiring; Clarke, Chapman & Co., two three-phase motors (100 and 200 H.P.) and switchgear.

Electric Plant Contract.—Messrs. Brown, Boveri & Co., of Baden, have recently obtained one of the largest orders for electric generating plant ever placed in Europe, consisting of five three-phase generating units, each rated at 17,000 k.v.a. (at 0·6 power factor) at 10,000 to 11,000 volts and 50 cycles, with direct-coupled exciters of 130 kw., for coupling to water turbines of 14,000 H.P. at 250 revs. per min.

This generating plant is to form one-half of the power equipment of the new generating station now being built for Messrs. A. S. Rjukanfos, of Christiania, for the production of saltpetre from atmospheric nitrogen. The station, when completed, will be the largest in the world. Messrs. Brown, Boveri & Co. (London), to whom we are indebted for the foregoing particulars, in referring to the extremely severe character of furnace work of this description, mention that the weight of one of these generators is about 200 tons, the diameter being nearly 20 ft., and add that the above order was obtained in competition with the leading firms of the Continent. It was settled, it is stated, on the designs and not on considerations of price, and, further, that their Baden firm has no financial interest in the Christiania undertaking.

Water Turbine Contracts.—Messrs. Jens Orten-Boving & Co. have obtained the order for five water turbines of 5,300 H.P., and two of 450 H.P. for the City of Winnipeg, the total value of the contract being $97,150.

The turbines, which are of the Francis type, are the largest of their kind in the world, and a considerable amount of the work of construction will be done in this country, though the main hydraulic part will be delivered from Sweden. Unfortunately, the manufacture of Francis

turbines requires long experience: otherwise these large turbines would have been turned out in Great Britain. The question of impulse wheels is quite a different matter, since the execution of work to drawings is comparatively simple in their case, and Messrs. Willans & Robinson, who are manufacturing impulse wheels to the design of Messrs. Böving & Co., will shortly have several very large wheels under construction.

BUSINESS NOTICES.

The business of the Premier Electric Lamp Co. (Ltd.), of Huyton Quarry, near Liverpool, has been absorbed by the British Tungsten Lamp Co. (Ltd.), who will continue the manufacture of all lamps previously made, and also metal filaments of the highest quality, at the works at Huyton Quarry. For some months past the company has been engaged in the equipment of the factory with machinery and plant of the latest pattern, and the lamps now being produced are giving entire satisfaction. The "Wultun" lamp is manufactured solely by them under patented process, and is claimed to be the most durable and reliable lamp upon the market. It will burn in any position, and does not blacken, with an average life of 1,000 hours. The "Wultun" lamp is manufactured throughout by British labour at Huyton Quarry, and every lamp is thoroughly tested before leaving the factory.

Electrical Installations (Ltd.) notifies that Mr. H. Bell ceased to be secretary to the company as from Aug. 28, and is no longer connected with it in any capacity.

The partnership between Joseph Hemingway, Chas. Wright and Herbt. Thos. Wright (trading as Wright Bros. & Co.), electrical engineers, 6, Queen's Elm-parade, London, S.W., has been dissolved.

Sale by Auction.—Messrs. Blake, Son & Williams, will sell by auction, at two o'clock on Monday next, on the premises of the "X" Electric Synd., Beddington-corner, Carshalton-road, Mitcham, electric motors, dynamos, switchboards, drilling and weighing machines, Dey electric time register, Chubb's safe, &c. Catalogues from the auctioneers, 45, High-street, Croydon.

Plant for Sale.—Rhyl municipal electricity department advertise for sale a 165 kw. d.c. steam dynamo (Alley & MacLellan engine and Lancashire dynamo). Particulars from the electrical engineer, Mr. Ernest H. Wright.

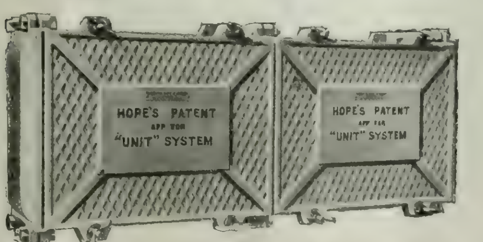
Patents Development.—The proprietors of the following patents wish to enter into negotiations with firms in Great Britain for the sale of same or for the grant of licences to manufacture under royalty:—

No. 23,429/1901, relating to "Electric locomotives." Applications to Messrs. Hyde & Heide, 3, Broad-street Buildings, Liverpool-street, London, E.C.

The owner of letters patent No. 20,677, "Relating to the Manufacture of Rubber Stamps," advertises that he has made arrangements with Mr. H. A. Barber, of 58, West Smithfield, London, E.C., for manufacturing same and supplying the trade.

CATALOGUES, &c.

IRONCLAD DISTRIBUTION FUSE BOXES.—In our INDUSTRIAL SUPPLEMENT for Aug. 20 we gave a description of a system of ironclad distribution fuse boxes made by Messrs. Parmiter, Hope &



Sugden, which possessed certain points of interest. In this system the cases are all cast iron, built up in such a way as to allow of either end being removed and an additional case-unit being added without impairing the watertightness and gastightness of the arrangement. A double unit of this description is shown in the accompanying figure, and similar boxes may be added at either end as desired, in accordance with power requirements. For further information we would refer our readers to our Supplement article.

AUTOMATIC TRANSFORMER SWITCHES AND BELL TRANSFORMERS.—The Foster Arc Lamp & Engineering Co. have ready two pamphlets dealing respectively with transformer switches and bell transformers.

COMMUTATION-POLE TRACTION MOTORS.—Messrs. Siemens Bros. Dynamo Works send a pamphlet on this subject which is of special interest at the present time. As will be remembered, this pamphlet was dealt with at some length on page 920 of our last issue, to which we would refer our readers.

"TUBOLITE," &c.—The Linolite Co., who are makers of "Tubolite," have two pamphlets on this interesting subject ready for delivery. The first deals with the metal filament lamps which have recently been designed for use in this system. The "Challenge" door alarm made by this company is the subject of the second pamphlet.

B.T.-H. TUNGSTEN LAMPS.—We have received from the British Thomson-Houston Co., of Rugby, a small show card for advertising these well-known lamps, a reduced facsimile of which is given in the

accompanying illustration. Hassall has added one more to his long list of poster successes. The British Thomson-Houston Co. will send one of these posters to any dealer in B.T.-H. tungsten lamps on request to the Publication department at Rugby.

LITHOLITE INSULATORS.—Litholite (Ltd.) have issued a couple of pamphlets dealing with this subject.

GENERAL ENGINEERING WORK.—Messrs. Gilbert Little & Co., Bradford, forward a number of pamphlets relating to some of their manufactures. These cover a large range, and include cable and ropeways, coal-washing machinery, belt conveyors of various kinds and other apparatus connected with these branches of engineering work.

AIR HEATING AND CONDENSING.—The Hudson Economiser Co., of 2, Bishopsgate-street Without, London, E.C., will forward to those interested a pamphlet dealing with the recovery of exhaust steam and the use of hot air for heating buildings and factories. Some interesting information on these subjects is contained in the pamphlet.

BANKRUPTCIES, &c.

Ernest Fenwick Jones, electrical engineer, &c., 132, York-road, West Hartlepool, has been adjudicated bankrupt.

Mr. A. Cripwell, 12, Cherry-street, Birmingham, has been appointed as trustee in the bankruptcy of Herbt. John Burdett, electrical engineer and contractor, 16, Regent-street, Rugby, and 32, Earl-street, Coventry.

A meeting of creditors of the Wireless Control Synd. (Ltd.) (in voluntary liq.) will be held on Sept. 13 at 14, Gracechurch-street, London, E.C. Mr. E. Mason, 6, Gracechurch-street, E.C., is liquidator.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Proceedings of the Royal Society." Vol. LXXXII. No. A558. Series A., "Mathematical and Physical Sciences." (London: Harrison & Sons.) 3s.

"Transactions of the American Electrochemical Society." Vol. XV. (South Bethlehem: The American Electrochemical Society.) $3.

"The Apprentices' Course of Experimental Physics and Mechanics." By J. L. Maxim. (London: Longmans, Green & Co.) 1s. 6d.

COMPANIES' MEETINGS AND REPORTS.

DICK, KERR & CO. (LTD.) The profits earned during the 12 months to June 30 amounted to £28,168. 2s 3d. Out of this has been paid debenture interest and trustees' fees, and the sum required to provide for the premium payable on the redemption of the present debenture stock reserved. These items absorb £12,693. 9s. 4d., leaving £15,474. 12s. 11d., to which is added £81,566. 17s. 2d. brought forward, making £97,041. 10s. 1d. Preference share capital requires £18,300, and a dividend of 6 per cent. on the ordinary share capital of £260,000 (less tax) £15,600. £63,141. 10s. 1d. is carried forward. The directors regret that the severe competition referred to in the last report has continued throughout the past year in a more acute form. In addition, the quantity of work carried out in all departments, has been considerably below the average.

DIRECT WEST INDIA CABLE CO. (LTD.)—It was reported at the meeting last week that the net result of the year's working to June 30 was an available balance of £5,189. 11s. 1d., compared with £6,149. 12s. 11d. for the previous year. An interim dividend of 3 per cent. (tax free) had already been paid, and it was proposed to make a further equal payment (tax free), which would leave £3,389. 11s. 1d. to be carried forward. The hurricane of September last year did very serious damage to the company's cable property, and the necessary repairs and renewals, together with work at Bermuda, involved an outlay of £3,820. 19s. 5d. The balance to credit of revenue which was last year increased to £34,396. 11s. 11d., has been debited with £900 applied to dividend, and with the £3,820. 19s. 5d. expended in renewals and repairs, and is credited with £3,389. 11s. 1d. surplus revenue of the past year. It now stands at £33,065. 3s. 7d. The company's cables had worked efficiently. A license to establish, instal and work a wireless coast station was granted to the company by the Jamaica Government on Feb. 16 last, and the cost to date has been put to capital expenditure.

HALIFAX & BERMUDAS CABLE CO. (LTD.)—At the meeting last week the directors reported that the net result of the year's working (to June 30) was an available balance of £3,312. 13s., compared with £3,095. 12s. 1d. for 1907-8. An interim dividend of $2\frac{1}{2}$ per cent. (tax free) had already been paid, and it was proposed to make a further equal payment (tax free), which would leave £812. 13s. to be carried forward. Opportunity was taken of a cable ship being in the vicinity of Bermuda to engage her to thoroughly overhaul and renew where necessary the harbour cable and the shore end of the main section at a cost of £817. 0s. 10d. The balance to credit of revenue, which was last year increased to £18,443. 13s. has been debited with £1,250 applied to dividend and with the £817. 0s. 10d. expended in renewals, and credited with £812. 13s. surplus revenue. It now stands at £17,189. 5s. 2d. The company's cable had worked efficiently. The report and accounts were adopted.

JOHNSON-LUNDELL ELECTRIC TRACTION CO. (LTD.)—The directors' report for the 13 months to June 30 last states that the sale of the works at Southall was duly completed and the purchase price paid. The operations of the year have been limited to carrying forward certain improvements in the apparatus connected with the company's regenerative system and to maintaining the patents. The efforts of the Board to make a sale of the patents at a satisfactory price have not yet been successful. In the course of the current year it is hoped that something in this direction may be accomplished, or that a proposal to reorganise the company may be submitted for the shareholders' consideration. Messrs. J. H. Holmes & Co. have transferred in terms of their undertaking the whole of the paid-up shares held by them.

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—Sir Edgar Speyer presided at the meeting on Tuesday, and said he was glad to record material progress. The figures in the report showed a healthy increase in all the tube railways, as well as in the District Railway, and reduced working cost. In that connection he desired to express his great appreciation to their general manager (Mr. Stanley) for his very efficient management and for the favourable results which he had achieved.

WESTERN UNION TELEGRAPH CO.—The quarterly report of this company for the quarter ending Sept. 30 has been issued. There was a surplus April 1, 1909, of $16,582,537.25 and net revenues during the quarter ended June 30, 1909, were $1,867,194.58. Appropriating for dividend of $\frac{3}{4}$ per cent., paid July 15 last $747,391.50, and for interest on bonded debt $433,062.50, left surplus June 30, 1909, of $17,269,277.83. Net revenues of the quarter ending Sept. 30 inst., based upon nearly completed returns for July, partial returns for August, and estimating the business for September, will be about $2,000,000.00, or after providing $433,062.50 for interest on bonded debt, $1,566,937.50. Deducting, for dividend of $\frac{3}{4}$ per cent., about $747,486.00, leaves a surplus of $18,088,729.33. The committee recommend that a dividend of $\frac{3}{4}$ per cent. be declared payable on and after the Oct. 15 next.

YORKSHIRE ELECTRIC POWER CO.—Mr. A. G. Lupton, who presided at the meeting on Tuesday, said that a profit of £1,069 remained after paying interest, £1,528 on the paid-up mortgage capital of over £67,000, whilst the mains on which that capital had been spent were only beginning to bring in revenue in the period under review. The revenue from the textile industries continued to be the largest individual one amongst the various classes of industries supplied by the company, but the other load was also increasing in a satisfactory manner. A good deal was being said of the revival of trade, and lately the company's meter returns had begun to confirm that, though only very gradually. The increased output had been the result of new business. Consumers in undeveloped portions of the company's area were continually pressing for the company's mains to be extended to them, and the directors had decided in the first place to meet the urgent demands from the Castleford district. It was hoped that supply in that direction would be available before the end of the year. The increased demand brought with it the necessity for more generating plant. A larger boiler unit had been put down, and in order to meet the demand expected from agreements since made and under negotiation another boiler of similar capacity had been ordered. It had also been decided to instal a fourth turbine of a capacity equal to any two of those at present in the station. Space had been reserved, so that no new buildings would be required. Those extensions would be profitable, but they entailed the provision of further capital. The whole of the borrowing powers of the company had been exhausted. Under the powers of the company's Act further capital could only be obtained by the issue of ordinary shares at par value. That was not at present practicable, and it would be necessary to amend the company's Act by applying to Parliament for further powers to authorise the issue of preference stock. At the same time, the directors considered it advisable to ask for other powers which had been granted to later-formed companies, which would much facilitate the work of this company. These clauses were entirely non-contentious, and the directors believed there would be no difficulty in obtaining them, and that the cost of promoting the Bill would not be excessive.

In reply to a question, the chairman said at Brighouse the local authority had not only begun to take the company's power but had ceased to supply their own. A considerable growth of the supply of electric power was anticipated at Brighouse, but he did not think a material part of the increase would be shown in the coming half-year's accounts.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

BOUDJAH ELECTRIC LIGHTING CO. (LTD.) (104,953.)—Reg. Sept. 14, capital £5,000 in £1 shares, to undertake the electric lighting of streets, public places and private dwellings in Boudjah or elsewhere, to obtain concessions for electric lighting and electric power supply in the Turkish Empire. Private company. First directors, D. Forbes, jun., T. S. Catto and F. W. Parry. Reg. office, 110, Cannon-street, London. E.C.

CUNNINGTON & HARRIS (LTD.) (104,982.)—Reg. Sept. 16, capital £5,000 in £1 shares (2,000 pref.), to adopt an agreement with S. Harris and to carry on the business of electrical engineers, electricians, dealers in electric fittings, &c. Reg. office, 21, North Audley-street, London, W.

MORTGAGES AND CHARGES.

LE RADIANT (LTD.).—Particulars of £2,000 debentures, created August 24, 1909, filed pursuant to sec. 93 (3) of the Companies (Consolidated) Act, 1908, amount of present issue being £700. Property charged, company's undertaking and property, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (Sept. 23).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{15}{16}$d. per oz. Consols $88\frac{1}{8}$—$88\frac{1}{4}$ for money and for account. Consols Pay Day, Oct. 1; Stock and Shares Continuation Days, Sept. 27 and Oct. 12; Ticket Days, Sept. 28 and Oct. 13; Pay Days, Sept. 29 and Oct. 14; Mining Shares Carry Over Days, Sept. 24 and Oct. 11.

PRICES OF METALS (London).—*Copper*, cash, $59\frac{7}{16}$; three months $60\frac{5}{16}$. *Lead*, English, $12\frac{7}{8}$—$13\frac{1}{8}$; foreign, cash, $12\frac{5}{8}$—$12\frac{11}{16}$; three months, $12\frac{7}{8}$. *Spelter*, cash, $22\frac{15}{16}$—23; three months $23\frac{3}{16}$—$23\frac{1}{4}$. *Tin*, English, 135—137; foreign, cash, 138; three months, $139\frac{1}{8}$. *Iron*, Cleveland, cash, 51/$9\frac{1}{2}$, and three months, 52/5. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

AMERICAN TELEPHONE & TELEGRAPH CO.—The earnings for the first eight months of 1909 show a net surplus (after providing for interest and dividends) of $7,532,000, compared with $6,836,000 for the corresponding period of 1908.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the four weeks ended Aug. 27 were 735,625, compared with 615,469 units in the corresponding period of 1908.

ESCHER, WYSS & CO. (LTD.)—A dividend at the rate of 7 per cent. for the year ended March 31 last has been declared.

FOLKESTONE ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend of 4 per cent. per annum (2s. per share), less tax, on the ordinary shares for the past half-year.

HOVE ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares at the rate of 8 per cent. for the half-year ended June 30 last, payable 15th prox.

RIO DE JANEIRO TRAMWAY, LIGHT & POWER CO.—The board have declared a dividend of 1 per cent. on the issued share capital, payable Nov. 1.

SIR W. G. ARMSTRONG, WHITWORTH & CO. (LTD.)—An interim dividend at the rate of 10 per cent. has been declared on the ordinary shares.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The directors announce an issue of 30,000 ordinary shares of £5 each to holders of the ordinary shares, in the proportion of one new share for every four held.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 15	1,393	− 45	15	23,833	− 558
Airdrie	,, 10	242	+ 26	36	7,879	− 75
Anglo-Argentine	,, 16	39,266	+ 1,674	37	1,442,268	+ 88,925
Ayr Corporation	,, 18	671	+ 108	18	7,545	− 55
Baker St. & Waterloo Ry.	,, 18	2,930	− 285	11	31,810	+ 160
Barnsley	,, 10	176	+ 2	36	6,045	− 310
Barrow	,, 10	264	+ 17	36	8,427	− 603
Bath Electric Trams, Ltd.	,, 15	862	+ 44	37	29,062	+ 1,402
Birmingham Corporation	,, 18	6,502	+ 73	25	160,944	+ 3,859
Birmingham & Mid.	,, 3	886	+ 20	35	29,523	+ 320
Blackburn Corporation	,, 15	1,188	+ 32	25	28,393	− 907
Blackpool and Fleetwood	,, 18	1,213	+ 191	...	...	...
Bolton Corporation	...					
Bombay	Aug. 19	R39,261	+ R5,391	33	R1,239,746	+ R74,542
Bournemouth Corporation	Sept. 15	1,937	− 24	24	44,478	+ 266
Bradford Corporation	,, 18	4,889	+ 335	24	122,365	+ 3,085
Brighton Corporation	,, 19	1,113	+ 63	25	26,704	+ 1,299
Bristol Trams & Carriage	,, 17	5,772	+ 623	17	100,917	+ 5,132
urnley Corporation	,, 18	1,337	+ 129	25	32,322	+ 210
urton Corporation	,, 19	264	− 5	25	6,739	− 177
ury Corporation	,, 19	1,266	− 7	†25	29,786	− 487
alcutta Tramways Co.	,, 18	R52,604	+ R2,914	11	R548,332	+ R31,890
amborne-Redruth	,, 18	131	− 13	38	4,669	− 170
ardiff Corporation	,, 11	2,180	− 83	24	53,980	+ 446
avehill	,, 10	90	+ 9	36	3,241	− 120
entral London Railway	,, 18	5,039	− 3,270	11	54,206	− 25,134
haring C., Euston & H'stead	,, 18	3,635	+ 150	11	39,920	+ 4,470
hatham & Dist. Lt. Rys.	,, 16	908	+ 34	37	30,527	+ 1,741
ity & South London Rly.	,, 19	3,010	+ 23	11	33,539	+ 1,220
ity of Birmingham	,, 10	2,776	+ 57	36	100,757	+ 1,046
olchester Corporation	,, 15	210	− 7	11	2,286	− 868
ork Electric Trams Co.	,, 16	504	+ 38	11	16,497	− 670
roydon Corporation	...	...	...	...	...	...
evonport & Dist. Trams	,, 10	383	− 116	36	13,364	− 3,298
over Corporation	,, 18	230	− 22	25	5,740	− 395
ublin & Lucan Railway	,, 17	154	− 4	11	1,853	+ 39
ublin United	,, 17	5,267	+ 13	11	67,312	+ 1,001
udley-Stourbridge	,, 10	867	+ 23	36	29,667	− 697
undee Corporation	,, 15	1,197	− 15	†18	21,304	− 514
ast Ham Council	,, 18	1,092	+ 119	§24	25,132	+ 3,438
xeter Corporation	,, 17	352	+ 20	25	8,917	+ 610
ateshead & Dist. Trams	,, 19	989	− 17	36	35,869	− 335
asgow Corporation	,, 18	17,940	− 8	‡16	266,015	− 2,756
ossop Trams	,, 18	135	+ 7	38	4,651	− 127
avesend—Northfleet	,, 10	237	+ 4	36	7,613	− 117
eat Northern & City Rly.	,, 18	1,303	+ 3	11	13,739	− 38
.Northern, Piccadilly, &c.	,, 18	5,110	− 100	11	53,725	+ 490
reenock & Port Glasgow	,, 10	650	+ 147	36	20,012	+ 756
artlepool Tramways	,, 10	265	+ 17	36	8,547	− 212
astings Elec. Trams Co.	,, 16	1,373	+ 26	11	15,709	− 124
ong Kong	,, 18	$8,275	+ $447	...	...	...
uddersfield Corpn.	...					
ull Corporation	,, 18	2,537	+ 101	24	62,295	+ 1,993
ord District Council	...	...	...	...	...	...
ceston District Council	,, 16	135	− 13	24	3,340	− 213
swich Corporation	,, 18	454	− 13	25	10,722	+ 175
.e of Thanet Co.	,, 18	1,020	+ 36	§42	30,791	+ 517
rrow	,, 10	123	+ 9	36	4,289	+ 394
ighley Corporation	,, 16	157	+ 5	24	4,237	+ 141
dderminster & District	,, 10	118	+ 5	36	4,015	− 195
lmarnock Corporation	,, 18	153	− 6	18	2,775	− 97
narkshire Trams Co.	,, 16	1,453	+ 163	37	47,677	− 287
ncashire United	,, 15	1,325	− 54	37	49,411	− 465
amington	,, 10	190	+ 6	36	6,391	+ 230
eds Corporation	,, 11	6,933	+ 483	24	163,311	+ 3,376
icester Corporation	,, 18	2,256	+ 62	11	24,913	− 115
ith Corporation	,, 18	584	+ 76	18	11,731	+ 1,511
ncoln Corporation	,, 18	121	+ 3	25	3,118	+ 107
verpool Corporation	,, 11	11,070	+ 266	‡36	389,154	− 2,149
verpool Overhead Rly.	,, 19	1,374	+ 54	†12	17,580	+ 172
andudno & Colwyn Bay Ry	,, 17	468	+ 75	42	12,450	+ 2,123
ndon County Council	,, 4	36,714	+ 2,147	§22	820,937	+ 31,888
ndon United	,, 18	6,635	− 897	‖22	229,700	− 22,864
westoft	...	...	...	...	...	...
idstone Corporation	...	...	...	...	...	...
nchester Corporation	,, 18	14,862	− 178	25	373,689	− 2,907
rsey Railway	,, 18	1,911	+ 84	11	21,003	+ 770
rthyr	,, 10	222	− 4	36	7,761	+ 96
tropolitan Dist. Railway	,, 18	9,557	− 196	11	103,003	+ 5,344
tropolitan Elec. Trams	,, 10	6,965	+ 140	36	223,750	+ 17,763
ddleton	,, 10	331	+ 12	36	12,327	− 924
lson Corporation	,, 18	144	+ 3	§24	3,506	− 70
wcastle-on-Tyne Corp.	,, 18	3,666	− 231	24	95,605	− 1,390
wport (Mon.)	,, 18	634	− 22	25	16,700	− 336
rthampton Corporation	,, 17	511	+ 52	25	12,289	+ 360
ham, Ashton & Hyde	,, 10	612	− 7	36	20,315	− 1,247
ham Corporation	,, 19	1,530	− 49	25	48,107	− 3,402
th (N.B.) Corporation	,, 15	167	+ 13	§17	2,369	+ 15
th (W.A.) Elec. Trams	,, 17	1,317	+ 63	37	51,899	+ 376
erborough	,, 10	124	− 8	36	4,294	− 345
tsmouth Corporation	...	...	...	...	...	...
teries	,, 10	1,532	+ 80	33	63,785	− 1,207
ston Corporation	...	...	...	...	...	...
herham Corporation	,, 16	563	− 51	24	14,431	− 685
hesay	,, 10	281	+ 85	36	8,692	− 3
ord Corporation	,, 17	4,373	+ 65	‡25	115,177	− 3,259
erness	,, 10	60	− 6	36	1,879	− 239
ffield Corporation	,, 15	5,691	+ 208	§25	142,949	− 948
gapore Trams	,, 18	$9,365	+ $382	...	...	...
th Metropolitan	,, 10	848	− 73	36	29,018	− 323
th Staffs	,, 10	903	− 52	36	30,263	− 1,523
thend Corporation	,, 15	636	+ 39	24	14,958	+ 2,229
thport Tramways	,, 10	341	+ 11	36	10,771	− 284
yb'dge, Hyde, &c., Jt. Bd.	,, 18	740	+ 15	§24	19,343	− 635
derland Corporation	,, 19	1,155	− 37	25	29,404	− 1,042
derland District	,, 15	437	− 45	46	21,196	− 937
nsea Trams	,, 10	1,014	+ 48	36	34,935	+ 737
ndon Corporation	...	...	...	...	...	...
nton	,, 10	52	+ 8	36	1,469	− 36
emouth and District	,, 10	324	+ 79	36	9,422	+ 731
eside Trams Co.	,, 15	412	+ 17	11	5,116	+ 284
lasey District Council	,, 18	956	+ 61	§24	23,945	+ 622
sall Corpn.	,, 18	570	− 27	37	18,981	− 1,219
rrington Corpn.	,, 16	358	− 26	24	9,262	+ 34
t Ham Corporation	,, 9	2,308	+ 2,192	23	55,496	+ 3,492
ton-super-Mare	,, 10	270	+ 45	36	6,163	+ 364
verhampton Co.	,, 10	412	− 18	36	15,108	− 1,343
verhampton Corpn.	,, 16	881	+ 103	11	9,044	− 232
cester	,, 10	321	− 41	36	10,195	− 101
xham	,, 10	113	+ 3	36	3,560	− 147
shire W.R. Trams	,, 19	1,261	− 4	38	45,235	...
shire Woollen District	,, 19	953	+ 88	36	32,835	− 201

These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shre.	Last Dividend	Name.	Price Wed., Sept. 22.	Rate % Yielded £ s d	Dividend Due.	Business Week to Sept. 22. Highest.	Lowest.
		ELECTRICITY SUPPLY.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord ...	9½ −10	6 0 0	Mar, Sep.	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝ −10	4 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 −10½	5 14 0	Feb. Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	100 −104	4 6 6	Jan. July	—	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	5 15 9	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov.	..	—
5	4/6	Brompton & Kensington Elec. Sup. Ord. ..	7¼ −7¾	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	7½ −8	4 5 [illegible]	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97 −100	4 0 0	June, Dec	9[illegible]	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 −4½	5 16 6	Feb, Aug	1¼	—
5	2/3	Do. 4½ per Cent. Pref.	4½ −5	4 10 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 −99	4 1 0	Jan. July	[illegible]	.
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	100 −102	4 5 0	..	[illegible]	[illegible]
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅞ −4⅜	5 2 6	Jan, July	.	..
5	2/0	†Chelsea Electric Supply Ord.	3½ −4	4 10 0	March ..		..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	101 −103	4 7 0	June, Dec	101½	—
10	5/0	City of London Electric Lighting Ord...	10⅝ −10⅞	5 10 0	Feb. Aug	[illegible]	[illegible]
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾ −12¼	4 11 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4 0 0	June, Dec	124	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 −103	4 7 6	Jan, July	..	—
5	..	County of Durham Elec. P.D. Ord.	1½ −2		April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 −3½	3 14 1	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅝ −8½	3 3 0	Feb, Aug	.	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞ −11⅛	5 8 0	Mar, Sept	11	[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	104 −107	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 −103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4½ −5	5 10 0	April, Oct	[illegible]	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 −5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 −100	4 10 0	Feb, Aug	—	—
5	4/6	Hove Electric Lighting Ord.	7½ −7⅞	5 11 6	April, Oct	..	—
5	4/0	Kensington & Knightsbridge Ord.	6⅞ −7½	6 2 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ −[illegible]	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 −98	4 2 0	..	—	—
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 −101	3 19 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85 −89	5 1 0	Jan, July	..	..
8	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 6 8	Mar, Sept	1⅞	..
5	3/0	Do. 6 per Cent. Pref.	5 −5¼	5 14 0	Mar, Sept	5	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 −97	4 2 6	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	4 −4½	6 2 0	April, Oct	4[illegible]	4½
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝ −5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ −86½	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	96 −99	4 11 0	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	5⅛ −5⅜	3 12 9	Feb, Aug	—	..
100	4½%	Do. 4½ per Cent. Deb.	[illegible]	5 4 8	Jan, July	..	..
5	..	Newcastle Elec. Supply Ord.	4½ −4¾	..	Feb, Aug	—	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4½ −5	5 0 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 −98	4 1 8	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 −101	4 1 8	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 −91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	12¼ −13¼	5 6 0	March ..	..	—
5	2/6	†Oxford Electric Ord.	5 −5½	5 5 0	March ..	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 −[illegible]	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅝ −9⅛	5 9 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 4	Feb, Aug	[illegible]	[illegible]
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	84 −[illegible]	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord...	½ −¾	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2⅝ −3	6 16 0	April	—	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 −103	4 17 0	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	—	—
1	0 3⅜	Do. 7 per Cent. Cum. Pref.	[illegible]	5 18 0	Feb, Aug	[illegible]	[illegible]
St.	4½%	Do. 4½ 1st Db. Stk. Red.	102 −105	4 6 0	April, Oct	..	—
5	2/6	Urban Electric Supply Ord.	½ −1	—	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1⅜ −1⅝	..	April, Oct	1[illegible]	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	77 −81	5 11 6	April, Oct	..	—
5	5/0	Westminster Elec. Sup. Ord.	8½ −9	5 11 0	Mar, Sept	[illegible]	—
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 −5⅜	4 3 6	Jan, July	[illegible]	..
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	99 −101	3 19 0	Jan, July	100½	[illegible]
1	..	Bath Elec. Trams Pref. Ord.	¼ −⅜	..	April	..	.
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	87 −91	4 19 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	87 −90	5 0 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8 −8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8 −8¼	4 14 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100 −101	3 19 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	½ −⅝	—	June, Dec	[illegible]	[illegible]
10	8/0	Do. 6 per Cent. Cum. Pref.	1⅞ −[illegible]	12 0 0	Feb, Aug	[illegible]	[illegible]
St.	5%	Do. 5 per Cent. Perpetual Debs.	84 −87	5 15 0	April, Oct	[illegible]	[illegible]
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	63 −67	6 14 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	61 −63	4 15 0	Feb, Aug	[illegible]	..
St.	4%	Do. 4 per Cent. Pref. Stock	85 −87	4 12 0	Feb, Aug	..	—
St.	2½%	Do. Deferred Stock	43 −45	5 11 0	Feb	44⅛	..
100	4%	Do. 4 per Cent. Debs.	101 −103	3 18 0	Jan, July	103	..
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	95 −97	4 2 6	Jan, July	95	[illegible]
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ −5¼	4 15 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	97 −101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord. ...	31 −3[illegible]	4 1[illegible] 0	Feb, Aug	31¼	[illegible]
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	108 −110	4 11 0	Feb, Aug	..	..
St.	5%	Do. (1896)	104 −107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100 −103	5 2 6	Feb, Aug	..	..
St.	5%	Do. (1903)	96 −100	5 0 0	Feb, Aug	—	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 −102	3 18 0	May, Nov	—	..
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾ −13¾	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ −1	..	Feb, Aug	¾	..
10	4/0	G. Northern, Picc. & Brompton 4% G.Pf	5 −5½	—	Feb, Aug	.	-
St.	4%	Do. 4 per Cent. Deb. Stock	93 −[illegible]	4 2 6	Jan, July	97½	..
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¼ −[illegible]	..	Mar, Sep.	..	..
St.	4½%	Do. 4½ Db. St.	76 −[illegible]	5 11 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 −4½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 −6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	89 −[illegible]	5 10 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅛	.	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58 −[illegible]	6 7 0	Jan, July	..	—
10	5/0	Lanarkshire Tramways	9¾ −10	5 1[illegible] 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ −90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	[illegible]	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	[illegible]	8 6 8	Feb, Aug	—	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref. ...	2¼ −2¾	..	Jan, July	[illegible]	.
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 −70	5 14 0	Jan, July	[illegible]	[illegible]
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	..	.
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	.
1	—	Do. Deferred	[illegible]	..	April.. .	.	.
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 1 6	Feb, Aug	[illegible]	.
St.	4½%	Do. 4½ per Cent. Deb. Stock	91½ −95½	4 13 0	Jan, July	[illegible]	.
St.	1%	Metropolitan Railway Consolidated	35¾ −[illegible]	1 5 3	Feb, Aug	[illegible]	[illegible]
St.	2½%	Do. Surplus Lands Stocks	65 −67	4 5 6	Feb, Aug	65	[illegible]
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3 16 9	Feb, Aug	[illegible]	[illegible]
St.	3½%	Do. 3½ per Cent. "A" Preference	86 −88	3 19 0	Feb, Aug	[illegible]	[illegible]
St.	3½%	Do. 3½ per Cent. Convertible Pref.	85 −87	4 0 6	Feb, Aug	[illegible]	[illegible]
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 −94	3 14 6	Jan, July	[illegible]	..

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

ELECTRIC RAILWAYS & TRAMWAYS—Continued.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Week to Sept. 22 Highest	Lowest
St.	3½	Met Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 3	Jan, July	92½	..
St.	..	Metropolitan District Railway Ord.	16 —16½	—	Feb, Aug	16⅝	15¾
St.	..	Do. Extension Pref. (5 per Cent.)	47 —49	—	Feb, Aug	47½	47½
St.	3½	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	66 —68	5 3 6	Feb, Aug	68½	67½
St	3%	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	76½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	3	Do. Guar. Stock 4 per Cent	94 —97	4 2 6	Mar, Sept	95¼	..
St.	6	Do. 6 per Cent. Perp. Deb Stock	143 —145	4 2 9	Jan, July	144½	..
St.	4	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	95⅝	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—⅝	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—⅝	6 14 0	Feb, Aug	..	—
St.	4½%	Do. 4½ per Cent. Deb Stock	86 —89	5 1 0	May, Nov	..	—
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—⅞	9 12 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent Deb. Stock	69 —73	5 9 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	81 —85	5 18 0	Jan, July	..	—
..	..	UndergdE.Rys.Lond. Inc.Bds with coup. 3	35 —37	..	June, Dec	37½	36
..	5	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103	102⅞
—	4½	Do. 4½ Bonds with coup. 8	89 —90	5 0 0	..	89½	88¾
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	—	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	..	—

ELECTRIC MANUFACTURING, &c.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Highest	Lowest
St.	..	Anchor Cable Co. 4½% Deb. Stock	102 —104	—	..	103	—
1	..	Aron Electricity Meter Ord.	½—¾	..	..	..	—
1	1/4½	Do. 6% Cum. Pf.	⅞—1⅛	6 17 6	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.	4⅜—4⅝	4 12 9	April, Oct	4½	4½
1	0/7½	Do. Pref.	1⅛—1¼	4 0 0	..	..	..
5	4/0	†British Insulated & Helsby Cables Ord.	7⅛—7⅜	6 11 0	July, Feb	7½	..
5	3/0	Do. 6 per Cent. Pref.	6½—6¾	4 12 0	Jan, July	6⅝	—
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	—
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	89 —94	4 16 0	Mar, Sept	½	—
5	..	British Westinghouse 6 per Cent. Pref.	⅛—⅜	—	Feb, Aug	—	—
100	6%	Do 6 per Cent. Prior Lien Dbs (rd.)	97 —99	6 1 0		98	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	39½	..
St.	4½%	BrushE.Eng.Co.4½% Perp. 1stDeb.Stock	41 —46	9 18 9	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	1/0	Callender's Cable Con.Ord.	10⅝—11⅛	5 17 9	Jan, July	10⅞	10⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅝—5¾	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	105½	..
1	1/0	Castner-Kellner Alkali Co.	2 —2⅛	5 18 0	May, Nov	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106 —109	4 2 6	Feb, Aug	106½	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅜—1½	6 11 9	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/7½	Consolidated Electrical Co.	⅞—1	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1⅜—1⅝	9 8 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co. (Nos. 1 to 85,000)	⅞—1¼	13 7 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	90 —93	5 7 6	Jan, July	..	..
1	0/7½	†Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	—
5	2/0	Dick, Kerr & Co. Ord.	1 —1¼	8 0 0	Sept	1	1
5	0/7½	Do. 6 per Cent. Cum. Pref.	1½—1¾	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	84 —87	5 15 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅛—3/16	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅜—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 5 0	Jan, July	..	..
2	..	Electric Construction Co.	7/16—11/16	..	Jan, July	..	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	9 16 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	65—69	5 16 0	Jan, July	—	..
St.	5%	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	71—77	6 10 0		—	—
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅞—8⅛	6 1 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	85 —88	4 11 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.	12½—13½	5 15 6	Feb, Aug	12⅞	12⅞
5	2/3	Do 4½ per Cent. Pref.	5⅛—5⅜	4 2 0	Feb, Aug	5⅜	5⅜
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 4 0	Mar, Sept	..	..
10	5/6	India Rubber, Gut. Per., &c., Wrks.	14½—15½	6 9 9	Feb, Aug	15⅛	15⅛
10	5/4	Do. 5 per Cent. Cum. Pref.	10½—10⅞	..	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	100 —102	3 19 0	April, Oct	..	..
1	..	National Elec. Construction Co.	⅜—⅝	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	¼—½	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	½—¾	..	May, Nov	½	..
St	4½%	Do. 4½ per Cent. Perp. Deb. Stock	82 —85	5 5 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	—	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	—	..	..
12	12/0	Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	34½	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	100½—102½	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2¼	4 3 0	—	2¼	2¼
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1¼	4 0 0	—	1⅛	1⅛
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 —117	4 5 3	—	114⅞	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	103 —105	3 15 6	June, Dec	..	..
10	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
10	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 6	..	107½	107
10	8	J. G. White & Co. 6% Cm. Pref.	10—11	7 5 4		..	..
1	1/0	Willans & Robinson Ord.	⅝—⅞	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅝—3⅛	9 12 0	Apr, Oct	2⅝	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	..	..

TELEGRAPHS.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Highest	Lowest
1	..	Amazon Telegraph	2⅞—3⅛	..	June, Dec	..	..
100	5%	Do 5 per Cent. Debs. (red.	95 —98	5 1 0	June, Dec	..	..
St.	15/0	Anglo-American	61½—62½	5 2 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	104—105	5 15 0	F,My,Ag,N	105	104½
St.	3/0	Do. Deferred	21½—22	1 15 3	F,My,Ag,N	21½	21½
St	4%	Commercial Cable 4 per Cent. Deb. Stk.	90 —92	4 7 0	Jn,Ap,Jy,O	91	—
10	6/0	Cuba Submarine Ord.	9⅞—9⅜	6 0 0	Feb, Aug	9⅞	—
10	10/0	Do. Preference 10 per Cent.	17⅛—18⅛	5 10 0	Feb, Aug	..	—
5	2/6	Direct Spanish Ord.	3 —3½	5 14 0	April, Oct	—	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅛—8⅝	5 12 0	April, Oct	—	..
St	4½%	Do. 4½ per Cent. Deb.	100½—102½	4 8 6	Jan, July	..	..
20	5/0	Direct United States Cable	12⅝—13⅛	6 4 6	Jn,Ap,Jy,O	13⅛	13⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St	25/0	Eastern Ordinary	129 —132	5 6 0	Ja,My,Jy,O	131	129½
St	17/6	Do. 3½ per Cent. Pref. Stock	85 —87	4 0 6	Ja,My,Jy,O	86½	86
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104½—106½	3 15 0	May, Nov	..	..
10	2/6	Eastern Extension	11⅞—12⅛	5 14 0	Ja,Ap,Jy,O	12⅛	11⅞
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	—	..
20	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	4 8 0	May, Nov	..	..
10	1/0	G.N. of Copenhagen, with Coupon 77	26 —27	6 13 6	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 9 0	June, Dec	..	..
20	5/0	Indo-European ex. all	51½—52½	5 16 9	May, Nov	53½	53
100	$1	†Mackay Companies Common	90 —92	4 7 0	Ja,Ap,Jy,O	90	..
100	$1	Do. Preference	78 —80	5 0 0	Ja,Ap,Jy,O	78½	75
1	..	Marconi's Wireless Teleg. Co.	⅞—1	..	April	1½	..
1	..	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	100 —102	3 13 0	June, Dec	..	..
20	1/3	West Coast of America	1⅛—1⅝	3 17 0	May	1½	1½
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
10	..	West India & Panama	1⅛—1⅜	..	May, Nov	½	..
10	6/0	Do. 6 per Cent. 1st Pref	8⅞—9	6 17 6	May, Nov	8⅞	8⅞
10	1/0	Do 6% 2nd Pref.	[illegible]	6 10 0	May, Nov	—	—
100	5%	Do. 5 per Cent. Debs.	[illegible]	4 16 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅛—13⅞	5 2 0	Mr,Jn,S,D	13⅞	13⅜
100	4%	Do. 4 per Cent. Deb. Stock (red.)	103 —105	3 18 0	June, Dec	..	..

TELEPHONES.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Highest	Lowest
100	2$	Amer. Telephn. & Telegh. Cap. St.	146 —148	6 11 1	..	147⅞	.
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	—	.
St.	5%	†Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —103	4 17 0	Mar, Sept	..	.
5	5/0	Chili Telephone	8 —8⅜	4 15 6	August ..	..	.
1	0/7½	Monte Video Telephone Ord.	⅝—⅞	6 17 0	Nov	..	.
1	0/6	Do. 5 per Cent. Pref.	⅝—⅞	5 14 0	May, Nov	..	.
St.	6%	National Co. Pref. Stock	106 —107½	5 11 6	Feb, Aug	107	10
St.	6%	Do. Def. Stock	121 —123	4 17 6	Feb, Aug	121⅜	12
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—10⅞	5 9 0	Feb, Aug	10⅝	.
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10⅛—10⅞	5 9 0	Feb, Aug	..	.
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5¼	4 8 0	Feb, Aug	5¼	5
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	..	.
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	.
1	1/0	Oriental	1⅛—1¼	5 4 6	April, Oct	1³⁄₁₆	.
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 15 3	April, Oct	..	.
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —85	4 11 0	Jan, July	87	.
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100½—100½	4 8 6	Jan, July	..	.
5	5/0	United River Plate	6½—6¼	5 18 0	July	6¹¹⁄₁₆	
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅝	4 9 0	June, Dec	..	
St	4½%	Do 4½ Deb. St. Red.	104 —106	4 5 6	Jan, July	105½	.

FINANCIAL INVESTMENT, &c.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Highest	Lowest
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	..	
10	5/6	Globe Telegraph & Trust	10½—10¾	6 7 0	Sp DcMr Ju	[illegible]	1
10	3/0	Do. 6 per Cent. Pref.	13¾—14¼	4 4 0	Sp DcMr Ju	14¹⁄₁₆	
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 3	April, Oct	..	

COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Highest	Lowest
5	—	Anglo-Argentine 5% Cum. 1st Pref.	4⅝—4⅞	5 2 6	April, Oct	4¹¹⁄₁₆	
5	—	Do. 5% Cum. 2nd Pref.	4⅛—4⅜	5 5 0	Jan, July	4¹⁄₁₆	
St.	4%	Do. 4% Deb. Stock	92½—93½	4 5 6	June, Dec	93⅛	
St.	..	Do. 4½% Deb. Stock	97 —99	..		97½	
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	—	
5	3/6	Brisbane Electric Trams. Invest. Ord.	6½—7	4 6 0	May	7	
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	..	
St.	8%	Brit Columbia El.Ry.Df. Ord. ex rights	144 —149	5 7 6	Mar, Sept	146½	1
St.	6%	Do. Pref. Ord. Stock ex rights	117 —122	4 18 6	May, Nov	120⅞	1
St.	5%	Do. 5% Cum. Perp. Pref. Stock	106 —110	4 11 0	Jan, July	108	1
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 0	Jan, July	..	
St.	4½%	† Do. 4½% Perp. Con. Deb. St.	101 —103	4 2 6	—	103	1
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —99	5 1 0	Mar, Sept	98	
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	90 —94	6 8 0	Feb, Aug	92	
5	2/0	Calcutta Tramways (1 to 137,610)	4¾—5¼	3 16 0	Mar, Sept	5¼	
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	4¾	
1	4½%	Do. 4½% 1st Deb. Stock (red.)	97 —100	4 10 0	Jan, July	—	
St.	..	Cape Electric Tram Shares	[illegible]	..	..	..	
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅞—6	4 1 6	F,My,A,N	5⅞	
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..	
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	81 —83	6 1 0	June, Dec	..	
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	92 —96	5 4 0	Feb, Aug	4½	
1	..	Kalgoorlie Elec. Trams Sh.	¹⁄₃₂—³⁄₃₂	..	..	..	
100	5%	Do. 5 per Cent. "A" Deb. Stock	92 —95	5 5 0	Jan, July	93½	
5	6%	Do. 6 per Cent. "B" Ditto	66 —70	8 12 0	Jan, July	..	
5	1/0	Lisbon Elec. Trams. Ord.	²⁹⁄₃₂—1¹⁄₃₂	4 4 9	July	..	
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 1 0	Jan, July	1	
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	98 —102	4 18 0	Jan, July	..	
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..	
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	96 —97	5 3 0	Feb, Aug		
100	$1½	Mexico Trams Co Com. St.	125 —123	3 18 0	..	129⅝	1
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	90 —92	5 8 6	..	93	
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,600)	103 —105	4 6 0	Feb, Aug	..	
St.	4½%	Do. do. (Nos. 1 to 4,600)	104 —106	4 5 0	..	105	
1	0/6	Perth Elec. Trams Ord.	⅝—⅞	8 0 0	May	—	
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 0	Jan, July	..	
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6⅝—6¼	5 4 8	..	—	
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	..	
100	..	Rio Janeiro Tram, Lt. & P. Co.	92 —94	..	..	95⅜	9
..	5%	Do. 30 yr. Gold Bnds.	94 —96%	5 4 6	—	95⅜	9
100	5%	Do. 50 yr. Mt. Bnds.	86½—87½	5 14 0	..	87½	8
—	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	149 —152	6 11 0	..	—	
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	101⅞	10
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	.	

COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.

Share	Last Dividend	Name	Price Wed., Sept. 22	Rate % Yielded £ s. d.	Dividend Due	Business Highest	Lowest
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5 —5½	5 14 0	Mar, Sept	..	
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9⅝—10⅛	5 18 9	..	—	
St.	4½%	Do 4½ per Cent. Deb. Stk. (red.)	94 —96	4 14 0	Jan, July	—	
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	93½—95½	..	..	94½	
6	4/9	Calcutta Elec. Supply Ord.	6⅛—6⅝	6 1 0	April, Oct	6¼	
100	$1½	Canadian Gen. Elec. Co. Com. St.	122 —127	5 13 0	—	124⅛	12
100	$3½	Do. 7% Cm. Pf. Stock	120 —122	5 15 6	..	121	1
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	
500	5%	Elect. Development Co of Ontario	84 — 86	5 16 0	—	85½	
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	-	
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	
10s	1/4	Kalgoorlie Elec. Power & Ltg. Ord.	⁷⁄₃₂—¹¹⁄₃₂	..	—	..	
1	0/7½	Do. 6 per Cent. Cum. Pref.	¾—⅞	6 18 3	April, Oct	—	
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	79 —81½	6 1 6	..	81½	
St.	$1	Mexican Lt & Power Co. Com. St.	68 —72	8 3 9	—	72	
500	5%	Do. 5% 1st Mort. Gold Bnds.	82 —84	5 19 0	..	84½	
100	$1¼	Montreal Lt. Ht. & Power Co. Cap. St.	127 —131	4 15 0	F,My,A,N	..	
1	1/7½	River Plate Electricity Co. Ord.	1⁷⁄₁₆—1⁹⁄₁₆	5 11 0	April	..	
1	1/2⅝	Do. 6 per Cent. non-Cum. Pref	1 —1⅛	5 6 6	May	..	
St.	5%	Do. 5 per Cent. Deb. Stock	103 —106	4 14 0	Jan, July	..	
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5⁷⁄₁₆—5¹¹⁄₁₆	5 5 3	April, Oct	..	
5	3/0	Do. 2nd Pref.	5⅝—6	5 0 0	—	.	
100	$1	Shawinigan, Water & Power Co. Ca	97 —99	4 1 0	—	9⅞	
..	5%	Do. 5 per Cent. Bds.	105½—107½	4 13 0	Jan, July	10	
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	98½—99½	4 10 6	—	99½	
St.	4½	Toronto Power Co. 4½. Db St.	99½—100½	4 9 6	..	100	
		Victoria Falls Power Co. Pref.	[illegible]	5 14 9	Jan, July	[illegible]	

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NOTES.

The Magnetic Storm.

THE magnetic storm last Saturday, although in some respects not more severe than others of recent years, was much more erratic in its changes, and probably on that account its interference with telegraphic communication was very severely felt in this and other countries. Between the hours of noon and six o'clock many of the lines in this country were hopelessly blocked. While ordinary lines with earth returns were suffering in this way, wireless transmission appeared to be immune. Considering the fact that magnetic storms are generally attributed to electric currents in the atmosphere—it matters little whether by electric discharge giving rise to the aurora borealis, by cathode and other rays, or by radio-activity of the sun, giving a stream of electrons in the neighbourhood of the earth—it has not unnaturally been contended that magnetic disturbances might give rise to the "atmospherics" so troublesome to the wireless operator. This view, however, does not seem to be justified, as appears from a letter by Dr. W. H. ECCLES appearing in our Correspondence columns. Dr. ECCLES, though unaware of what was occurring magnetically at the time, happened to be working in a wireless station; but notwithstanding the severity of the magnetic storm, he observed nothing unusual in the "atmospherics" received on that occasion.

Railless Electric Traction.

THE Briton's innate conservatism, while sometimes preventing him from adopting well-tried improvements until after they have long been employed by other nations, often prevents him from too rashly venturing along new lines until the merits and demerits of the case have been fully considered. It is with the latter object, no doubt, that tramway managers have hesitated to extend their systems into thinly populated outlying districts by means of trackless-trolley methods, although such equipment has been employed for some time at certain places on the Continent. Having seen the operation of a trackless car on the experimental road laid down at the Hendon car shed of the Metropolitan Electric Tramways Co. by the Railless Electric Traction Co., we see some justification for their backwardness in this respect. The necessity for a metallic return calls for the use of at least two trolley wires, while to prevent polarity reversals at crossings it has even been proposed to use three wires (two of which are positive) and a patent and very heavy swivel trolley head; all of which makes for complication, a feature certainly to be avoided. Complication also ensues from the fact that the British idea of the value of human life necessitates that some further protection should be used than that provided by the motor alone, which is all that is employed on the Continent. A description of the technical features of the car used will be found on another page of this issue, but it must be said that the experimental road scarcely allows the capabilities of the car to be adequately judged. There are too many curves and gradients in a very short length for any great speed to be safely attained; and during our inspection the 'bus scarcely ever moved faster than a crawl. This demonstration certainly showed (what was known before) that a car can be worked under trackless conditions on an experimental road, but it is still necessary for

working trials to be undertaken in conjunction with other traffic before the adaptability of the arrangement to conditions pertaining in this country can be accurately gauged.

The Underground Railways of London.

In accordance with our practice of recent years, we publish elsewhere in the present issue, a detailed analysis of the operation of London's underground electric railways. In the adoption of "Tubes" this country has been well to the fore, and the working results on these electrically-operated railways are therefore of more than local interest. Although many points have to be borne in mind in drawing conclusions from the costs per car-mile as set forth on another page, it is doubtful if really more reliable results would be obtained by adopting the "seat-mile" as the basis of comparison. Mr. A. L. C. Fell pointed out last week in his presidential address to the Municipal Tramways Association that the "seat-mile" should be taken instead of the "car-mile" in comparing the operating costs of various tramways, but in the case of the "Tubes" the possibility of thereby arriving at a strictly comparable result is prevented by the fact that at "rush-hours" a large number of passengers are carried for whom no seats are available. Since, however, we give the seating capacity of the cars on the various railways, our readers, if they so desire, can take the seating capacity into account in comparing the costs per car-mile. If the "seat-mile" were adopted as the basis of comparison it would be found that the best result, as regards total working expenses, would be shown by the Great Northern & City Railway—viz., 0·086d. per "seat-mile"—the City & South London Railway taking second place with a figure of 0·089d., whilst the Piccadilly & Charing Cross tubes show results of about 0·097d. per "seat-mile." This placing is, however, to some extent misleading, for the cost of current in the case of those railways which obtain their power supply from the Chelsea generating station of the Underground Electric Railways Co. of London includes an allowance for capital charges and depreciation; whereas, in the case of the City & South London Railway, the Central London Railway, and the Great Northern and City Railway the cost of current is only stated in their accounts as the actual generating expenses at their respective power stations. It will therefore be seen that an accurate comparison is extremely difficult to make.

In regard to the future operation of these railways, the competition by electric tramways and motor omnibuses is likely to make still further inroads on the traffic of some of the "Tubes," though in several instances the number of passengers shows a gratifying increase, which is being maintained at the present time. While such increase is partly due to greater publicity and appreciation of the facilities afforded by the "Tubes," it is also accounted for by the interchange of traffic between the various railways, and in this connection further developments are likely to take place in the future. Although efforts have been made to minimise delays, we think that some improvement is still possible in timing the lifts to meet the trains, though the long underground walk necessary in many cases to reach the platforms, coupled with the delay by lifts, will always act as a deterrent to short-distance passengers.

Electricity in Building Operations.

Our supply authorities are always on the look out—or at least they all should be—for "fresh woods and pastures new" in which electric energy can be supplied. New spheres are not opened up without effort, but once they are secured they are apt to become of increasing value. A case in point is the application of electricity to building operations. Large buildings are more and more the order of the day, and the amount of power plant used in this class of work is considerable; generally, however, the usual steam plant is inefficient and costly to work, so that the opening for electric plant, which is much more portable in its character, should be promising. Examples of electrical machinery of this kind are illustrated in our present issue. There are no doubt two main difficulties. The first is the conservative character of the British builder, which requires a good deal of overcoming. A satisfactory start, however, has been made, and although the builder may look upon the engineer with suspicion, he is likely to accept the opinions of his brother builders that the use of electrical plant is really an advantage. The second difficulty is that the builder does not, as a rule, restrict his operations to one particular locality. He is, therefore, apt to be a possible consumer of a number of supply authorities, and as each of these will probably offer a supply differing somewhat from each of the others, the unfortunate builder must keep a varied assortment of motors to meet the different conditions of supply. Here then, if the movement is to be a success, the supply authority must step in and be prepared to hire out the necessary motors. We trust that supply engineers will not be slow in taking up the matter, for if electricity is available from the start on suitable terms, not only is a desirable power load obtained for a considerable time, but electricity will in all probability be used finally in the building when completed.

New Cable to Argentina.—The Chamber of Deputies at Buenos Ayres has now finally passed the Bill (which had already been adopted by the Senate) approving the construction and laying of a new submarine telegraph cable, establishing direct communication between Argentina and Europe, via Ascension, by the Western Telegraph Co. The concession is for a period of 25 years, and (according to the "Hamburger Nachrichten") reserves to the State a monopoly of wireless telegraphy.

The Tramways and Light Railways Association.—The official circular of this Association for September contains a report of the proceedings in the arbitration re "Fuses and Heat Coils," which was held on July 23, 1909, before Mr. G. L. Macfarlane, K.C. The cases of Sir Robert Hunter, C.B., solicitor to the General Post Office, and of Mr. Sydney Morse, representing the Tramways and Light Railways Association, are given in full; as is also the proof of Mr. Stephen Sellon, the engineer representing the Association, and the arbitrator's award, delivered on August 12, 1909.

Westminster Electric Supply Corpn.—We understand that this company have arranged for their junior employés to attend evening classes in electricity and electrical engineering at the Battersea Polytechnic. Owing to the number of students desirous of attending, a special class has been formed.

Cable Interruptions.	Date of Interruption.
Tourane—Amoy	June 17, 1909
Assab—Perim	July 8, 1909
Dakar—Conakry	Aug. 19, 1909
Sheik Seyd—Perim	Sep. 15, 1909
Hong Kong—Macao	Sep. 25, 1909

"Electrical World."—It is announced that Mr. T. C. Martin is retiring from the co-editorship of the "Electrical World" to take up the position of general secretary of the National Electric Light Association, of which he was one of the founders, and with whose work he has been constantly associated. There is no doubt that Mr. Martin's departure will be a loss to our contemporary, but perhaps a gain to the electrical industry in the United States as a whole.

University of London (University College).—A public lecture, introductory to the session in the Faculty of Engineering, will be given on Wednesday, Oct. 6, at 5 p.m. by Prof. J. A. Fleming, F.R.S., on "Electrical Inventions and the Training of Electrical Engineers." The chair will be taken by Mr. W. M. Mordey, President of the Institution of Electrical Engineers. Elsewhere will be found particulars of other arrangements for the forthcoming session.

Northampton Institute.—It is announced that Dr. C. V. Drysdale is about to give a course of 20 experimental lectures on Wednesday evenings, starting on the 6th inst., on the subject of "Testing Electrical Plant." The lectures will start with the consideration of electrical and mechanical measurements, after which the testing of generators, motors and transformers, and alternating-current measurements will be dealt with. Finally, questions relating to alternating-current motors and the determination of the various quantities involved in their design will be considered. The lectures, of which further details are given elsewhere, will be supplemented by laboratory work.

Personal.—The retirement is announced of Mr. Edward John Houghton, electrical engineer to the London, Brighton & South Coast Railway, after a service of 52 years. His chief assistant (and son), Mr. R. H. Houghton, B.Sc., has been appointed electrical engineer in his stead, with sole charge of the telegraphs, electric lighting, power and electric traction on the railway.

Mr. E. J. Houghton was born in Kent in 1844, and entered the telegraph service of the London, Brighton & South Coast Railway in his fourteenth year. He became assistant telegraph superintendent in 1869 and electrical engineer in 1875. Mr. Houghton introduced several improvements into the telegraphic apparatus used in connection with the signalling, and also invented a system of electric lighting of trains.

Victoria–London Bridge Electric Railway.—It is announced that, owing to some difficulties with the Board of Trade with reference to provisions for public safety in the matter of signals, the opening of the electric service on the Victoria-London Bridge section of the London, Brighton & South Coast Railway will not take place as arranged, but that the ultimate date (December 1st) agreed upon would not be departed from.

It is further announced that so far as the equipment of the permanent way, the wiring and the provision of the new trains are concerned, everything is in order for opening the line, but objections have been raised by the Board of Trade that the view of certain of the signals is obscured by some of the overhead apparatus, and it will be necessary for these defects to be remedied before the trains can be run. For some weeks experimental trains have been running on the section between Battersea Park and Peckham Rye, and the results have been of an entirely satisfactory character.

Moscow Contracts.—Consul H. M. Grove (Moscow) says, in his report for 1908, that the whole of the work of the concession for the electrification of the Moscow tramway system, to be paid for by Moscow city bonds, was virtually in the hands of a British syndicate, which was to have taken over this loan at 75 per cent. Unfortunately, the concession was allowed to fall through. The requisite funds having been obtained by means of a loan raised in London, nearly all the plant has been ordered from Germany. This contract for the construction of the electric trams was (Mr. Grove remarks) only the first contract the town was then willing to hand over to the British syndicate—other things were to follow which would have been even bigger.

Royal Observatory at Greenwich and the Electric Tramways.—In connection with the stoppage of the work of conversion of a part of the London County Council's tramways to electric traction in the neighbourhood of Greenwich, it will be remembered that the Admiralty decided that to permit the existence of electric tramways on a system other than one providing for insulated return within 8 miles of the Observatory would be likely to interfere with the magnetic work of the Observatory, and an agreement was come to providing that all lines within a 3 mile radius should be constructed on a system that would meet with the approval of the Admiralty. The short piece of line between Beresford-square, Woolwich, and the Free Ferry does not come within the 3 miles radius, but just touches it, and a hitch seems to have arisen from a fear on the part of the Admiralty that the overhead system was to be brought inside the limit, though such is not the case. In regard to the projected lines from Woolwich to Eltham, which do come within the 3 mile limit, the Admiralty is also standing out for a system providing for an insulated return. The earnings of the line are not likely to be such as to justify the use of the costly conduit system, and up to the present the Highways Committee of the Council have not submitted an alternative system of which the Admiralty can approve.

L.C.C. Electrical and Highways Branch.—The Electrical and Highways branch of the Engineer's Department of the London County Council has removed from 42, Cranbourne-street, London, W.C., to Hungerford House, Victoria Embankment, W.C., (adjoining the Charing Cross Railway station on the "Underground"). Here the testing of electricity meters will in future be done, and the electrical work supervised by the branch conducted. The new building of the branch is shown in the accompanying illustration.

THE NEW EMBANKMENT HOME OF THE L.C.C. ELECTRICAL DEPARTMENT.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, October 1st (to-day).

IRON AND STEEL INSTITUTE.

Meeting at the Institution of Civil Engineers, Great George-street, Westminster. [A list of the Papers of electrical interest was given in our issue of September 3rd, p. 817.]

SATURDAY, October 2nd.

INSTITUTION OF MINING ELECTRICAL ENGINEERS.

2:30 p.m. General Meeting at the Royal Victoria Station Hotel, Sheffield.

MONDAY, October 4th.

THE SOCIETY OF ENGINEERS.

7:30. Meeting in Room 18, Caxton Hall, Westminster, S.W. Paper on "The Status of the Engineering Profession," by Mr. G. A. Thomas.

THURSDAY, October 7th.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

8 p.m. Meeting at Caxton Hall, Westminster. Presidential Address by Mr. W. N. Twelvetrees.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

Monday, Oct. 4th, "A" Company ……	Technical drill, 7:0 p.m. to 9:30 p.m.
Tuesday, Oct. 5th, "B" Company ……	Technical drill, 7:0 p.m. to 9.30 p.m.
Wednesday, Oct. 6th.	Gymnasium, 6:30 p.m. to 9:30 p.m.
Thursday, Oct. 7th, "C" Company ……	Technical drill, 7:0 p.m. to 9:30 p.m.
Friday, Oct. 8th, "D" Company ……	Technical drill, 7:0 p.m. to 9:30 p.m.

THE UNDERGROUND RAILWAYS OF LONDON.

In our issues of November 8, 1907, and December 11, 1908, we analysed the accounts and details of working of the various underground railways of London, and we now give a detailed analysis for the 12 months ended June 30th last—*i.e.*, a period covering two half-yearly reports of the directors—of the same railways, certain figures given in last year's analysis being also included for the sake of comparison. Table I. herewith relates to what are generally termed the "Tubes" (excluding the

Table I.—*General Data and Costs regarding the Electric Railways of London to June 30, 1909.*

Items.	Central London. 12 months, June, 1908-09.	Central London. 12 months, June, 1907-08.	City & South London. 12 months, June, '08-09.	City & South London. 12 months, June, '07-08.	Baker Street & Waterloo. 12 months, June, '08-09.	Baker Street & Waterloo. 12 months, June, '07-08.	Great Northern, Piccadilly & Brompton. 12 months, June, '08-09.	Great Northern, Piccadilly & Brompton. 12 months, June, '07-08.	Charing Cross, Euston & Hampstead. 12 months, June, '08 9.	Charing Cross, Euston & Hampstead. 12 months, June, '07 8.	Great Northern & City. 12 months, June, '08-09.	Great Northern & City. 12 months, June, '07 8.
Miles of route constructed	6·90	6·90	7·3	7·3	4·7	4·7	9·4	9·4	8·0	8·0	3·4	3·4
Capital expenditure (total)........	£4,057,309	£4,044,469	£3,143,576	£3,135,303	£3,194,600	£2,122,720	£6,980,931	£6,768,442	£5,767,976	£5,622,177	£2,311,282	£2,310,762
Total number of cars	238	238	165	165	110	110	225	225	158	158	76	76
Average seating capacity of car.	48	48	32	32	50	50	50	50	50	50	63	63
Passenger train mileage	1,642,908	1,327,630	1,364,680	1,378,342	1,231,583	1,045,645	2,383,708	1,909,504	1,809,805	1,656,910	676,913	710,753
Car-mileage	8,605,822	7,606,188	6,823,400	6,587,702	3,737,791	3,403,532	7,236,850	6,948,776	5,663,913	5,477,241	1,895,344	2,134,085
Number of passengers	40,985,732	36,548,370	22,982,662	23,047,167	27,662,191	23,603,677	36,146,384	31,361,256	27,878,245	22,013,996	11,575,452	14,418,776
Number of passengers per car-mile	4·76	4·85	3·37	3·49	7·41	6·95	5·0	4·52	4·92	4·02	6·12	6·78

Items.	Central London. Total for 12 mnths June, 1908-09.	Per car-mile. 12 mnths June, 1908-09.	Per car-mile. 12 mnths June, 1907-08.	City & South London. Total for 12mnths June, 1908-09.	Per car-mile. 12m'ths June, 1908-9.	Per car-mile. 12m'ths June, 1907-8.	Baker Street & Waterloo. Total for 12mnths June, 1908-09.	Per car-mile. 12m'ths June, 1908-9.	Per car-mile. 12m'ths June, 1907-8.	Great Northern, Piccadilly & Brompton. Total for 12 mnths June, 1908 09.	Per car-mile. 12m'ths June, 1908-9.	Per car-mile. 12'mths June, 1907-8.	Charing Cross, Euston & Hampstead. Total for 12mnths June, 1908-09.	Per car-mile. 12m'ths June, 1908-9.	Per car-mile. 12m'ths June, 1907-8.	Great Northern & City. Total for 12mnths June, 1908-09.	Per car-mile. 12m'ths June, 1908-9.	Per car-mile. 12m'ths June, 1907-8.
Maintenance of Way, Works, &c.	£	d.	d.	£	d.	d.	£	d.	d.	£	d.	d.	£		d.	£	d.	d.
Salaries, office exp. & gen. supt.	932	0·02	0·03	140	0·01	0·00	200	0·01	0·01	429	0·01	0·01	353	0·01	0·01	88	0·01	0·01
Maint. and renewals of per. way	5,320	0·15	0·17	1,761	0·06	0·09	1,922	0·12	0·12	2,929	0·10	0·11	2,790	0·12	0·12	854	0·11	0·12
Repairs to signals, teleph. & teleg.	1,698	0·05	0·04	670	0·02	0·04	1,134	0·07	0·08	2,028	0·07	0·07	2,137	0·09	0·08	316	0·04	0·05
Repairs to stat'ns, build., tun., &c.	1,020	0·03	0·02	1,022	0·04	0·03	3,091	0·20	0·07	5,090	0·17	0·05	3,649	0·15	0·05	395	0·05	0·04
Ventilation	849	0·02	0·02	...	...	...	878	0·06	0·06	1,804	0·06	0·06	1,063	0·05	0·04	...	...	...
TOTAL........................	9.819	0·27	0·28	3.593	0·13	0·16	7.225	0·46	0·34	12.280	0·41	0·30	9.992	0·42	0·30	1,653	0·21	0·22
Repairs and Renewals of Rolling Stock and Lifts.																		
Salaries, office exp. & gen. supt.	235	0·01	0·01	100	0·00	0·00	101	0·01	0·02	240	0·01	0·02	161	0·01	0·02	74	0·01	0·01
Repair and renewal of cars	7,951	0·22	0·24	3,174	0·12	0·15	6,961	0·45	0·43	8,544	0·28	0·28	5,950	0·25	0·23	769	0·10	0·15
Repair and renewal of lifts	3,450	0·09	0·11	...	...	...	1,169	0·07	0·07	1,843	0·06	0·06	1,268	0·05	0·04	251	0·03	0·05
TOTAL........	11.636	0·32	0·36	3,274	0·12	0·15	8,231	0·53	0·52	10,627	0·35	0·36	7,379	0·31	0·29	1,094	0·14	0·21
Traffic Expenses.																		
Salaries, wages, &c.	36,013	1·00	1·10	20,085	0·70	0·78	16,471	1·06	1·21	28,570	0·95	0·99	22,263	0·94	1·04	10,014	1·27	1·22
Fuel, light., water & general stores	9,784	0·27	0·26	3,405	0·12	0·12	4,848	0·31	0·44	7,772	0·26	0·36	7,086	0·30	0·39	1,998	0·25	0·33
Car cleaning..........................	2,303	0·06	0·07	...	...	...	1,947	0·13	0·16	3,472	0·12	0·16	2,889	0·12	0·15	514	0·06	0·07
Clothing	885	0·02	0·03	579	0·02	0·02	222	0·01	0·03	356	0·01	0·01	318	0·01	0·01	225	0·03	0·03
Printing, stationery & miscel'ous	4,952	0·14	0·15	1,093	0·04	0·04	2,048	0·13	0·21	3,346	0·11	0·15	2,834	0·12	0·16	873	0·12	0·09
Lift working............................	11,705	0·33	0·33	10,029	0·35	0·36	7,478	0·48	0·56	12,379	0·41	0·46	8,752	0·37	0·45	1,989	0·25	0·25
Current and generating expenses	*47,935	*1·34	*1·54	*26,052	*0·91	*1·01	24,055	1·55	1·85	40,479	1·34	1·55	39,149	1·66	1·79	15,566	1·97	1·86
TOTAL........................	113.577	3·16	3·48	61,243	2·14	2·33	57,069	3·67	4·46	96,374	3·20	3·68	83,291	3·52	3·99	31,179	3·95	3·85
Sundry Items.																		
General charges	15,1[illegible]9	0·42	0·46	6,126	0·22	0·23	4,132	0·27	0·29	4,882	0·16	0·16	3,495	0·15	0·13	3,644	0·46	0·50
Law charges and Parliamentary charges, Govt. duty, &c.	1,145	0·03	0·04	385	0·01	0·01	1,011	0·06	0·05	2,820	0·09	0·02	548	0·02	0·02	104	0·01	0·02
Compensation	677	0·02	0·02	...	...	...	481	0·03	0·03	3,145	0·10	0·03	652	0·03	0·03	5	0·00	0·01
Rates and taxes	31,478	0·88	1·00	6,644	0·23	0·23	8,739	0·56	0·60	15,745	0·52	0·51	9,679	0·41	0·40	4,330	0·55	0·48
Joint lines and stations expenses	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	844	0·11	0·12
TOTAL	48.419	1·35	1·52	13,155	0·46	0·47	14,363	0·92	0·97	26.592	0·87	0·72	14,374	0·61	0·58	8,927	1·13	1·13
TOTAL WORKING EXPENSES......	183.451	5·10	5·64	81.265	2·85	3·12	86.888	5·59	6·30	145.873	4·83	5·05	115.036	4·86	5·16	42,853	5·43	5·41
Revenue: Passenger traffic	330,148	9·20	9·54	165,505	5·80	6·09	169,355	10·88	10·33	288,329	9·56	8·92	190,504	8·07	6·78	74,263	9·41	9·91
Revenue: Merchandise, Advt., &c....	22,136	0·62	0·57	10,756	0·38	0·39	8,511	0·55	0·45	12,899	0·43	0·34	8,744	0·37	0·36	5,366	0·68	0·66
TOTAL............	352.284	9·82	10·11	176.261	6·18	6·48	177.866	11·43	10·78	301,228	9·99	9·26	199,248	8·44	7·14	79.629	10·09	10·57
Balance	168,833	4·72	4·47	94,996	3·33	3·36	90,978	5·84	4·47	155,355	5·16	4·21	84,212	3·58	1·98	36,776	4·66	5·16

Waterloo & City Railway), whilst in Table II. are given the working costs of the Metropolitan District Railway and the Metropolitan Railway, which railways differ in some respects from the above-mentioned "Tubes," and have, therefore, been treated separately.

Summarising the results as shown in the tables, it may be said that, although the Great Northern & City Railway has to record a very unsatisfactory year's working (due to the competition of the London County Council tramways), and the Central London Railway and the City & South London Railway show little, if any, progress, due in the one case to the fluctuating traffic in connection with the Shepherd's Bush Exhibition and the severe competition of motor and other omnibuses, and in the other case to tramway competition, the undertakings controlled by the Underground Electric Railways Co. of London are making great headway. It will be remembered that the undertakings consist of the Baker-street & Waterloo Railway, the Great Northern, Piccadilly & Brompton Railway, the Charing Cross, Euston & Hampstead Railway and the Metropolitan District Railway. Progress is also shown by the Metropolitan Railway, but owing to the mixed nature of the traffic over this company's lines, and also owing to the fact that so many steam locomotives are employed, we are unable to make a satisfactory analysis of the accounts of this railway, and therefore merely give the total sums figuring under each item.

Table II.—*General Data and Working Costs.*

Items.	Metropolitan District Railway. 12 months, June, 1908-9.	12 months, June, 1907-8.	Metropolitan Railway. 12 months, June,'08-09.	12 months 1907-8.
Miles of route constructed and owned by company	24·3	24·3	84·5	84·5
Capital expenditure (total)	£12,126,687	£12,144,804	£15,073,721	£15,028,439
Total No. of cars (*exc.* 12 elec. locos.)	359	359		
Average seating capacity	52	52	Steam train mileage	
I. Car-mile., Dist. cars on Dist. Ry.	10,579,080	8,840,549	284,328	299,130
II. Car-mileage, Dist. cars on joint and foreign lines	5,592,025	6,665,427	Electric train mileage	
III. Total car-mileage by Dist. cars	16,171,105	15,505,976	3,304,614	3,250,160
IV. Car-mile., other Cos' on Dist. Ry.	1,790,356	2,396,712		
V. Total car-mile. on Dist. Ry.	12,369,436	11,257,261	Goods train mileage	
VI. Total car-mile., Dist. and foreign cars on Dist. Ry. and by Dist. cars on joint and foreign lines	17,961,461	17,902,688	176,751	200,356
Number of passengers	64,453,617	55,435,318	101,249,950	96,600,000*
Number of passengers per car-mile (based on car-mileage, No. V.)	5·21	4·95		

Items.	Total, 12 mths June, 1908-9.	Per car-mile. 12 mths June, 1908-9.	Per car-mile. 12 mths June, 1907-8.	Car-mileage used as basis.	Total, 12 months, June, 1908-9.	Total, 12 months, June, 1907-8.
	£	d.	d.		£	£
Maintenance of Way and Works.						
Salaries, office exp. and gen. supt.	1,098	0·02	0·02	No. V. (above.	1,898	1,332
Main. and renewals of Perm'nt way	23,967	0·47	0·56		21,737	24,690
Repairs to signals	7,819	0·15	0·19			
Repairs to stations, buildings, &c.	14,022	0·27	0·17		24,628	21,133
Total	46,906	0·91	0·94		48,263	47,155
Repairs and Renewals of Rolling Stock.						
Salaries, office exp. and gen. sup.	1,492	0·02	0·03	No.III.	718	740
Repairs and renewal of cars	43,351	0·65	0·64		19,712	18,403
Total	44,843	0·67	0·67		20,430	19,143
Electric Train Working.						
Elec. current and generating exp. (inc. interest on power house)	117,587	1·56	1·87	No. VI.	Loco. and generating expenses and car cleaning	Loco. and generating expenses and car cleaning.
Wages of trainmen	34,144	0·51	0·60	No.III.		
Car cleaning, depôt expenses and running stores	4,951	0·07	0·09			
Total	156,682	2·12	2·56		149,797	149,031
Traffic Expenses.						
Salaries and wages	28,534	0·55	0·62	No. V.	82,248	81,553
Fuel, light, water and gen. stores	6,384	0·12	0·16		7,912	8,067
Clothing	536	0·01	0·01		2,280	2,221
Printing, stationery, billposting, &c.	7,377	0·14	0·14		5,810	5,110
Total	42,831	0·82	0·93		98,250	96,951
Sundry Items.						
General charges	21,276	0·41	0·49	No. V.	46,358	37,688
Law charges & Parly. exp., Govt. duty	1,072	0·02	0·03		4,254	4,662
Compensation	1,518	0·03	0·06		1,947	8,217
Rates and taxes	31,011	0·60	0·78		49,962	48,409
Joint lines and stations expenses	7,280	0·14	0·18		5,799	7,854
Total	62,157	1·20	1·54		108,320	106,830
TOTAL WORKING EXPENSES	353 419	...	...		425.060	430,250
Deduct: Work done for other cos.	63,340	...	...		29,777	38,511
Less work done by other cos.	11,884	...	...			
NET WORKING EXPENSES	301,963	5·82	6·66	No. V.	395.283	391.739
Revenue from passenger traffic	498,820	9·66	9·31		619,443	575,618
Revenue from sundry receipts	36,373	0·70	0·81		136,330	128,820
TOTAL REVENUE	535,193	10·36	10·12		755.773	704.438
Balance	233,230	4·52	3·46		360,490	312,699

* Approximate.

Considering first Table I. it will be observed that the same form of analysis as last year has been adopted, and for the first time a comparison is possible of the progress made by the Charing Cross, Euston & Hampstead Railway. As was to be expected, the traffic on this tube shows a considerable increase compared with that during the first year's operation, as is indicated by the increase in the number of passengers per car-mile from 4·02 to 4·92; and as the working expenses have decreased from 5·16d. to 4·86d. per car-mile the prospects of this tube have considerably improved. The most striking result, however, is probably the reduction in the working expenses of the Baker-street & Waterloo tube from 6·30d. to 5·59d. per car-mile, which latter figure is, nevertheless, considerably greater than the 4·83d. per car-mile recorded on the Great Northern, Piccadilly & Brompton tube.

Taking into consideration the size of the cars on the various railways—as is to some extent indicated by the seating capacity given in Table I.—the most creditable record is, perhaps, that of the City & South London Railway, which shows working expenses of only 2·85d. per car-mile, the seating capacity of each car being 32 passengers, compared with about 50 on most other tubes. In this connection attention should be paid to the fact that the cars in use on the Great Northern & City Railway are considerably larger than the others, each providing seats for 63 passengers. In regard to the details of the working expenses, it will be noticed that in almost every case a considerable reduction is shown in the cost of current per car-mile, and generally the cost of repairs shows little, if any, increase. We have frequently referred to the hardship inflicted on many of the tubes by rates and taxes, and attention may again be drawn to the sum of 0·88d. per car-mile appearing under this heading in the accounts of the Central London Railway; this figure, although less than that of 1d. per car-mile recorded a year ago, is still a severe handicap on any undertaking, particularly when it is exposed to the competition of motor omnibuses, on which rates and taxes bear but lightly.

It will be remembered that the Lot's-road power station supplies the current for operating the trains on the various

Table III.—*Locomotive and Generating Expenses for 12 months ended June, 1909.*

Items.	Central London.	City & S. London.	Metro-politan.	G.N. & City.
	£	£	£	£
Salaries, office expenses, &c.	2,555	913	3,940	525
Coal and coke	16,225	8,259	55,508	5,828
Water and gas	273	150	1,587	1,013
Oil, tallow, stores, &c...............	1,908	1,035	2,944	243
Wages	15,038	10,817	39,246	4,847
Repairs and renewals	12,785	4,879	36,399	3,109
Less Miscellaneous	849	...	864	...
Totals	£47,935	£26,053	£138,760	£15,565

undertakings (enumerated above) of the Underground Electric Railways Co. of London, and as this power station is operated as an independent undertaking it will be seen that the cost of current on these railways is not comparable with that item as given for those tubes possessing their own power stations. In Table III. will be found details of the generating expenses of these railways, from which table an idea of the relative importance of the various items can be obtained.

With regard to the revenue, it is discouraging to notice the continued decrease of traffic on the Great Northern & City line, the receipts dropping from 10·57d. to 10·09d. per car-mile, and representing no less than 2,843,324 passengers—the total number of passengers for the 12 months ended June 30th last was only 11,575,452. The diminished revenue per car-mile recorded on the Central London Railway and the City & South London Railway is counterbalanced by diminished working expenses, but as reductions in the latter item cannot be depended on in the future, it is to be hoped that the attempts of the directors to find means for retaining, if not increasing, the traffic on these lines will prove successful. In this connection it will be remembered that at the present time a 1d. fare for distances up to three stations is on trial on the Central London Railway, but the results of this policy are not yet clearly indicated. We expect, however, great improvement from the forthcoming extension of this railway to Liverpool-street.

Turning now to Table II., little comment is necessary, beyond drawing attention to the provision of a column for the Metropolitan District Railway showing the particuar car-mileage employed in calculating the various costs per car-mile. This distinction is necessary owing to the complicated nature of the traffic over this railway, as is sufficiently indicated by the figures given under the various car-mileage totals. It will be noticed that a large reduction is shown this year in the net working expenses of the District Railway, and this, together with the fact that the revenue shows signs of expansion, should prove very gratifying to the company's staff, which, in the past, has been criticised for the results attending electrification.

As regards the Metropolitan Railway, we have referred above to the difficulty of comparing the results with those on other lines, and the figures given are merely instructive as showing the growth of revenue and the decrease in working expenses.

WHY MANUFACTURERS DISLIKE COLLEGE GRADUATES.*

BY FREDERICK W. TAYLOR.

In the criticism which I have to offer I am not opposed to engineering education as a preparation for life. On the contrary, in all cases where possible I invariably select an engineering graduate for almost any large position that has to be filled. There ought to be no question as to the value of young engineers, but, on the other hand, teachers are not in very close touch with the general public opinion of the country in the matter.

I do not think there is a shadow of doubt that the overwhelming majority of employers in this country want, if possible, to have nothing to do with young graduates if they can avoid doing so. That is a fact, and one that ought to be appreciated. I want you to appreciate that this sentiment exists very largely in this country. I think those who have had the longest and largest experience with engineering graduates want them the most, but I daresay they only want them on the average after they have been out of college one or two years. They want someone else to take them first.

Now that is one side of the question. The other side comes to me from my personal observation. I think it is also true that nine out of ten of these young men are dissatisfied for at least one or two years. They find their employers unappreciative and exacting. They are not given any kind of opportunities commensurate with their education and what they are able to do. They are asked to do work that mere boys could do. Almost invariably, they want to leave their first employer, and it is only after going to their second or third that they become aware of the fact that the boys that they make light of are the ones who can do things and are the ones favoured by the employers, and that the whole or nearly all of the employers of the country are not really unappreciative. Some ten years ago I made up my mind never to employ a college man who had not been out two years at least, if I could help myself. Then he will have learned something about life and what the world is.

Now are those two conditions indispensable ? Are they indispensable conditions to the young graduate ? Is it necessary that the young graduate should be turned out so that he is unhappy and discontented for a period of two years more or less after he graduates ? And is it necessary that the young graduate should go out with such an education that the average employer, who is an honest man, who really believes that he is right, feels that these young men are not what he wants ? Is that condition indispensable ? I most firmly believe not. I believe that the young graduate can be turned out so as to be useful right from the start, and I believe that there are two particular faults which are responsible for this condition of affairs, both of them remediable.

The first of these is because of the fact that during the four years that these young men are at college, they are under loose discipline, and are allowed a greater freedom than they have ever had before, or will ever have again.

I will cite some illustrations. In most universities and colleges the student is given, every term, a certain number of cuts for which he is held to no responsibility. He can simply absent himself from recitations, from lectures, from duty that belongs in the college course, and no one ever asks what he has done, or where he has gone. If that same young man absents himself once without a reasonable excuse, when he gets into business, he is usually hauled up and asked in the most impertinent manner, why he was away. No cuts in business, no talk about how many cuts a man has. The second or third time that he does cut, he is discharged. Young college men work when they please, and as much as they please, the only restrictions being that they have to pass certain examinations. Their habits are left almost entirely to themselves. When they begin commercial life those habits are regulated and rigidly prescribed by someone else.

The radical difference of treatment which these young men receive in college, from what they receive afterwards, to my mind, is the lesser of the two reasons for the two fundamental facts that I have described, namely the unhappiness of the young man when he gets out, his failure to fit in his surroundings, and great lack of demand for these young men throughout the country.

The reason for this is that for twenty-two years these young men are allowed to go without even a single look at conditions which they are to face throughout their lives. The work of the student, of the young man, is that of absorbing ; he is engaged in the performance of getting things fastened in his mind for himself, for his own use. That is his life for twenty-two years. The moment he gets out he begins directly the opposite. Absorbing ceases and becomes a very minor part of a man's work. He begins giving the few ideas, or the many which he may have gotten, to help some one. He has been served for twenty-two years by some one else, the moment he gets out he begins serving others. Is it any wonder these young men find great difficulty in suddenly changing from the attitude of sponges, or absorbers, to that of human beings actively engaged for the benefit of someone else ? I think the wonder is that they adjust themselves so quickly to it.

The central idea that the boy gets at college is training, training of the mind, storing the mind full of things. Now I say, without the slightest hesitation, that for success in life, intellectual training comes second or third. Without the slightest question, character comes first ; good sense, second, and intellectual training third. The entire emphasis of the college life is on intellectual training. As long as the man commits no offence which sends him to jail, it is very little of the business of the management of those universities what those boys do.

What is the remedy for these two faults ? I do not believe there is any panacea for all faults, but I do believe that there is a great

* From "The Electric Journal." Slightly abbreviated.

palliative possible. I believe that every young student in our colleges, from the student who intends to be a minister, on the one hand, to the mechanical engineer, on the other hand, should leave college at the end of the freshman year and spend at least one year in actual hard work in a shop of some kind. I say shop, because he will be certain to be under careful and constant supervision when working in a shop as a workman, alongside workmen.

I would not send them there with the idea of getting intellectual training. If they do, it is a mere incident. I would send them there mainly for the purpose of giving them a real look at life's work and give it to them early enough so as to affect the last three or four years of their college life. When they start work in a shop, under good rigid discipline, they then begin to get the character training, which is almost entirely lacking at college. They then begin to learn the great lesson of life, that almost nine-tenths of the work that every man has to do is monotonous, tiresome and uninteresting. Then they start to develop the character which enables them to do unpleasant, disagreeable things. This is the greatest training, to my mind, which they get in the shop. They learn that life is made up mainly of serving other people, not that the world is there to teach them something new. I think that almost invariably they start into the shop with the common idea, " Now I am here to learn something, to get something in this shop that is going to be a fine engineering education for me." They fail at once, for there is no great intellectual training in the shop. Many of them cannot stand the monotony and fail to get the real character training that comes from that work.

There is another thing that they learn, which is of enormous importance for these young men, and I think it has more to do with making them earnest and determined than anything else. You could lecture to them and talk to them from now to doomsday, and tell them that the man who goes along the street in greasy overalls, that the man who runs a lathe, is mentally as well equipped as they are and they won't believe it. They may acquiesce mentally, but away back in their brains they say, " Oh, yes, I will believe it, but it is not so." That is their mental attitude.

Young men who work in any first-class establishment find that men who cannot talk grammatically, that men who chew tobacco, slouch along the street with greasy overalls on, who hardly look up, who are scarcely willing to speak to you politely as you go along, are intellectually as clear as they are. That is what the young men learn. I remember very distinctly the perfectly astonishing awakening at the end of six months of my apprenticeship, when I discovered that there were three men in the paint shop, I being the fourth, who were all smarter than I was. Now when a young man gets it clearly in his head that he is made of the same kind of clay as those other men, then his only hope is not to be outstripped in better education. He sees clearly enough, if he uses his eyes, that it is energy, grit, pluck, determination, ability to stick to it, character which makes success in the manufacturing and in the engineering world. He will finally come to the conclusion, " I can get that as well as the other fellow, I have as much grit, I can probably get more." He probably has more, and he goes back to college with the determination to get the better education.

This development of character I look upon as the greatest good that comes from work in the shop. Prof. Furman, of Stevens Institute, published last winter, in the Stevens Indicator, a record of the careers of the graduates of Stevens Institute. In the group of successful graduates of Stevens Institute more than half were engaged, not in engineering, but in executive work, in managing, as presidents, vice-presidents, superintendents, managers, in some capacity in which engineering was entirely secondary and incidental, and in which the real work was executive work. Now that is a very important fact which shows what has taken place with the graduates of one of the oldest mechanical engineering schools of this country.

At college a very large amount of time is given up to the study of materials. Practically his whole chemical course is the study of materials. A very considerable part of his course in physics has to do with materials. The greater part of his work in a mechanical laboratory is a study of materials. Do you, gentlemen, realise that the great raw material with which more than one-half of the successful graduates of our technical schools have to deal, receives not a single hour of study at our colleges and universities, not one hour? That the great raw material with which the managers, superintendents, presidents, every man of our large companies is dealing is men? And these one-half of the students, who are finally called upon to manage workmen, learn nothing whatever about that at college. At twenty-two years of age on the average they land outside of college without the slightest knowledge of the great raw material with which more than one-half of them will have to work throughout their lives.

Now, those of you who have worked much with workmen, will realise fully that it is next to impossible to study them from the top. Workmen can only be properly studied side by side and shoulder to shoulder. The man who undertakes to study them from the top, gets a superficial knowledge of his workmen, and in many cases an entirely wrong and misleading idea. The only way that a man can become familiar with the line of thought of his workmen, with the process of reasoning by which they approach the great problems that are in their minds, is by becoming intimate with them, by working side by side with them, so that they forget that you are not one of their kind, and genuinely tell you what they think.

I say without the slightest hesitation that no man is well equipped to manage workmen who cannot say ten sentences consecutively to a workman and have that workman say at once " Oh, he has worked. I know about him. He has worked." Absolutely, unconditionally in ten ordinary sentences, if it be about work, the workman will size up the fact as to whether he has been a workman or not. And until a man is intimately acquainted with them and knows their methods of thought, their methods of expression and the way they look at things, he is at a very great disadvantage as a manager.

Just now, in this country, we are facing a great problem in the management of our men; the problem upon which, I think it may be said with almost certainty, that England has made a grand failure. We are facing that problem and are up against it hard—the problem of soldiery, and no man can properly and thoroughly appreciate this great problem unless he has worked among men when they soldier, knows their arguments for and against it and has some idea of how to remedy that great defect; the defect which has come close to ruining the English industries.

Now there is one more thing. More and more, management is becoming a question of co-operation on a large scale. The whole training of the young man while he is at the university is an individual training. He has not the slightest training in co-operation, except possibly what he gets from his baseball or football team in the university; and yet every year the problem of co-operation becomes a greater one.

These young men at twenty-two go out without having seen any co-operation, thoroughly unfitted for it in many respects: thoroughly unfitted to do what they are told promptly and without asking questions and making suggestions. They will not become one of a train of gear wheels, and it is absolutely necessary for every man in an organisation to become one of a train of gear wheels. The training he usually receives in no way fits him for that. But the year in a shop will give him at least a good look at it. He has to work as one of a train of gears during that year. I do not think there is any equivalent for this work. Certainly the university shop is in no wise an equivalent. There they are in competition, not with men who are engaged in working for a living, but with other students. They are not rubbing against other men and getting their viewpoints, learning something as to how work ought to be done. They may get a little good out of it, but as far as the great work they ought to have, the character training and the study of men, they get nothing. The thing that comes close to it in college is the three or four months of vacation work. Even during this time, however, they fail to get it because all they do is to go in there with the idea of learning something. It is a novelty to them and they fail to get right down to the real monotonous grind which trains character. Then again, in three months, they cannot get close enough to the workmen to know their viewpoint.

Most of you gentlemen are telling your students, or advising them that they had better work as a workman for a year or so at least when they go out. About one in fifty does it. They start with the idea of serving an apprenticeship, but they do not do it. Even when they go in with the best of intentions, they cannot get away from this habit of absorbing, they cannot get down to the monotonous, to the tiresome work. They are not really learning anything. They fellt that they have a fine college education and could do that work as well as the workman, so it does not make any difference whether they work in a shop or not. And you educators say, " Oh, yes, you should take your two years' course outside. It is up to you. Take a year or two years' apprenticeship." They don't do it, and they won't do it. They find themselves, when they are up against apprenticeship conditions in a shop, competing with young fellows of sixteen or seventeen. They cannot say, " There is not a single thing I do not know," and yet they are too old. Then, they are intellectually fastidious, while the young freshman who comes out gets next to the workmen better than the other. He is not, of course, so fastidious a man. He gets next to the working man and learns much more than the other fellow.

About ten or twelve years ago I made up my mind not to take another young college graduate unless he has had two years' work outside, but, in going through the list, I found that there was a certain set of young men who were satisfactory right from the start. Men who had by necessity been forced to leave school and go to work. So I found that I had to modify my conclusion, by saying that I would not take a man unless he had worked outside for at least two years, or unless he had worked as a workman before he graduated. I have no other reasons why these young college men were not competent, but the facts are there. That is why we came to exclude college men who had not had actual service.

Now I want to strengthen this theory by some facts. Prof. Furman, from the observations on the graduates at Stevens Institute, has come to the conclusion that a large percentage of the older graduates who now stand highest in their professional work are those who started as mechanical shop apprentices. Again, the joint committee appointed by seven of the engineering societies unanimously voted that it was desirable to have two years' apprenticeship before students graduated as engineers.

Now, as to the liberal education, I believe that one year, conducted with a totally different kind of idea of human nature under more practical conditions, with men struggling for a living is vastly more broadening than a year of travel abroad. I am very sure that in my case the thing that impressed me was the apprenticeship, and not the travel, and I feel that it has a very liberalising effect. If I wanted to give a boy a broad liberal view, I would get him in contact with men who are really working for a living, make him see how the other half lives. That gives him a lasting sympathy for men.

One thing more, is it possible or practicable to get this year's work for a young graduate? I feel absolutely sure it is, provided those young men are sent out to work in working conditions. If they are sent out to get an education, no. But if they are sent out and made to do a day's work, they are the finest kind of raw material. Take the average young man. He has some bad ideas, but all you have to do is to mould that young man to your needs, give him character and common sense, and when the shops begin to take these young men from our universities and colleges, particularly if it becomes a regular thing, that every year from such and such a place we can get eight or ten men, the supply will not equal the demand. Now I had great difficulty two years ago in getting one of the manufacturers to take a single college man, although he was one of the most distinguished graduates of a technical school. After trying one or two of them for a year, they now want all they can get of those men. Those men come there to do the tiresome and monotonous work, and never get any notion that they are there to learn. If they should get that notion into their heads while there, they would be stepped upon like this, "You are not here to learn anything; you are here to make money for us." Now, in point of fact, they *were* there to learn. That man lost money on them every year, but they never found that out. They are there to learn, they are studying, but they never find out that they are studying, and every time they come up with a kick, they are knocked down flat.

THE TIPS OF TEETH ON ARMATURE CORES.

BY MILES WALKER.

Summary.—The author deals with the main considerations controlling the design of tips of teeth and the effect of the shape on the magnetic leakage. Curves are given showing the relation between the dimensions of the tip and the permeance of the leakage path, so that the designer, while modifying the shape, can see exactly what he is doing and can with a minimum amount of calculation decide on the shape which will best meet all conditions.

The main considerations to be kept in view in designing the tips or "horns" of teeth on armature cores are as follows:—

1. The object of the tip is to make the head of the tooth as wide as possible without increasing unduly the reactance of the conductors in the slot.

2. Sufficient iron must be provided at the root of the tip to carry the flux passing through it and to give it sufficient mechanical strength.

3. The permeance of the magnetic path encircling the slot is to be kept as low as possible.

4. The slot should be of such a shape as to only require a simple tool to punch it, and the corners should be such that they will punch well without requiring frequent repairing of the die.

5. The mouth of the slot must sometimes be not less than a certain minimum, as when a certain sized wire is to be passed through it.

6. The method of drawing the slot and of making the punch for it should be capable of being easily standardised.

In this article the following names of parts and symbols will be used. Fig. 1 illustrates the parts.

h = height of slot in inches.
b = width of slot ,,
r = root of tip ,,
g = mouth of slot ,,
p = lip of mouth ,,
α = angle of slope of tip.

As to the general shape of the tip, it is only in special cases that anything is to be gained by the use of a large radius at the

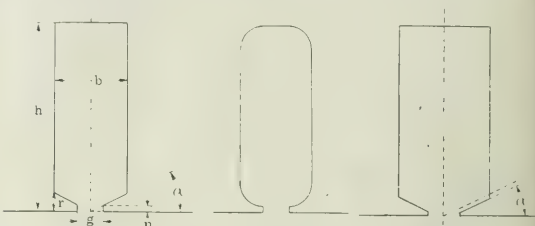


Fig. 1. Fig. 2. Fig. 3.

corner of the root, as in Fig. 2. For a standard slot of normal size (b from 0·25 in. to 1 in., h from 0·5 in. to 2 in.), intended to take various numbers of conductors and various amounts of insulation, the shape of the slot shown in Fig. 1 is as good as any other. In drawing it the corners may be shown sharp, but the die maker will put on a very small radius to get good results in punching. He can make a cheaper tool than if he has to work to special radii which are different in different slots.

In general, the best value for the angle α is about 27 deg—that is, $\tan^{-1} 0{\cdot}5$. This angle gives sufficient iron in the root

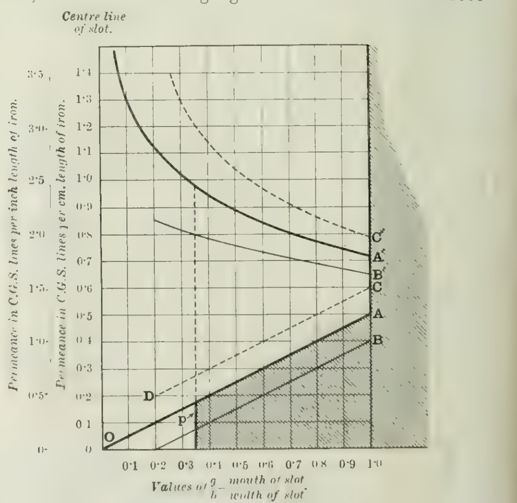


Fig. 4.—Magnetic Leakage across Mouth of Slot.

of the tip both for the working flux and for the leakage flux, when the flux density in the air-gap is as high as 60,000 lines per square inch. The angle might in some cases be reduced where it is desirable to save space, but in general the same effect can be obtained by drawing the sloping line a little lower down while still keeping it at the same slope as shown in Fig. 3. For slots of the most ordinary sizes the apex of the angle α may lie on the centre line of the slot, as shown in Fig. 1.

The dimension g may be fixed by the necessity of putting wires of a certain size through the mouth of the slot. In any case, it should not be made too small (say not less than 0·05 in.), or the metal of the punch will not have sufficient strength. Subject to these considerations, g will be made as small as possible, so that the face of the tooth may be as large as possible, due regard being paid to the effect of the shape of the tip on the permeance of the path for the lines immediately encircling the slot.

It is useful to have a diagram like that given in Fig. 4. which gives at a glance the value of the permeance of the magnetic path across the mouth of the slot for different shapes of tip. This diagram is used in the following way :—

Suppose that g, the mouth of the slot, is to be 0·35 of b, the width. At the point 0·35 on the horizontal scale erect a perpendicular, as shown in the figure. If it has been decided provisionally that the apex of the angle α shall lie on the centre line of the slot, this perpendicular is drawn to meet the line OA, and the shaded area then gives us a picture of the tip. As the perpendicular is one-half of the abscissa, we can judge at once whether the dimension p is or is not too small to punch well. Now, carrying up the perpendicular (as shown by the dotted line) until it cuts the curve A′, we get an ordinate which gives

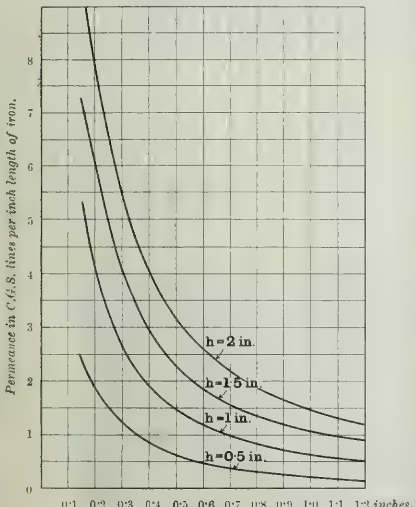


FIG. 5.—MAGNETIC LEAKAGE ACROSS BODY OF SLOT.

us the value of the permeance of the path across the mouth of the slot. For instance, in the case taken in the figure there would be 2·5 C.G.S. lines across the mouth of the slot for every inch length of core, for every $10/4\pi$ amperes carried by the slot. This is so whatever may be the size of the slot, the permeance only depending on the facts that we have assumed—viz., the position and slope of the line OA and the ratio g/b.

In order to get the total permeance of the slot the values obtained from Fig. 4 must be added to the permeance of the path across the slot from one parallel side to the other. This can be conveniently found from the curves given in Fig. 5. Thus, with a slot 0·6 in. wide and 1·5 in. high, we find from the curve marked $h=1{\cdot}5$, taking the abscissa 0·6, that there is a leakage of 1·87 lines across each inch length of slot for every $10/4\pi$ amperes carried by the slot. These curves assume that winding on the slot extends to a point distant $b/4$ from the mouth of the slot.

Thus, from Figs. 4 and 5, the total permeance of the slot is obtained without calculation, and the way in which the permeance changes with changes in the shape of the tip is at once seen.

If for any reason it is desirable to lower the sloping line, as in Fig. 3, then a line such as 0·2, B in Fig. 4 will be the boundary line of the tip, and the curve B′ gives the permeance of the path across the mouth of the slot. If, as in turbo machines, it is necessary to make the tip thicker at the root, the sloping line may be taken in a position such as D, C. Then the permeance is given by the curve C′. For any intermediate size or shape of slot it is easy for the eye to interpolate the point on an imaginary curve, say between the curves A′ and B′, which gives the permeance of the path across the mouth of the slot.

These curves may be regarded as supplementary to those given by Dr. Goldschmidt, p. 353, Vol. LX., of THE ELECTRICIAN, in his excellent article on the leakage of induction motors.

The curves in Fig. 4 are plotted from empirical formulæ whose form is dictated by theoretical considerations which are sufficiently obvious. For the curve A′ the leakage from the sloping face is taken as

$$2{\cdot}54 \times 0{\cdot}25 \log_e b/g$$

while the formula

$$2{\cdot}54 \times \frac{1{\cdot}5}{\log 2p/g}$$

is found to give very closely the leakage from the lip p. In plotting curves B and C the same values of the leakage from the sloping face can be taken for any given value of g, and the leakage from the lip can be calculated as above.

EQUITABLE RATE MAKING.*

At a recent meeting of the Missouri Electric, Gas, Street Railway & Water Association Mr. C. W. Hough read a Paper with the above title, in which he showed the method of arriving at the Doherty readiness-to-serve system of rates. He said that before deciding on a rate schedule for any central station the costs should be carefully analysed. The theory is that each customer should pay his proportion of expense and profits for the service rendered. The total cost to the consumer is not a simple item, but can be divided approximately into four parts, represented by a consumer's charge, a capacity charge, an output charge and profit. Mr. Hough took as a basis of income and expense the statistics given by the last United States census report (1902) on the electrical industry. An analysis of the income and expense of all the purely electric private stations in the United States showed that of the gross income the total expense was 80 per cent. and the surplus 20 per cent. of the gross income. The expense was composed as follows :—

	Per cent.
Interest on bonds	16·00
Rents, Taxes, &c.	7·71
General salaries	8·00
Labour	20·87
Rent of power	3·00
Fuel	15·50
Freight	1·46
Oil and waste	0·95
Incandescent lamps	2·20
Carbons	1·40
Arc globes	0·23
Miscellaneous supplies	2·68
Total	80·00

These items should be distributed as correctly as possible into three items—consumer's charge, capacity charge and output charge. The consumer's charge should cover cost of reading meters, making out bills, collecting, and all costs which vary with the number of customers. The capacity charge should cover bond interest, general salaries, general expense and all items of expense due to the capacity of the station. The output charge should cover operating supplies, fuel, oil, waste, engineers, firemen and all expense dependent upon the output of the station and profit. The author then proceeds to apportion the above items, making the consumer's charge 5·41 per cent., capacity charge 34·51 per cent., and output charge 60·08 per cent. These proportions will vary with every plant, and the above figures are merely used as an illustration, for they represent the average results as shown by Government reports.

The output of the 80 private stations of Missouri for the year 1902 was 49,756,499 kw.-hours, with a dynamo capacity of 27,714 kw., or a load factor equivalent of 1,800 hours' use per year or five hours' use per day. The income from sale of energy was equivalent to about £16 per kilowatt of plant capacity per year, or a net income

* Abstracted from the "Electrical World."

per unit of 2·1d. ; but as the lost and unaccounted for current was approximately 30 per cent. the rate charged was 3d. per kilowatt-hour.

To determine a "readiness-to-serve" rate schedule equivalent to 3d. per kilowatt-hour the proportions previously determined were applied, giving a consumer's charge (5 per cent.) of 0·15d., a capacity charge (35 per cent.) of 1·05d., and an output charge (60 per cent.) of 1·8d. The consumer's charge is usually fixed arbitrarily at $1 per customer per month. This can be lowered as the number of customers increases and the expense per customer decreases. The "readiness-to-serve," or capacity, charge is 1·05d. per kilowatt-hour for five hours' use per day, which is equivalent to $3·15 per month of 30 days per kilowatt of connected load. The "readiness-to-serve" charge is usually based on a 16 c.p. lamp equivalent. The kilowatt-hour charge is 1·8d. for all current used as registered by the meter. As it is usual to allow a discount of 10 per cent. from the gross bill for prompt payment, it is necessary to add this to the rate for output. This makes the rate 2d. per kilowatt-hour.

This rate schedule, as expressed to customers, will take the following form: Four shillings per month consumer's charge, plus 7·5d. per 16 c.p. lamp or equivalent connected load, plus 2d. per kilowatt-hour for current used as registered by meter, less 10 per cent. discount for payment by the 10th of the month. On this schedule the rates per kilowatt-hour for different hours' use per day are as follows: one hour per day, 7·25d. ; four hours per day, 3·3d. ; 24 hours per day, 2·22d.

From the foregoing any central station can take its own items of cost as a basis and work out a readiness-to-serve rate which will be approximately correct, and will be equitable to the central station and to the consumer. The author, in conclusion, said that a trial of this rate system will convince any central-station manager that it is the most equitable and satisfactory system yet devised.

THE ELECTRICITY SUPPLY STATIONS OF THE NEW YORK EDISON COMPANY.

In recent issues we have described the electric supply undertaking of the Commonwealth Edison Co. of Chicago. The almost unparalleled growth of the demand for electric power in that city is to some extent re-echoed by the experience of the New York Edison Co. When, in October, 1901, supply was commenced from the Waterside station No. 1 of this company it was believed that the generating plant capacity of 64,000 kw. for which provision was made would prove ample to meet all demands for electrical energy for many years to come. But so rapidly did the load increase that a second, and larger, station had to be erected within a few years, and it was only with difficulty that plant could be installed rapidly enough to supply the requirements of the company's consumers. A comparison of the two Waterside stations is interesting as showing the evolution in power station plant within only a few years.

Waterside station No. 2 was placed in operation in November, 1906, and the last unit was installed in Waterside station No. 1 in 1907. The difference in the design of both stations may be briefly summarised as follows: Waterside station No. 1 was originally designed for sixteen 3,500 kw. engine-driven units. The equipment actually installed consists of eleven 3,500 kw. steam engine-driven units, and three 10,000 kw. and two 5,000 kw. vertical turbine units. The boiler room contains 56 water-tube boilers, 19 of which are fitted with inclined-grate stokers and eight with superheaters. The boilers are arranged in two double-decked rows, one on each side of the boiler room, 14 in a row, or 28 on a side. A view of the engine-room of Waterside Station No. 1 is given in Fig. 3.

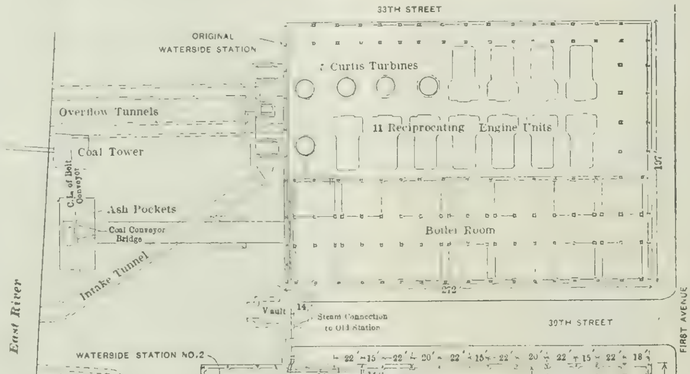


Fig. 1.—Plan View of Waterside Stations of the New York Edison Co.

Waterside No. 2 at present contains six 8,000 kw. vertical turbo-generators, two 7,500 kw. horizontal turbine units, and one 14,000 kw. vertical unit; another 14,000 kw. vertical unit being installed this year, completes the equipment of the station. The boiler room contains 96 water-tube boilers, each rated at 650 H.P. The boilers are fitted with superheaters and are arranged upon the cross-fire room plan. The two stations adjoin one another, as seen in the view from the river (Fig. 2), and in the plan (Fig. 1) showing the lay-out of the two stations. Architecturally, the newer building is somewhat more ornate and pleasing in appearance than the older station. A base of granite extends to the height of the second storey, above which rise red brick walls surmounted by a terra-cotta cornice. All the wall and dormer window trimmings are of terra-cotta, while the roof monitors have a copper finish. The structure is fireproof throughout. Brick and concrete have been used in connection with the steel skeleton. The boiler room and turbine room floors are of very heavy construction, designed for uniform loads up to 600 lb. per square inch. In addition, the structure carries on the boiler-room side five large bins capable of holding 20,000 tons of coal. The bins are of reinforced concrete construction with vertical stiffeners of I-beams embedded at intervals.

The interior finish of the No. 2 station is worthy of mention. The entire exposed surfaces of the walls of the operating room, from the level 25 ft. above the finished basement floor up to the underside of the roof arches, and the exposed surfaces of the walls enclosing the high-tension switchboard room on the third mezzanine floor are fitted with "Grueby" glazed faience tile. The wainscoting or base from the operating-room floor up to the level of the first mezzanine floor is built out 8 in. beyond the face of the walls above and two shades of green tile are used; the ground being of a dark shade and the panels of a lighter shade of green. From the space between the top of the wainscoting up to the underside of the crane girders, the

ground is of flat gray with panels of purple. The space between the top of the cornice under the crane girders up to the underside of the roof arches is finished in white tile. The pilasters, pediments, architraves and the continuous ornamented cornice under the crane girders for both sides and end of the operating room are finished in gray glazed faience. The walls of the high-tension switchboard room, on the third mezzanine floor, have a white tile ground. The

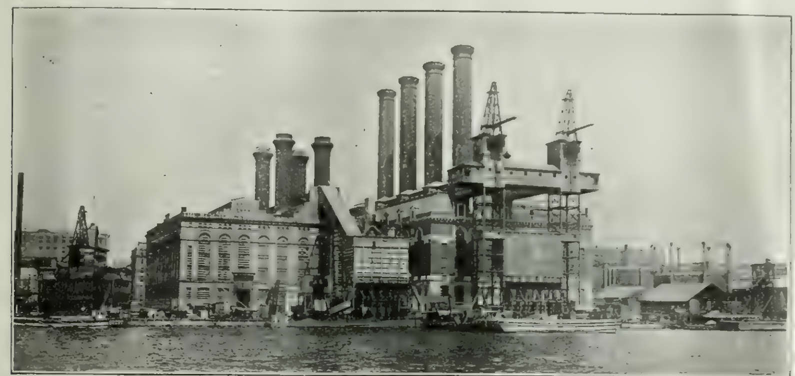


FIG. 2.—VIEW OF WATERSIDE STATIONS OF NEW YORK EDISON CO.

flooring of the main entrance vestibule, entrance lobby and the stair elevator hall on the main floor under the westerly mezzanine galleries is finished in white marble mosaic with a decorative border of coloured marble mosaic of a Greek fret design. A seal or monogram of the company, about 30 in. in diameter, executed in coloured mosaic is placed in the centre of the floor of the lobby. The surface

FIG. 3.—ENGINE ROOM OF WATERSIDE STATION NO. 1.

of the walls, columns, pilasters and piers, and the door and window jambs and trim and room and bases of the vestibule, entrance lobby and the stair and elevator hall are finished in marble. The entire area of the floor of the high-tension switchboard room, on the third mezzanine floor, is covered with an interlocking rubber tile.

From the above it is evident that much thought has been given to make the interior of the station as finished in appearance as any high-class office building, and the traditional power house is as different from Waterside station No. 1 as a hut is from a palace.

Coal and Ash-handling Apparatus.—The [illegible] boilers in the station, of which an elevation is given in Fig. 4, will require at periods of maximum demand an average of 150 tons of hard coal per hour, which is delivered to them from steel and concrete bunkers over 80 ft. above the ground. Five bunkers extend across the full width of the building and alternate with the four smoke-stacks on the same horizontal centre line. The three intermediate bunkers have a single large bin holding 5,000 tons of hard coal without trimming, and two small side bins have a capacity of 300 tons of coal. The end bunkers contain approximately 3,200 tons of coal, giving a total storage capacity of about 20,000 tons. The bituminous coal is delivered in boat loads of about 800 tons each, and the small quantity for which storage is provided is used chiefly in the stokers and for mixing with the buckwheat coal used in the hand-fired boilers.

The bunkers are filled by 3-ton automatic dump cars travelling in a continuous circuit on loop tracks that provide two lines parallel

to the axis of the building and extend beyond the power house to the top of the coal tower. The tracks are near the centre line of the building, are about 120 ft. above ground and are carried from the river end of the building to the hoisting tower on a deck-plate girder bridge having a span of about 90 ft. Soft coal is delivered on the same tracks as the anthracite coal and dumped in the bins at the front end of the building. Two hand-operated distributors receive the soft coal as it drops from the cars overhead and direct it to various parts of the front bin so that the bunker is well trimmed. At present the semi-bituminous coal used with the anthracite coal in the hand-fired boilers is brought to the boilers in barrows and mixed in the proportion of 20 per cent. bituminous with 80 per cent. buck wheat by the fireman. It is proposed to effect this mixing in the bins overhead by unloading soft coal and hard coal at the same time and timing the cars so that four cars of anthracite will dump over each car of semi-bituminous coal. Intimate mixture is not required, so that the plan should give the desired result.

The coal is hoisted from the boats by the clamshell buckets at one operation to the maximum height. The hoist of about 180 ft. is believed to be the highest of its kind that has yet been attempted, and each of the two $1\frac{1}{2}$ cub. yd. buckets is calculated to make two trips per minute, thus giving a total capacity of 360 tons per hour. The buckets are suspended from a trolley running on a horizontal arm of the stationary jib, about 40 ft. long, and operated by a Rawson & Morrison hoisting engine with two drums, one for lifting and the other for closing. The arrangement of coal pockets is shown in Fig. 5.

All the machinery in the tower is operated by steam, and the coal hoisting and conveying requires six men. The number required for handling the ashes is variable. The ashes are removed from the ash pits through chutes emptying into cars running on tracks beneath the ash hoppers. The cars are 6 ft. long and hold from $1\frac{1}{2}$ cubic yd. to 2 cubic yd. They run on a 2 ft. track, and are pulled by storage-battery locomotives (*see* Fig. 6) operating at 80 volts, 44 cells being employed. Three locomotives are at present in use, one of which is kept in reserve. The ash conveyor is of the overlapping gravity-bucket type. The ashes are dumped from the cars into a hopper, and the conveyor discharges them into an ash pocket through a movable dumping block. At present there is being erected a double skip hoist for disposing of the ashes. The ashes will dump from the cars inside the building into a loading hopper large enough to take two or three carloads of ashes. The skip hoist will be operated by a 35 H.P. 240 volt direct-current motor and will dump the ashes into the ash storage bin at present used. It is expected that by this means labour and maintenance costs can be reduced. The bucket conveyor will then be held in reserve.

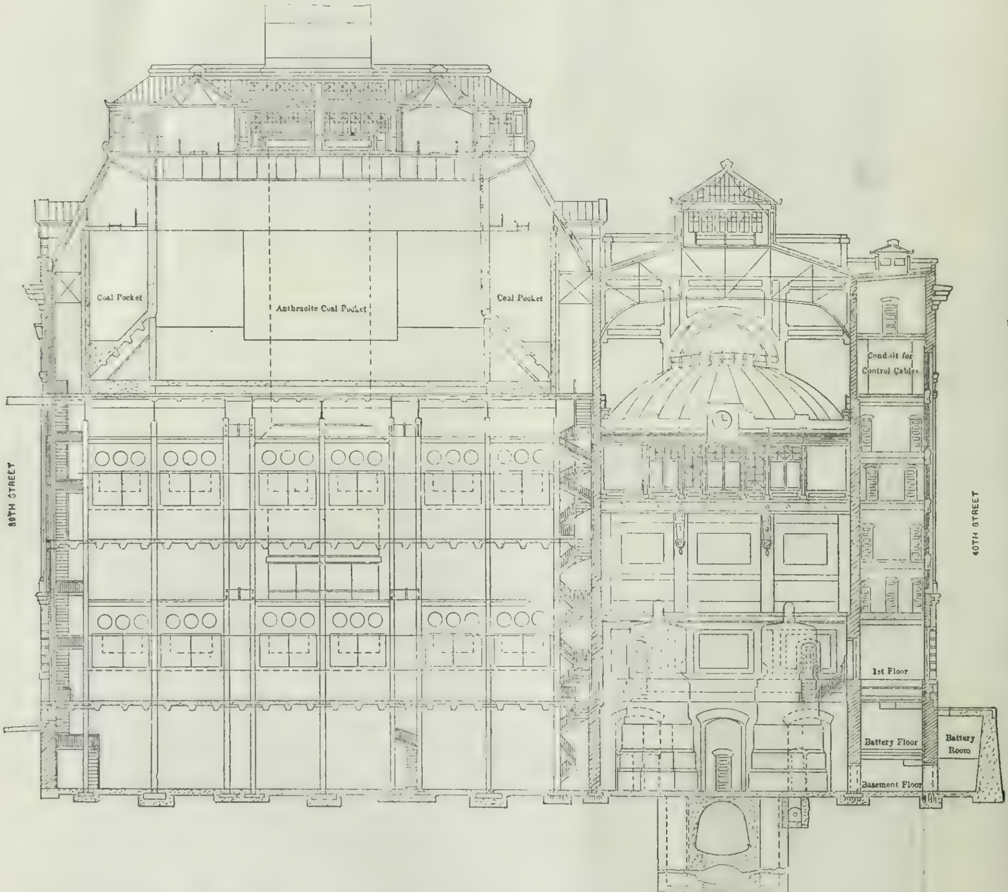


FIG. 4.—CROSS-SECTIONAL ELEVATION OF WATERSIDE STATION NO. 2 OF THE NEW YORK EDISON CO.

Boilers.—The boilers installed are all of the water-tube type, built by Messrs Babcock & Wilcox. Space is provided for 48 boilers on each boiler floor, or 96 boilers in all. There are upon each floor three main firing rooms, each having a row of three batteries of two boilers each on either side, and at either end of the building a half firing room with a single row of six boilers. This arrangement permits the use of four chimneys, each of which serves 24 boilers. Where the boilers are hand-fired, shaking grates are employed and two firemen are allotted to three boilers, each man firing about 11 to 15 tons of coal per eight hour shift. It is found that the type of shovel used in

throwing the coal bears an important relation to the efficiency of the firemen. With the deep grates, the angle of the shovel makes a great difference in the ease with which the fuel can be spread over the fire. The men normally hold the handle of the shovel horizontally and the angle the blade makes at that time determines the proper spreading

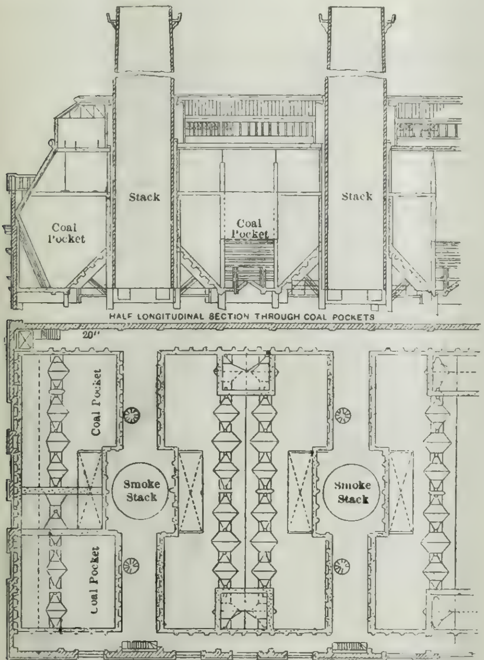


FIG. 5.—ARRANGEMENT OF COAL POCKETS.

of coal on the fuel bed. The shovel found to give best results has a handle 27 in. long. The angle is such that with the scoop resting level with the floor the end of the handle is 19 in. above the floor. Heretofore the handle was 25 in. above the floor. With a grate not so deep, so flat an angle would not be required. It is, of course,

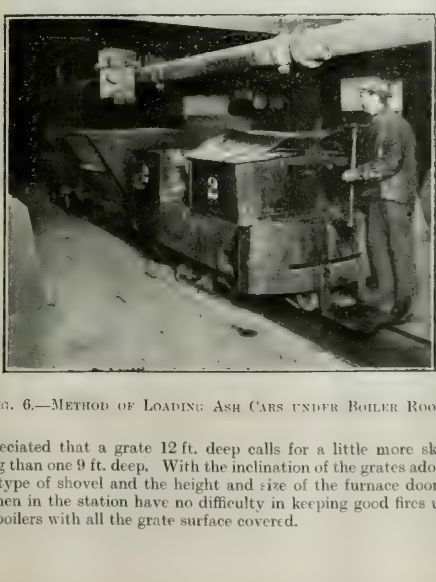


FIG. 6.—METHOD OF LOADING ASH CARS UNDER BOILER ROOM

appreciated that a grate 12 ft. deep calls for a little more skill in firing than one 9 ft. deep. With the inclination of the grates adopted, the type of shovel and the height and size of the furnace door, the firemen in the station have no difficulty in keeping good fires under the boilers with all the grate surface covered.

Twelve of the boilers are fitted with underfeed stokers of the Taylor type. The stoker consists of an inclined grate made up of air-perforated tuyeres, which are simple cast-iron plates laid up in steps. Between each row of tuyeres are two cylindrical rams, the upper ram receiving the coal from the hopper and the lower ram feeding only coal and partially consumed coke delivered from the upper ram. The two rams move in unison, the upper one deriving its motion from a geared crankshaft at the front of the hopper, and the lower ram from the connecting rod of the upper. The travel of the upper ram is fixed, being about 10 in., while that of the lower ram is adjustable to suit the conditions due to handling coals of varying ash content. In practice the stroke of the lower ram is about 2 in. to 3 in. The lower end of tuyeres rests on a rectangular box which acts as a support, and also as an air box, connecting all the tuyere rows to a common source of air supply. From the lower or back end of this box is hinged the segmental, sectional dump plates, operated by levers from the boiler front. This plate is unperforated, as combustion is supposed to be complete by the time that sufficient ash has accumulated to require dumping. The operation of the stoker is as follows: Coal is fed between the several rows of tuyeres from the hopper, meeting in its

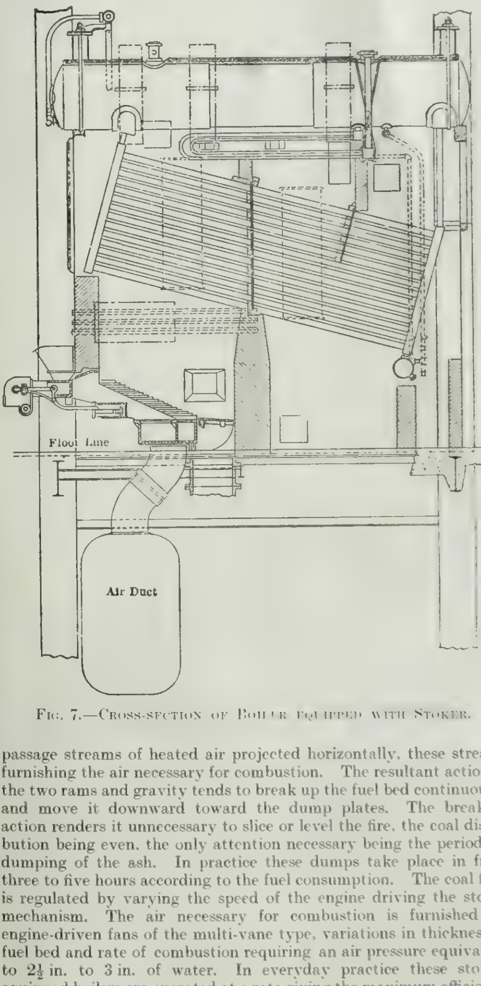


FIG. 7.—CROSS-SECTION OF BOILER EQUIPPED WITH STOKER.

passage streams of heated air projected horizontally, these streams furnishing the air necessary for combustion. The resultant action of the two rams and gravity tends to break up the fuel bed continuously and move it downward toward the dump plates. The breaking action renders it unnecessary to slice or level the fire, the coal distribution being even, the only attention necessary being the periodical dumping of the ash. In practice these dumps take place in from three to five hours according to the fuel consumption. The coal feed is regulated by varying the speed of the engine driving the stoker mechanism. The air necessary for combustion is furnished by engine-driven fans of the multi-vane type, variations in thickness of fuel bed and rate of combustion requiring an air pressure equivalent to $2\frac{1}{2}$ in. to 3 in. of water. In everyday practice these stoker-equipped boilers are operated at a rate giving the maximum efficiency of the combined boiler and furnace, the normal variations of load being met by the boilers equipped with hand-fired furnaces. There is, however, a large margin of capacity available in the stoker-equipped boilers to meet abnormal demand. Fig. 7 shows a sectional elevation of a boiler equipped with the stoker.

(*To be continued*)

ELECTRICITY IN BUILDING OPERATIONS.

Summary. A description is first given of the application of the electric drive to the machinery employed by builders and contractors, typical installations being illustrated. The opinions of a few building contractors as to the advantages to be obtained by the use of electric power are then put forward, and finally the position of the electric supply authorities in various towns is outlined, as indicated by the prices charged for electrical energy and the provisions made for hiring-out electric motors.

Introductory. By far the larger part of the output of the electricity supply undertakings of this country is at the present time devoted either to the lighting of private or public buildings or the use of small motors for the various purposes required in connection with shops, office blocks and similar buildings. Engineers who are interested in the development of such electricity supply undertakings will not need to be told that the greatest factor in securing an increased load is the careful attention which is necessary in order to get a light and power proposition before the people interested in building extensions at such an early date that opposing interests have not had time to fully awaken to the situation. To this end in the electric development of new buildings, which is by far the most promising field in our urban areas of supply, the co-operation of the architect and the builder is eagerly sought, and from these considerations it is apparent that the importance of an electrical engineer being in evidence at the genesis of a building is of the first magnitude.

Although a great deal of attention has been paid to the advancement of the interests and claims of electricity among builders and contractors, and also among architects, it is not quite certain that at the present date the former class, at any rate, are fully awake to the advantages which are attendant upon the supply of electricity, and it is therefore worth while making an examination as to the present position of electricity in relation to building operations. It is evident that if the building contractor can be shown that the introduction of electricity is to his advantage in his work, the key to a very important situation will have been obtained. It is, therefore, proposed here to make reference, under various heads, to the machinery which is used by builders and contractors, and to illustrate the way in which electricity can be, and is, most conveniently supplied to such machines. It is then proposed to give the experience of one or two builders and contractors in regard to electrically-driven machinery, and also particulars as regards prices and conditions under which a supply is given for temporary purposes by various Corporations and private undertakings. Arising out of this, it will be interesting to note the extent to which contractors avail themselves of electricity supply for temporary work, and to detail the objections which at present stand in the way of the more general adoption of electric power for this class of work. In order to complete the subject it will also be necessary to give some indication as to the general extent to which electric supply companies or Corporations lay themselves out in order to push this part of the business.

Machinery Used.

With regard to the machinery employed in building operations, it will be found that the principal classes of plant used by building contractors in carrying out temporary work consists of mortar mills for grinding the materials used in brick buildings; pumps, where deep foundations have to be made and where the ground is particularly liable to be flooded, as on a clay soil; hoists and derrick cranes, for elevating materials to a height, this class of plant becoming increasingly important in the case of large and high buildings such as office blocks; stone dressing plant and stone breakers, and, less frequently, air compressors, for use in lifting water, providing air pressure for caisson sinking or other purposes.

Until comparatively recently the whole of the above classes of plant appears to have been steam driven, with a very few notable exceptions, but it is nowadays recognised that a much more economical method of drive is secured by means of electric power. In addition to the saving in driving costs, there are advantages which cannot be tabulated under the headings of pounds, shillings and pence, but are of considerable moment to a contractor who is anxious to obtain best results.

Mortar Pans.—The economies effected by using electricity in a mortar pan are most real. They are accounted for partly by the difference between the cost of coal and of electricity (as now supplied) as a driving force. In addition to this, steam power requires one man always in attendance at his engine, whereas an electric motor requires practically no attention. This is of exceedingly great importance in long runs such as are taken by mortar pans. In the case of electric supply there is no question as to getting a suitable supply of water, nor is there any danger of fuel or water running short. No time is wasted in getting up steam, there is no banking up of fires during the dinner hour, and no cleaning of engines after the day's work is done.

A recent instance of electrical working may be quoted. In connection with the construction of the new Home Office buildings, near the Houses of Parliament, London, two mortar pans were in operation simultaneously, doing exactly the same amount of work. One pan was driven by steam and the other

Fig. 1.—Electrically-driven Mortar Mill and Hoist.

by electricity current being supplied from the mains of the Westminster Electric Supply Corpn. An accurate comparison could, therefore, be made as to the result on the basis of 50 hours' work per week. It was found that the steam-driven pan cost £2 for coal and £2 for labour, whereas the total cost in connection with the electrically-driven pan for the same period was 25s. It was estimated that by the adoption of electricity in this one particular case there was a saving of from £10 to £12 per week in the erection of the building, without taking into account any other of the advantages of the electric drive.*

These advantages may be summarised as follows: An electric motor can be quickly moved as work proceeds; it can be used in positions where engines are impossible; it needs a minimum of attention; there is safety from fire or explosion, and a steady and reliable drive is provided. In order to get an idea of the amount of power required for this class of work, the following figures are useful. They are provided by Barrows & Co., of Banbury, who manufacture under-geared mortar pans, with revolving pans on steel girder

*For full particulars see The Electrician for Sept. 30, 1904, p. 944.

frames. It is claimed that these pans take less power than stationary pans in which the rollers are rotated by the upright shaft, that the work is more steady and the gearing is less strained. The brake horse power required for a 6 ft. diameter pan underdriven mortar mill is 10 B.H.P.; a 7 ft. diameter pan requires 15 B.H.P., and an 8 ft. diameter pan 20 B.H.P. The 6 ft. pan revolves at 23 revs. per min., the pulley speed being 122, diameter 2 ft. 6 in.; the 7 ft. pan revolves at 17 revs. per min., the pulley speed being 180 revs. per min., diameter 3 ft.; the 8 ft. pan revolves at 15 revs. per min., pulley speed 100 revs. per min., diameter 3 ft. 6 in. These particulars show how simple a matter the electric driving of a mortar mill becomes, a normal belt-drive being all that is necessary.

Fig. 2.—Electrically Driven Continuous Concrete Mixer.

By the courtesy of the city electrical engineer of Sheffield (Mr. S. E. Fedden), and of Messrs. Clarke Chapman & Co., of Gateshead, we are able to show, in the accompanying Fig. 1, an electrically-driven mortar mill and material hoist which was used in the erection of the new Hippodrome in that city, both of which constitute very interesting applications of the electric drive. An incidental advantage of having an electricity supply service in this building was that, on this contract there was a considerable amount of night work, and building construction was illuminated by flame arc lamps.

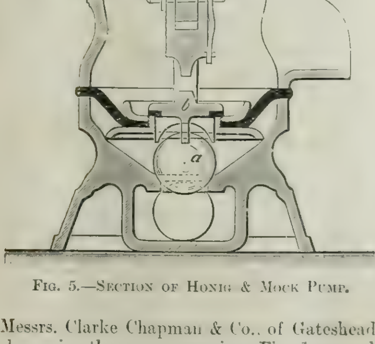


Fig. 5.—Section of Honig & Mock Pump.

Concrete Mixers.—In the newer developments of building construction, such as the use of concrete steel, the sphere of the concrete mixer, is becoming increasingly important, and some particulars of the electric drive supplied to these machines may be interesting. Fig. 2 illustrates a concrete mixer of the Carey-Latham type, capable of an output of 20 cubic yards per hour. The machine shown is driven electrically.

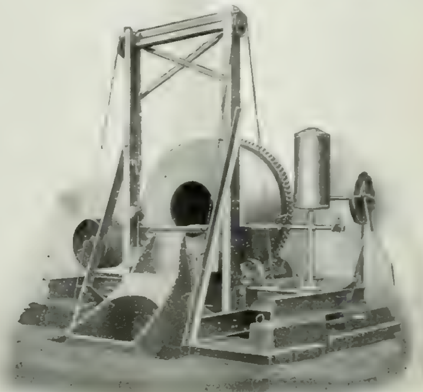


Fig. 3.—Concrete Mixer with Intermittent Delivery.

Fig. 3 illustrates another type of mixer having an intermittent delivery, constructed by Messrs. Ransomes Ver Mehr. The drum, mounted on rollers, is revolved at from 14 to 16 revs. per min. and is fitted with a series of blades which intermix the material, and, when these are in a sufficiently mixed condition, feeds the mixed concrete through the discharge shoot without stopping the machine. It will be seen that in this design the motor drive is incorporated, and this is a very

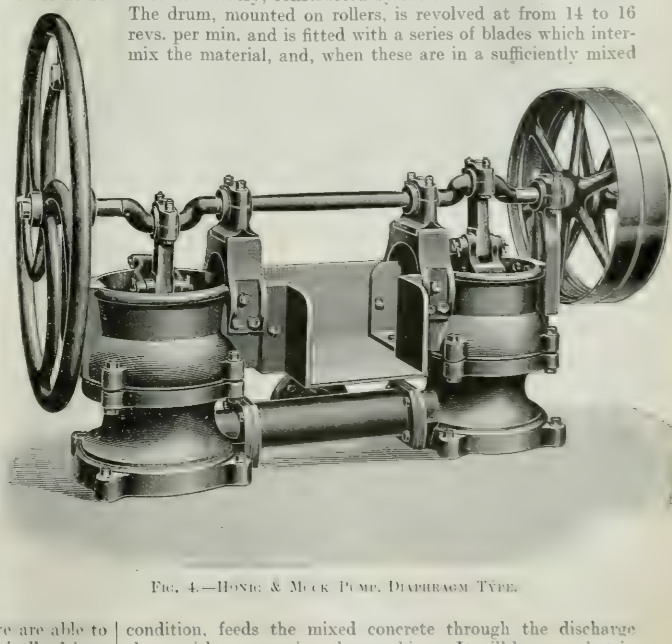


Fig. 4.—Honig & Mock Pump, Diaphragm Type.

encouraging symptom of the demand for electrically-driven builders' machinery.

PUMPS. Pumps used by builders must be of a type capable of passing suspended material together with the water, whether the pumps be used for surface water or deep well work; and in order to typify the requirements of surface work we may illustrate the class of pump manufactured by Honig & Mock (Ltd.), of London. These are of the diaphragm pump type, and are either single or double acting. Fig. 4 shows a general view and Fig. 5 a section of this pump, operated by mechanical power. Such pumps must be slow acting, and their speed range can be gauged by the fact that a pump of 14,000 gallons per hour, discharging through a 4 in. pipe, runs at about 50 revs. per min. The power required by such a pump depends very largely upon the lift and head required, as there is very little internal friction, the diaphragm being of rubber, and a very short stroke being used.

Messrs. Duke & Ockenden, of London, who specialise in water supplies, have supplied centrifugal pumps for the electric drive to a considerable extent for builders' purposes. They also use electric drive for pumping operations for buildings where wells are, by reason of space available, placed down in the basement. Belt drive is preferable in these places, but

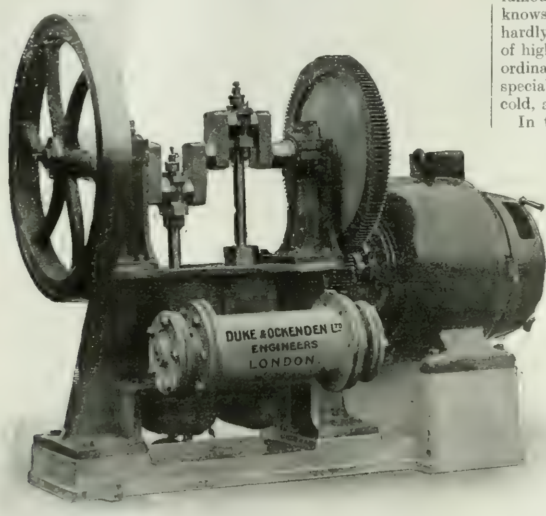


FIG. 6.—MOTOR-DRIVEN COMPRESSOR.

in places where space is somewhat cramped, worm drive is used. As an example of a compressor pump, Fig. 6 shows the type of motor-driven compressor which is useful for this purpose. This particular example is a two-stage compressor with a 7 H.P. electric motor attached, used for filling air reservoirs to a pressure of 200 lb. per square inch.

As a further example of electrical pump drive for building purposes may be mentioned an installation fitted by Alfred Williams & Co., of Artesian Works, Bow, at Mansion House-chambers, near the Bank of England, London, for the purpose of raising water from an artesian well. The pump is noiseless, being electrically-driven, with a worm and worm-wheel reduction gear, running in an oil bath. The working barrel is lowered down the bore hole to a depth of 250 ft. It delivers 1,000 gallons per hour into a 12,000 gallon reservoir in the basement of the building, and, by means of a set of three-throw electrically-driven pumps, the water is then forced up into tanks on the roof of the building The pumps start and stop automatically. The supply of current is taken from the City of London Electric Supply Co. It is evident that in buildings where a permanent pumping installation of this sort is contemplated, or indeed where the application of motive power of any sort is intended, it is much to the advantage of the supply authority to negotiate with the building contractor for a temporary service for his own purposes on very reasonable terms.

(To be continued.)

PRODUCTION OF IRON AND STEEL BY THE ELECTRIC SMELTING PROCESS.*

BY E. J. LJUNGBERG.

For making steel of ordinary quality the electric method still seems to be too expensive, even where cheap water power is available. At Gysinge, one of the works belonging to the Stora Kopparbergs Bergslag, there is one Kjellin induction furnace with a capacity of 2 tons, but as this is working as a Talbot furnace, not more than about 1 ton at a time is tapped. The continuous current used in this furnace represents about 200 kw., and the output in 300 days amounts to about 1,200 tons of ingots using 50 per cent. pig and 50 per cent. scrap. As no other pig iron is used except the famous Dannemora brand made by the firm, which, as every one knows, is extremely low in phosphorus and sulphur, the process can hardly be called a refining process. The product is a carbon steel of high quality, possessing some superiority over steel made by the ordinary melting processes, the quality which I would instance specially being that it is comparatively soft to work, either hot or cold, although high in carbon. It is a superior carbon tools teel.

In the electric furnace, as well as in the crucible plant, there are also produced, among different kinds of special steel, high speed self-hardening steel, tungsten steel, chromium steel, and nickel steel. Such steels can easily be made in electric furnaces when the necessary care is taken. For a country like Sweden, possessing practically no coal mines, but numerous waterfalls, the manufacture of iron and steel direct from ore by the agency of the electric current is of much more interest than the melting of pig and scrap to make steel. At the works at Domnarfvet extensive and costly trials have therefore been made in the direct reduction of ore during this and the past few years.

In these experiments two modifications of a furnace, constructed by Mr. Wallin in Berlin, and several modifications of a furnace, constructed by Messsrs. Grönvall and Lindblad (the Electro Metal Company), Ludvika, have been tried. The accompanying diagram shows the latest form of furnace, similar to a common blast furnace but with three electrodes fed by three-phase alternating current at about 40 volts, 60 cycles, and 9,500 amperes, averaging 674 H.P., instead of tuyeres. In this furnace, which has been running for 1,903 hours, there have been produced 28 tons of iron, containing from 0·95 to 3·09 per cent. of carbon. In the manufacture of this iron there was used: Ore 442 tons, lime 24 tons, coke 41 tons, charcoal 58 tons, electrodes (including wasted ends) 6·5 tons, and electric current 891,623 kw.-hours.

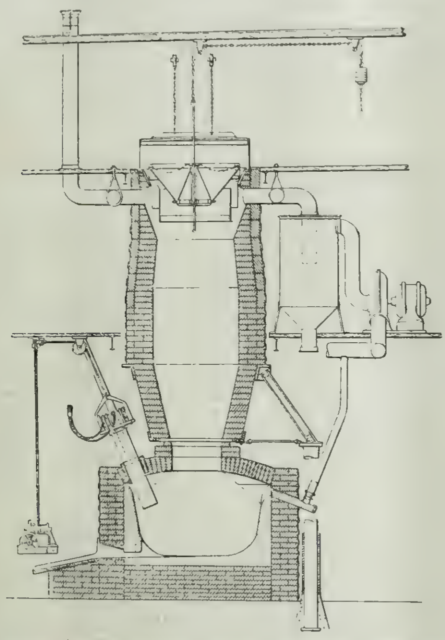
The temperature of the escaping gases from the furnace is generally very low, and the gases contain on an average about 22 per cent. of carbon dioxide (from 8 to 41 per cent.). The amount of carbon monoxide varies from 39·4 per cent. to 61 per cent. The gases contain practically no nitrogen, but steam from the water in the ore, lime, coke or charcoal is present. The efficiency of the electric current ought to be higher than hitherto, if the considerable loss of heat by cooling water and radiation can be reduced. These losses seem to be about 30 per cent.

The diagram shows a vertical section through the furnace, which consists of a lower portion or smelting chamber, corresponding to the hearth of a blast-furnace, and a top section or shaft. The latter is supported on columns, which prevent any weight from bearing on the arch of the smelting chamber. The latter is so proportioned as to provide a considerable amount of free space between the charge and the arched roof through which the carbon electrodes project into the charge. The brickwork is thus protected against any very

* Abstract of a Paper read before the Iron and Steel Institute.

high temperature, and remains a non-conductor of electricity. This is an important feature of this furnace, since experiment has shown that if the electrodes enter the chamber at the point where the charge touches the walls, a very high temperature is generated at this point; the brickwork is destroyed and becomes a conductor of electricity, giving rise to a more or less complete short-circuit. The brickwork may be further cooled by means of a blast of cool gas taken from the top of the furnace and blown in round the electrodes with a fan, no heat being lost by this proceeding.

The ore and fuel are crushed to a suitable size, and are fed into the top of the furnace through the bell hopper in the usual way, the ore being partially reduced by the carbon monoxide rising through the charge. The latter spreads out in the smelting chamber as



VERTICAL SECTION THROUGH ELECTRIC FURNACE AT DOMNARFVET.

shown, and the reduction is there completed. Since the electrodes project well into the charge, the highest temperature occurs in the centre of the latter and the brickwork is thus kept cool compared with the walls of an ordinary blast furnace. It will be seen from the figures given above that a step has been taken in the direction of replacing a considerable part of the fuel used in making iron and steel by the electric current, and that the problem is technically solved. As regards its commercial value, it is too early to make any definite statement yet.

THE METAL TUNGSTEN AS "VALVE" ELECTRODE.*

BY L. H. WALTER, M.A.

Summary.—It is here shown that the metal tungsten, like aluminium and tantalum, behaves as a valve electrode in a large number of electrolytes, those which have been tried being for the most part of high conductivity and less adapted to the securing merely of high critical voltages. The critical voltages in the strong acids are as a rule higher with tungsten than with aluminium, but not so high as with tantalum. The sensitiveness to heating is not at all pronounced. The sensitiveness to cutting off of the current appears, on the other hand, to be very great indeed. The great activity and considerable concentration of the electrolyte used must, however, be borne in mind.

The number of metals which show the effect known as "valve action" when used as electrodes in electrolytic cells has of recent years been considerably increased; and owing mainly to the thorough and systematic investigations of G. Schulze,* a somewhat better understanding as to the phenomena involved has been arrived at. From the two first known, aluminium and magnesium, the list has been extended until it now definitely includes quite a large number of metals. If, however, these are classified as belonging either (1) to those showing the more general behaviour—which consists in the cell developing a film offering a very high resistance to a direct current passing through it in the direction in which the metal functions as anode, and a comparatively negligible resistance in the reverse direction—or (2) to those that show the less general phenomenon, in which a similar high resistance is offered, due to a film which forms under alternating current even, during the phase which is anodic so far as the valve metal is concerned, there remain but two additional metals, viz., tantalum and niobium, which, as recent work has shown, can be classed with the original two as manifesting the true rectifying effect.

The author has now found that yet another metal, hitherto untried, gives the valve effect in a very pronounced manner; in addition, this metal, tungsten, "forms" under alternating current. The effect was first observed when making experiments with a sealed-in tungsten lamp filament used as anode in a form of electrolytic detector with sodium chloride solution as electrolyte. In the course of this work it was noticed that on raising and still further raising the polarising P.D., the characteristic "boiling" or hissing of the detector, due to evolution of gases, was entirely absent; and when it was found that 8 volts could be applied directly across the electrodes without the least "boiling" in the telephone, the similarity in the behaviour to that of the tantalum point electrode suggested that there must exist, in this case also, a marked asymmetric effect.

Experiments with Direct Current.—Experiments with a somewhat larger anode, consisting of a non-sheathed length of an inch or so of the filament from a 50 c.p. Osram lamp, with dilute sulphuric acid as electrolyte and applied voltages up to 45 volts, showed that the phenomenon was not merely an asymmetric effect due to the difference in the areas of the electrodes as in Holtz's † asymmetric cells, but was apparently a real "valve" effect. The investigation was

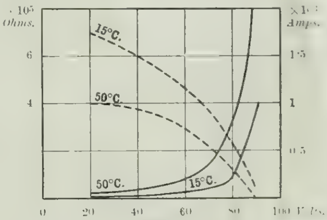


FIG. 1.

continued and extended to higher voltages. The maximum pressure obtainable at the time being 90 volts, it was found that this voltage could be withstood by the tungsten anode in sulphuric acid of 1:15 concentration (15), in potassium iodide (0·2), acetic acid (0·1), potassium bichromate (1·8), sodium potassium tartrate (0·1), and borax (1·0) solutions, none very dilute. The residual current through the cell in milliamperes after 10 seconds is shown by the figures within brackets, the area of immersed anode being 0·034 sq. cm. approximately. It was found convenient to embed the end of the filament in a plug of Wood's fusible alloy which itself formed a stopper at the top of a perforated ebonite tube that served to protect the very delicate filament from injury.

The behaviour of tungsten in sulphuric acid of considerable strength with an applied P.D. of 90 volts is of special interest, in that, were it possible to make use of this electrolyte in rectifiers with tungsten anodes, the dimensions of the cells would be able to be much reduced as compared with those of the cells usually employed, since the conductivity of the acid is so high. For this reason, although it appears probable that, as in the case of other metals, *e.g.*, aluminium and tantalum, the critical voltage is notably higher in other less active electrolytes, the first experiments were confined to the examination of the behaviour with sulphuric acid and with potassium bichromate. These are also good tests for the aluminium and tantalum: Schulze gives for the critical voltages of these two metals 45 and 190 volts respectively in sulphuric acid and 95 and 70 volts in potassium bichromate. A few other electrolytes of high conductivity were also tried, including hydrochloric and nitric acids. A table showing the milliamperes through the cell in the effective direction is given by the author in his communication.

* An original communication (slightly abbreviated) accepted by the Council of the Institution of Electrical Engineers for publication in the Journal.

* "Zeitschrift für Electrochemie." Vol. XIV., p. 333, 1908.

† "Physikalische Zeitschrift." Vol. VI., p. 480, 1905.

Owing to the fact that tungsten is at present only obtainable in the form of lamp filaments, the anode used is necessarily of very small dimensions and surface, and hence, with a view to eliminating any differences which might be due to the unequal size of the electrodes, two test cells were made up having anodes, of aluminium and tantalum respectively, of such dimensions as to offer a surface of the same order to the electrolyte, approximately 0·1, 0·15, 0·4 sq. cm. in the case of tungsten, aluminium and tantalum respectively. The lead cathodes had a surface of about 30 sq. cm., the circular containing cell measuring 3 in. high by 1½ in. diameter. With such a cell a current up to 0·5 ampere could safely be passed in the non-effective direction for short periods, the ohmic resistance being about 6 ohms. The sulphuric acid used was battery acid of density 1·200, while the potassium bichromate was approximately a 5 per cent. solution. The valve electrode was simply dipped into the electrolyte from above. While such high limiting voltages may not be reached this way as with Schulze's arrangement, the obtaining of very high critical voltages possesses only a theoretical interest, since the cell is of little practical use anywhere near the breakdown voltage.

A difficulty arises as to the representation of the results: Schulze gives curves showing the critical voltage plotted against time in minutes as abscissa. In the present case, for showing the sealing-off property of the anode, the residual current through the cell, in milliamperes after 20 seconds, is plotted as ordinate against the P.D. across the cell as abscissa.

Besides the critical voltage there are two other factors which determine the suitability or unsuitability of a valve electrode: the effect of higher temperatures upon the cell and the effect of cutting off the current. As regards the former, the effect of the temperature of the electrolyte upon the leakage current in sulphuric acid is shown in Fig. 1. The full curves give the normal current at 15°C. and at

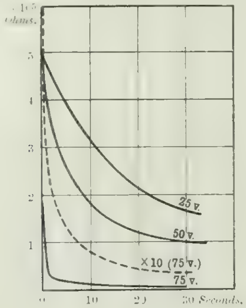


Fig. 2.

50°C. respectively, the dotted curves the respective resistances. These latter indicate very clearly where the critical voltage must lie (zero resistance) without it being necessary actually to break down the film. The usual behaviour, namely, that the leakage current is greater at higher temperatures, is observed, but the critical voltage is very little altered.

The effect of cutting off the current for shorter or longer periods can be seen in Fig. 2 for three different applied voltages, viz., 25, 50 and 75 volts, also in sulphuric acid. The points of the full-line curves which lie on the vertical axis show the normal resistances of the cell; the other points give the resistances plotted from the currents observed on remaking the circuit after the current has been cut off for times up to half a minute. At 25 and up to 50 volts it will be seen that the decrease of resistance of the anode film, though fairly rapid, is of a different order from that which occurs at 75 volts. It is interesting to observe that if the curve for 75 volts is reproduced with ordinates all multiplied by 10, the curve so obtained (dotted curve of Fig. 2) is very similar in shape to those for the lower voltages.

Experiments with Alternating Current.—But few experiments have as yet been made with the cell on alternating current. The first trials with an arrangement of three cells having together four anodes, which served as a bridge, showed that, using new tungsten anodes which had never previously been formed, a direct current was at once obtained on switching on the alternating supply, the applied voltage being 25 volts and the rectified current, which was passed through three accumulator cells, being 0·25 ampere. With a voltage of 25 at the direct-current (rectified) terminals and 0·043 ampere on a moving coil instrument in the same circuit the reading of a hot-wire ammeter in the alternate-current circuit was 0·13 ampere (anodic current density >4 amperes/cm.^{2}), hence the current transformation ratio as defined by Jakob,* was about 33 per cent.; this being, however, only about 1 minute after closing the circuit.

The difficulty here was that currents smaller than 0·1 ampere were not readable on the ammeter which was available. This current could be exceeded for short intervals, but owing to the small anode surface and the consequent high-current density, the heating was so great that the efficiency rapidly fell off. Now that flicker filaments are promised in the near future it is hoped to obtain results for longer periods.

In conclusion, it may be stated that, although the tungsten used is chemically metal, it can hardly be looked upon as physically in the metallic (massive) state. Tungsten having been shown to behave chemically quite differently according as it is in the fused or reguline condition, or in the state of powder—notably in the greater indifference to acids shown by the fused form—it appears probable that the metal will make a more favourable showing when it is obtainable in the drawn condition, which has already been shown to be realisable, by previously alloying with nickel.

A TUNGSTEN COMPARISON LAMP IN THE PHOTOMETRY OF CARBON LAMPS.†

BY H. E. IVES AND L. R. WOODHULL.

In the photometry of incandescent lamps the substitution method is commonly used. That is, the lamp measured is not compared directly with a standard, but with a "comparison lamp," which is carefully calibrated against a candle-power standard or standards at the beginning of a run, and at frequent intervals. It is necessary, of course, with carbon lamps to use only seasoned ones, and to keep close watch on their candle-power by checking with standards; so a tungsten lamp has been tried, operated at voltages to give carbon lamp colours, as a comparison lamp in the testing of carbon filament lamps. The object in view was to obtain a long-lived and constant comparison light which at the same time would give perfect colour match with all types of carbon lamps, and two months' experience with the tungsten comparison lamp has shown it fully to equal expectations, and to be much superior for the purpose to carbon lamps.

The details of installation are as follows:—An 80-watt 120-volt lamp was taken, and the voltages determined experimentally, at which it gave the same colour as 4, 3·5, 3·1 and 2·5 watts per candle lamps (Gem). These voltages were 79, 84, 87 and 97 respectively, corresponding approximately to 4·5, 3·7, 3·4 and 2·6 watts per mean spherical candle. Obviously the candle-power varied greatly for these different voltages. With a candle-power scale, as used on the Bureau of Standards commercial photometer, it is necessary to have the comparison lamp accurately 16 c.p. A means to accomplish this with the tungsten lamp was imperative, and was found in the use of diaphragms, since the candle-power of the 80-watt lamp at all colours was greater than 16. It was impossible to place the diaphragms before the lamp itself since the distance of the diaphragm from the centre of radiation, due to the size of the bulb, would permit an error of 3 per cent. in the candle-power readings at the ends of the scale. Two means of overcoming this difficulty presented themselves. First, an image of the filament could be formed by a lens or concave mirror, and the image diaphragmed. Secondly, a ground-glass screen could be placed in front of the lamp, and the diaphragms placed over this. The latter plan was adopted as most convenient, although it was then necessary to back the lamp with a mirror to secure sufficient light.

In order to set the lamp to give exactly 16 c.p., the same procedure was adopted as in the Bureau's work with carbon lamps. The voltage is adjusted by trial (or by knowledge from previous work) to give very nearly the correct candle-power reading. Then a number of standards are read, and from the mean deviation of the readings from the standards' true values the change in voltage which will give the correct reading is calculated. For carbon lamps (3·5 watts per candle) the percentage change is given by the relation $(V_2/V_1)^{5\cdot 6}=cp_2/cp_1$, or in the differential form, $5\cdot 6\ dV=d(cp)$. In order to follow the same plan with the tungsten lamp, it was necessary to know the voltage candle-power relation at the efficiencies used. This was obtained from data given by Mr. F. E. Cady,‡ from which it follows that from 2·6 to 4·5 watts per mean spherical candle the voltage exponent ranges from 3·8 to 4; the relationship to use is therefore $3\cdot 9\ dV=d(cp)$. By the use of this relation (actual

* "Sammlung Elektrotechn., Voriräge," IX., p. 76, 1906.

† Abstracted from the "Bulletin" of the Bureau of Standards.

‡ "Transactions," Illuminating Engineering Society, October, 1908.

numerical values are kept tabulated on the photometer table) the comparison voltage is accurately fixed.

Because of the comparatively low voltage of the tungsten lamp it has been found convenient to place in series with it an adjustable rheostat and measure voltage across the two. In this way, by placing stops on the rheostat corresponding to 3·1, 3·5, &c., watts per candle, the comparison voltage is made uniformly 100 volts, or some other convenient voltage if desired. For instance, with a run of 110-volt lamps, the voltage on each side of the photometer can be 110, and may be checked without moving from the same potentiometer post.

The tungsten comparison lamp has proved eminently convenient and practical, and after two months' daily running of from four to seven hours, chiefly at colours corresponding to 3·5 and 3·1 watts per candle, the voltage to give 16 c.p. has changed less than $\frac{3}{10}$ths of 1 per cent.

EXPERIMENTAL METHOD FOR THE ANALYSIS OF E.M.F. WAVES.*

BY P. G. AGNEW.

For obtaining a knowledge of the harmonics present in the E.M.F. wave of a generator several types of apparatus are obtainable, notably oscillographs and curve tracers, but most of such apparatus is elaborate and expensive. Of some 20 methods summarised by Orlich† all but one, the method of resonance due to Dr. M. I. Pupin, require highly specialised apparatus. Dr. Pupin‡ passed the current to be analysed through a non-inductive resistance across the terminals of which he connected a tuning circuit, consisting of a condenser and an adjustable inductance. By adjusting for resonance with any desired harmonic, and by observing the rise of potential across the condenser by means of an electrostatic voltmeter, it is possible to calculate the amplitude of the harmonic; but it is necessary to have a relatively wide range of adjutsable self-inductance and electrostatic voltmeters with a considerable range of sensitiveness.

The experiments here described were undertaken to determine whether it is possible to get an approximate value of the first and second harmonics present in an E.M.F. wave by means of ordinary portable instruments and calibrated condensers. A distorted E.M.F. wave will pass more current into a condenser than a pure sine wave having the same effective value. One ought, then, to be able to use this fact to determine the amplitudes of the harmonics to which the distortion is due. For simplicity, suppose the third harmonic only to be present, and let E be the reading of the voltmeter and I that of the ammeter. If E_1 and E_n represent the E.M.F.s of the fundamental and harmonic, then one may consider that they cause the respective currents i_1 and i_n to flow in the condenser. If C is the capacity and ω is 2π times the frequency of the fundamental, and if the resistance of the ammeter be neglected

$$E^2 = E_1^2 + E_n^2; \qquad i_1 = E_1\omega C;$$
$$I^2 = i_1^2 + i_n^2; \qquad i_n = E_n n\omega C.$$

From these four equations E_1, E_n, i_1 and i_n may be calculated. Preliminary experiments on waves, obtained by combining E.M.F.s of different frequencies in known proportions, indicated that the method was limited to the determination of one harmonic, and that it did not give good results even then. Of course, account must be taken of the resistance and inductance of the ammeter; also it is extremely difficult to obtain indicating instruments whose error is, say, not greater than 0·1 per cent., under the conditions of frequency and wave form implied.

The necessity of knowing the absolute values of the current and voltage may be avoided by substituting an adjustable resistance in place of the condenser and adjusting it to give the same readings on the ammeter and voltmeter as were observed with the condenser. Suppose that the third and the fifth harmonics are present. Let L be the total inductance and R the total resistance of the circuit, shown herewith; then the three components of current are

$$i_1 = E_1/\sqrt{R^2 + (\omega L - 1/\omega C)^2};$$
$$i_3 = E_3/\sqrt{R^2 + (3\omega L - 1/3\omega C)^2};$$
$$i_5 = E_5/\sqrt{R^2 + (5\omega L - 1/5\omega C)^2}.$$

These three currents, being of different frequencies, combine to give a resultant as though they were mutually in electrical time-quadrature with each other. The resultant current is, therefore $I = \sqrt{i_1^2 + i_3^2 + i_5^2}$. Let us choose a value of C such as to make R small, and denote by a_1, a_2, a_3, the squares of the impedances for the three components of E.M.F., or the expressions under the radical signs in the denominators above; now choose a second value of C and adjust R for the same readings of total current and total E.M.F., I and E, calling the new values of the squares of the impedances a_4, a_5, a_6. Finally, short-circuit the condenser, again adjusting R for the same readings of I and E, giving, correspondingly, a_7, a_8, a_9. Then if we put $m_1 = 1/a_2 - 1/a_8$, $m_2 = 1/a_3 - 1/a_9$, $m_3 = 1/a_1 - 1/a_7$, $m_4 = 1/a_5 - 1/a_8$, $m_5 = 1/a_6 - 1/a_9$, $m_6 = 1/a_4 - 1/a_7$, it may easily be shown that

$$\frac{E_3}{E_1} = \sqrt{\frac{m_3m_5 - m_2m_6}{m_2m_4 - m_1m_5}} \text{ and } \frac{E_5}{E_1} = \sqrt{\frac{m_1m_6 - m_3m_4}{m_2m_4 - m_1m_5}}.$$

The relations between the several component currents are clearly shown in the diagram of Fig. 2. When the relative magnitudes of the component currents are changed by altering the constants of the circuit, the vector I remains of the same length, but rotates to a new position on a sphere of radius I. The solution of the spherical triangle determined by the three positions of the end of the vector I, when the several component vectors are changed by known percentages, allows one to assign definite values to each vector. The method cannot be expected to yield reliable values of harmonics which are present to the extent of only 1 or 2 per cent. Accordingly, if in a numerical calculation a component comes out as a small imaginary quantity of the above order of magnitude, it should be taken to be zero.

Two values of capacity are required for the determination of two harmonics. It has been found by experiment that the ratios of the two values of capacity employed may conveniently lie between 1·5 and 2, for the cases of nearly sinusoidal and much distorted waves respectively. With such a ratio, and when R_1 (the first value of the resistance) is kept as low as possible, R_2 (the second value) will be, roughly, half of R_3 (the third value), thus giving good spacing. The use of good paper condensers and soft-iron ammeters will give fairly accurate results on badly distorted waves, but for good waves it is better to use standard mica condensers with a dynamometer-ammeter, and the accuracy may be still further increased if an approximate value of the phase angle of the condensers is known. The recently introduced type of thermo-ammeter has the advantage of having a negligible inductance and extremely low resistance, but the needle is so slow in assuming its final position that the supply must be very steady to get consistent readings. Yet some inductance is of advantage in that it may be used to neutralise the reactance of the condenser, and also to reduce the effect of the residual higher harmonics of which the formulæ do not take account.

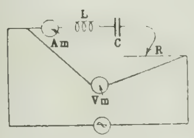


FIG. 1.—ARRANGEMENT OF TESTING CIRCUIT.

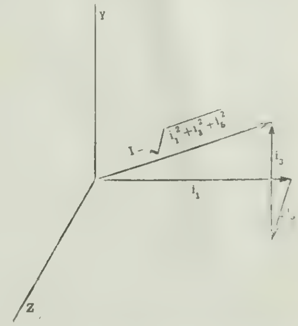


FIG. 2.—SPACE VECTORS OF COMPONENT CURRENTS.

The author then considers a few actual analyses, and sums up as follows: The accuracy of the method is intermediate between that of the curve tracer and that of the oscillograph; the error may be taken as not over 3 per cent. of the fundamental. It has the disadvantage of giving no idea of the phase relations, and hence of the form factor, and of not lending itself to the analysis of current waves, unless a considerable amount of power is available. Its chief advantages are that no special apparatus is required and that the calculations are relatively simple; also, direct access to the generator or the use of a synchronous motor is unnecessary, so that observations may be taken at a distance from the machine.

* Abstract of an article in the "Electrical World."

† Orlich, "Aufnahme und Analyse von Wechselstromkurven." Braunschweig, 1906.

‡ "Am. Journal of Science," XLVIII., pp. 379, 473, 1894.

MUNICIPAL TRAMWAYS ASSOCIATION.

PRESIDENTIAL ADDRESS ON "TRAMWAY PROBLEMS IN THE FUTURE."*

BY A. L. C. FELL.

(*Concluded from page 965.*)

Conditions of Labour.—Speaking generally, conditions of labour have vastly improved during the past 10 years. The introduction of electric traction on tramways has benefited the employés and the undertakings which we represent, healthy occupation being found for many thousands of men. An analysis of the number of passengers carried at various times on an ordinary day in London shows that there is a very high peak for a short time in the morning and another high peak, which lasts somewhat longer, in the evening. This means that a large number of cars are run only for a short time in the morning and again in the evening, and it is most difficult to cut down the spread-over time of the employés working these cars. At the present moment about 40 per cent. of the cars are not required for service between 10 a.m. and 4 p.m. In connection with many tramway undertakings the situation is saved by the fact that the tramway lines pass through the centre of the city, and a considerable mid-day traffic is available, while there is also a "mid-day meal load." Gradually, no doubt, the mid-day traffic will develop, but I am afraid that it will be a long time before a sufficient number of passengers will travel between the hours of 10 a.m. and 4 p.m. to entirely overcome the difficulty with regard to spread-over time. The only solution appears to be the introduction of a heavy goods service, worked in conjunction with railway and dock undertakings. A service of this description would be very beneficial to the tramway undertakings and to the employés, and would relieve the congested traffic in the main streets, and in many instances the necessity for street widenings would disappear.

Conciliation Boards.—It may be of interest to the members of the Association to know the steps which have been taken to form conciliation boards in connection with the London County Council tramways undertaking. The proposal made by the London County Council that conciliation boards should be formed for dealing with questions relating to rates of pay and hours of labour, and that the scheme should be formulated on the basis of that prepared by the Board of Trade for dealing with similar matters in railway undertakings has been very promptly taken up. The Board of Trade, in the first instance, issued voting papers to all employés, except those holding official positions or those under 21 years of age, to ascertain if the employés were in favour of conciliation boards. The result of the voting was a large majority in favour of the proposal. A certain number of men refrained from voting for reasons best known to themselves, but even if all those who did not vote had voted against the proposal there would still have been a majority of nearly 2,000 in favour. The next step was to ask the employés in each section of the scheme to nominate representatives for election on sectional boards. It was arranged that each nominee should be supported by at least 20 employés entitled to vote in the section for motormen and conductors and six employés in other sections. I understand that the Board of Trade will now call together the whole of the representatives and describe the scheme in detail. The machinery, therefore, for dealing with any difficulties which may arise will shortly be in working order. By means of conciliation boards it is hoped that many matters may be set straight in a friendly and equitable manner by bringing the broad-minded view of the elected representatives of the employer and employé to bear on the subject. My experience has been that much more can be done by a round-table discussion in this manner than by the sudden presentation of lists of grievances a few days before Bank Holidays or on the eve of a municipal election. Under the new scheme, any points relating to hours of labour and rates of pay can be dealt with as they arise. If an agreement cannot be arrived at, the matter will be settled by an independent arbitrator. If the experiment in London is satisfactory, I hope it will extend to all municipal tramway undertakings in the country, that it will be possible in time for the various boards to co-operate. Personally, I think that conciliation boards, with a final reference to an arbitrator, will do much to smooth over difficulties with regard to rates of pay and hours of labour, but matters of discipline should not be dealt with through this channel. In my opnion, the chief official of a municipal tramways undertaking should take the place of the managing director of a commercial undertaking; the committee directing the policy and leaving the manager to work out the details. It is impossible for the manager to do full justice to the concern, for which he is held responsible, if he is not allowed to deal with all matters of discipline in his department. It is a fatal thing if an employé or official in any grade is allowed to approach a committee over his head without the knowledge of the chief official. The same thing applies in all grades of the tramway service. I am glad to say that in London it is distinctly understood that everyone in the department who has a grievance should, in the first place, approach his immediate superior. If he then does not get what he considers fair treatment he can, if necessary, lodge his complaint through the proper channel to the chief officer.

Steel Wheels.—In 1902 I ventured to write a Paper on the subject of "Steel Wheels," in which I strongly urged their adoption. This Paper was written after making a series of tests under trying conditions in Sheffield. My remarks were subjected to very adverse criticisms by many correspondents in the technical press. The following are a few extracts :—

(1) "Given a well-laid track, and the best chilled wheels, properly designed to suit circumstances, there cannot be the slightest doubt that they are by far the most economical in the long run, and the practice of using tyres for tramway work is certainly a step backwards." (2) "We have only about 20 axles, mounted with steel-tyred wheels, and we are weeding them out little by little." (3) "We turn the tread and re-form the flange of two pairs of wheels per day." (4) "The steel-tyred wheel—a very costly article and quite unnecessary had the conditions been properly studied." (5) "We learn from a reliable source that a steel flange will not last more than four months' constant running on a good track." (6) "Beyond the comparatively rapid wear of steel flanges, there is a greater liability to cause flats on the tread." (7) "As the chilled wheel is now giving satisfactory results on more than 75 per cent. of the tramways in the United Kingdom, the article above referred to is all the more extraordinary, and as it might prove misleading to some, it is proposed to look carefully into the figures given."

These statements have been proved to be incorrect, and with regard to the last quotation I have just made inquiries and find that, with a very few exceptions, steel wheels have been adopted throughout the country. Replies have been received from 53 municipal tramway-owning authorities. It appears that there are 35,600 wheels in use on these undertakings, of this number 33,064 have steel tyres and 2,536 are chilled iron, or, say, 93 per cent. are steel tyred and only 7 per cent. are chilled iron. This just shows how opinions change in a period of seven years. I think the steel makers in this country are to be congratulated on the results, especially as they are now able to produce steel tyres having a life which exceeds the most sanguine anticipations of seven years ago.

Half-penny Fares.—The question of the advisability or otherwise of ½d. fares is a delicate one, yet I think it is one which deserves very serious consideration, and, as regards all the smaller tramways systems, undoubted condemnation. On the large city systems these fares are, in my opinion, justifiable, but I venture to suggest that it is now time for those who control tramway policy to consider whether these extremely low charges are compatible with the proper discharge of their financial obligations, the due conduct of the services and the adequate maintenance of the track and equipment. Hitherto the 1d. fare has been looked upon as the backbone of our British tramway revenues just as is the 5 cent fare in the United States, the 10 centimes fare in France, and the 10 pfennig fare in Germany, but we now seem to be drifting into still lower regions, and I think we ought to pause and reflect very deeply before we accept the ½d. fare as a standard fare on all tramways. On large tramway systems the ½d. fare is a valuable asset if short stages are adopted, but the tendency nowadays is to gradually lengthen these stages, and they become unprofitable by encroaching on the reasonable 1d. stage. On small systems the ½d. stage is a great source of danger and should be avoided. I am speaking, of course, purely from a managerial point of view, and with the general impression at the back of my mind that tramways should not only serve the public as well as possible but should also pay their way and not be a burden to the ratepayers.

The Past and the Future.—Twenty years ago we looked to America for guidance in tramway matters, and in a rough-and-ready manner America showed us how it should be done; to-day we rather think that we can show America how it should be done, but our indebtedness to that country still remains, as through its bold policy of development the tramway world has been able to benefit by the pioneer work by avoiding the weak and assimilating all the good points. The tramway men in this country in their turn have endeavoured to remodel and improve, with the result that British tramway installations are now looked on all over the world as examples of solid permanent work. We have had many inquiries from Australia, Canada and New Zealand, and I feel certain that this Association will be glad to do anything possible to assist our fellow-subjects over the seas. I venture to think that 20 years hence tramways will predominate and rare specimens of an extraordinary vehicle which was called a

* Abstract.

motor omnibus will be found in the South Kensington Museum. The question of local railway competition will be settled and internal pick-up traffic will be recognised as legitimate tramway work, and all longer distance through traffic will be dealt with by the railway companies, the tramways acting as feeders for railway undertakings. Corrugations may be a thing of the past and a suitable material may have been found for paving tramway tracks, and many other of our present troubles will possibly have disappeared, but we can always be quite certain that by that time a new crop of troubles for this Association to overcome will have arisen, and the fastidious tramway passenger will still have to be encouraged to ride by all the arts known to a tramway manager, who will have to continue to put his best energies into the work or he will find that patronage is withdrawn in favour of the pneumatic tube, which will convey a passenger from his home to his office. There will still be the old question of the survival of the fittest, and I feel that by that time our Association will be the fittest of the fit. The Municipal Tramways Association has not got a very long past, but it is a past of which we are all proud. In the comparatively short time it has been in existence much useful work has been accomplished, and the energy of the members and the support which it has received from the municipalities generally, augurs well for the future, which I am certain will prove the Association to be an ever-growing power for utility in the tramway world.

THE DETERMINATION OF THE ECONOMY OF REVERSING ROLLING MILLS.*

BY C. A. ABLETT, B.SC.

Since the last autumn meeting of the Iron and Steel Institute, five steelworks have decided to adopt electrically driven reversing rolling-mills, making in all over twenty firms who have come to this decision, and twelve such plants are at work in different parts of the world, one at least being installed to replace an engine less than ten years old which was in good condition.

The capital cost of an electrically driven reversing-mill is greater than that of a steam-driven mill driven by a plain two-cylinder engine, but in the last two years the experience gained in setting a number of such plants to work has enabled this cost to be very materially reduced. Further reductions are scarcely possible unless some new method of reversing-mill driving is evolved in place of the Ilgner system, which has been employed exclusively up to the present, and the present state of electrical knowledge does not offer much prospect of this.

In a very large number of cases the economies which can be effected by the adoption of electric driving are found amply to justify the increased capital expenditure. At the present time, the question of saving in fuel consumption is the chief inducement offered by electrical driving to most steelmakers, as the possibilities in the direction of greater output are not fully recognised, there being as yet no published figures relating to this.

Tests are frequently made to determine the economy of a reversing-mill engine, either (I) by indicating the engine and estimating the steam consumption per indicated horse-power from some of the larger diagrams, or (II) where boilers can be isolated, by measuring either the feed water or the coal burnt for a considerable period, and keeping a record of the tonnage of steel rolled over that period, so that the result is expressed in pounds of coal or pounds of steam per ton rolled.

In the author's opinion the results of such tests have little value for the following reasons.

Where the steam consumption is estimated from indicator diagrams, it is common practice to consider only a few of the larger diagrams where the engine is working fairly economically. With a cogging-mill the ingot is seldom in the rolls for more than one-seventh of the total time taken to roll it down, and if a continuous set of diagrams be taken, it will be found that less than one-quarter of these represent anything like the full power of the engine. The steam consumption corresponding to small diagrams is naturally considerably higher per indicated horse-power than that which corresponds to full load, so if the steam consumption was worked out for all the diagrams taken in rolling down an ingot, with a continuous indicator, the average steam consumption per indicated horse-power would be shown to be much higher than if only a few of the larger diagrams were chosen.

In calculating the steam consumption from a set of continuous indicator diagrams, different constants should be employed, according both to the size of the diagrams and the way in which the engine is working, so that it is a very difficult matter to devise any means of making tests to check up the constants. A further disadvantage of determining the steam consumption from indicator diagrams is that no clue is furnished to the losses taking place before the steam comes to the engine stop-valve, such as blowing off from the boilers and radiation, condensation, and leakage losses in the pipework. These are naturally higher in proportion to the total work done with a reversing-mill engine than with a continuous running engine, as the reversing engine is only giving full power for a small proportion of the total time it is working, while the pipework is always full of steam. The quantity of high-pressure steam which is exhausted at each reversal of the engine without doing any work, and which is clearly shown on the continuous indicator diagrams, is frequently not taken account of in determining the steam consumption.

The method of measuring the feed water or coal burnt per ton of steel rolled, which can only be carried out where it is possible to isolate boilers for the purpose, is open to the objection that two entirely different quantities are included in one measurement—*i.e.*, the economy of the engine, and the actual work done in rolling the steel. This prevents any comparison being made between different engines, unless the same sections are being rolled from the same sized ingots under similar conditions in both cases. Where it is possible to isolate the boilers supplying a reversing-mill, engine reliable figures for the steam or fuel consumption can be obtained by making a simultaneous test to determine the actual work required in foot-pounds to roll the ingots, supposing that the same sized ingots are being rolled down to the same section for a number of hours.

In using this method of making tests it is naturally desirable to take some preliminary diagrams to check the valve-setting and to show if each end of each cylinder is doing its proper proportion of the work of the engine or not, and it will be found best to take these diagrams during the last passes when the bloom is long and the engine is giving diagrams approximately of the same size for a dozen strokes or more. Where a compound engine is in use, continuous indicator cards should be taken simultaneously on one end of a high-pressure and one end of a low-pressure cylinder.

The above-mentioned tests do not furnish any clue to the mechanical efficiency of the engine, and in the author's opinion the usual method of arriving at this—*i.e.*, taking indicator diagrams when the engine is driving the mill at full speed running light—shows the mechanical losses to be considerably less than they really are when ingots are being rolled, and that this is particularly the case when the engine is geared to the mill.

The energy consumption of an electrically driven reversing rolling-mill as expressed in kilowatt-hours (Board of Trade units) per ton rolled can be determined in the simplest possible manner by inserting an ordinary integrating wattmeter in the supply system, which is an instrument that can always be left in circuit and requires no attention. If a reading of this instrument before the commencement of a shift and a second reading at the end of the shift are taken, the difference gives the total kilowatt hours used during the shift, and dividing this by the tonnage rolled the total kilowatt-hours per ton is obtained. Such readings can quite easily be taken for every shift, and a continuous check on the energy consumption can be kept. Results expressed in kilowatt-hours per ton are generally found most useful, as the cost of the kilowatt-hour varies according to local conditions, and knowing this cost, the total cost of power can be arrived at directly. The efficiency of the electrical plant can also be checked in the simplest possible manner by placing a second integrating wattmeter in the armature circuit of the mill motor. The records of this wattmeter will be less than those of the one placed in the supply circuit, the difference being the losses in the electrical plant. This does not take account of the efficiency of the mill-motor armature, but as this is of the order of 97 to 98 per cent. it can well be neglected. The following figures show some characteristic values for the kilowatt-hours per ton rolled obtained from tests on reversing-mills:—

	Kilowatt-hours per ton.
$4\frac{1}{2}$ in. × $4\frac{1}{2}$ in. billets from 2·5 ton ingots. Output, 53 tons per hour	22·5
6 in. × 6 in. blooms from 2·5 ton ingots. Output, 63 tons per hour	17·5
8 in. × 8 in. blooms from 2·5 ton ingots. Output, 80 tons per hour	13·0
12 in. × $9\frac{1}{2}$ in. blooms from 7 ton ingots measuring $34\frac{1}{2}$ in. × 25 in. Output, 65 tons per hour	11·2
32 in. × 9 in. slabs from 6 ton ingots measuring 36 in. × $19\frac{1}{2}$ in. Output, 40 tons per hour	4·3
32 in. × 5 in. slabs from 6 ton ingots measuring 36 in. × $19\frac{1}{2}$ in. Output, 40 tons per hour	5·8
Flange rails, 100 lb. per yard, from 2 ton ingots. Output, 30 tons per hour	48·0
Beams, 120 lb. per yard, from 1·5 ton ingots	36·0
Channels, 92 lb. per yard, from 1·5 ton ingots	37·0

* Abstract of a Paper read before the Iron and Steel Institute.

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THE ENGINEERING GRADUATE.

We do not doubt that it has very often occurred to those responsible for the teaching in our technical colleges to ask themselves the question, "Is the engineering graduate really what the employer wants?" On the other hand, the employer rarely vouchsafes any opinion on the matter. We therefore think it well to call attention to an interesting article appearing in the current issue of the "Electric Journal," and which we reproduce elsewhere, somewhat abbreviated, by Mr. F. W. TAYLOR, who voices the opinion of the manufacturer in the United States. We may mention that Mr. TAYLOR is a past-president of the American Society of Mechanical Engineers, and, as an employer, he is entitled to speak with authority. He has employed many graduates, and although he recognises the value of the graduate, he emphasises the American opinion that this type of the young engineer is not, as a rule, desired. He is accepted, but he is not desired. It is only fair to say that the average employer comes to value him; but, nevertheless, would much prefer someone else to take him first.

From his own personal observations, Mr. TAYLOR has come to the conclusion that nine out of ten of these young engineers are dissatisfied for at least one or two years after they start. They find their employer unappreciative and

exacting, they are not given opportunities commensurate with their education, and they are asked to do work that mere boys could handle. Consequently, they are dissatisfied, and it is only after going to their second or third employer that they become aware of the fact that the boys they make light of are the ones who can do things. This experience led Mr. TAYLOR to decide at one time that he would never employ a college man who had not been out for at least two years.

This state of things Mr. TAYLOR attributes to two causes. The first of these is the extreme difference between college life and factory life. In the college there is very little discipline, and there is greater freedom than the students have ever had before, or will ever have again. Their habits are left almost entirely to themselves. But when they begin commercial life their habits are regulated and rigidly prescribed by someone else. The other reason is that the young engineer has to make certain drastic changes in his state of mind when he comes into commercial life. For 22 years or so he has been absorbing information and having things done for him. Suddenly this process has to be completely reversed; he has to make himself useful to other people and to bring his knowledge into play. This is a very great change, and it is not easy to adjust the mind to it.

The remedy suggested by Mr. TAYLOR is that all college students, even if their destiny be the church, should, after the first year at college, spend a year in actual hard work in the shops. The advantage of so doing is that they begin to get the character-training which is almost entirely lacking at college. They then begin to learn that almost nine-tenths of the work that every man has to do is monotonous, and they start to develop the character which enables them to do unpleasant, disagreeable things. In his opinion of the value of shop training we think Mr. TAYLOR is right, and many people will, no doubt, agree with him. The only question is:—When should the training be taken? The alternatives that are generally considered are whether the shops should be taken before or after the college course, although there is one notable exception, for one of our colleges places the time spent in the shops in the position suggested by Mr. TAYLOR. Granted that life in the shops has this value, there is an objection to leaving it to the end of the course, namely, that when a man leaves college he is generally capable of obtaining some sort of position in which he will receive a salary, and, therefore, there is little inducement for him to go into the shops. Moreover, the older he becomes the more disinclined is he to go through that kind of life. Whether discipline at college can ever be much improved by this or any other course is doubtful, for the simple reason that during that time of the student's life it is the student who pays, whereas subsequently it is the employer who pays, and there is a vast difference in the mental attitude in consequence. Nevertheless, this fact does not detract from the value of experience gained in shop life.

We are glad to note that Mr. TAYLOR is strongly averse to the idea of post-graduate courses if they are to interfere in any way with coming into touch with actual work in the shops. He suggests that the average young man needs no post-graduate course; that what he does need is closer touch with actual life, and that the tendency of universities to lengthen their courses up to five or six years is a most unfortunate change. We cordially agree with this view. From the commercial standpoint the student is liable to suffer if he spends more than three years of his life in this way, for the very simple reason that he is living under conditions which are extremely uncommercial, and the longer he continues on these lines the harder it is for him to adjust himself to the new conditions when he is launched into the commercial world.

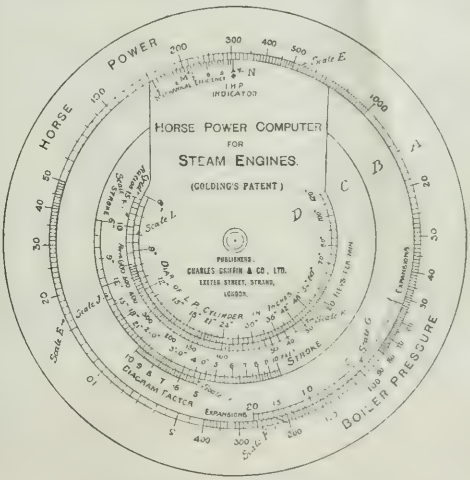
REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

"Horse-power Computer for Steam, Gas and Oil Engines." By H. A. GOLDING. (London: Charles Griffin & Co.) 5s.

"Horse-power Computer for Petrol Motors." By H. A. GOLDING. (London: Charles Griffin & Co.) 6d. net.

During the last few years the principle of the slide rule has received many extensions so as to provide an easy solution of a variety of problems. The latest device of this kind, which may be considered as a modified slide rule, is Mr. Golding's computer for horse-powers. A large number of variables enter into the design of steam engines, varying from the steam pressure, stroke and number of revolutions per minute down to the number of expansions to be permitted, and questions of



GOLDING'S HORSE-POWER COMPUTER.

condensing and non-condensing. Consequently the problems are varied and somewhat tedious to work out. Mr. Golding's computer provides a short cut, and can be best explained by a reference to the figure and the following sample problem:—

Example.—To find the I.H.P. of a compound engine, L.P. cylinder 24 in. diameter, stroke 3 ft., revolutions 100, boiler pressure 160 lb., expansions 10. Referring to the figure, this problem is solved as follows:—Set 10 on scale G to 160 on scale F. Read m.e.p. on F opposite 1 on G. Subtract a suitable back pressure, set 3 ft. stroke on J to 0·7 on H, set 24 in. on L to 100 on K, and read I.H.P. (304) off N on scale E.

It will be noticed that there are one or two quantities that must be assumed, apart from ordinary dimensions. This remark applies particularly to the number of expansions and what is called the "diagram factor," the latter being the ratio of the total mean effective pressures in all the cylinders referred to the low-pressure cylinder, to the theoretical mean effective pressure obtained by expanding steam hyperbolically from the boiler pressure r times. These quantities are depen-

dent upon the art of the designer, but in order to save trouble, in the pamphlet that is issued with the computer, a table is given for the most economical number of expansions for various boiler pressures and different types of engine. Similarly, a table of approximate diagram factors is given for typical engines, both jacketed and non jacketed.

Upon looking at the computer, one is struck by the number of different scales and discs, there being four movable concentric discs and more than double that number of different scales. Probably the first sensation of the designer will be that it will take him some little time to become sufficiently familiar with the instrument to be able to make effective use of it. We do not doubt, however, that when the instrument is once mastered that it will prove very useful, assuming, of course, that the data on which it is based are quite correct, and that familiarity is maintained by constant use.

A less ambitious computer by the same author is that for giving the horse-power of petrol motors according to the rating formula of the Royal Automobile Club. However unscientific such formulæ may be, they have their advantage in giving some sort of idea of the probable horse-power of petrol motors as used at the present day on motor cars. It cannot be said that the computation by arithmetic, much less by the ordinary slide rule, is a very laborious affair, as it only involves the square of one number multiplied by another and divided by a third: but for the motorist who wishes to avoid mental labour Mr. Golding's computer may prove useful, and as the cylinder bore is given in both inches and millimetres the instrument provides incidentally a rapid means of converting from inches to millimetres or vice versa.

As circular slides of this type are liable to be badly worn by bending up the edges in order to turn the discs round, we would suggest that it would be an advantage if a small knob could be added to the movable slide. In all cases this is not possible, but where it could be done we think it would save wear and tear.

Elektrische Lichteffekte. By Prof WILHELM BISCAN. (Leipzig: Carl Scholtze.) Pp. 184. M.10.

This work deals in a comprehensive and authoritative manner with the subject of indoor and outdoor illumination from the decorative point of view, and should prove of considerable value, especially to the "illuminating engineer." The information contained in the ten chapters and appendix comprising the volume is excellent, and is the outcome of the author's practical experience. It is of a thoroughly practical character, is simply written, and contains a number of illustrations in addition to four special coloured plates.

Chapter I. is descriptive of the carbon filament, metal filament and Nernst lamps, the open, enclosed and flame arc lamps and the mercury vapour lamps as regards their suitability and relative advantages for decorative purposes. The account is very clear and instructive, and only touches upon the constructive details in a general manner. In chapter II.—Shop Window Lighting—the author remarks that the ultimate aim of all shop window lighting is to advertise, but he rightly condemns that kind of illumination so often met with which consists in blinding the eyes of those in the street by means of miniature "suns" in the shape of flame arc lamps hung low down in front of the window. As often as not they defeat their purpose. He also discusses the points which should be considered for artistic and effective shop window lighting; of these the colour of the light source is of first importance, and is well treated. Before showing in a very striking manner by means of four coloured plates how colours change with the nature of the light incident on them, he briefly and simply explains the theory of colour.

The methods of connecting lamps are next given in chapter V., which also includes details of wiring material and special fittings for temporary wiring. Chapter VI. is on special lighting effects by means of glow lamps, and attention is drawn to the careful selection of the correct tints to be used. The motor-driven drum controller for effecting colour changes in sign lighting, is also dealt with here. Much instructive matter is contained in chapters VII. and VIII. on the principles and the arrangement of the cinematograph, theatre projectors and illuminated fountains. The subject of theatre and stage lighting is well handled in chapter IX., and chapter X. contains details of a few special stage effects. The book concludes with an appendix on the important question of the emergency lighting of theatres and public buildings.

The work can be thoroughly recommended, and is just the kind required by those interested in electric lighting. Apparently an equivalent English book does not exist. H. G. S.

AMMETER FOR THE ACCURATE MEASUREMENT OF LARGE ALTERNATING CURRENTS.*

BY E. F. NORTHRUP, PH.D.

Summary.—The author first discusses the laws governing the pressure in a conductor of circular cross-section conveying an electric current, and then describes an ammeter based on the variation of the pressure in a liquid conductor. This instrument is particularly adapted to the measurement of large alternating currents, and details of the accuracy obtainable are given in the Paper.

The accurate measurement of alternating currents too large to be measured by a Kelvin balance or a Siemens type of electrodynamometer has been hitherto a difficult and costly measurement seldom made. The usual practice has been to use a series transformer, but as the ratio of transformation varies with the load, the frequency, the wave form of the current, the magnetic leakage, the eddy current losses and with other less important influences, the accuracy of the method is very low.

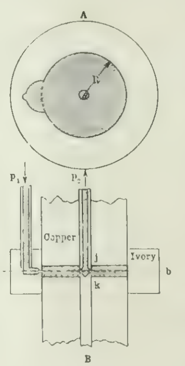


FIG. 1.

The new method here proposed is based upon the utilisation in a current meter of the recently observed centripetal pressure which exists in the interior of a liquid conductor carrying an electric current. When an electric current of large density is passed through a fine jet or stream of mercury or molten metal, the stream suffers, at some point of its length, a constriction and, if the current is sufficient, the constriction divides the stream with consequent vaporisation of the metal. This fact was observed and first described by Paul Bary ("L'Industrie Electrique," April 25, 1901). The phenomenon was considered in 1907 by the present writer in a Paper † before the American Physical Society, under the title "Some Newly Observed Manifestations of Forces in the Interior of an Electric Conductor," and Mr. Carl Hering put on record his observations and explanation of the phenomenon as manifested in resistance furnaces in a Paper read before the American Electrochemical Society, entitled "A Practical Limitation of Resistance Furnaces; the 'Pinch' Phenomenon."‡

In the writer's Paper an ammeter was described and shown working, which measured direct or alternating currents, its operation depending upon the pressure forces in a conductor. Later, several other ammeters for the commercial measurement of large alternating currents were constructed. The success and accuracy of these instruments suggested that apparatus carefully constructed on similar principles might be used for accurately measuring a large electric current even, perhaps, in absolute measure.

Theory of the Ammeter. In Fig. 1. B is a vertical section and A a cross-section on the line *ab* of B. The cell is filled with mercury. When an electric current passes from *j* to *k* through the mercury, a difference of hydrostatic pressure is created between the outer and inner circumferences of the circular cell. In order to determine this pressure difference a communication must be established between the outer and inner circumferences of the cell. This may be accomplished by the arrangement diagrammatically shown in the section B. When current flows, mercury will tend to flow down the tube

* Abstract of a Paper read before the American Electrochemical Society.

† See THE ELECTRICIAN, September 13, 1907, p. 868.

‡ THE ELECTRICIAN, July 19, 1907, p. 562.

p_1 and up the tube p_2. This flow will continue until the difference in level at which the mercury stands in the tubes p_1 and p_2 establishes a pressure difference equal and opposite to that produced by the current between the inner and outer circumferences of the cell. By measuring the difference in level between the tubes p_2 and p_1 the pressure difference produced by the current may be determined. If the conditions are rightly arranged, the current will be a known function of this pressure difference and hence the current value may become known.

Inasmuch as the tube p_2, which communicates with the interior of the cell, must have a finite diameter, and as this tube consists of insulating material, such as ivory, which is necessitated by the condition for obtaining a uniform current distribution in the cell, it becomes necessary to determine the pressure difference between the inner and outer walls of the hollow liquid cylinder as a determinate function of the current which flows with uniform distribution throughout a right cross-section of the cylinder. This, as will be shown, is a perfectly determinate problem, but one which involves certain assumptions if it is required to calculate the instrumental constant. These assumptions, however, may be realised in practice by employing properly constructed apparatus for the purpose. Of the assumptions made, three have especial importance: (1) The cross-section is that of a circular cylinder having a common axis for its inner and outer circumferences. (2) The current distribution throughout a right section of the cylinder is perfectly uniform. (3) The lines of current flow in the cell or hollow cylinder are everywhere throughout its axial length parallel to the axis.

The assumption of uniform current distribution requires the most care. As mercury has over 60 times the resistance of copper the current distribution throughout the mercury cell would not be uniform if the upper and lower faces of the cell were not parallel. Though the intensity of the pressure is independent of the axial length of the cell, it is nevertheless necessary to give the cell a moderate length so that the percentage difference between different parts of its faces, taken as parallel, may be small. To secure a justification of the assumption of uniform current distribution, the construction of the cell in respect to the points above mentioned must be attended to with special care.

The parallelism of the lines of current flow throughout all portions of the cell may be secured by the construction indicated in Fig. 1, B. Here the mercury enters the outer circumference of the cell through a narrow slit not over $\frac{1}{2}$ mm. wide, and leaves the cell from the inner circumference, entering the tube p_2 through a similar narrow slit. With such narrow slits the lines of current flow cannot bend into the spaces where the mercury enters and leaves the cell.

The pressure difference produced by the current might be determined by measuring directly the difference in level at which the mercury is caused to stand by the current in two tubes as p_1 and p_2, but a more accurate method is available. The author next considers the theory of the apparatus on similar lines to his Physical Society Paper* and shows that on the assumption of uniform current distribution the current $I=\Delta \times \sqrt{P}$, where $P=$ the resulting pressure difference, and the constant

$$\Delta = \sqrt{\frac{\pi(R^2-d^2)}{1+\frac{2d^2}{R^2-d^2}\log_e\frac{d}{R}}},$$

d being the radius of the internal wall and R the radius of the external wall. The assumption of uniform current distribution is entirely justified for the case of direct and slowly alternating currents and is so practically for frequencies as great as 133 cycles per second. Owing to the so-called "skin effect," with rapidly alternating currents, the current tends to leave the centre of the cell and to crowd toward the circumference. The error which might arise from this cause is examined later and shown to be negligibly small. The constant can be determined, of course, experimentally with very high precision by using a direct current, which is measured with a potentiometer, and by determining at the same time the pressure P. If a meter, however, is to measure several thousand amperes, the outfit for making an experimental determination of the constant Δ would be elaborate and costly, and it is very desirable, therefore, to know all the conditions of the problem and be able to determine Δ by calculation.

Cells in Series.—While to measure the current it is necessary only to determine the pressure difference between the centre and the circumference of a single cell of mercury, there are reasons, based upon simplicity of construction and increased accuracy, why it is often desirable to pass the current through several mercury cells in series and arrange the construction so that the pressure differences set up in all the cells are added together, by joining the centre of one cell with one or more small tubes to the circumference of the next, and so on throughout the series. The manner in which this is carried out in practice is shown by the view of the 2,000-ampere meter illustrated in Fig. 2. When the pressure differences of n

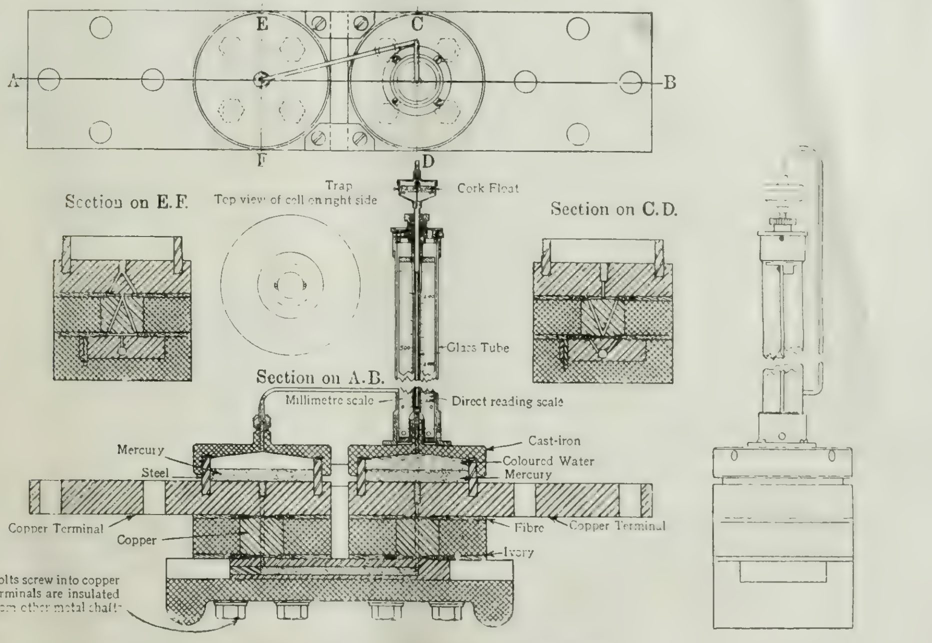


Fig. 2.—Meter for measuring 2,000 amperes.

* The Electrician, *loc. cit.*

equal cells are added thus in series, the final pressure is n times as great as that of one cell, and $I = \sqrt{Ap/n}$.

To determine the power which is dissipated in the cells of a multicellular meter, let $d=0$, then $I^2 = pA/n$, where A is the area of one cell. The power dissipated in one cell will be $w = I^2r$, where r is the ohmic resistance of the cell. If l is the axial length of the cell and ρ is the specific resistance of mercury, we have $r = \rho l/A$. Hence, if $W = nw$ is the total power dissipated in the meter, we have $W = nI^2\rho l/A = p\rho l$.

This last equation leads to the important conclusion that the power which will be dissipated in any construction of mercury ammeter of the type above described is independent of the number of cells used and of the area of these cells, but is numerically equal to the pressure produced, to the specific resistance of the liquid in the cells, and to the axial length of each cell. It follows, using cells of a fixed axial length and mercury as the working liquid, that the watts which must be expended to produce unit pressure is a fixed quantity. If the meter is constructed to raise a column of water, as an index of the pressure produced, and if the axial length of the cell or cells is ½ mm. (a length that is practical to employ), and mercury is used as the fluid in the cells, then there will be expended in the meter approximately 1 watt for every 2 cm. to which the column of water is raised. It is evident from this that if it is required to have the scale of the meter 50 cm. high, it must be able to get rid of the heat produced by 23 watts, and this follows entirely regardless of the current which is measured.

It would seem that there is nothing to gain by designing the meter to have more than one cell. Experience shows, however, that several minor advantages are gained by using two or more cells. Since the pressure with a given current is proportional to the number of cells divided by the area of one cell, it follows that as the number of cells is increased, the current density in any one cell is diminished. The heat developed, therefore, is less localised with several cells. Also, if several cells are used, the area of each is larger, and hence their exact dimensions are more easily determined. Further, if only one cell is used its area would be small for small current meters, and any cause, as a spot of poor amalgamation of the surface of the cell, tending to disturb the uniform current density in the cell has a relatively larger percentage influence than is the case where several cells of larger area are used. Also, the mechanical construction lends itself very suitably to two, four, six or eight cells, &c., and the commercial form of the meter is made with two or a greater even number of cells. Where a 50 cm. scale is to be used, the instrument is hardly adapted to the accurate measurement of currents under 200 to 500 amperes at full scale reading. Its field of special usefulness is to be found in the accurate measurement of alternating currents of over 1,000 amperes.

Methods of Measuring the Pressure.—For the reasons given above, the difference in level of mercury which can be obtained is approximately 1·6 mm. per watt of power expended in the meter. This difference might be read directly with a cathetometer, but to make a practical instrument it is necessary to magnify greatly the small motion the mercury would have. This might be done by causing the rising column of mercury to move a pointer; it has seemed a better plan, however, to use a column of coloured water as the indicator.

The method is shown plainly in Fig. 2. The mercury well, which communicates with the centre of a cell, is given a large diameter, and the surface of the mercury in this well only rises a fraction of a millimetre when the water column rises 50 or more centimetres. With this construction, the friction which the surface line of the mercury makes with the wall of the well is vanishingly small and has no influence on the precision of the indications or on the accurate return to zero of the water column when the current is turned off.

Water, coloured red, is used as the indicator in preference to all other liquids on account of its small coefficient of expansion at room temperatures. The water is kept from evaporating by joining with a small metal tube the top of the glass tube in which it rises to the top of another well in communication with the circumference of a cell.

Mechanical Construction.—Not less than eight radically different forms of construction were designed and tested before the form here described was reached and found to be fully satisfactory. This present form is intended to serve as a laboratory and calibrating instrument, and for use in measuring large currents in connection with electric welding and electric furnace practice. It reads 2,000 amperes at about the 50 cm. mark on the scale. The constant is easily changed, so that it will read from 500, say, to 6,000 amperes at the same scale mark by simply changing the area of its four mercury cells.

Fig. 2 makes a description of details unnecessary; one important feature deserves, however, especial mention. It will be noted that the two holes which join the circumference of one cell to the centre of the next cell enter the circumference of a cell on that diameter of the cell which lies at right angles to the plane through the centres of the set of cells on the right and left. This point being neglected in the earlier constructions, it was found that the meter did not exactly obey the "square" law. The cause of the variation was finally located as due to the shifting of the centres of maximum pressure to the left and to the right of the geometrical centres of the cells. With a wrong construction, errors from this cause as great as 4 to 5 per cent. may be produced, but with a correct construction, the errors are too small to be detected.

The axial depth of each of the four cells is made only 0·5 mm., which was found to be quite sufficient to permit the mercury to flow with perfect freedom between the well amalgamated faces of the cells. Carefully turned rings of ivory quite effectively maintain unchanged the separation of the opposing faces of the cells, and absolutely prevent permanently any leakage of the mercury. For instruments which are to have their constants determined experimentally and not by calculation it was found not to be necessary to line with insulating material the walls of the tubes connecting the centres to the circumferences of the cells, since very little current flows through the mercury in the tubes, and the back pressure set up is too small to consider. A trap is provided at the top of the scale to stop the rise of water in case of overload.

The scale consists of two brass strips which lie on the right and left of the index tube. On the right-hand strip a scale reading in amperes is laid off, and on the left-hand strip is marked a millimetre scale. This last may be used with a knowledge of the constant of the instrument, when one wishes to read to a high precision. When full current is suddenly turned on, the red liquid column rises from zero to full scale reading in from 4 to 5 seconds, and returns very exactly to zero in the same time when the current is turned off. The movement of the fluid column is just short of aperiodic, and

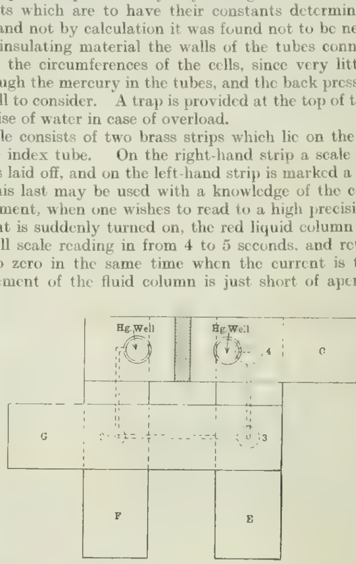


Fig. 3.

follows every fluctuation of the current with great sensitiveness. It is an instrument which is very comforting to read after one has worked with a Kelvin balance which persists, with fluctuating currents, in perpetually oscillating. The scale has a vertical adjustment sufficient to take care of changes in the zero which will result from tipping the instrument.

Accuracy and Sources of Error.—The precision with which measurements of direct and alternating currents may be made with a 2,000-ampere mercury meter was very carefully determined by a series of measurements made at the Electrical Testing Laboratories in New York, using a potentiometer and direct current. Sample readings given in the Paper show that the readings of the instrument can be repeated with a precision of about 0·02 per cent. at the 500 mm. mark, and about 0·03 per cent. at the 100 mm. mark. The observations prove that there is no effect analogous to pivot friction which would cause the readings to be different with a rising and a falling current. The temperature rise in 20 minutes with full load current is seen also to be small and to have no appreciable effect upon the readings.

From readings taken with direct current the constant of the instrument was calculated from the formula $K = h/I^2$, where h is the height in inches at which the liquid column stands, and I is the corresponding direct current in amperes. The value of K so obtained was 0·0000048223. Assuming the square law to hold rigidly and using the above value of K, a direct reading scale was ruled on brass and fitted to the instrument. A set of readings taken on this scale showed that at the top of the scale the mean of a number of readings may be relied upon to be correct to better than 0·10 per cent.

Before the constant was obtained, a set of relative measurements were made with direct current, and an alternating current of 25 cycles, 60 cycles and 135 cycles per second. The meter was connected in series with a 1,000-ampere Kelvin balance, and within the

limits of error of observation, the meter read the same on direct currents and on alternating currents of the above frequencies.

The temperature rise of the instrument after running with various currents all above 1,000 amperes for at least six hours and between 1,500 and 2,000 amperes for at least one hour was found to be 16 C. This rise in temperature caused the zero to rise from 1 mm. to 2 mm. The adjustment possible with the scale, however, permits the resetting of the zero.

Multiple Scale Meters. An inspection of Fig. 3 shows how this is accomplished. It is a diagrammatic top view of an ammeter of four sets of cells, (1), (2), (3), (4), each set having different diameter cells. There are four terminals, G, F, E, C. According as connection is made to different pairs of these terminals one or more sets of cells are brought into use, giving different current values at full scale reading.

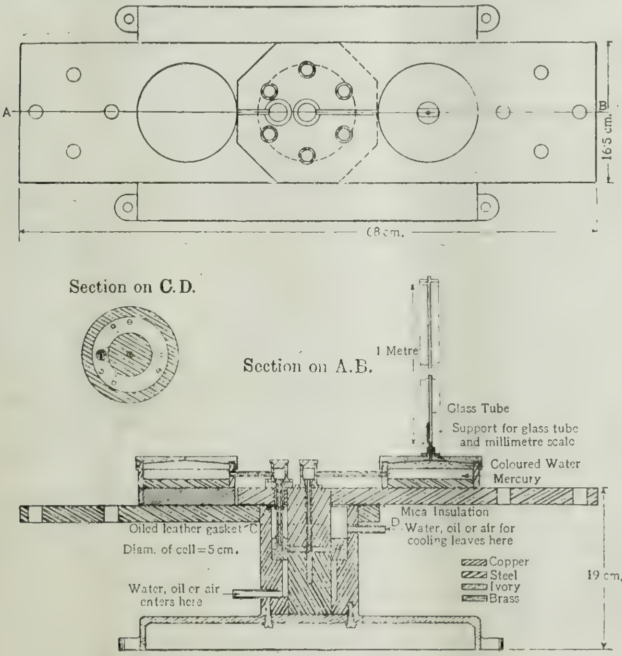


FIG. 4.

The Absolute Measurement of Current.—The theory and tests described above give a guide to the design of a current meter to measure current in absolute measure. In the method here proposed, a current as large as 1,400 C.G.S. units or 14,000 amperes would be measured, and 1 C.G.S. unit of current would be known then as a small fraction of this large current. By thus approaching the true value of the C.G.S. unit of current, from a high as well as from a low value of current, greater precision would be obtained, and the true value of the unit would become known with greater accuracy. The design suggested for an absolute current meter is embodied in Fig. 4, and the figure is almost self-explanatory. The chief feature to note is that the current after having passed through the single cell returns in a tabular conductor which surrounds the cell. As there is no magnetic field in the interior space of a hollow conductor, the cell is entirely shielded from the influence of the field surrounding the return conductor.

The important assumption is made in the formula that the current density is uniform over the cross-section of the cell. It is thought that this result can be satisfactorily attained by the construction shown. It is further necessary that the current stream lines shall be straight and parallel to the axis of the electrodes and not be distorted where the mercury enters and leaves the cell. By the construction proposed in which the mercury enters and leaves by narrow slits of about 0·5 mm., this source of error would be unquestionably avoided. The pressure produced would be determined by reading with a cathetometer the height to which the water column rises. The heat generated in the meter would be abstracted by a flow of oil in the space between the inner and outer conductors, allowing very large current densities to be used.

The formula for calculating the current in absolute measure would be (without corrections):—

$$I = \left(\frac{\pi(R^2 - d^2)}{1 + \frac{2d^2}{R^2 - d^2}\log\frac{d}{R}}\right)^{\frac{1}{2}} (h\delta g)^{\frac{1}{2}}$$

where h is the height in centimetres to which the water rises, δ the density of water at a particular temperature and g the acceleration of gravity. The first quantity in brackets is the constant of the instrument, to be obtained by an accurate determination of the two dimensions R and d. It should be noted that the quantity d does not have to be very accurately measured. Also, as the square roots of h, δ and g enter the formula, the error made in measuring the current is only one-half the error made in measuring any one of these quantities. The error in the current measurement will be, however, almost directly proportional to the error made in measuring the radius R of the cell, hence the advantage in choosing the radius as large as possible with the current available for the measurement. The temperatures of the different parts must be determined, of course, with considerable precision to correct for expansions of the faces of the cells and the change in density of the water column. These temperature measurements might be made accurately and easily with thermo-couples.

The above theory, design and calculations of a large current meter have been given, not because it is hoped that investigators will use the method, good as it seems, for the absolute measurement of current, but because the principles laid down will apply equally well to the construction and use of a current meter of fine precision for measuring very large alternating currents.

NOTE.—Since the above Paper was written, the author received from Mr. J. R. Carson a very complete and able mathematical analysis of the influence which would be produced upon the constant of the mercury ammeter by changes in the frequency of the current used. He expressed the conclusions of his analysis in a curve. The curve shows that the percentage change in the pressure difference is a function of both the frequency of the current and of the radius of the mercury cell. For a cell 2 cm. in diameter and a frequency of 500 cycles per second, the pressure difference is reduced below that which would be obtained with direct current only 0·028 per cent. Thus, this analysis, as well as the experiments made by the author, confirm the conclusion previously stated, that for all commercial frequencies the ammeter constant is very exactly the same for both direct and alternating currents.

CORRESPONDENCE.

MAGNETIC STORMS AND WIRELESS TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: During the great magnetic storm on Saturday last, which held up the postal telegraph traffic for several hours, I happened to be working at a wireless telegraph station in Surrey. I was wearing the telephones from about 2:30 till 4 p.m., and my apparatus was ranging in adjustment from 200 to 1,000 metres wave length. In view of the fact that this magnetic storm was of very exceptional severity, it is, I think, of interest to put on record that no trace of the disturbance was perceived on my receiving apparatus. The "atmospherics" or "strays" audible that afternoon called for no remark—they were quite ordinary in character and not frequent or strong—and the signals received were as good as usual.

Had I known of the existence of the storm I should have made special trials over a much wider range of wave-lengths. So far as the observations go, I think we may conclude that, in

the first place, there is no very direct connection between "strays" and magnetic storms, and, in the second place, that there are no intense high-frequency oscillations or very rapid local variations of magnetic force in these changes of field that constitute a magnetic storm.—I am, &c., W. H. ECCLES.

South Western Polytechnic, Chelsea, S.W., Sept. 29.

TARIFFS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your remarks on the Marylebone tariff (August 13th, p. 693), there is no doubt that double wiring is a nuisance and an encouragement to the use of gas. A perfect tariff, simple enough for the consumer to understand, is a counsel of perfection. I therefore throw out the following suggestion for the specialists in tariffs, who are legion. Possibly it may be what Mr. Seabrook intends, but, if so, the fact is not quite clear.

Put in single wiring, one meter and one demand indicator only. Now, from the published tariff for the particular class of load to be dealt with in any case assess the minimum annual charge for the maximum possible lighting load. Say this is 1 kw. with an annual charge of £10. 10s. Similarly deal with the maximum possible power load, say 3 kw. and £1. 15s. We have then a total annual charge at the rate of £12. 5s. for 4 kw. possible load. On this basis the actual annual charge for any registered maximum demand can be proportionately fixed and the tariff charge per unit added.

Additions to the installation must, under the Electric Lighting Acts, be notified to the undertakers, who could re-assess the annual charge.—I am, &c.,

Calcutta, August 31. J. W. M.

INDUCTIVE SIGNALLING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In THE ELECTRICIAN of December 18, 1908, and January 15, 1909, you published particulars relating to my apparatus and system for inductive signalling, and many other uses, since fully described in the pamphlet recently issued by the India Rubber, Gutta Percha & Telegraph Works Co., of 106, Cannon street, and Silvertown, London. In view of your kindness to me in this matter, I send you herewith a verbatim extract from a letter which—owing to the last two months having been spent by me at sea—has only just come into my hands. The letter is from Mr. S. Urata, a leading technical officer in the Japanese Imperial Telegraphs.—I am, &c.,

EDW. RAYMOND-BARKER.

(*Copy.*)

Tokio, Japan, Aug. 14, 1909.

Dear Mr. Raymond Barker: Many thanks for a copy of the pamphlet on the Two-Tone Transmitter. I am happy to say that your Two Tone Transmitter, together with Gott's Fault Searcher, has become one of the most necessary instruments which we have to take with, every time we go out to sea for cable work. We have not yet used it for the communication between shore and the ship, though I am certain of its practicability. But we always find those instruments most useful in finding out the very cable we seek at beach where many other cables are landed; and also in making sure before cutting any doubtful cable when we hooked it on board the cable ship. In these cases we hear the traffic signals, or nothing from the wrong cable, while the two-tone sound pleases us if we hit on the right one.

Once or twice at first in trial on shore we failed by using the sheath of the same cable as earth, but the mistake was found long before any actual case was tried. Once we succeeded to find out the faulty point in a cable in tank which was quite impossible to localise exactly by ordinary electrical test, nor to find out from the outward appearance of the cable. (Signed) S. URATA.

RAILLESS ELECTRIC TRACTION AT HENDON.

The desire to extend their systems into outlying and thinly-populated districts, coupled with the necessity of reducing as far as possible their capital expenditure on a portion of the route not likely to be highly revenue-earning, has led to the search among tramway managers for some arrangement which, while not preventing an extension of the standard track when occasion requires it, will allow them to supply temporarily traffic facilities at a low cost. One of the methods proposed for this purpose is the "railless" system, which has been given a certain amount of prominence lately and which consists in supplying current from overhead wires to a sort of "tram-'bus" which runs on the ordinary road surface. Much has been said both for and against these methods, and some tests, which have recently been carried out at the Hendon car shed of the Metropolitan Electric Tramways Co. by the Railless Electric Traction Co. will not, therefore, be wanting in interest.

A short length of roadway abounding in curves and gradients has been laid down in the vicinity of the car sheds and on it runs are made with an experimental car with a view to showing the capabilities of the system. The line, as at present constructed, is on the twin-wire principle, but provision is made at all the points of suspension for the addition of the third wire whenever desired. The trolley head, although running upon the twin wires only, carries its two sets of wheels at a sufficient distance apart to permit of the centre contact being added when the third-wire system is proceeded with. The car is accordingly fitted with the automatic indicators and change over earthing switch, to illustrate the method employed for keeping the car frame at earth potential in the twin-wire system, in which the polarity of the wires is necessarily reversed at junctions and crossings.

The conditions under which such a system operates require that the trolley head should be of the usual under-running type carried at the end of a rigid boom and kept in contact with the overhead conductors by raising-springs in the trolley base. Another essential condition is that the trolley head should remain in contact with the overhead conductors under all conditions of service, and should permit of sudden and wide diversions of the car on either side of the centre line of the wires, without diminution of speed. It was apparent that this condition would not be fulfilled by the ordinary swivelling trolley base, and subsequent experiments have demonstrated the correctness of this conclusion. In these experiments a standard trolley base, trolley pole and head were mounted on a railless car, and it was found that the head could be kept on the wires only by increasing the tension of the raising-springs until the trolley wheel exerted on the trolley wire such a pressure as would be destructive to the overhead line, and that, even under these conditions, the trolley wheel could not be relied upon to maintain continuous contact. In order to meet the prescribed conditions in a satisfactory manner, the Railless Electric Traction Co. has designed a special trolley base, in which, besides the usual raising springs, there are additional springs working in a horizontal plane and controlling the pivot of the trolley base in such a manner as to relieve the trolley wheel of excessive side pressure against the trolley wire, even when the car is running at some distance from the wires. With this attachment the head travels freely under the wires, and without appreciable side pressure, at whatever angle the pole may be trailing, from 90 deg. on one side to 90 deg. on the other.

One of the features that differentiate engineering practice in this country from the standards of other nations is the adoption of precautions to minimise the risks of injury to passengers. One of the possible dangers of this character attending tramway operation is that of electric shock from any metallic portion of the car that might be in accidental contact with the motor circuit. Against this risk tramway engineers have protected themselves by the simple device of bonding all metallic parts to each other or to the under frame, whereby they are necessarily maintained at earth potential through the wheels. This method, being of course impossible on a trackless car fitted with rubber-tyred wheels, a metallic return, and a second trolley wire is necessarily used; it is now proposed in certain cases to use an ingenious three-wire arrangement as an alternative. In the equipment at Hendon two trolley wires only are used, one acting as the positive and the other as the negative conductor; and the positive and negative trolley wheels are mounted as before on a common rotatable head. The framework of the car, instead of being directly attached to one of the trolley wheels, is, as shown in Fig. 2, connected to the middle of a single-pole double-throw switch, by which it can be connected at will to either one or the other trolley wheel. A polarised relay is mounted on the car, one coil of which is energised by the trolley circuit, the other by a small storage battery. When the single-pole switch is in the correct position to connect the framework of the car of the particular trolley which is at that instant negative (and therefore on the earthed wire) the relay is inoperative. But should the polarity of the trolley be for any cause reversed, the relay instantly brings into action an electric hooter, mounted in the front canopy of the car. The hooter continues in action until the driver reverses the switch and thereby connects the framework to the other trolley wire. In conjunction with this apparatus is a second hooter for notifying the driver of a breakdown in the insulation of the motor circuit.

With regard to the design of car to be used on this system, experience has shown that the rear wheels should be utilised for propelling a road vehicle and the front wheels for steering only. If the

front wheels are used for driving as well as steering, the weight which they are required to carry must be either insufficient for adhesion or too great to permit of easy steering. A road vehicle is frequently subjected to such shocks as make it impossible to carry any considerable weight on the driving axle, a design has therefore been adopted in which the motor or motors are attached to the frame of the chassis and the weight, therefore, entirely spring suspended from the axle. The chassis (Fig. 1) is generally of the motor omnibus type, and two designs have been standardised in both of which the rear wheels are independently chain-driven from the two ends of differential countershaft. The first design requires only one motor, which is placed with its axis parallel to the centre line of the car, and drives both ends of the countershaft through differential gearing. In the second design are two motors, also placed with their axles parallel to the length of the car, one in front of and the other behind the countershaft, each motor driving one-half of the countershaft through a bevel gear. The two motors are thus mechanically independent and each drives one of the rear wheels. In both cases the controller is fixed under the driver's seat and operated by a lever working over a notched quadrant. Foot and hand brakes are provided for the driving wheels and countershaft. The second design has the advantage of series-parallel control, which, however, is not of such importance for a road vehicle as for a tram car. The road resistance of a trackless trolley car bears a much higher proportion to its weight than does rail-resistance to the weight of a tram car. Consequently, it seems that the energy consumed by a railless car in overcoming its inertia during accelerations bears a much smaller proportion to the total energy consumed in completing a given cycle of operations than is the case with a tram car. Thus, series-parallel control, which reduces the energy expended during acceleration, effects no appreciable economy in the over-all consumption of electric power. Series-parallel control for railless vehicles has, however, practical advantages, for it provides a second efficient running speed which is often of service in crowded traffic. It also enables a railless car to return to the car sheds without external assistance, should one motor be burnt out or damaged while in service.

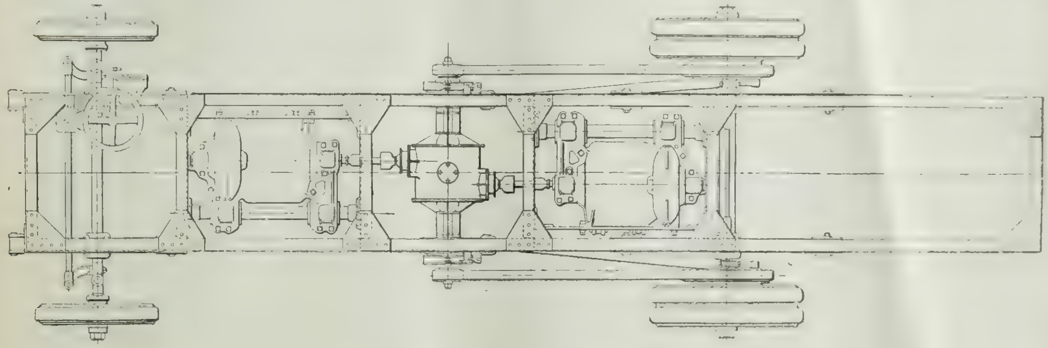


Fig. 1.—Chassis used on Railless Bus at Hendon.

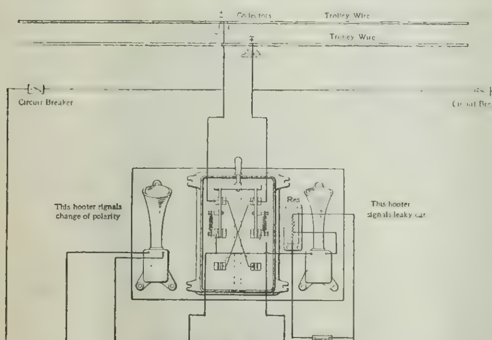


Fig. 2.—Diagram of Connections on Hendon Railless Car.

The overhead line at Hendon comprises a pair of trolley wires, but the Railless Electric Traction Co.'s triple hanger is employed so that both types of trolley head may be experimented with. The electrical equipment on the car consists of two 25 H.P. railway motors of the British Thomson-Houston Co.'s standard construction, with the usual series-parallel controller and grid resistances. The car is also furnished with the relay and electric hooters, as described above, for operation on a two-wire installation, this apparatus being supplied by Messrs. Brecknell, Munro & Rogers, of Bristol, who also constructed the trolley base, pole and head as well as the overhead line fittings. The car body is of the single-deck type, with seating capacity for 22 passengers inside and two additional seats on the rear platform, and was built by Messrs. Milnes, Voss & Co., of Birkenhead.

ELECTRICITY IN MINES.

Part II. of the annual report for 1908 of the chief inspector of mines has just been issued by the Home Office. It deals with the question of labour, and from the electrical standpoint is of more than usual interest, since it contains a report by **Mr. R. Nelson, electrical inspector of mines**, who entered on his duties on November 17th last. The growth of the use of electricity as a means of transmitting energy in mines is shown by the fact that since the establishment in 1905 of the Electrical Special Rules in Mines no less than 1,158 notifications of the introduction of electric motive power in such mines have been made to the district inspectors. In his report Mr. Nelson says:—

A few conclusions may be drawn of general application. In the first place, the standard of safety underground (apart from such special circumstances as the possible presence of explosive gas) is undoubtedly much lower than in ordinary surface work, and also much lower, I have no hesitation in saying, than it might be made without added cost by the mere exercise of a little forethought. Since the issue of the Special Rules governing the use of electricity in mines an improvement has, no doubt, been effected, and the standard of safety in some of the more recent installations is fairly high (in one isolated case I visited in South Wales I should describe it as very high), but the majority of underground installations fail lamentably in one or more well defined directions, involving grave risks of greater or less magnitude or, at the least, danger to the lives of individual workmen. The common faults above mentioned it might be well to give in detail:—

Defects of Construction.—(1) Exposed high and medium pressure conductors at surface, and exposed high and medium pressure conductors

and switchgear underground. (2) Frames, bedplates, covers, &c., of high and medium pressure apparatus not "earthed" or inefficiently earthed. (3) Switchgear and cables, the former mounted on wood and surrounded by as much wood as possible and the latter a confused mass, placed frequently in the main intake airway. The whole arrangement inviting two occurrences: (*a*) Shock by accidental contact with an exposed live part. (*b*) fire. (4) Defective joints in cables. (5) The omission of insulating bushes where frames of machines and switch boxes are pierced by cables.

Defects of Organisation. (1) The absence of a trained electrical engineer. (2) The handling when not absolutely unavoidable of live cable or apparatus for adjustment or repair. (3) The absence of a definite and distinct rule that unskilled men may handle electrical cables and apparatus only when the pressure is "off," and only then if the work be under the direct supervision of an electrical engineer. Other defects, as the lack of adequate systematic inspection of plant, are not given above, as if the defects of organisation here mentioned be remedied such defects will automatically cease to exist.

The very general lack of technical knowledge which exists has serious results. Tenders are obtained for electrical plant from several contracting firms, and the lowest tender is usually accepted. The purchaser, having no special knowledge of electrical matters, is quite unable to judge whether the work is good or bad, his only guide being the outward appearance of the fittings. He is, therefore, entirely in the contractors' hands. The result is frequently disastrous, even as regards the efficient use of the capital, apart from the more serious risk of accident.

Electrical plant for mines should first be tendered for to strict specification, and, secondly, constantly supervised during progress. There are firms of contractors who are willing and anxious to do good work, and such firms prefer the strict specification and welcome the supervision. The loose and short-sighted methods which, however, so frequently obtain with colliery owners result in firms of this class being unable to compete against more ignorant or less scrupulous rivals, with a consequent lowering of the general standard of electrical engineering as applied to mining, very apparent to anyone acquainted with what good work is. The remedy rests in the employment of competent electrical engineers for the purchase, installation and operation of electric plant, and I feel, as matters stand at the present date, that this cannot be too strongly impressed upon colliery owners in their own interest.

In 1908 1,174 separate fatal accidents occurred in mines, involving a loss of 1,345 lives, a decrease of 21 in the number of accidents and an increase of 66 in the number of deaths compared with the year 1907. The number of persons disabled for more than seven days, but non-fatally, was 143,258. It is interesting to notice that 603 of the total number of deaths and 52,579 of the number of persons disabled resulted from falls of ground, whilst only 11 deaths (an increase of 1 compared with the previous year) and 22 cases of non-fatal injury were attributed to electricity.

Of the 11 fatal electrical accidents, in six cases the shock was received from cables, in one from a switch, in one from a signal wire in contact with a bare cable, in one from contact with a live terminal, and in one from a controller. In the majority of accidents the electrical pressure was only from 250 to 580 volts.

The above figures refer to accidents underground; in addition to these there were four fatal and 12 non-fatal accidents on the surface, due to electricity. In regard to quarries 92 deaths and 4,809 non-fatal accidents were recorded, electricity only being responsible for one accident, and that non-fatal.

In the report, statistics are given of the number of coal-cutting machines in the United Kingdom. These machines were in use at 414 collieries and numbered 1,659, compared with 1,493 in 1907. The amount of mineral thereby obtained was 13,590,358 tons. It is interesting to notice that 737 of the machines were driven electrically and the remaining 922 by compressed air. Of the electrical machines, 409 were of the disc type, 230 of the bar type, 89 of the chain type, two of the percussive type and seven of the rotary heading type.

Of the 30,699 safety lamps in use in 1908, 2,190 employed electricity as the illuminant, compared with 2,684 in the previous year. As to the method of lighting the lamps, in 270,168 instances electricity was employed out of a total of 644,068 cases in which lamps were lighted, internal igniters being employed in 5,535 cases, whilst the lamps were opened in 358,751 instances. As showing the dangers attendant on the use of electric re-lighters the following incident is described in the report:—

At a colliery in the Midland district a re-lighter in use contained two primary batteries, the E.M.F. of which was about 2·5 volts, and a Ruhmkorff coil, which was hermetically sealed in a strong iron box. The apparatus was of the latest design, and had been in use for over two months. An official of the colliery proceeded to re-light a lamp of the maker's pattern by fixing it on the revolving cylinder, and when he attempted to pass the current through the lamp an explosion occurred in the lower iron box which contained the batteries and the Ruhmkorff coil. The force of the explosion shattered the iron box and the flame burnt the official. The re-lighter was situated in a current of fresh air which had travelled not more than 250 yds. from the downcast shaft, and the place was quite free from firedamp. No lamp on this occasion had been re-lit for about 10 hours. There can, therefore, be no doubt that the explosion was due to the ignition by means of an electric spark of hydrogen gas in an atmosphere surcharged with oxygen, the hydrogen and oxygen having been generated by electrolytic action. Within two months of this accident another and similar re-lighter at another colliery in the same district, also situated in the main intake airway, exploded and burst the door. These accidents point to the danger of using re-lighting apparatus in mines in which firedamp occurs, unless they are of such design that it is absolutely impossible for them to cause an ignition of firedamp.

WATER-HAMMER.

The memorandum for the year 1908 by Mr. C. E. Stromeyer, chief engineer to the Manchester Steam Users' Association, is entirely devoted to a consideration of this difficult subject, to which Mr. Stromeyer has devoted much attention. Having constructed a glass model of a steam-pipe arrangement he found that he could reproduce on a small scale the same classes of water-hammer which, according to the Board of Trade reports, have been the cause of about 120 steam-pipe explosions, and in the present memorandum, from which we take the following extracts, he compares such explosions with his theory.

One of the greatest difficulties with regard to explosions in general, and of steam-pipe explosions in particular, must always be that the sudden loud report either obliterates the recollection of what was being done at the time, or a feeling that the handling of a cock or valve had in some mysterious way been the cause of the explosion, combined with the fear of being blamed, makes people minimise or wilfully forget what they were doing at the time. These tendencies, and the deaths of those who were handling the exploded valves, are the difficulties which engineers who inquire into pipe explosions have to contend with. A further and equally serious difficulty is introduced by the incompleteness and the vagueness of official reports. This was excusable in the past, when the nature of water-hammer was not understood; but, since I have frequently demonstrated its nature, it is tantalising to find that the modern reports are quite as incomplete as regards essential details as are the old ones.

With regard to formal investigations into cases of water-hammer, one may safely say that little scientific information can be drawn from them, even if the newspaper reports of proceedings are consulted. Usually there are about a dozen findings about personal responsibility and related matters, and only one question and answer as to the cause of the explosion. It would be highly desirable if, in cases of formal investigations, the preliminary inquiries on which they are based were also published, and it would be better still if the technical expert of the commission were to draw up a technical report with full details as regards dimensions, pressures, materials, &c.

The deductions to be drawn from examination of the various reports on water-hammer, as summarised in an appendix to this memorandum, are as follows: By placing the junction valve of a single boiler at the highest point of the steam-pipe range, and leading a horizontal pipe or an inverted L pipe to the engine, so that under no condition can water lodge in a horizontal or slightly slanting pipe, either over the engine valve or over the boiler junction valve, then absolute safety from water-hammer will have been attained. With two or more boilers, and with two or more engines, the slight danger is introduced, even if the pipes are horizontal or slightly inclined, that the flowing steam may dam up some of the water. This slight danger grows to be a serious one if, as in electric light stations, there are many boilers and many engines attached to a single main, and especially if this main is of a ring form, as is often the case.

If a horizontal steam pipe rises after it leaves the boiler junction valve, if the steam pipe falls and then continues in a horizontal or slightly inclined direction towards the engine, or if any portion of the pipe bends upwards at both ends, then water can accumulate either in the horizontal pipe near the boiler or over the engine stop valve or in the pocket, and then water-hammers may be brought about as follows: By admitting steam above the water surface in a partially filled pipe or by admitting steam under the enclosed water. If steam is resting on the water in the pipe, then water-hammer can be brought about by running off the water or otherwise disturbing it, as, for instance, by admitting steam to an engine. Water-hammer can also be produced in pockets by the slow condensation of steam, and

if a plug of water lying in a pocket is set in motion serious harm may be done at distant parts of the steam range.

In order to prevent these water-hammers all pockets should be provided with water catchers having gauge glasses and automatic drains, or they should have at least automatic drains; but these have to be very carefully looked after. In one case where, for the sake of extra safety, two automatic drains were fitted, both got out of order and a water-hammer resulted. Drain pipes to or from the automatic drains should be of ample diameter, and preferably of copper, for fear of getting choked by rust.

Drain cocks on steam pipes have been the cause of about one-fifth of all water-hammers. If they are kept partly open they are likely to choke; if used occasionally they may let out the water and disturb its surface, or may be inoperative and not remove the water as expected, either because they are choked or because there is not enough pressure in the pipe to drive out the water. Seeing that no steam valve can be relied upon for permanent tightness, one has to expect, even in those cases where the boilers are shut off overnight, that water may lodge in convenient pockets.

In conclusion, no very definite rules can be formulated for complicated pipe arrangements, and it is certainly wrong to assume, as is generally done, that there is safety either in horizontal or in slanting pipes.

IRONCLAD FITTINGS.

Contractors and users will no doubt welcome anything which tends to simplify and facilitate the work of wiring up. The new lines of iron-cased switches which are now being made by Messrs.

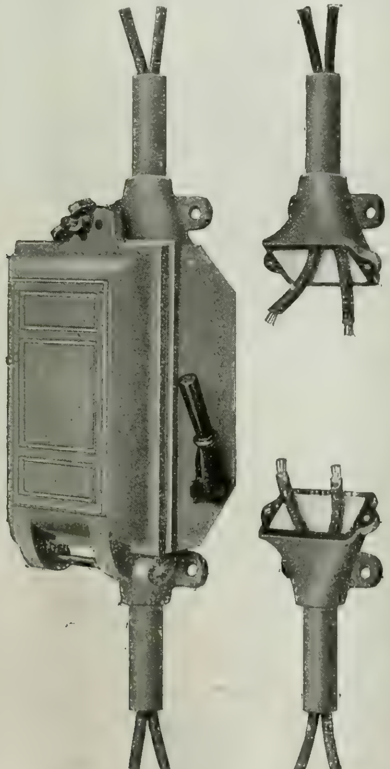


Fig. 1.—Examples of Dorman & Smith's Ironclad Fittings.

Dorman & Smith, of Ordsal Electrical Works, Salford, and of which they have sent us particulars, have been specially designed with this object in view.

From the adjoining illustrations it will be observed that a bevelled inlet, as shown, is employed instead of the ordinary method of bringing the pipes or cables immediately to the box itself. This inlet being easily detached from, or fixed to the switch box, the wiring is facilitated, and the arrangement possesses the further important advantage that, in the event of it being necessary to remove the switch box, this can be done without disturbing the pipes or wires. The switches are specially applicable to alternating current installations where it is desirable for lead and return to be carried in the same pipe.

Messrs. Dorman & Smith are supplying this new pattern in both their watertight and non-watertight iron-cased switches. The same firm have also placed on the market a new patented type of strong iron well glass fitting which, as in the case of the switches, has been

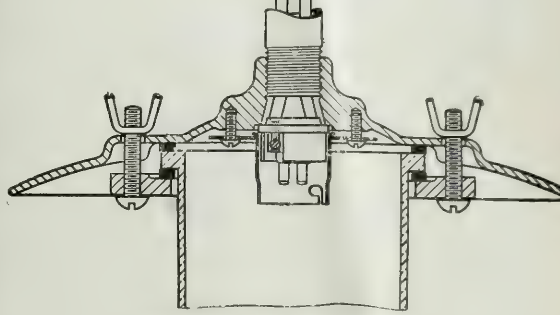


Fig. 2.—New Well Glass Fitting.

designed primarily with the object of facilitating the wiring up of the fittings and at the same time effecting some economy by reducing the number of parts.

In these fittings the usual lampholder nipple is dispensed with and the wires have consequently a straight run through from the tube in to the lampholder insulator eliminating the usual dangerous bends in the insulated wires at this point.

LUNDBERG'S NEW TYPE OF INTERMEDIATE SWITCH.

A perusal of Messrs. A. P. Lundberg & Co.'s catalogues doubtless gives rise to different feelings in different minds. In ours the feeling is one of profound admiration of the ingenuity displayed in getting out the various designs. It seems to be possible by a proper application of these switches to be able to switch your light on or off from any conceivable position, and in practically every way that is ever likely to be required.

Fig. 1.—Lundberg's New Intermediate Switch.

Our readers will remember that Messrs. Lundberg have had on the market for some time a switch known as the "pivot intermediate" switch, which was arranged for work in connection with two-way pivot tumbler switches. Previous to its introduction, when specifications necessitated the employment of the tumbler type of switch throughout, it was necessary to link two two-way pivot switches for use at intermediate positions. This resulted in a very clumsy arrangement and led to complicated connections, with the result that drum type switches were generally installed for such positions, with a resulting lack of uniformity that was unpopular with the consumer. This type of switch was largely adopted for corridor and

staircase lighting, as well as for control in rooms, enabling such to be controlled from any number of positions desired. It found a large application on board ship and was also employed for working fans in hot climates.

A new type of switch illustrated herewith (Fig. 1) replaces the present type, and embodies certain improvements. In it a system of double-clip contacts is being adopted, while mica insulation is used on the rocking contact arm. The screws which hold the various members of the rocking contact arm together are provided with porcelain bushes. By this means, it is claimed, the construction is now proof against breakdown, which might be caused through overheating or moisture. The provision of double contacts is almost a necessity in this type of switch, as the current is passing through the switch in only one of four possible ways at a time. The path for the current is therefore varied, and as all the switches in the circuit are in series with each other, the need for efficient contact at all such points is very evident. The contact arrangement is shown in Fig. 2.

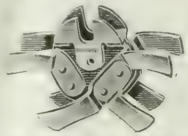


Fig. 2.—Contacts in the New Intermediate Switch.

The improved switch movement adopted has allowed, it is claimed, a better method of construction for the rocking contact arm to be used, and this last method is the subject matter of two new patents recently granted to Messrs. Lundberg. The switch is made for both surface and flush work, and can be easily converted, by the omission of one of the new shaped contact arms, into a series parallel switch without "off" position, and, by the removal of two of the new shaped contact arms, into a double-pole switch. The latter type of switch, although one not much used in this country, has been employed to a considerable extent on the Continent. The intermediate switch can also be used for reversing purposes without any alteration to the rocking contact arm, though in this case it has no "off" position. These switches can, of course, for these three purposes, be preferably fitted with porcelain covers, or if with metal, be fitted with fibre linings to avoid any risk of short-circuiting.

CABLE SUSPENDERS.

The illustrations herewith show a patent cable suspender which has been brought out by Messrs. W. T. Glover & Co. The sling is made up of sheet lead, substantially braided with compounded yarn,

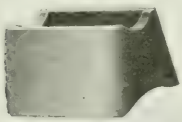


Fig. 1.—Steel Collar.

Fig. 2.—Steel Hook.

Fig. 3.—Complete Suspender.

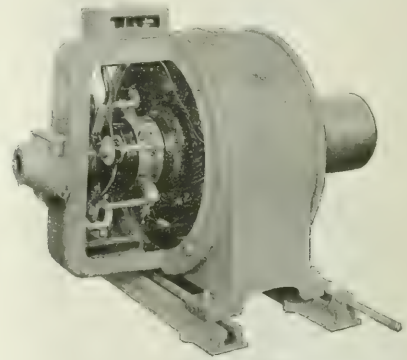
the nature of which is varied to suit local conditions. This combination of lead and braid provides the necessary tensile strength, and offers prolonged resistance to atmospheric influence, whilst an exceptionally wide base of support for the cable is provided. The hook and collar shown in Figs. 1 and 2 are made of galvanised malleable steel, the lower part of the hook being wedge shaped, and so proportioned that, with the cable in position, the ends of the sling enter the collar without appreciable bending. Since the strain is uniformly distributed over the whole sectional area of the two ends of the sling owing to the method of support, advantage may be taken of this to reduce the number of suspenders.

The sling is sufficiently pliable to adapt itself to the contour of the cable without danger of chafing, while its broad base distributes the weight over a long bearing surface, thus reducing to a minimum any risk of damage to the dielectric. The hooks slide very readily along a span wire, but the slings do not slip along the cable. The complete suspender is shown in Fig. 3.

B.T.-H. CONTINUOUS-CURRENT MOTORS AND GENERATORS.

The continuous-current motor is by this time such a standardised piece of apparatus that it is only in the matter of detail that any great improvement can be expected. Makers, however, always pay attention to such improvements in order that an increase in efficiency and economy, and a decrease in price may be obtained. It is, doubtless, for these reasons that the British Thomson-Houston Co., Rugby, have recently put on the market a new type of continuous-current motor, one of which is illustrated in the accompanying figure.

In the design of these motors only the best quality of insulation is used. The insulated conductors, of which the field coils are



B.T.H. Open Type Motor.

formed, are subjected to a special drying process and are then treated with a moisture and acid-proof compound, for the purpose of removing and excluding all moisture from the coils. These coils are all tested with an alternating-current pressure of 1,500 volts applied between the coils and frame for a period of 60 seconds while the machine is hot.

The armature core consists of sheet steel laminations of high permeability slotted on the periphery to receive the windings and clamped under pressure between end flanges. All the laminations are coated with an insulating compound before assembly to minimise losses due to eddy currents. Radial ventilating ducts, to allow of a free circulation of air, are provided. The armature windings consist, as usual, of form wound coils carefully insulated and inserted in the armature slots, which are previously lined with a sheet of insulation. The commutator is built up of hard-drawn copper segments of ample wearing depth, which are insulated from one another by means of carefully selected mica and from the clamping rings and shell by means of micanite cones and a sleeve. The commutator shell is forced into position and rigidly keyed to prevent any movement between it and the armature winding. Ventilating ducts are also provided for cooling purposes. The magnet frame is of cast-iron, and the poles are of laminated wrought iron which can be removed with the field spools without any displacement of the armature being necessary. The field coils can readily be taken off when required.

The brushes are of carbon and are carried in brushholders of the clock-spring type, so constructed that the tension of any brush is uniform throughout its life and is readily adjusted without removing

it from the commutator and without the use of any tool. Any brush can be removed while the machine is in operation without disturbing the others. Connection is made between the brushes and the body of the holder by flexible wires.

These motors are designed to have a temperature rise, according to the type, based on a six hours' run at the corresponding horsepower at normal voltage. They can be run at other voltages if a slightly increased temperature rise is allowed. All these motors and generators will stand an overload of 25 per cent. for half an hour and a momentary overload of 50 per cent. without injurious heating or sparking. These motors are made in a number of types designed for use on every class of work.

PARLIAMENTARY INTELLIGENCE.

The Government and Marconi's Wireless Telegraph Stations. In the House of Commons yesterday (Thursday) the Postmaster-General (Mr. S. Buxton) stated, in reply to a question by Sir W. Holland, that he was glad to say that arrangements had been completed with Marconi's Wireless Telegraph Co. to transfer to the Post Office all their coast stations communicating with ships, including all land and leases and the surrender of all rights which they held under agreement with the Post Office of 1904. The Post Office secured the right of using, free of all royalties existing, Marconi patents and any future patents and improvements for a term of 14 years, for communication between stations of the United Kingdom and ships or between outlying islands, and accepting the transmission of public telegrams to all stations on the mainland. The inclusive consideration to be paid to the company was £15,000. The arrangement was in no sense an inclusive one. All the stations would, under the Radio-Telegraphic Convention, be open for communication equally to all ships, whatever system of wireless telegraphy they might employ. The Post Office would be free to use or experiment with any system of wireless telegraphy. The company would retain the licence of their long-distance stations at Poldhu and Clifton, which were primarily intended for shore-to-shore communication with America. Arrangements had also been made with Lloyd's for the transfer to the Post Office of all their wireless stations in communication with ships and the surrender of all claims to licences for such communication. In return Lloyd's would receive the plant value of their stations, and have transmitted to them, with due regard to the secrecy of private telegrams, information received at the Post Office stations in regard to the positions and movements of ships and other maritime intelligence. Lloyd's and the Marconi Co. had mutually agreed to cancel an agreement between themselves which was made in 1901, and which had proved a source of dispute, and therefore an obstacle to the development of wireless telegraphy. He was satisfied that it was to the public interest, both from a commercial and a strategical point of view, that the coast stations used for communication with ships should be in the hands of the Government, and should be worked as part and parcel of the telegraphic system of the country. He thought it important also that no private monopoly in wireless telegraphy should be allowed to grow up. He trusted that the new arrangement would result in an even more rapid extension of the use of that important invention than had taken place in the past. He might add that the negotiations and arrangements had been conducted with the knowledge of, and in consultation with, the Admiralty, who considered it important that the coast wireless stations should be in the hands of the Post Office.

Electricity in Mines.—In the House of Commons on the 23rd ult. Mr. MARKHAM asked the Secretary of State for the Home Department whether he had applied to the Chancellor of the Exchequer for any grant of public money to make the experiments which the inspectors of his department stated were necessary should be made without delay to safeguard the lives of miners where electricity is employed.

Mr. MASTERMAN said the Secretary of State had not received any recommendation from the inspectors of mines as to the necessity or urgency of any experiments with regard to electricity, though he had seen a Paper read at the Institute of Mining Engineers by Mr. Nelson, in which he suggested that certain experiments on live cables would be of interest and might be valuable. The whole subject of the regulations for the use of electricity in mines was about to be referred to an expert Committee, who would doubtless consider how far any such experiment would be useful, and by whom they could best be made. Their recommendations would have the Secretary of State's careful consideration.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A practical manager, having complete knowledge of ingredients and methods, is required for the rubber department of a cable factory in Spain; also a business man, with experience in estimating costs of manufacturing similar goods and capable of general representation, is required. See an advertisement.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

Mr. William Brown, B.Sc., lecturer in electro-technology at the Royal College of Science for Ireland, has been appointed, as from Oct. 1, to the chair of physics in the college, which will become vacant on that date owing to the retirement of Prof. W. F. Barrett, F.R.S. The post of lecturer, rendered vacant by Mr. Brown's promotion, has been filled by the appointment of Mr. Felix E. W. Hackett, M.A., B.Sc., one of the junior fellows of the Royal University of Ireland.

In addition to Mr. H. H. Holmes, sales manager, Mr. K. A. Boshell, chief clerk in the general office, and four members of the sales department staff of West Ham Corporation have resigned their posts to take up positions under Marylebone Council. The vacancies at West Ham will be filled as follows:—Mr. Farndon, assistant sales manager, to be promoted to the position of sales manager at £250 per annum, rising to £300 at the end of 12 months' satisfactory service Mr. Edgerton, at present motor superintendent, to be appointed assistant sales manager and meter superintendent at £200 per annum, rising to £250 after one year's satisfactory service. The clerical staff of the general office and sales department is to be amalgamated and re-arranged, and Mr. Johnson, at present in the accounts department at £125 per annum, is to be appointed chief clerk at £150 rising on satisfactory service by annual increments of £10 to £180 per annum.

Bristol Corporation have promoted Mr. A E. Wilson, at present distribution superintendent, to the position of deputy city electrical engineer (vacant by the resignation of Mr. H. H. Couzens) at a salary of £300 per annum. Mr. W. B. Morgan, station superintendent at Avonbank, has resigned having obtained an appointment at Dawson City, Klondike.

EDUCATIONAL NOTICES.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 commenced on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

City and Guilds Technical College (Finsbury).—The Session for evening classes begins on Monday, Oct. 4, at 6 p.m. The courses of instruction include lectures and laboratory work in mechanical and electrical engineering, industrial and technical chemistry, drawing, &c. Programmes may be obtained at the College, Leonard-street, Finsbury, or at the head office of the City and Guilds of London Institute, Gresham College, E.C.

Northampton Polytechnic Institute.—A course of 20 experimental lectures, as mentioned in another column, will be given by Dr. C. V. Drysdale on the "Testing of Electrical Plant," on Wednesday evenings from 7:30 to 8:30 p.m., commencing on Wednesday, Oct. 6. The lectures will be supplemented by laboratory work, and special laboratory demonstrations of generator, motor and transformer testing. Briefly, the syllabus is as follows:—

Electrical Instruments, including power factor indicators, frequency meters, devices for obtaining wave-forms and the effect of inductance capacity and eddy currents in wattmeters. *Mechanical Measurements*, including the dynamometers of Ayrton and Perry, Hefner Alteneck, Ganz and Fischinyer, and methods involving resonance, stroboscopic principles, &c. *Continuous-current Generator and Motor Testing*, including Field's method and acceleration methods of testing, measurement of reactance voltage, commutator losses, leakage coefficients and heating tests. *Alternating-current Measurements*, including polyphase measurements, determination of power factor, measurement of inductance and capacity, iron testing and dielectric losses. *Transformer Testing*, including vector diagrams, prediction of regulation and differential methods of testing. *Testing of Alternators*, including Hopkinson, Mordey and Behrend's methods, predetermination of regulation, &c. *Alternate-current Motors*, including Heyland diagram, prediction of performance, determination of "V" curves of synchronous motors and commutator motors.

Acton.—At the last meeting of the Council the following motion was passed:—

That the maximum demand system, based on the load factor for power and heat, would be fairer to the Council and the consumers than the flat rate now in force, and that it be referred, together with the engineer's report, to the Electricity committee to fix the charge.

In reply to Councillor Ince, Mr. BLAIR said the Metropolitan Electric Supply Co. proposed in the recent negotiations that if the Council took not less than 180,000 units per annum for street lighting the company would supply at 1d. per unit during the usual burning hours, such price to be subject to revision every 10 years, or (at the option of the Council) at an annual charge per lamp, to include maintenance and attendance, based upon the price for energy at the time being. The cost of the current now used for street lighting was calculated at 0·98d.

Councillor SCHULTESS YOUNG proposed a resolution to ask the company if they were willing to take over the provisional order for the remainder of its term and supply current for street lighting and for power

and heating at 1d. for private consumers' lighting at 6d., and trade customers at 5d., and that the charge be 3½d. for all other purposes. That the reply be circulated amongst the ratepayers, with the statement as to the alternative new station, and that the opinion of the ratepayers be taken. The voting for and against the motion was equal. The chairman did not vote, but declared the resolution not carried.

Alleged Smoke Nuisance. At Tower Bridge Police Court on Wednesday the City of London Electric Lighting Co. were summoned (before Mr. Baggallay) by Southwark Borough Council for alleged smoke nuisances at their premises in Bankside. There were nine summonses relating to the company's three shafts on different days.

At the outset a difficulty arose as to proving the service of the notices to abate the nuisances. A messenger stated that the notices were handed to him by an inspector, and he placed them in an envelope and delivered them on defendants' premises. He could not say that the copies produced were actual copies of the originals which he served.

Mr. BAGGALLAY remarked that it was a most perfunctory way of doing official business. In order to prove the notices copies must be produced by the person who served them, and he must identify them as copies. That had not been done, and the summonses must be dismissed. He allowed defendants five guineas costs.

Alleged Theft.—Woolmer J. V. Duncan and Louis Ernst were charged at North London Police Court on Saturday with being concerned in stealing and receiving three ampere meters, six voltmeters and six cell testers, the property of the Foxcroft & Duncan Engineering Co. (Ltd.), of London Fields, and Arthur Pamington was charged with receiving the goods knowing them to have been stolen.

Mr. SAUNDERS (for Duncan and Ernst) said there would be an answer to any allegations. Mr. Duncan was originally proprietor of the business, and he was now one of the principal share and debenture holders of the company.

It was stated that Ernst was employed by the company, and that Pannington, who had a stall in Farringdon-road, had upon the stall articles alleged to be the property of the company, and that he said he bought the articles from Ernst.

The accused were remanded.

America's "Possession" at Stratford-on-Avon.—There will take place on Wednesday next, Oct. 6, a ceremony which will attract Americans both resident in or on a visit to this country. The American Ambassador (the Hon. Whitelaw Reid) will perform the opening ceremony of the Harvard House, which is the name our American cousins have applied to what was at one time known as the "Ancient House" at Stratford-on-Avon. The house was built by the father of Katherine Rogers, who married Robert Harvard, of Southwark, London, and became the mother of John Harvard, founder of America's famous university of that name. We are informed that for the convenience of Americans and others who desire to visit Stratford-on-Avon on the opening occasion the Great Central Railway Co. are issuing special tickets available between London and Stratford-on-Avon at cheap fares, and have made fully adequate arrangements for the comfort and convenience of passengers. Tickets can be obtained in advance at Marylebone station or at any of the company's numerous ticket offices in London.

Australasia.—The "Australian Mining Standard" states Mr. A. Wyllie, city electrical engineer of Auckland (N.Z.), has expressed the opinion that the scheme of Mr. I. von Edeskuty for utilising water power instead of extending the Council's steam-driven plant at the electricity works is impossible.

Mr. Wyllie says the water power used by Dunedin Council cost them considerably more than Auckland's steam power will cost. The water power available from falls near Auckland is almost trivial compared with the city's needs. He mentions the city of Worcester as an instance in which water power was first used, and steam plant had afterwards to be put in because of the inadequacy of the water supply.

Eaglehawk (Victoria) Borough Council has obtained the consent of the Public Works Department to the establishment of electricity supply works, and has decided to invite tenders for carrying out the scheme, which is estimated to cost £7,000. It is proposed to use 100 c.p. metal filament lamps in the principal streets.

The Echuca Shire Councils' electric lighting plant, at Rochester (Victoria), was started last month. The streets are lighted electrically, and negotiations are proceeding with the Railway Commissioners for a supply for lighting the railway station.

In a recent report, Mr. D. Curle Smith, electrical engineer to Kalgoorlie (W. Australia) Council, recommended that, in view of the tendency that exists among large electric power consumers to instal suction gas plants instead of electric motors, the following sliding scale be charged :—For 500 units per month 4d. per unit, 1,500 units per month 3d. per unit, over 1,500 units per month 2½d. per unit.

At a meeting of representatives of the N.S.W Electrical Traders' and Contractors' Assoc. and the Electrical Employés' Union recently, the employers stated that they were frequently imposed upon by incompetent workmen; they therefore wanted the men to pass a practical test and obtain licences. It was agreed that both parties should endeavour to secure a wages board for the trade, and that this board should determine the conditions under which licences should be granted.

Inverell (N.S.W.) Council have decided to adopt electric lighting. An estimate by Mr. J. E. Donoghue, of the Balmain Electric Supply Co., put the initial cost of mains, &c., at £10,840 The prices would be 6d. for lighting and 3d. for power. With gas at 10s. per 1,000 in Inverell, the equivalent price of electrical energy would be 11¼d. per unit. The Council should make a profit of £1,481 per annum on the electric lighting.

Barking.—The Lawes Chemical Manure Co. are installing a further 100 H.P. in motors at their works.

Battersea (London.)—Metal filament lamps are to be substituted for carbon lamps in the baths and libraries at a cost of £124, and the mains are to be extended at a cost of £120.

Cardiff.—The Lighting committee have decided to erect additional electric lamps in the neighbourhood of the new college building in Cathays Park.

Cathedral Lighting.—The Cathedral Board recently decided to remove the whole of the gas fittings at St. Patrick's Cathedral, Dublin, and the contract for electrically lighting the building has been placed with Messrs. Wm. Coates & Son. The total cost is estimated at nearly £1,000, and the aggregate candle-power of the lamps to be installed will be about 5,000. Electrically-driven rotary organ blowers are to be substituted for the hydraulic blowers at present in use.

City of London.—At the meeting of the Court of Common Council last week it was reported that—

The County of London Electric Supply Co. had given notice of intention to commence laying and amending e.h.t. electric mains and three 2½ in. iron conduits crossing London Bridge, thence along the east side of London Bridge to Adelaide-place and King William-street to Monument station, crossing Eastcheap, and thence in a north-westerly direction along King William-street to Lombard-street, crossing Cornhill and Threadneedle-street to Princes-street and Lothbury, along Moorgate-street to London Wall and Finsbury Pavement, South Place, and crossing South Place to the boundary of Finsbury.

Mr. Deputy MILLAR WILKINSON asked if the Corporation could not order the company to take some alternative route.

The CITY SOLICITOR said the County of London Electric Supply Co. had sent in a notice, as it had a perfect right to do. If the route suggested was disapproved of, the Corporation would have to submit an alternative one, and if that was not accepted by the company a Board of Trade arbitrator would have to be called in to say what route should be taken.

The TOWN CLERK said the matter was under consideration.

Clerkenwell (London.)—The County Court has been wired for electric lighting, and current is taken from the mains of the Islington electricity department.

College Lighting.—During the recent summer vacation additions to the electrical mains at Malvern have been numerous, particularly to the Malvern College and College Master's houses, where an installation comprising over 600 metal filament lamps has been installed upon the advice of Mr. W. J. Rendell Baker, electrical engineer to the Malvern Council who prepared all specifications, &c., the work being carried out by the local firm of Mr. A. Sparkes under the direct superintendence of Mr. J. Houlton, engineer and manager for Mr. Sparkes.

A supply of alternating current at a pressure of 100 volts is taken from the Urban's Council's distributing mains. The installation is divided into two sections, controlled from a primary switchboard, each section in turn being split up into convenient circuits supplied from secondary boards. The whole of the wiring is enclosed in steel tubes, efficient junction and inspection boxes being provided. To minimise the necessity of joints, the looping-in system has been adopted as far as practicable. The lighting of the large hall is effected by 16 four-light suspended fittings. In the class rooms the ordinary drop pendant has been adopted. The installation comprises some 300 points, and 35 watt osram lamps have been fitted throughout.

Dundee.—Preparations are now practically complete for receiving submarines at Dundee Harbour. During the past few days the work of laying electric cables to the dockside and erecting standards has been proceeding, and a complete electric light installation has been erected.

Electrical Exhibitions.—As stated in our last issue, an interesting exhibition of electrical appliances for cooking, heating, lighting and power was held at Greenock Town Hall from Sept. 21 to 25 inclusive.

The exhibition was organised by the Corporation electricity department in co-operation with the local contractors, and proved highly successful. In order to induce the right sort of people to visit the exhibition, complimentary tickets were issued by the department, but the demand for these became so great that a charge for admission was made on the last day. It is estimated that nearly 10,000 persons visited the exhibition, and hundreds had to be turned away in the evenings.

Numerous inquiries have since been received by the electricity department and the local contractors, and several substantial orders were booked during the course of the exhibition.

During the exhibition practical demonstrations were given of cooking by electricity, and the lighting of the hall was effected by a series of five "Excello" flame arc lamps which were loaned by the Union Electric Co. The exhibits included various applications of motors to industrial purposes, advertising signs, h.t. and mining switchgear, tramway controllers, &c.

At the closing ceremony on Saturday last, Bailie J. W. BENNETT referred to the great increase in the supply of electricity in Greenock during the past few years. The success of the present exhibition, which had justified the anticipation of its promoters, had been in a great measure due to the efforts of Mr. J. A. Robertson, burgh electrical engineer, who had inaugurated the exhibition and supervised its equipment.

In reply, Mr. ROBERTSON acknowledged the assistance he had received from the manufacturers whose apparatus had been on view. The exhibits were representative of almost every electrical manufacturing company in the country, and those firms had loaned their goods free of cost. Mr. Robertson also referred to the help given by the local electrical contractors and by the staff of the electricity department.

Bexhill Corporation electricity department are organising another electrical exhibition, a former show having proved eminently successful.

Epsom.—35 tantalum lamps are to be substituted for existing lamps at an estimated cost of £70, and an increased annual cost of £24. 7s. 6d. for current. The arc lamps in High-street are to be replaced by eight flame arc lamps at a cost of £135, and an increased annual cost of £20.

The ratable value of the Council's electricity undertaking has been fixed at £740, an increase of £360 on the previous assessment.

Exhibitions.—At the model engineering exhibition, which opens at the Royal Horticultural Hall, Westminster, London, on Oct. 15, there will be shown a number of interesting exhibits, including a number of model aeroplanes, including the machine designed by Mr. G. P. Smith and which won the gold medal in a recent contest at Wembley Park. Working model steam and electric railways, electric clocks, light machine tools, model motor boats, a model engineers' workshop in operation, and a working demonstration of wireless telegraphy by the latest Marconi apparatus will also be shown. For the competitions for engineering and electrical model making over 100 entries have, we are informed, been received. The exhibition will remain open till Oct. 23.

Mr. F. B. O. Hawes, secretary of the National Electrical Manufacturers' Association, writes us as follows in regard to the Brussels Exhibition, 1910: —

The chairman of the committee of this association has just returned from Brussels, and desires me to point out to you the importance of this exhibition commencing in April next year. This will be the most important exhibition which has been held on the Continent since that at Paris. I would remind you of my letter of July 28 last, in which attention was drawn to some of the directions in which this association can be of use to exhibitors, and beyond those mentioned is the matter of insurance, regarding which our expert wishes me to point out to members the necessity of making special arrangements jointly.

Germany.—Counsul-General Sir Wm. Ward (Hamburg) states in his report that the company formed at Hamburg to utilise the tides for producing electricity, &c., and to which he referred in his last annual report, does not seem to have advanced during the year beyond that initiatory stage.

At a meeting of the shareholders recently it was announced that the construction of the works required for commencing operations will now take place. The managing engineer expressed confidence, but some other persons thought the cost would be too great to render the undertaking profitable.

Vice-Consul Behncke reports that electricity supply works are to be erected at Lübeck.

Vice-Consul Sinclair states that works are being erected near Aurich to utilise peat in the generation of electrical energy. It is reported that the Government will take 2,000,000 kw.-hours per annum for use at Emden Harbour.

Vice-Consul Stevenson says a telephone apparatus factory at Hanover reports an increase of 20 per cent. in its turnover. The company has paid for the past year 10 per cent. on £150,000 capital, and contemplates increasing the latter by £50,000.

Haslingden.—The question of obtaining a provisional electric lighting order has been referred to a sub-committee.

Hayti.—The formation of the Cie d'Eclairage Electrique des Villis de Port au Prince et du Cap Haitien has been authorised, the former contract for the electric lighting of the towns having lapsed.

India.—The electric power installation on the Swat river for the Malakand tunnel is now practically completed.

Italy.—Decrees have been published authorising agreements between the Ministry of Public Works and the Societa Ferrovia del Mottarone for the construction and working of an electric railway from Stresa to Mottarone, and between the municipal authorities of Venice and certain communal authorities in regard to wayleaves for an electric tramway from Mestre to Mirano.

Kingsbury (Middlesex.)—It is reported that a number of residents are anxious to be supplied with electric energy, and some have wired their houses. The owner of houses now being built in Stag-lane is desirous to obtain current, and, therefore, negotiations are proceeding with the North Metropolitan Electric Power Supply Co. for a supply for public and private lighting.

L. & Y. Railway Co.'s Electric Service.—The L. & Y. Railway Co. announce that, commencing Oct. 1, the electric service between Liverpool and Aintree, will be extended to Maghull, and a frequent and regular daily service of electric trains will be in operation.

Leicester.—On Tuesday the Council were recommended by the Tramways committee to apply for sanction to a loan of £7,000 for cables and works in connection with the supply of electrical energy from the tramways generating station for power, &c.

At the Council meeting on Tuesday, Councillor [illegible] said the Council had authorised the Tramways committee to take the necessary steps to supply electric current to those who desired it for power. In pursuance of that they had taken the steps, and now supplied some 40 or 50 motors. That had involved them in an expenditure of about £2,000, and it was estimated that they would require about £5,000 more during the next two years. The expenditure would not involve ratepayers in any burden, as, after working expenses and capital charges, they made a fair profit.

The recommendation was adopted.

London County Council Tramways.—On Thursday last the portion of the electric tramways from Hackney station to a junction with the Tottenham line at Stamford Hill, via Amhurst-road and Dalston-lane, was opened.

An extension of the tramways, on the conduit system, from Rainton-road, Greenwich, to Chapel-street, Woolwich, near the Dockyard, is to be commenced at once.

A memorial, signed by 1,800 tradesmen and residents, asking Hampstead Council to oppose the proposal of the L.C.C. to lay tramways along Adelaide-road and Finchley-road was presented to the Council last week.

Longton.—An unopposed inquiry was held on Wednesday into the application of the Council for sanction to borrow £1,740 for electric lighting extensions.

Mansfield.—An inquiry was held here on Wednesday into the application of the Urban District Council for permission to borrow £3,500 for extensions of the electric light mains, house services, &c.

Melbourne (Derbyshire).—The Parish Council decided last week to ask Mr. Jardine at what charges electrical energy will be supplied for lighting if the Council consent to his proposed application for a provisional order.

Mr. Jardine had stated in a letter to the Council that if he obtains the provisional order he proposes to erect a factory to carry on a new industry, in which employment will be found, at the outset, for from 150 to 200 people. As stated in our issue of Sept. 17 last, the Council have accepted the tender of the Midland Machine Trust for the supply of current for 26 tantalum lamps at 15s. each for the season and for certain arc lamps at £4.

Municipal Telephony.—At the autumn meeting of the Executive Council of the National Chamber of Trade last week, a resolution (moved by Ald. J. Brown, of Hull), was carried expressing the opinion of the Chamber that experience had proved that municipalities could work telephone exchanges cheaply, efficiently and to the general benefit, and urging the Association of Municipal Corporations to pass a resolution requesting the Government to make arrangements for the working after the year 1911 of telephones by corporations and local authorities.

Newport (Mon.)—The Electricity and Tramways committee have decided to engage an expert to report upon the position of the electricity undertaking.

The Borough Engineer has been directed to make inquiries of the Board of Trade as to the question of attaching trailers to the present cars. It was stated that if trailer cars could be adopted it would mean further capital expenditure, but a large increase in the revenue. Trailers were in use in other towns, and it was considered that they should be employed in Newport.

Obituary.—We regret to record the death of Mr. John Rance, jun., which occurred on Sept. 16 at Clapham, London. Mr. Rance was 41 years of age. He was successively electrical engineer to gold mining companies in South Africa and the Straits Settlements, and was afterwards, and until recently, in the service of Messrs. Jessop & Co., Calcutta.

Ontario (Canada).—It is announced that the Attorney General has refused to grant a fiat authorising an application to the law courts for an injunction to restrain the Hydro-electric Commission from carrying out the contract entered into by them with the Ontario Power Co.

Personal.—Mr. S. E. Bastow (Bruce Peebles & Co.) was entertained to dinner recently by a number of his friends in Edinburgh, prepara-

[illegible] this country for a tour round the world on behalf [illegible] Mr. Bristow left by the "Tunisian" from Liverpool last week [illegible], and will proceed from there to Australia, New Zealand and South Africa. He expects to be away for at least six months, and we are sure his many friends will wish him a safe and prosperous journey.

[illegible], a Belgian, has been appointed, for a term of three years, as Director-General of Turkish Posts and Telegraphs.

Plymouth.—The local offices of the Orient Line are now lighted electrically.

Poplar (London).—In view of the low cost of production of electrolytic disinfectant fluid and its efficiency, it has been decided to duplicate the plant at a cost of £430. During the last four years 80,000 gallons of fluid have been produced at a cost for materials and [illegible] under £160.

Port Glasgow.—The question of establishing electricity works is to come up for discussion by the Council at an early date. There is evidence that a scheme would prove successful, as certain occupiers are inquiring for a supply of current. Last week Mr. Jas. Lithgow informed the Council that there was a proposal to light some shops in the reconstructed Bay area with electricity, and inquired if there was any likelihood of an electric lighting scheme being undertaken by the Council in the early future.

Private Fire Brigade Tournament.—The first part of the 11th annual tournament of the London Private Fire Brigades Association was held on Sept. 25 on the Parade Ground of the Royal Hospital Schools, Greenwich.

Twenty [illegible] from London and the provinces, competed for the [illegible] challenge trophy for the private fire brigade championship of the United Kingdom, and for other trophies, including the "Dewar" challenge shield and the "Marshall" challenge cup for London private fire brigades. In these events the Robertson Electric Lamps fire brigade was successful in winning the championship of the United Kingdom, also the "Dewar" challenge shield, the winning times constituting records for drills of this class. The same team also carried off 1st prize in the four-men drill, 1st in the five-men drill, and a substantial lead of 18 points towards the best aggregate for the "Marshall" challenge cup. The second part of the tournament takes place in November.

Russia.—Imports of mathematical and electrical instruments from Germany into Russia were valued at £472,000 in 1908, £352,000 in 1907, and £434,000 in 1906. The imports of British goods of the same class, and in the same years, were valued at £15,000, £29,000 and £22,000.

From official statistics it appears that at present the total length of electric tramways in Russia is 1,312 versts (about 875 miles), of which 1,086 versts (about 725 miles), or over 80 per cent., belong to Belgian companies, and the remaining 226 versts are being exploited by municipalities. There are 85 joint-stock and five private companies run by Belgian capital operating tramways in Russia.

Smoke and Vibration.—On Friday last, in the course of a L.G. Board inquiry into applications by Torquay Council for sanction to certain loans, the inspector, Mr. A. A. G. Malet, said the Board had received a petition from occupiers of property complaining of a nuisance arising from smoke and vibration at the electric lighting station, but the Councils' observations had not yet been received by the Board.

The Town Clerk said the Electric Light committee considered the petition on Monday. They had endeavoured to place contracts for smokeless coal, the stokers had strict injunctions to prevent, as far as possible, emission of smoke, and the committee had also provided £150 for the [illegible] of a smoke preventive apparatus.

The Inspector understood it was not vibration that was complained of, but a buzzing noise coming from the ventilators in the engine room.

The Town Clerk said the Council were obliged some time since to provide some better means of ventilation, and, while effecting an improvement in one direction, some little trouble had come in another. In 1905 the Council applied to the L.G. Board for permission to transfer the electricity works to a more suitable site, at a cost of £42,000, but the Board declined to grant a loan. Another remedy for the smoke trouble would be to heighten the chimney at the station, but the Corporation were hampered by restrictive covenants and owners of adjacent property objected to the heightening of the building.

The chairman of the Electric Light committee (Mr. [illegible]) said [illegible] the Board for permission to [illegible]. They were now making a profit of £2,000 a year, and in [illegible] they would be in a position to pay out of the profits the cost of superseded plant.

South Africa.—The Electric and Water Works and Fire committee of Cape Town Council are endeavouring to popularise the use of electricity for heating and cooking, and it is proposed to supply apparatus on hire. The committee propose to expend £50 on electric cooking apparatus for experiments.

Southampton.—Sanction has been received to a loan of £2,300 for extension of mains, and £700 for house services. £160 is to be spent on extension to Stoneham.

SPECIAL NOTICE.

NOW READY.—Vol. LXII. of "The Electrician" (1,028 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "The Electrician" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

Southend.—Last week the Council were recommended by the Light Railways and Electric Lighting committee to apply for sanction to a loan of £13,715 for equipping two sub-stations near Chalkwell Park and the Thorpe Hall Estate, and that the electrical engineer (Mr. R. Birkett) be authorised to prepare specifications and plans required for carrying out the work.

Ald. Martin, in moving the adoption of the report, said complaints had been made that they were not able to supply electricity in certain parts of the town. When the proposed improvements were carried out they would not only be able to supply the whole district up to Leigh, but would be able to maintain and increase the pressure in the whole of the other districts, and also increase the capacity of the central station.

Ald. Brightwell said he had gone somewhat fully into the scheme, but he had had the advantage of the advice of three Corporation officials, including Mr. Birkett, and he had come to bless it. The town was still growing rapidly, and they must face the necessity of spending money to keep pace with the times. In the near future the town would have grown to such gigantic proportions that they would want to move their works to a site near the water, where they could produce their electricity at a cheaper rate. It was his firm conviction that by spending that money they would easily recoup themselves for the outlay. The report was adopted.

Tottenham.—Lighting the Council offices with gas cost £92. 5s. 3d. a year, while the estimate for electricity was £85, and the North Metropolitan Electric Power Supply Co.'s revised terms for supplying electricity (a flat rate of 4d. per unit, with a discount of 10 per cent. for the office block, the discount to be increased to 15 per cent. when the remainder of the Council's buildings are lit with electricity) have been accepted on a three years' agreement.

Tramway Orders.—The report by the Board of Trade of their proceedings under the Tramways Act, 1870, during the session of 1909 has been issued.

The number of applications made to the Board in December, 1908, for provisional orders under the Tramways Act, 1870, was five—viz., Bolton, Keighley, Morecambe, Portsmouth and Whitworth. All the applications were for power to construct new or extension tramways, and all were promoted by local authorities. The aggregate length of the proposed tramways was 4 miles 74 chains of double line and 6 miles 50 chains of single line, and the estimated cost was £121,317. Provisional orders were made in every case. A bill to confirm the orders was introduced into the House of Lords on May 3. A petition was lodged in the House of Lords against the Whitworth order by the L. & Y. Railway Co., but the Select Committee to whom the bill was referred passed the order, after making certain amendments in it. The bill met with no further opposition, and received Royal Assent on Sept. 20.

Tramway Transfer.—Hertford County Council propose to lease to the Metropolitan Electric Tramways (Ltd.) a light railway in Arkley, Barnet Vale and Chipping Barnet for 42 years, from Feb. 26, 1904.

The company are to pay, first, a rent of £1,510. 1s. per annum ([illegible]5 per cent. per annum on the £30,201. 0s. 10d. expended by the Council in the construction of the railway), and, second, a sum equal to 5 per cent. per annum on money which the Council have spent since Dec. 31, 1908 (or may hereafter spend), on land for widening routes, &c., or in the construction of the railway, widening of roads or bridges, &c. In the event of the failure of the company to comply with the conditions of the lease, or if the working of any part of the railway is discontinued for seven days or more (except for necessary repairs or through circumstances beyond the control of the company), the Council may re-enter into possession of the undertaking.

Victoria-Crystal Palace Tube.—As stated in our last issue a syndicate proposes to apply for parliamentary powers to construct a new tube railway from Victoria to the Crystal Palace.

A syndicate is being formed for carrying out the scheme, at an estimated expenditure of £3,500,000. Mr. Stephen Sellon is consulting engineer to the promoters. Stations will be constructed at or near the following points along the line of route, which would be 6⅞ miles in length: Upper Norwood, Upper Sydenham, Lordship-lane, Dulwich, East Dulwich, Denmark Hill, Camberwell, Oval (connecting with City & South London Tube), Albert Embankment, and Victoria (connecting with the main lines and District Railway). A branch line (1½ miles long) from Camberwell to the Elephant and Castle would have an intermediate station in Walworth-road. The journey from Victoria to Sydenham would be completed in 20 minutes, against the present scheduled time of 31 to 37 minutes, and the third-class fare would be 4d., or perhaps 3½d., against 7d.

Village Lighting.—The village of Great Lumley (Co. Durham), and part of the colliery company's property in the village will shortly be lighted electrically. Most of the poles are already erected.

Walthamstow.—The Lighting committee have decided in favour of an application being made to the L.G. Board for sanction to borrow £9,036, the estimated cost of converting 921 gas lamps to electricity.

Watford. Applications for electric current have been received from the Countess of Essex for Cassiobury and from Messrs Benskins for a further supply.

West Ham.—An agreement has been entered into to supply current to the Avenue Press (Ltd.), including hire of motors and apparatus, for five years, with the option of renewal for a further five years; also for a bulk supply to the Bradford Rubber Co. for five years, renewable at termination to 7, 14 or 21 years. The last named Company have agreed to hire their motors from, and for the necessary wiring, &c., to be carried out by, the Council.

Negotiations are taking place with the chief engineer to the Port of London Authority for bulk supply to the Royal Albert and Victoria Docks.

Having regard to the Electric Lighting Acts (Amendment) Bill, the Town Clerk has been authorised to communicate with East Ham and Woolwich Councils with a view to obtaining their consent to the supply of current by West Ham for use within East Ham and North Woolwich.

Upon the suggestion of the electrical engineer (Mr. Couzens), the rates for current for heating are to be similar to the standard rates for power—viz., 1d. per unit, less discount for quantity.

Wireless Telegraph Notes.—It is announced that the interesting experiments with wireless telegraphy which have been a feature in connection with the Zeppelin airships, are to be continued on a larger scale, when some new examples of Zeppelin airships will be launched.

Mr. Marconi has again expressed his hope that his new station at Glace Bay will be re-opened on Jan. 1, when the buildings will be made fireproof.

It is stated by the "Australian Mining Standard" that Sir John Quick, the Postmaster-General, is interesting himself in a system of wireless telegraphy, the invention of Mr. S. Irwin Crookes, a New Zealander, on the ground that the erection of the system can be made very cheaply and that for distances up to 400 miles the system is very effective.

Wireless Telephone Notes.—An installation of wireless telephony, the invention of Mr. Andrew Burns, of Portobello, has been established on the pier at Portobello, and a practical demonstration of the system was given a few days ago. Two stations were provided on the pier, about half a mile distant from each other, and the demonstration is said to have proved successful.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Barrow-in-Furness.—The electricity department accounts for the year ended March show capital expenditure £113,247 (increase £2,375).

Revenue was £12,902 (compared with £12,429 in previous year), total costs £6,287 (£6,440) and gross profit £6,616 (£5,989). Interest and sinking fund required £6,999 (£6,789), the net deficiency being £384 (£791). The combined maximum load was 884 kw. (892 kw.) and the load factor 13·65 (13·41). The equivalent 8 c.p. lamps connected are 78,119 (69,749). Units sold were 1,057,330 (1,047,776); average prices obtained 4·217d. (4·228d.) for private lighting 1·398d. (1·352d.) for power, 2·856d. (2·491d.) for public lighting, and 1·936d. (1·919d.) for traction. There are 152 motors (1,004 H.P.) connected, compared with 137 (864 H.P.) at March, 1908. 29 (16) radiators, 52 (14) flat irons, 9 (1) water heaters and 23 (nil) kettles are out on hire. The borough electrical engineer (Mr. H. R. Burnett) states that £965 was spent out of revenue during the year on repairs, maintenance and renewals, and that there would have been no deficit on the year but for the fact that the demand for current for the tramways was reduced by 28,597 units.

Derby.—The accounts of the electricity supply department for the year ended March last show capital expenditure £287,028 (increase £11,566).

Revenue was £38,251 and gross profit £16,506. After meeting capital charges there was a net profit of £365. 3,958,311 units were sold, of which 1,167,481 were for power, 1,513,748 for traction, 955,855 for private and 321,227 for public lighting. There are 1,547 consumers for lighting (against 1,433 at March, 1908), and 355 (300) for power and heating. The connections, including motors and all lamps, are 180,572 (equivalent) 8 c.p. lamps (against 166,388). The horse-power for motors connected is 1,600 (1,500).

Leicester.—On Tuesday Councillor Jennings stated that the receipts of the electricity department for the half-year amounted to £13,966, and the total expenditure had been £5,924, leaving a gross surplus of £8,042. After paying interest (£3,791) and sinking fund (£3,344) the net profit for the half-year was £907. There had been a decrease of output of the value of about £1,800. During the year the increase in customers for light and motors totalled 209.

Leyton.—The estimates for the half-year ending March 31 next, having been reconsidered, the estimated deficiency on the electricity undertaking for the six months has been reduced from £419 to £393.

This deficiency will be met from the surplus of £2,353 from the preceding half year, leaving an estimated net surplus for the year of £1,960, of which £500 is to be placed to reserve and the balance (£1,460) is to be applied in relief of rates.

Tenders are to be invited by the Council for wiring Canterbury-road school.

Melbourne (Australia).—The report of the Corporation electricity department for the year ended Feb. 28 last states that the capital expenditure during the year was £45,405.

Revenue was £102,635 (against £92,364 in previous year). Working expenses were £50,177 and gross profit was £52,458 and net profit £10,907. The sinking fund has been increased by £4,648, making a total of £63,981 to the credit of the fund and £5,000 has been contributed to the town fund. There is £48,778 standing to the credit of depreciation and renewals fund. Total connections are 143,763 (equivalent) 16 c.p. lamps (against 57,791 in 1904), having increased 148 per cent. in that period. Lighting units sold were 3,380,162 (increase 402,979 over previous year) and power and heating units 1,911,355 (increase 230,380), the units generated being 8,642,154 (936,459 increase).

Plymouth.—The accounts of the electricity department for the year ended March show income £23,956, against £24,511 in 1907-8.

Gross profit was £11,562 (£11,363) and net profit £2,233, of which £1,992 has been applied to reduction of rates and £241 added to reserve. For 1907-8 £1,300 was transferred to relief of rates and £733 added to reserve. The reserve fund now stands at £10,191.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited for the supply of 50 coin attachments, suitable for coins of different values, to the Postmaster-General's department in VICTORIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 100,000 porcelain insulators to the Postmaster-General's Department, VICTORIA. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-st., London, S.W.

Tenders are invited for the supply to the Postmaster-General's Department, New South Wales, of a common battery switchboard for the NORTH SYDNEY telephone exchange. Tender form, specifications, &c., may be obtained from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

The Directors of the METROPOLITAN RAILWAY Co. invite tenders for the supply of general stores during the 12 months' ending Oct. 31, 1910. Manufacturers and others desirous of tendering should apply to the Secretary, Mr. W. H. Brown, for forms. The company's requirements include electric wires and cables, lamps, carbons, switches, fuses, telephones, &c., and electrical insulating materials. Patterns and samples will be on view until Oct. 2 inclusive, and tenders must reach the Secretary by 10 a.m. Oct. 4.

GLASGOW Corporation want tenders by Oct. 4 for supply, erection, &c., of switchboard, distribution boards, mains, cables, switches, wiring, &c., for power and lighting purposes at Shieldhall outfall works. Specifications, &c., from the Office of Public Works, 64, Cochrane-street, Glasgow.

WORTHING Corporation want tenders by noon Oct. 11 for supply of vulcanised bitumen sheathed concentric and triple concentric cables. Specification from the Resident Engineer at the Electricity Works.

WALLASEY Council want tenders by noon, Oct. 13 for supply of about 260 tons of tramway rails, and for fishplates, tiebars, anchor plates, points and crossings. Specification, &c., from the Public Offices, Egremont, Cheshire.

BRUMBY and FRODINGHAM Council want tenders by Oct. 16 for the electric lighting of the streets. Specifications, &c., from Mr. J. Green, Council Offices, Frodingham, Scunthorpe.

LAUNCESTON (Tasmania) City Council want tenders by 4 p.m., Nov. 1, for one year's supply of electrical fittings, incandescent lamps, wires and cables and carbons. Specifications, &c., from the City Electrical Engineer.

The Spanish Ministerio de Fomento requires tenders for the construction and working of an electric tramway from Sans to Coll Blanch, BARCELONA. The "Madrid Gazette" for Sept. 13 contains particulars, and can be seen at 73, Basinghall-street, London, E.C. Tenders (addressed to the Direccion General de Obras Publicas, Madrid), will be opened at noon, Nov. 20. Local representation is necessary.

The Turkish Ministry of Finance will receive tenders until Oct. 14 for a concession for the provision of telephone facilities in Constantinople and its environs. The *cahier des charges* may be obtained from the Ministry of Finance, Constantinople.

TENDERS RECEIVED AND ACCEPTED.

Amongst many recent orders received by Messrs. Reavell & Co. is one for the supply of an electrically-driven compressor for Rotherham Corporation, for supplying air to the pneumatic sewage ejectors in the borough. The machine has a large range of variation in speed, which is controlled by hand. It is also fitted with two special air relay devices, one set for the maximum pressure and the other for the minimum pressure which automatically operate a whistle when the pressure reaches either limit. The firm are also supplying a large machine of the quadruplex double ended type to the order of the G.P.O. for pneumatic despatch at the central post-office. Each end of the machine has a device for automatically controlling the volume, and may be used for either vacuum or pressure.

Melbourne City Council have accepted the tenders of Ship Carbons (Ltd.) for 432,000 arc lamp carbons, £1,218; the Allgemeine Elektricitats Gesellschaft for 18 transformers, £427; Pfaff, Pinschof & Co. for 80 a.-c. flame arc lamps, £340; Austral Otis Engineering Co. for 763,000 arc lamp carbons, £2,050; Chatteris Engineering Works Co. for overhead travelling crane, £286; R. Bulmer for 250 wooden poles, £401; and Peacock & Smith for copper feed-water pipes, £25.

In our issue for Sept. 17 (p. 927) we gave a list of the tenders accepted by Swansea Council for street lighting equipment, and Messrs. Venner & Co. ask us to announce that they are sub-contractors to W. Lucy & Co. for the time switches for controlling the new street lighting scheme. In regard to the tender for the Leyton street lighting contract given above, about 100 of the firm's time switches are included as a sub-contract.

Battersea (London) Council have accepted the following tenders in connection with the wiring of premises and the supply of goods on the hire purchase system: Beck Flame Lamp (Ltd.), flame arc lamps; Brockie-Pell Arc Lamp Co., enclosed arc lamps; Brit. West. Co., motors; G. A. Gunn & Phillips & Co., arc lamp installations; Stegmann & Co., Phillips & Co., and J. W. Gunn, motor installations.

Leyton Council have received the following tenders for supply of public lighting lanterns, with clock switches for incandescent lamps:

Electrical Joint Box Compound Co. (*accepted*)	**£307**	**10**	Tilley Bros.	£333	0
B. Thomas	443	0	Venner & Co.	330	0
Reason Mfg. Co.	350	0	General Electric Co.	325	0
Haydn Harrison	315	0	W. Lucy & Co.	318	0
			Pontifex & Co.	308	0

On Tuesday Bristol Corporation confirmed the acceptance of the following tenders:

Electrical Co., a.c. meters, 1909-10 contract, at £762. 8s.; General Electric Co., carbons, 12 months ending April 30, 1910, £366. 12s. 4d.; Siemens Bros. Dynamo Works, arc lamp globes for 1909-10, £31. 2s. 6d.

The D.P. Battery Co. have received an order for the renewal of the large batteries at Waterloo owned by the Liverpool District Lighting Co., and for their maintenance for eight years.

Islington (London) Council has accepted the tender of the Steeplejack and Engineering Co. at £275 for repairing the shafts at the generating station.

The management committee of the Belfast district lunatic asylum have accepted the tender of John Dowling & Sons for wiring the Purdysburn Asylum at £460.

York Corporation are recommended by the Electricity committee to accept the tender of Dick, Kerr & Co. for the extension of the electricity mains along the tramways route at £2,031. 4s. 1d.

Willesden Council have accepted the tender of Duncan Watson & Co. for maintaining the inter-communication telephone system at the public offices.

Chelsea (London) Council have accepted the tender of Wright Bros. & Co. for alterations to electroliers and for preparing a plan showing the electric lighting wires and mains in the Town Hall.

Brighton Guardians have accepted the tender of C. G. Reed & Sons for electric light fittings.

Plymouth Council have accepted the tender of the Brush Electrical Engineering Co. for a turbo-generator at £2,244.

Belfast Tramways and Electricity committee have accepted the tender of the Tudor Accumulator Co. for supply of a milking booster.

Burnley guardians have placed an order with Carter & Co. for electrical fittings.

West Ham Corporation have placed an order with the Armorduct Mfg. Co. for supply of certain sizes of cables up to March 31 next.

Hanley Council have placed an order with the Brush Co. for a motor generator at £144.

Storage Battery Contracts.—Amongst the orders, which we are informed the D.P. Battery Co. received last week, they have been commissioned by H.I.H. Empress Eugenie to instal a storage battery of their LS 13 type at Farnborough Hill, and by the Crown Agents for the Colonies to supply a battery of 118 L 15 type cells for the Bahamas. They have also been favoured with orders for 16 of their specially designed 25 volt batteries for private residences.

BUSINESS NOTICES.

Owing to the lease of 2, Queen Anne's-gate having changed hands, Messrs. Lacey, Sillar & Leigh, consulting engineers, have been obliged to move (as from Sept. 29) to Iddesleigh Mansions (first floor), Caxton-street, Westminster, S.W. The telegraphic address remains "Advisedness London" and the telephone number is 76 Victoria.

In consequence of the acquisition of 34, Gt. George-street by the Government, Mr. Sidney Sharp has removed to 13, Victoria-street, Westminster, S.W.

Mr. W. H. Booth, artesian and steam engineer, has removed to Caxton House (West Block), Westminster, S.W. Telephone 2,065 Victoria.

The Adnil Electric Co. have appointed Mr. J. B. Chambers, engineer and representative for the Yorkshire district. Mr. Chambers has been connected with the engineering department of the firm for some years past, and his address is 76, Hill Top Mount, Roundhay-road, Leeds.

Messrs. J. & H. Grevener intimate that they have taken over the Electromotor & Dynamo Co., and that the new branch is still being conducted under the supervision of the late manager of the latter company.

Messrs. Tyler & Freeman, 20, New Bridge-street, E.C., ask us to announce that they are re-arranging and extending their offices, and in doing so are making up a fresh file of catalogues, and that they would be glad if manufacturers of electrical and mechanical apparatus and machinery would send them complete copies of their catalogues, with prices, &c.

Plant for Sale.—Rhyl municipal electricity department advertise for sale a 165 kw. d.c. steam dynamo (Alley & MacLellan engine and Lancashire dynamo). Particulars from the electrical engineer, Mr. Ernest H. Wright.

Patent Amendment.—Electrical Regulators & Economisers (Ltd.), 51, North John-street, Liverpool, seek leave to amend the specification of Letters Patent No. 16,968/1907, granted to Mr. H. S. Martin for "An Improved Electrical Resistance Device for use with Lamps and for Other Purposes." Particulars of the proposed amendment were given in the Illustrated Official Journal (Patents) for Sept. 22, and notice of opposition must be given within one calendar month from that date.

"**Iron and Steel Trades Journal.**"—We have received a copy of the British edition of the special Diamond Jubilee number of this journal. The issue contains much interesting matter of a historical and reminiscent character; we congratulate our contemporary upon having attained its 60th year of publication, and we hope that it will continue to prosper. The special issue is published at 1s.

CATALOGUES, &c.

Adjustable Speed Motors.—Messrs. Laurence, Scott & Co. forward a pamphlet with the above title, which has been prepared particularly for the use of machine tool makers. This firm have specialised for many years in the manufacture of adjustable speed motors for direct-driven tools. The word "adjustable" is used in preference to "variable," as the latter also applies to series wound motors in which the speed varies automatically with the power, while the catalogue refers only to shunt motors.

Electrical Supplies.—Messrs. Drake & Gorham have ready a new trade list of general electrical supplies.

"Rugby" Lamps.—We have received from the Rugby Lamp Co. a pamphlet dealing with their metal filament lamps, of which the essential features are fully described and illustrated.

"Primus" Crude Oil Engines.—Mr. E. Atkinson Smith, Westminster, has issued a leaflet dealing with this subject.

Temperley Fixed Transporters.—From Applebys (Ltd.) we have received an illustrated brochure dealing with their fixed

transporters. Full details of the apparatus are given and their numerous excellent illustrations exemplifying the equipment work all over the country as well as in other parts of the world.

CONTINUOUS-CURRENT MOTORS AND GENERATORS. The British Thomson-Houston Co., Rugby and London, have issued a price list dealing with an entirely new line of continuous-current motors and generators, with which we deal fully on another page of this issue.

"CLARK FISHER" GALVANOMETERS. We have received from the Reason Mfg. Co., Brighton, a booklet dealing with this subject, which we feel will be of such interest to our readers that we propose to deal with it fully in our next issue.

"TUDOR" ACCUMULATORS. We have received from the Tudor Accumulator Co. a copy of their new illustrated export catalogue, dealing with stationary batteries. The aim of the makers in compiling this new list has been to provide all the data necessary to enable intending purchasers to prepare the preliminary work connected with Tudor battery plants without previously referring to the company. With this end in view full details are given, after a short historical introduction, of the various types of cells, sizes of plates, methods of mounting, details relating to box accessories, erection and acid, together with the characteristics of the various types of battery, rates of discharge and charge, and other electrical details. Full information is also given concerning the various types of cells made by the company. Near the end of the catalogue two examples and estimates, which contain all items essential for the setting up of an up-to-date battery plant, and which show the manner in which the prices are made up, are given. Useful tables showing the weight and capacity of batteries, including the necessary accessories and spares packed for shipment, for all the different types contained in the list are also to be found. We recommend all interested in battery work to procure a copy of this list.

OSRAM LAMPS.—The General Electric Co., it seems, have made adequate provision for the lighting season, which has already arrived. Their preparations have included, among other things, the issue of a number of artistic circulars dealing with this well-known lamp, and we understand that the demand for these has been so great that already over 600,000 have been printed and circulated during September and additional advertising matter has to be printed for October. The various folders are supplied with the company's customers' names and addresses, and are, we learn, very popular. One of these folders is a very artistic production, and contains a number of illustrations of public and other buildings where "Osram" lamps are installed, thus illustrating how widespread is the use of the lamps. We illustrate two of the postcards issued by the company, from which it will be seen that they are not behind their competitors in the way of effective publicity.

EXAMPLES OF METAL FILAMENT LAMP ADVERTISEMENTS

"LLOYD" DYNAMOS AND MOTORS.—A copy of their latest catalogue dealing with this subject, and which gives the fullest particulars of their continuous-current machines has been received from the Electrical & Engineering Supplies Co. Illustrations of the various types of machines and all other necessary details are given.

OIL-BREAK CIRCUIT-BREAKERS.—Mr. George Ellison, Birmingham, sends us a leaflet dealing with this subject, together with an illustrated calender card, on which is contained some details of starters for a.c. motors. The oil-break circuit-breakers described in the leaflet are made in four sizes, the largest having a maximum capacity of 300 amperes. They are built for wall mounting and conduit wiring, and are specially designed for colliery work.

BANKRUPTCIES, &c.

The first meeting of creditors of Ernest Fenwick Jones, electrical engineer, &c., 132, York-road, West Hartlepool, will take place on Oct. 6 at 3, Manor-place, and the public examination on Oct. 7 at the Court House, John-street, Sunderland.

The liquidator (Mr. J. W. Close, East-parade, Leeds), in the winding up of McPhail and Simpson's Dry Steam Patents Co. (Ltd.) has been released.

A first and final dividend of 4s. 3½d. is payable to-day (Oct. 1) at the O.R.'s, Derby, to the creditors of Lancelot W. de Grave, electrical engineer, 19, Queen-street, Derby.

A meeting to receive an account of the winding up of the Lyon Patent Refrigerator Co. (Ltd.) (in vol. liq.), will be held on Oct. 30 at 6, Castle-street, Liverpool.

A meeting to receive an account of the winding up of the General International Wireless Telegraph & Telephone Co. (Ltd.) will be held at 110, Cannon-street, London, E.C., on Oct. 26.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

August 11, 1909.

18,471 TUCKER. Electrical switches.
18,484 TAYLOR. Balancers, auto-transformers and boosters on direct-current systems.
18,499 PINK. Electric traction.
18,500 JOHNSON. Electric circuit closer. (Date applied for, 18/12/08. Comprised in application No. 27,554, 18/12/08.)
18,522 PERRY & BROWN. Systems of telegraphy and telephony.
18,524 MARCONI & MARCONI'S WIRELESS TELEGRAPH CO. Transmitting apparatus for wireless telegraphy.
18,535 MILCH. Control of induction motors.

August 12, 1909.

18,590 MARINO. Preserving or protecting the lead supports of the positive electrodes of secondary or storage batteries from peroxidation.*
18,594 LANGE. Commutators for dynamoelectric machines.
18,624 VIRY. Electrical devices for controlling movements from a distance. (Date applied for, 14/8/08.)*†

August 13, 1909.

18,636 TAYLOR. Charging and discharging accumulators or secondary batteries.
18,665 VANDERVELL & MIDGLEY. Switch mechanism for small electric lighting installations.*
18,675 MEDWAY & SCOTT. Automatic switchgear for the remote control of electric motors
18,687 RORKE & RORKE. Switch for controlling electrical circuits.*
18,690 BOURKE. Insulators for telegraph, telephone and like wires.*
18,691 HAMILTON & FERRANTI. Counting trains for electricity meters and the like.

August 14, 1909.

18,755 THOMAS. Electrical timing mechanism for clocks and the like.
18,756 TURQUAND & TURQUAND. Electric lamps and galvanic batteries.
18,758 HERD. Regulating the sensitiveness of the tripping devices employed in connection with the automatic operation of electrical switches.
18,771 LEAKE & RUSHWORTH. Electrical or electrically operated fire-alarms.

August 16, 1909.

18,783 TAYLOR. Charging and discharging accumulators or secondary batteries.
18,799 GRAINGER. Electric lamps and filaments.
18,802 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Regulation of the speed of machinery. (Addition to No. 14,134/08.)*
18,804 SCOTLAND & SULLIVAN. Automatic telegraphic transmitters.
18,808 WEBER. Metallic filaments for incandescence lighting.*
18,831 SEGET. Electric signal.
18,847 VIRY. Electrical devices for controlling movements from a distance and methods of mounting the same. (Addition to No. 18,624/09.)
18,863 KRAUS. Electric pocket lamps.*
18,864 KRAUS. Electric lamp for miners and for the house.*

August 17, 1909.

18,869 BROADFOOT. Ships' telegraph apparatus.
18,880 CHARLTON. Cut-out for electric circuits.
18,922 MARCONI & MARCONI'S WIRELESS TELEGRAPH CO. Receiving apparatus for wireless telegraphy.
18,939 VERNIER. Electrical conductors.
18,950 CLEMENT. Telephone exchange system.*
18,954 LAKE. (Parker-Clark Electric Co., U.S.) Filament or resistor for heating units or lamps.*
18,965 B.T.-H. CO. (G.E. Co., U.S.) Electrodes for arc lamps and the like.

August 18, 1909.

18,990 KELVIN & JAMES WHITE & MILLS. [illegible]
19,012 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Rotors of dynamoelectric machines for reducing noises.*
19,024 UNTERBERG & HELMLE. Distributor for [illegible] multi-cylinder internal combustion engines. (Date applied for, 19/8/08.)*†
19,038 HORVATH. Electric incandescent metal or other filament lamps.
19,040 B.T.-H. CO. (G.E. Co., U.S.) Electrodes for arc lighting.

August 19, 1909.

19,045 CONNARE. Electric wall-adapter holder.
19,047 BOOTH. Installations of metal filament lamps connected in series.
19,057 KELVIN & JAMES WHITE, [illegible] [illegible]*
19,071 STRATTON, BEAVER & CLAREMONT. Armouring of electric cables and the like.

COMPANIES' MEETINGS AND REPORTS.

DICK, KERR & CO. (LTD.)—At the meeting on Tuesday the chairman (Mr. John Kerr) said there had been a very considerable diminution in the profits during the past 12 months' trading, as they only amounted to £25,[illegible] 2s. 3d. After paying debenture interest, &c., and adding £81,567 brought forward from last year, the total available for appropriation was £97,041. 10s. 1d. In 1907 and 1908 the directors' reports stated that severe competition had prevailed in all departments, and foreshadowed that that competition would become keener and business more difficult to obtain. The year under review was the worst the company had experienced for many years, for not only had they had to contend with very severe home and foreign competition, but there had also been a serions diminution in the amount of work offered. Their tale was not different from that of most of the industrial companies in the country, for it was common knowledge that competition in their class of business had been even keener than in any of the other branches of manufacture. The directors foresaw that state of things some years ago, and therefore took the opportunity of dealing with the accounts in a very conservative spirit, so much so that they built up reserves amounting to £216,000, and if they included the present year's carry forward the total reserves amount to £279,000. In dealing with the accounts for the past year they had adopted the same policy as they had always followed—*i.e.*, depreciated to the same extent, perhaps even a little more than the previous year, and reserved against all manner of contingencies, so that, although they showed a very diminished profit, everything had been done on the same scale as in years when they were making large profits. Their works in Preston and in Scotland had been maintained in the highest state of efficiency, and all that was wanted was a revival of business. They heard that business in America and Germany was improving very rapidly, and it was reasonable to hope that if those countries continued to show progress we in this country should get some share of it. It was impossible for the directors to hold out any bright hopes for the current year. They were doing their best, and they might rely that nothing will be left undone to improve matters, and should business take a turn for the better within the next few months they were quite ready to take advantage of it. They were gradually extending their connection in foreign markets, and were hopeful that when competition became less keen they would be able to get better prices and make more profit. The reputation of their manufactures and work generally stood as high as it ever did, and even now, although prices were cut to nothing, they were maintaining the same quality all through. He would like, on behalf of the directors, to express high appreciation of the management and staff of the company. They were very loyal and hardworking, and it was not their fault that the result of the year's trading had not been more satisfactory.

PUEBLA TRAMWAY, LIGHT & POWER CO.—The report states that the lighting business has suffered very severely during the last two years in consequence of the fight with the San Agustin Co. The board have put an end to the competition by securing for the company the control of the San Agustin Co. as from July 1, and they expect a material increase of revenue. The gross and net earnings of the power business continue to show a steady increase, and the results therefrom are satisfactory. The supply of power to the San Rafael Paper Mills (1,500 H.P.) commenced in Oct., 1908. The results fo the six months to June 30 show a marked improvement over those of the previous period. The net profits were £21,500, and the bond interest for the same period (£21,891) is practically covered. The board considers that the outlook is very promising.

WILLANS & ROBINSON (LTD.)—The accounts for the half-year ended June 30 show a loss of £3,501. 7s. 9d. Deducting this sum from the balance (£9,516. 11s. 6d.) brought forward leaves £6,015. 3s. 9d. available for distribution. The directors recommend payment of a dividend at the rate of 3 per cent. per annum on the preference shares, which will absorb £4,999. 19s., leaving £1,015. 4s. 9d. to be carried forward. There is no profit available for payment of interest on, or redemption of, funding certificates, and it is not possible to pay any dividend on the ordinary shares. The regrettable result shown for this half-year is due to the scarcity of work and to the low prices prevailing. The actual loss on the half-year's working at Rugby is £2,331. 7s. 7d. To this has to be added £1,170. 0s. 2d., the cost of keeping the Queen's Ferry works in proper order and repair. The whole of the debenture interest is now charged against the Rugby account, and in considering the loss of £2,331. 7s. 7d. on that account it must be borne in mind that this result is arrived at after charging the Rugby profit and loss account with £4,824. 0s. 8d., the amount of the debenture interest for the half-year. The sum shown in the profit and loss account as written off against depreciation of premises, plant, machinery, patents, &c. (£4,203. 8s. 10d.), is considerably less than in past half-years. The deficiency, however, in this provision is apparent and not real. A number of the working costs of the business, such as drawings, patterns, tools and other appliances, which in past half-years have been charged against capital account and subsequently written off by depreciation, have in this half-year been charged direct against profit and loss account. Although, therefore, the sum shown in the accounts as written off for depreciation this half-year is less than in the past, there are direct charges against profit and loss account to counterbalance this deficiency, and the actual provision made for keeping capital values on a sound basis is as ample as formerly.

Debenture stock to the amount of £8,767 has been redeemed during the half-year out of the late fire insurance fund. This has been purchased at prices considerably below par. The difference between the face value and price paid, amounting to £1,761. 6s. 6d., and the balance of the fund itself have been added to the main reserve fund, which, after deducting therefrom the amount paid on Mr. Robinson's retirement, stands at £62,629. 11s. 1d. The full preference dividend for the half-year might have been made up by drawing on the reserve fund. The directors, however, in view of the continued depression in business, do not feel justified in recommending such a course. The board are continuing their efforts for the disposal of Queen's Ferry works, and, although no sale has yet been effected, there is good reason to hope that negotiations now in progress will result favourably. A lawsuit which has been hanging over the company in connection with one of their gas engine contracts has, since the books were closed, been settled by the payment of £15,000. This liability is provided for by the reserve fund, and the settlement of this case leaves the probable loss on the final disposal of Queen's Ferry as the only serious outstanding liability arising out of matters which were inquired into by the advisory committee in 1904. There is a considerable quantity of Diesel engine work in the shops at the present time; but the Diesel Co. have so far been able to place only a small proportion of the orders due under their agreement. It is hoped that before long there will be a revival in the demand for electrical generating machinery, and the company is now in an excellent position for securing a good proportion of the business when the revival takes place. Meanwhile, every effort is being made to push new developments, such as turbo-pumps, water turbines and condensing plant, so as to widen the base of the company's operations and make it less dependent on one class of manufacture. The first of the high-lift turbo-pumps has successfully passed its trials, and there are a number of these and of the water turbines under construction in the shops. The directors do not for the present propose to make any addition to the board, nor to fill up the vacant post of chairman. These matters have their earnest attention, and as soon as they are able to put forward proposals which will fully meet the best interests of the company these will be laid before the shareholders.

CITY NOTES.

MEMORANDA (Sept. 30).—Bank rate $2\frac{1}{2}$ per cent. (since April 1, 1909). Price of silver, $23\frac{11}{16}$d. per oz. Consols 83—$83\frac{1}{8}$ for money; $83\frac{1}{8}$—$83\frac{1}{4}$ for account. Consols Pay Day, Nov. 4; Stock and Shares Continuation Days, Oct. 12 and 26; Ticket Days, Oct. 13 and 27; Pay Days, Oct. 14 and 28; Mining Shares Carry Over Days, Oct. 11 and 25.

PRICES OF METALS (London).—*Copper*, cash, 59 [illegible]; three months $60\frac{1}{4}$. *Lead*, English, $13\frac{3}{8}$—13 [illegible]; foreign, cash, $13\frac{1}{8}$—$13\frac{3}{16}$; three months, 13 [illegible]. *Spelter*, cash, $22\frac{1}{16}$—23; three months $23\frac{3}{16}$—$23\frac{1}{4}$. *Tin*, English, 137—139; foreign, cash, 140; three months, $141\frac{1}{8}$. *Iron*, Cleveland, cash, 52/6½, and three months, 53/3½. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

BABCOCK & WILCOX (LTD.)—Interim dividends of 8 per cent. on the ordinary shares and of 3 per cent. on the preference shares have been declared.

CALCUTTA ELECTRIC SUPPLY CORP. (LTD.)—The directors have declared an interim dividend on the ordinary shares at the rate of 6½ per cent. for the half-year ended June 30, payable Nov. 15.

EASTERN TELEGRAPH CO. (LTD.)—This company announce the payment on the 15th inst. of a dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending Sept. 30, 1909, and the second quarterly interim dividend of 1¼ per cent. on the ordinary stock (tax free) in respect of profits for the year ending Dec. 31, 1909. The transfer books of the ordinary stock will be closed from Oct. 7 to 14 inclusive.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The directors of this company have declared an interim dividend for the quarter ended June 30 last of 2s. 6d. per share (tax free), payable on 15th inst. The share register will be closed from Oct. 7 to 14 inclusive.

JOHNSON-LUNDELL ELECTRIC TRACTION CO. (LTD.)—A meeting of this company was held on Tuesday, but the proceedings were private.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—A preference dividend at the rate of 6 per cent. for the half-year ended Sept. 30 is announced.

LISBON ELECTRIC TRAMWAYS (LTD).—An interim dividend of 2½ per cent. (tax free) has been declared.

REUTER'S TELEGRAM CO. (LTD.)—The directors have declared an interim dividend of 4s. per share, being at rate of 5 per cent. per annum (tax free) for the half-year ended June 30.

SAO PAULO TRAMWAY, LIGHT & POWER CO. (LTD.)—A quarterly dividend at the rate of 10 per cent. per annum has been declared.

WILLIAM GRIFFITHS & CO. (LTD.)—At a meeting of the holders of preference shares on Tuesday a scheme for the reorganisation of the capital of the company was approved, and a resolution for the voluntary winding-up of the company for this purpose was passed.

WESTINGHOUSE ELECTRIC & MFG. CO. (U.S.A.)—The company has resumed its quarterly dividend on the preferred stock by declaring 1¾ per cent. for the quarter, and also 3½ per cent. back dividends.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate No. of weeks.	Aggregate Amount.	Aggregate Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 22	1,318	– 26	16	25,180	– 584
Airdrie	„ 17	222	– 4	37	8,062	– 78
Anglo-Argentine	„ 23	40,225	+ 1,989	33	1,482,493	+ 40,914
Ayr Corporation	„ 25	285	+ 11	19	7,836	– 41
Baker St. & Waterloo Ry.	„ 25	3,085	– 239	12	31,895	– 70
Barnsley	„ 17	163	– 9	37	6,262	– 314
Barrow	„ 17	274	+ 13	37	8,793	– 590
Bath Electric Trams, Ltd.	„ 22	867	+ 37	38	24,929	+ 1,139
Birmingham Corporation	„ 25	6,633	+ 111	26	167,627	+ 3,972
Birmingham & Mid.	„ 10	816	– 15	36	30,375	+ 304
Blackburn Corporation	„ 22	1,179	+ 95	25	29,572	– 783
Blackpool and Fleetwood	„ 25	876	+ 115	...	...	
Bolton Corporation	„ 25	2,442	+ 118	26	61,585	– 165
Bombay	Aug. 26	R37,316	+ R2,996	34	R1,277,032	+ R77,343
Bournemouth Corporation	Sept. 22	1,991	+ 17	25	46,379	+ 253
Bradford Corporation	„ 25	5,013	+ 498	25	127,105	+ 3,583
Brighton Corporation	„ 23	1,052	+ 112	26	27,756	+ 1,410
Bristol Trams & Carriage	„ 24	5,851	+ 777	18	105,778	+ 5,909
Burnley Corporation	„ 25	1,288	+ 238	25	33,670	+ 418
Burton Corporation	„ 26	259	– 9	26	6,398	– 186
Bury Corporation	„ 25	1,227	+ 61	†26	31,014	– 123
Calcutta Tramways Co.	„ 25	R18,020	– R2,606	12	R506,352	+ R29,281
Camborne-Redruth	„ 25	126	..	39	4,795	– 170
Cardiff Corporation	„ 13	2,305	+ 101	25	56,285	+ 517
Cavehill	„ 17	108	+ 13	37	3,347	– 107
Central London Railway	„ 25	5,255	– 3,310	12	53,461	– 23,444
Charing C., Euston & H'stead	„ 25	3,710	+ 200	12	43,630	+ 4,670
Chatham & Dist. Lt. Rys.	„ 23	903	– 23	38	31,429	+ 1,711
City & South London Rly.	„ 26	3,213	– 52	12	33,752	+ 1,16[illegible]
City of Birmingham	„ 17	2,823	+ 91	37	103,590	+ 1,140
Colchester Corporation	„ 22	207	– 25	12	2,493	– 894
Cork Electric Trams Co.	„ 23	551	+ 23	12	17,047	– 667
Croydon Corporation	„ 17	1,716	+ 319	37	38,417	+ 2,183
Devonport & Dist. Trams	„ 17	332	– 127	37	13,757	– 3,125
Dover Corporation	„ 25	225	– 3	26	5,926	– 398
Dublin & Lucan Railway	„ 21	163	+ 19	12	2,016	+ 58
Dublin United	„ 21	5,563	+ 561	12	72,875	+ 1,329
Dudley-Stourbridge	„ 17	846	– 22	37	30,533	– 719
Dundee Corporation	„ 22	1,211	+ 18	†19	23,516	– 509
East Ham Council	„ 25	1,006	+ 87	§25	26,137	+ 3,544
Exeter Corporation	...	..	...	...	...	...
Gateshead & Dist. Trams	„ 17	976	– 38	37	36,815	– 373
Glasgow Corporation	„ 25	17,201	– 51	‡17	253,306	– 3,240
Glossop Trams	„ 25	138	+ 11	39	4,700	– 116
Gravesend—Northfleet	„ 17	235	+ 11	37	7,819	– 105
Great Northern & City Rly.	„ 25	1,311	+ 5	12	15,010	– 33
Gt. Northern, Piccadilly, &c	„ 25	5,290	– 155	12	59,915	+ 335
Greenock & Port Glasgow	„ 17	686	+ 141	37	20,634	+ 897
Hartlepool Tramways	„ 17	258	+ 22	37	8,849	– 187
Hastings Elec. Trams Co.	„ 23	1,300	+ 31	12	17,099	– 93
Hong Kong	„ 25	$8,193	+ $500	...	...	
Huddersfield Corpn.	„ 18	1,022	+ 59	21	41,227	+ 1,214
Hull Corporation	„ 25	2,572	+ 11	25	64,868	+ 2,037
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	„ 22	142	– 3	25	3,462	– 211
Ipswich Corporation	„ 25	439	+ 5	26	11,100	+ 163
Isle of Thanet Co.	„ 25	763	+ 76	§43	31,560	+ 532
Jarrow	„ 17	118	+ 12	37	4,497	+ 406
Keighley Corporation	„ 23	177	+ 16	25	4,115	+ 155
Kidderminster & District	„ 17	111	+ 2	37	4,126	– 173
Kilmarnock Corporation	„ 25	140	– 6	19	2,915	– 102
Lanarkshire Trams Co.	„ 23	1,461	+ 161	38	49,142	– 125
Lancashire United	„ 22	1,419	+ 77	38	50,835	– 393
*Leamington	„ 17	212	+ 19	37	6,632	+ 249
Leeds Corporation	„ 18	6,895	+ 271	25	170,207	+ 3,662
Leicester Corporation	„ 25	2,243	+ 62	12	27,156	– 53
Leith Corporation	„ 25	617	+ 132	19	12,318	+ 1,012
Lincoln Corporation	„ 25	117	+ 2	26	3,235	+ 101
Liverpool Corporation	„ 18	10,759	– 10	‡37	399,913	– 2,159
Liverpool Overhead Rly.	„ 26	1,389	– 6	‡13	18,969	+ 166
Llandudno & Colwyn Bay Ry	„ 21	315	+ 14	43	12,791	+ 2,137
*London County Council	„ 11	37,276	+ 773	§23	858,2[illegible]3	+ 32,621
London United	„ 27	6,564	– 795	‖23	236,261	– 23,659
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	„ 25	205	– 31	25	4,993	– 340
Manchester Corporation	„ 25	15,408	+ 365	26	385,007	– 2,921
Mersey Railway	„ 25	1,991	+ 60	12	22,994	+ 850
Merthyr	„ 17	210	– 4	37	7,971	+ 91
Metropolitan Dist. Railway	„ 25	9,733	– 146	12	112,742	+ 5,193
Metropolitan Elec. Trams	„ 17	6,826	+ 568	37	230,576	+ 18,321
Middleton	„ 17	310	+ 8	37	12,667	– 915
Nelson Corporation	„ 25	153	+ 48	§25	3,661	– 24
Newcastle-on-Tyne Corp.	„ 25	3,899	– 103	25	99,504	– 1,498
Newport (Mon.)	„ 25	667	+ 25	26	17,367	– 311
Northampton Corporation	„ 24	519	+ 75	‡25	12,833	+ 435
Oldham, Ashton & Hyde	„ 17	562	+ 5	37	20,878	– 1,242
Oldham Corporation	„ 26	1,558	– 71	26	49,965	– 3,929
Perth (N.B.) Corporation	„ 22	136	– 3	§18	3,136	+ 12
Perth (W.A.) Elec. Trams	„ 24	1,403	+ 102	33	53,347	+ 183
Peterborough	„ 17	119	– 16	37	4,113	– 360
Portsmouth Corporation	...	...	...	...	...	...
Potteries	„ 17	1,950	+ 51	37	65,731	– 1,153
Preston Corporation	„ 22	737	– 9	12	9,209	– 23
Rotherham Corporation	„ 23	588	– 16	25	15,029	– 703
Rothesay	„ 17	333	+ 138	37	9,024	+ 135
Salford Corporation	„ 27	4,536	– 66	‡26	119,772	– 3,326
Sheerness	„ 17	59	– 2	37	1,939	– 241
Sheffield Corporation	„ 26	5,641	+ 26	§26	148,592	– 922
Singapore Trams	„ 25	$8,868	+ $279	...	...	
South Metropolitan	„ 17	882	+ 9	37	29,899	– 313
South Staffs	„ 17	833	– 68	37	31,036	– 1,590
Southend Corporation	...	...	...	...	...	...
Southport Tramways	„ 17	320	+ 11	37	11,092	– 272
Stalyb'dge, Hyde, &c., Jt. Bd.	„ 25	781	+ 101	§25	20,116	– 532
Sunderland Corporation	„ 26	1,028	– 142	25	30,433	– 1,184
Sunderland District	„ 22	449	– 30	47	[illegible]	– 957
Swansea Trams	„ 17	1,093	+ 45	37	35,937	+ 772
Swindon Corporation	„ 22	169	+ 13	...	...	...
Taunton	„ 17	49	+ 5	37	1,519	– 30
Tynemouth and District	„ 17	270	+ 31	37	9,692	+ 762
Tyneside Trams Co.	„ 22	421	– 3	12	5,537	+ 231
Wallasey District Council	„ 25	937	+ 72	§25	21,882	+ 631
Walsall Corpn.	„ 25	519	– 12	33	19,499	– 1,232
Warrington Corpn.	...	...	...	...	...	...
West Ham Corporation	„ 16	2,358	+ 222	21	57,805	+ 3,716
Weston-super-Mare	„ 17	223	+ 12	37	6,383	+ 376
Wolverhampton Co.	„ 17	465	– 8	37	15,573	– 1,351
Wolverhampton Corpn.	„ 22	880	+ 76	12	9,924	– 156
*Worcester	„ 17	297	– 10	37	10,492	– 111
Wrexham	„ 17	111	+ 10	37	3,673	– 137
Yorkshire W.R. Trams	„ 26	1,362	+ 86	39	46,597	...
Yorkshire Woollen District	„ 17	1,019	+ 26	37	33,851	– 175

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed. Sept. 29.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week High-est.	Business Week Low-est.
		ELECTRICITY SUPPLY.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	9½ –1[illegible]	[illegible]	Mar, Sep	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½ –1[illegible]	4 [illegible] 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	[illegible]	[illegible] 14 [illegible]	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 –1[illegible]	4 [illegible]	Jan, July	1[illegible]	..
5	2/0	†Bromley (Kent) E. Lt. & Power Shares	4½ –4[illegible]	[illegible]	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 –96	4 16 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7½ –7[illegible]	[illegible] 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7½ –8	[illegible]	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	97 –100	[illegible]	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 –4½	[illegible] 15 [illegible]	Feb, Aug	4	4½
5	2/3	Do. 4½ per Cent. Pref.	4½ –5	4 [illegible] 0	Feb, Aug	4	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	[illegible] –99	4 1 [illegible]	Jan, July	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	[illegible]	4 [illegible] 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3½ –4½	5 2 6	Jan, July	[illegible]	[illegible]
5	2/0	Chelsea Electric Supply Ord.	3½ –4	[illegible]	March	[illegible]	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	1[illegible] –103	4 7 [illegible]	June, Dec	..	—
10	5/0	City of London Electric Lighting Ord.	10½ –1[illegible]	[illegible] 3	Feb, Aug	1[illegible]	1[illegible]
10	6/0	Do. 6 per Cent. Cum. Pref.	1[illegible] –12½	4 1[illegible]	Jan, July	12[illegible]	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	12[illegible] –124	4 0 [illegible]	June, Dec	—	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	1[illegible] –103	4 7 [illegible]	Jan, July	..	—
5	..	County of Durham Elec. P. D. Ord.	1½ –2	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 –[illegible]	[illegible] 1 1	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7½ –[illegible]	[illegible] 3 [illegible]	Feb, Aug	7	7½
10	6/0	Do. 6 per Cent. Cum. Pref.	10½ –11½	5 [illegible]	Mar, Sept	11	1[illegible]
St.	4½%	Do. 4½% Deb. Stock (red.)	1[illegible] –1[illegible]	4 [illegible] 6	Jan, July	[illegible]	..
St.	4½%	Do. Second Deb. Stock	1[illegible] –103	4 7 6	May, Nov	..	..
5	2/0	†Folkestone Electricity Supply Co. Ord.	4½ –4[illegible]	5 1[illegible] 6	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅞ –5⅛	4 1[illegible] 6	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	97 –[illegible]	4 [illegible]	Feb, Aug	—	—
5	4/6	Hove Electric Lighting Ord.	7½ –7⅞	5 11 6	April, Oct	7½	—
5	4/0	Kensington & Knightsbridge Ord.	7 –7½	5 [illegible]	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	5⅞ –6⅛	4 14 [illegible]	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 –93	4 2 [illegible]	..	—	—
St.	4%	†Kensingtn. & Kngthbg. Co. & Notting H. Co. (Joint Station) 4% Deb. Stock (red.)	[illegible] –102½	3 19 [illegible]	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85 –89	5 1	Jan, July	..	..
3	1/9⅗	London Electric Supply Ord.	1¾ –2¼	3 6 [illegible]	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 –5½	5 14 [illegible]	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 –97	4 2 [illegible]	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	4 –4½	6 2 0	April, Oct	4[illegible]	4½
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ –5	4 10 [illegible]	Jan, July	5	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 –10[illegible]	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock red.	88½ –[illegible]½	3 19 [illegible]	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. D.	[illegible] –99	4 [illegible] 0	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	5[illegible] –[illegible]	3 12 [illegible]	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	85 –87	5 1 [illegible]	Jan, July	..	..
5	..	Newcastle Elec. Supply Ord.	4¼ –4[illegible]	..	Feb, Aug	..	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4½ –5	5 0 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907	97 –9[illegible]	4 1 [illegible]	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	99 –101	4 1 [illegible]	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	81 –91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	12½ –13½	5 6 [illegible]	March	..	—
5	2/6	Oxford Electric Ord.	5 –5½	5 [illegible] 0	March	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 –[illegible]	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	[illegible] –[illegible]	5 9 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 –[illegible]	4 13 1	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	81 –[illegible]	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord.	[illegible] –[illegible]	..	Feb	..	..
5	4/0	South London Electric Supply Ord.	2[illegible] –3	6 15 0	April	..	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 –1[illegible]3	4 17 9	—	102½	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	[illegible]	—
1	0/3⅗	Do. 7 per Cent. Cum. Pref.	1[illegible] –1[illegible]	5 1[illegible] 0	Feb, Aug	1⅛	..
St.	4½%	†Do. 4½ 1st Db. Stk. Red.	100 –103	4 7 [illegible]	April, Oct	..	—
5	2/6	†Urban Electric Supply Ord.	⅝ –⅞	—	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	1¼ –1½	..	April, Oct	—	—
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	74½ –7[illegible]	5 11 [illegible]	April, Oct	—	—
5	5/0	Westminster Elec. Sup. Ord.	8½ –9	5 11 [illegible]	Mar, Sept	[illegible]	—
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 –5½	4 3	Jan, July	5[illegible]	..
		ELECTRIC RAILWAYS & TRAMWAYS					
St.	4%	Baker St. & Waterloo 4% Perp. Db. S.	99 –101	3 19 [illegible]	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.	½ –¾	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	85 –89	5 [illegible] 0	April, Oct	..	..
St.	4½%	B'ham & Midland Tram. 4½ 1st Db. Sk.	87 –90	5 0 [illegible]	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8 –8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8½ –8¾	4 16 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 –101	3 19 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	½ –¾	—	June, Dec	[illegible]	..
10	3/0	Do. 6 per Cent. Cum. Pref.	1¾ –[illegible]	12 0 0	Feb, Aug	2[illegible]	1⅞
St.	5%	†Do. 5 per Cent. Perpetual Debs.	81½ –81½	5 15 0	April, Oct	[illegible]	—
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	62 –65	6 15 [illegible]	May, Nov	..	..
St.	3%	Central London Ordinary Stock	61 –63	4 15 [illegible]	Feb, Aug	6[illegible]	61¼
St.	4%	Do. 4 per Cent. Pref. Stock	85 –87	4 12 0	Feb, Aug	[illegible]3	85
St.	2½%	Do. Deferred Stock	43 –45	[illegible] 11	Feb	44	..
100	4%	Do. 4 per Cent. Debs.	101 –103	3 18 [illegible]	Jan, July	[illegible]	..
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk	95 –97	4 2 6	Jan, July	95[illegible]	95½
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ –5¼	4 19 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs	97 –101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	30½ –3[illegible]½	4 1[illegible] 6	Feb, Aug	3[illegible]	..
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	10[illegible] –11[illegible]	4 1 0	Feb, Aug	..	..
St.	5%	Do. (1895)	104 –107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100 –103	5 2 [illegible]	Feb, Aug	..	..
St.	5%	Do. (1903)	96 –100	5 0 0	Feb, Aug	—	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 –102	3 15 0	May, Nov	—	—
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12½ –13[illegible]	4 7 6	Feb, Aug	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%	¾ –1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G.P.	8 –[illegible]	—	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 –98	4 2 6	Jan, July	97	95½
5	2/0	Hastings & District Elec. Trams. 6% C.P.	1¾ –[illegible]	..	Mar, Sept	..	—
St.	4½%	†Do. 4½ Db. St.	74 –79	5 11 0	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 –4½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 –6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	80 –82	5 10 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ –1⅛	..	Mar, Sept	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	58 –63	6 7 0	Jan, July	..	—
10	5/3	Lanarkshire Tramways	9½ –10	5 15 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	88½ –90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	¾ –⅞	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	4½ –5	5 0 0	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb.	82 –84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2½ –2¾	..	Jan, July	2	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 –70	5 14 0	Jan, July	..	—
St.	—	Mersey Con. Ord. Stock	1 –2	—	Feb, Aug.	..	..
1	10½	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	5 1 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	91½ –9[illegible]½	4 13 0	Jan, July	[illegible]	..
St.	1%	Metropolitan Railway Consolidated	[illegible]	1 5 9	Feb, Aug	8[illegible]	[illegible]
St.	2¾%	Do. Surplus Lands Stocks	65 –67	4 5 0	Feb, Aug	65	—
St.	3½%	Do. 3½ per Cent. Preference	89 –91	3 16 9	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. "A" Preference	86 –88	3 19 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	85 –87	4 0 6	Feb, Aug	86	85
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 –94	3 14 6	Jan, July	93[illegible]	—

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., Sept. 29	Rate % Yield-ed. £ s. d.	Dividend Due	Business Week to Sept. 29 High-est	Low-est
		ELECTRIC RAILWAYS & TRAMWAYS—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.	10½—10¾	—	Feb, Aug	10¾	10½
St.	..	Do. Extension Pref. (5 per Cent.)	47 —49	..	Feb, Aug	49	48½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. C. of London, Ltd.)	66 —68	5 3 6	Feb, Aug	67½	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	76 —78	3 17 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	101 —104	3 16 0	Jan, July	..	..
St.	3	Do. Guar. Stock 4 per Cent.	93 —96	4 3 6	Mar, Sept	95	93⅞
St.	6	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9	Jan, July	143½	..
St.	4	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	96½	95⅞
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—¾	—	May	..	..
5	..	Potteries Electric Traction Ord.	⅛—⅜	—	April, Oct	..	..
1	1/6	Do. 5 per Cent. Cum. Pref.	⅝—⅞	6 11 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	86⅞	86½
1	0 7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—⅜	9 12 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	69 —73	5 9 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	81 —85	5 18 0	Jan, July	..	..
..	!	UndergdE.Rys.Lon.6% In.bds.with coup.3	35 — 37		June, Dec	36½	35
..		Do. 5% Prior Lien Bonds	102 —103	4 17 6	..	103	102½
..	4½	Do. 4½% Bonds with coup. 3	87 —89	5 1 0	..	88½	87⅞
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—¾	—	March ..	—	—
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	—	—	—
St.	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
St.	..	Anchor Cable Co. 4½% Deb. Stock	102 —104		..	..	—
1	..	Aron Electricity Meter Ord.	½—¾			..	—
1	1/4½	Do. 6% Cum. Pf.	⅝—⅞	6 17 0	April, Oct	..	—
1	1/7½	†Babcock & Wilcox Ord.	4⅜—4½	4 11 0	April, Oct	4⅝	4½
1	0/7½	†Do. Pref.	1⅜—1½	4 6 0	..	..	..
5	4/0	British Insulated & Helsby Cables Ord.	7½—7⅞	6 11 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	6⅛—6⅜	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 3 0	Jan, July	..	..
St.	4½%	British Thomson-Houst'n 4½% 1st Mt.Db.	89 —94	4 16 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅛—⅜		Feb, Aug	..	..
100	6%	Do 6 per Cent. Prior Lien Dbs (rd.)	97½—99½	6 0 6		99½	98½
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	38 —42	9 10 0	Jan, July	..	..
St.	4½%	BrushE.Eng.Co.4½%,Perp.1stDeb.Stock	41 —45	8 18 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	27 —31	14 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con.Ord.	10⅞—11¼	5 17 0	Jan, July	10⅞	10⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅞	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 —107	4 4 0	Nov, May	..	..
1	1/0	Castner-Kellner Alkali Co.	2 —2⅛	5 18 0	May, Nov	2⅛	2
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106 —109	4 2 6	Feb, Aug	..	..
1	1 0	Chadburn's (Ship) Telegraph Ord.	1⅝—1⅞	6 11 9	March ..	..	—
	3/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/7½	Consolidated Electrical Co.	⅜—⅝	7 0 0	August ...	..	..
1	1/0	Consolidated Signal Co.	1⅛—1⅜	9 8 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	1	..
3	3/0	*Crompton & Co. (Nos. 1 to 86,000)	1⅛—1¼	3 7 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	90 —93	5 7 6	Jan, July	..	—
5	0/7½	Davis & Timmins	⅞—1⅛		Mar, Sept	..	..
5	5/3	†Dick, Kerr & Co. Ord.	⅞—1⅛	8 18 0	Sept ...	..	..
5	0/7½	†Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 1 0	Sept ...	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 —103	4 7 6	Jan, July	..	..
5	1/6	Edison & Swan United ("A" Sh.)(£3 pd.)	⅛—⅜		Feb, Aug	..	..
5	2/6	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	69 —73	5 9 6	June, Dec	..	..
St.	5%	†Do. 5 per Cent. 2nd Deb. Stock	82 —85	5 17 0	Mar, Sept	..	..
	..	Edmundson's Elec. Corp. Ord.	⅛—⅜		Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅛—¾	..	May, Nov	⅝	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	58 —61	7 5 0	Jan, July	..	..
2	..	Electric Construction Co.	⅜—½		Jan, July	½	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	9 16 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	65 —69	5 16 0	Jan, July	—	..
St.	5%	Ferranti Ltd. 5 per Cent.1st Mt.Db.St.	68½—74½	6 14 0	...	..	..
10	6/0	General Electric (1900) 6% Cum. Pref.	7⅜—7⅝	8 1 0	June, Dec	8⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	83 —87	4 12 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.	12½—13½	5 16 6	Feb, Aug	..	..
5	2/3	Do 4½ per Cent. Pref.	5⅛—5⅜	4 2 0	Feb, Aug	..	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 4 0	Mar, Sept	106	..
10	5/0	India Rubber, Gut. Per., &c., Wrks.	14⅞—15⅜	6 9 0	Feb, Aug	..	..
10	6/4	Do. 6 per Cent. Cum. Pref.	10⅛—10⅜			..	..
100	4%	†Do. 4 per Cent. Debs. (red.)	99 —101	3 19 0	April, Oct	..	..
1	..	National Elec. Construction Co.	⅛—⅜	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	—	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	82 —86	5 5 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	—			
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	—	—	..	..
12	12/0	Telegraph Construction & Maintenance	34½—36	5 0 0	Mar, July	34½	..
100	4%	Do. 4 per Cent Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 7 0		2⅜	2¼
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜—1½	4 0 0	—	1⅜	—
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 —117	4 5 3		115¾	..
St.	4%	Do. 4 per Cent. 1st Mort. Db.Sk.(red)	103 —105	3 16 6	June, Dec	104¾	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb.(red.)	105 —107	4 3 6	June, Dec	105½	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	106 —108	4 12 6		107½	106⅛
10	6%	J.G.White & Co. 6% Cm. Pref.	10—11	7 5 4		..	..
1	1/0	Willans & Robinson Ord.	⅛—⅜	3 15 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅝—3⅛	9 12 0	Apr, Oct	2⅝	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	78 —82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	2⅞—3⅛		June, Dec	..	..
100	5%	Do 5 per Cent. Debs. (red.	95 —96	5 4 0	June, Dec	—	..
St.	15/0	Anglo-American	61½—62½	5 2 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	104—105	5 15 0	F,My,Ag,N	105	104½
St.	5 0	Do. Deferred	21½—22½	1 12 6	F,My,Ag,N	22	21½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	89 —91	4 8 0	Jn,Ap,Jy,O	90½	90
10	6/0	Cuba Submarine Ord.	8½—9¼	6 9 6	Feb, Aug	8⅞	..
10	10/0	Do. Preference 10 per Cent.	17½—18½	6 10 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3 —3½	6 14 0	April, Oct	..	..
5	6/0	Do. 10 per Cent. Cum. Pref.	8 —8½	5 18 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	101½—102½	4 8 6	Jan, July	..	..
20	6/0	Direct United States Cable	13⅛—13⅝	6 3 6	Jn,Ap,Jy,O	13⅞	13⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	129 —132	5 6 0	Ja,My,Jy,O	131	130½
St.	17/6	Do. 3½ per Cent. Pref. Stock	85 —87	4 0 6	Ja,My,Jy,O	86½	86
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104 —106	3 15 6	May, Nov	105	104½
St.	2/6	Eastern Extension	11¾—12¼	5 14 0	Ja,Ap,Jy,O	12⅛	11⅞
100	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 16 0	Feb, Aug	—	..
25	4%	Eastern & S.Af. 4% Mauritius Sub.Debs.	100 —102	4 8 0	May, Nov	..	..
10	2 0	G. N. of Copenhagen, with Coupon 77	26 —27	6 13 6	Jan, July	26½	..
100	4½%	Indian & Bermuda 4½% 1st Mt. Db.(red.)	100 —102	4 9 0	June, Dec	..	..
25	6/6	Indo-European Telegraph	61½—62½	5 16 9	May, Nov	53⅞	..
100	£1	Mackay Companies Common	94 —99	4 1 0	Ja,Ap,Jy,O	98	91⅞
100	£1	Do. Preference	80 —82	4 17 6	Ja,Ap,Jy,O	81½	..
1	..	Marconi's Wireless Teleg. Co.	2—2¼	..	April	2⅛	..
1	4%	Pacific & European Tel.4%Guar.Dbs(red.)	100 —102	3 18 0	June, Dec	100	..
..	1/3	West Coast of America	1¼—1⅜	8 17 0	May	1⅜	1¼
..	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	..	..
..		West India & Panama	⅛—⅜	..	May, Nov	⅜	..
10	6/0	Do. 6 per Cent. 1st Pref	9 —9½	6 13 0	May, Nov	9	9⅛
10	1/0	Do. 6 per Cent. 2nd Pref.	8½—8¾	6 6 0	May, Nov	..	..
..		Do. 5 per Cent. Debs.	101½—103	4 15 6	Jan, July	..	..
10	2/0	Western Telegraph	13¼—13⅞	6 2 6	Mr,Jn,O,D	13½	13⅛
..	4%	Do. 4 per Cent. Deb. Stock (red.)	103 —105	3 16 0	June, Dec	104½	..
..		Western Union Telegh. $1,000 4% Bonds	105 —107	3 14 9		106	..

Share	Last Dividend	Name	Price Wed., Sept. 29	Rate % Yield-ed. £ s. d.	Dividend Due	Business Week to Sept. 29 High-est	Low-est
		TELEPHONES.					
100	2$	Amer. Teleph. & Telegh. Cap. St.	147 —149	5 6 9	..	149½	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	—	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —103	4 17 0	Mar, Sept	..	—
5	5 0	Chili Telephone	8 —8½	4 15 6	August ..	..	—
1	0/7½	Monte Video Telephone Ord.	⅝—⅞	6 17 0	Nov	..	—
1	0/6	Do. 6 per Cent. Pref.	⅝—⅞	5 14 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106½—107½	5 11 3	Feb, Aug	106⅞	106
St.	6%	Do. Def. Stock	121 —123	4 17 6	Feb, Aug	122½	121
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—10⅜	5 9 0	Feb, Aug	10⅜	10⅛
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10⅛—10⅜	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅜	4 8 0	Feb, Aug	5⅛	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	98½	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Oriental	1⅛—1⅜	5 4 6	April, Oct	..	..
1	0 7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 15 3	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	83 —85	4 11 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100½—101½	4 8 6	Jan, July	..	..
5	5/0	United River Plate	6⅛—6⅜	5 16 0	July	6⅛	6⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 0	June, Dec	..	..
St.	4½%	Do 4½ Deb. St. Red.	104 —106	4 5 6	Jan, July	104⅞	..
		FINANCIAL INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	3⅛	..
10	2 0	Globe Telegraph & Trust	10⅛—10⅜	6 8 6	SpDcMrJu	10⅜	10⅛
10	3/0	†Do. 6 per Cent. Pref.	13⅜—13⅝	4 5 0	SpDcMrJu	13⅜	13
10	6%	Submarine Cables Trust (Cert.)	131 —134	4 9 6	April, Oct	..	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	—	Anglo-Argentine 5% Cum. 1st Pref.	4⅝—4⅞	5 2 6	April, Oct	4⅝	4
1	—	Do. 6% Cum. 2nd Pref.	4⅛—4⅜	5 5 0	Jan, July	4⅜	4⅜
St.	4%	Do. 4% Deb. Stock	91½—93½	4 5 6	June, Dec	93	92
St	—	Do. 4½% Deb. Stock	96 —98			97	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	103½	..
1	3 6	Brisbane Electric Trams. Invest. Ord.	6⅞—7⅛	4 5 0	May	7	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	100 —103	4 3 0	Jan, July	..	..
St.	8%	Brit Columbia El.Ry.Df. Ord.	144 —149	5 7 6	Mar, Sept	147½	146
St.	6%	Do. Pref. Ord. Stock	118 —123	4 17 6	May, Nov	121	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.	106 —110	4 11 0	Jan, July	109	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp Con. Deb. St.	101½—103½	4 2 0	—	..	..
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	96½—98½	5 1 6	Mar, Sept	98	..
St.	6%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	90 —94	6 8 0	Feb, Aug	..	..
5	2/0	Calcutta Tramways (1 to 137,610)	4⅞—5⅛	3 14 6	Mar, Sept	5⅛	5
10	2/6	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	99 —101	4 9 0	Jan, July	—	..
St.	..	Cape Electric Tram Shares	⅛—⅜			..	..
5	1/3	City of Buenos Ayres Trams Co. (1904)Sh.	5⅛—5⅜	4 1 6	F,My,A,N	5⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101	4 19 0	May, Nov	—	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	82 —85	5 17 0	June, Dec	—	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94 —97	5 2 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..		..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	97½—99½	5 0 0	Jan, July	94	93
5	6%	Do. 6 per Cent. "B" Ditto	66 — 79	8 12 0	Jan, July	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 4 9	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 1 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	99 —103	4 17 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 3 0	Feb, Aug	..	..
100	$1	Mexico Trams Co. Com. St.	126 —129	3 17 6	..	128½	126
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92 —94	5 6 6	..	92½	90
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	104 —106	4 5 0	..	104½	..
1	1/6	Perth Elec. Trams Ord.	⅝—⅞	8 0 0	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	6⅛—6⅜	5 4 8	..	6⅛	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 9 0	..	100⅛	100
100	..	Rio Janeiro Tram, Lt. & P. Co.	92½—93½		..	93⅛	92½
..	5%	Do. 30 yr. Gold Bnds.	94 —96	5 4 6	..	95⅛	94⅛
100	5%	Do. 50 yr. Mt. Bnds.	87 —88	5 13 6	..	87⅛	..
—	$	†Sao Paulo Tramway, Light & Power Co. $100 Stock	148 —151	6 12 0	..	152½	151
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102⅛	..
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	..	..
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3 0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5 —5½	5 14 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	9⅞—10⅛	5 15 9	..	10	..
St.	4½%	Do 4½ per Cent. Deb. Stk. (red.)	94 —98	4 14 0	Jan, July	91⅞	..
..	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock	93½—95½	..		94½	94
1	4 9	Calcutta Elec. Supply Ord.	6⅛—6⅜	6 1 0	April, Oct	6⅛	..
100	$1	†Canadian Gen. Elec. Co. Com. St.	120 —125	5 12 0	..	124½	123
100	$3½	†Do. 7% Cm. Pf. Stock	116½—118½	5 18 0	..	117½	117
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	99	..
500	6%	Elect. Development Co of Ontario	84 — 86	5 16 6	..	84	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 — 94	5 6 6	Jan, July	—	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—2	—		—	..
10	1%	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	..	..
1	0/7⅛	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	6 18 3	April, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St	76 —80	6 5 0	April, Oct	..	..
St.	—	Melbourne E. S. Co. 6% Cum. Pref.	[illegible]			..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	91 —93	..	—	92½	92
100	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	80½—82½	6 1 0	..	81½	71
St.	$1	Mexican Lt. & Power Co. Com. St.	70 —74	6 15 0	—	72½	71
500	5%	Do. 5% 1st Mort. Gold Bnds.	85 —87	5 15 0	..	86⅛	85
100	$1	Montreal Lt. Ht. & Power Co. Cap. St.	127 —131	4 15 0	F,My,A,N	129½	129
1	1/1½	River Plate Electricity Co. Ord.	1⅛—1⅜	5 11 0	April	..	..
1	1 2½	Do. 6 per Cent.non-Cum.Pref	1 —1⅛	6 6 6	May	..	..
St.	6%	Do. 5 per Cent. Deb. Stock	103 —106	4 14 0	Jan, July	..	..
5	3/0	†Ontario Elec. Co. 6% Pref. (1-20,000)	5⅛—5⅜	5 5 0	April, Oct	..	..
5	1/0	†Do. 2nd Pref.	5½—5¾	5 1 0	—	5⅛	..
100	$1	Shawinigan Water & Power Co. Ca	97 —99	4 1 0	..	99	..
..	5%	Do. 5 per Cent.Bds.	105½—107½	4 13 0	Jan, July	107	..
St.	4½%	Do. 4½ Per. Con. Mt. Db. St.	99 —103	4 10 0	—	99½	..
St.	4½%	Toronto Power Co. 4½% Db St.	99½—100½	4 9 6	..	100½	..
..	6d.	Victoria Falls Power Co. Pref.	[illegible]	6 14 9	Jan, July	..	..
..		Do. 10/- paid					

* In ... has been made for ... interest, but not for ... † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote th...

THE ELECTRICIAN:

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NOTES.

Government Purchase of Marconi Stations.

Arrangements have now been completed for the transfer to the Post Office of all the Marconi Company's coast stations for wireless communication to ships. The company still retain their licence for the long distance stations at Poldhu and Clifden, as these scarcely come under the same category, being intended primarily for shore to shore communication between this country, the Continent and America. In addition to acquiring all the plant, leases, &c., of these small coast stations, the Post Office secures the right of using, free of royalty, the existing Marconi patents and any future patents for a term of 14 years, for these stations in ordinary working and for communication (except for transmission of public telegrams) between any two stations on the mainland, and for use on board the Post Office cable ships. As was announced in our parliamentary columns last week, the consideration paid to the Company is £15,000.

To the casual observer this sum will seem somewhat small, if not a hard bargain. Very possibly it is not much more than the actual present value of the stations, for depreciation is apt to be heavy on such apparatus as is used in wireless telegraphy, owing to the continued and rapid advances that have been made. On the other hand, the time, money and energy spent in developing these coast stations, and the business that is handled by them, must have been very much more than the sum mentioned, and, consequently, the reward for pioneer work does not seem to be large. From the point of view of the general public the purchase must be considered as a move in the right direction. A better service is likely to be the result if all inland telegraphy and shore-to-ship messages are handled by the same authority. Naturally, the Post Office will not be restricted to the Marconi or any other system, and the stations will be open to general use. More uniform working is likely to result if these stations form part and parcel of the general telegraphic system of the country, and it is quite possible that in time of war it would be more to the public interest for the working of such stations to be in Government hands than in those of private enterprise. The Marconi Company is to be congratulated on the success with which it has developed this particular sphere of wireless telegraphy, and we hope it will continue its success in the equipment of ships and stations elsewhere.

The Depreciation of Tramways.

In regard to the very liberal allowance made for depreciation, the tramway undertaking of the Glasgow Corporation stands practically alone in this country. For the year ended May 31 last a sum of £195,798—that is, 2·26d. per car-mile—was set aside to provide for the future renewal of the permanent way, rolling stock and plant, in addition to a sum of £16,275 paid into a reserve fund. This is in striking contrast with the amount of ⅘d. per car-mile which has been approved by the London County Council as a proper allowance for depreciation for the next few years. The amounts allocated to reserve fund and depreciation in the accounts for the past year of the Liverpool Corporation and Manchester Corporation tramways were somewhat higher, being 0·975d. and 1·06d. per car-mile respectively, but they do not approach the Glasgow figures. It is also worth noting that the total sum set aside for depreciation at Glasgow now amounts to more than 41 per cent. of the total capital expenditure, whilst large contributions are nevertheless made every year to the "Common Good." Although the car-mile is not a very satisfactory basis on

which to make comparisons, since the size and weight of the cars will affect the wear of both track and rolling-stock, the divergence shown in the allowances made for depreciation by the four largest tramway undertakings in this country is all the more remarkable when it is remembered that the London County Council undertaking, which makes the smallest allowance for depreciation, has the largest and heaviest cars. As, however, the greater part of this undertaking is still comparatively new, a more satisfactory estimate of the provision necessary for renewals will be possible in a few years' time, when the allowance for depreciation will again come up for consideration, and we do not doubt that a very much higher figure will then be adopted.

The Cost of Tramway Current.

In view of the arbitrations and discussions which have taken place recently as to what is an equitable charge to tramways for electric energy purchased from an electricity supply department, it is interesting to notice from the last annual accounts of the Glasgow Corporation Tramways, which are analysed elsewhere in the present issue, that the power expenses are given as 1·227d. per kilowatt-hour sent out to the sub-stations. In this particular case the tramways have their own generating station. As the load factor at the station was practically 40 per cent., it will be seen that tramway undertakings purchasing current at such a price as 1d. per unit cannot by any means be considered as unfairly treated. The dissatisfaction expressed by members of tramway committees in regard to the price at which energy is purchased is frequently brought about by reference to the works costs at tramway power stations. In several instances these works costs are under 0·40d. per unit (0·35d. at Glasgow), but the addition of a fair proportion of the rates, taxes, management expenses, &c., together with capital charges, brings the total cost to a figure comparable with the charges usually made for tramway supply. Thus, at Glasgow, the total costs are 0·76d. per unit (to which 0·47d. per unit is added for depreciation) for an output of over 27 million units, but when account is taken of the high load factor, which, of course, materially affects the capital charges per unit, it will be seen that the advantages claimed for independent power stations for supplying electric tramways are scarcely sufficient to justify the duplication of electrical plant. The general opinion at the present time is certainly in favour of a single power station for the generation of current irrespective of the uses to which the energy is to be put.

The Status of the Engineering Profession.

Elsewhere our readers will find an abstract of a Paper read by Mr. G. A. Thomas on "The Status of the Engineering Profession," the object of the author being to suggest effective means for improving the status of the profession, which at the present time suffers considerably from the want of concerted action on the part of its members. It is easy to suggest remedies, but much more difficult to get them carried out, and we think it may be said that Mr. Thomas' suggestions are rather ideals. Among other plans, he suggests that there should be a central organisation (provided by the three most important engineering societies) for the purpose of dealing with all questions affecting the profession. Such an organisation would, no doubt, be an advantage, but we fear that there would be much difficulty about its creation. The older societies and the newer societies do not run well together, and apart from this, there is the difficulty that the engineering profession is much less homogeneous than the medical, legal and other professions. The sphere of engineering is very large, and specialisation is increasingly necessary. Consequently, the interests of all members are by no means the same. A consulting engineer of the first rank does not mind very much if a badly qualified engineer puts up a plate in the same street. Our large manufacturers, also, are not much troubled by incompetent engineers, for the simple reason that those who are chiefly responsible must be competent, and they will soon discover if members of their staff have not the requisite knowledge. The same is true of important municipal positions. Consequently the whole subject has not, for the leading members of the profession, that keen interest which we should like to see. We do not suggest that this is any reason why reform should not be brought about, but it makes it very much more difficult to initiate reforms and to carry them to a successful conclusion.

Association of Engineers-in-Charge.—Prof. Henry Adams will deliver his presidential address to the Association of Engineers-in-Charge at St. Bride's Institute, on Wednesday, the 13th inst., the subject of the lecture being "Standardisation."

Electrification of the Chilian Railways.—According to the "Electrical World" the Chilian Government has decided to electrify 725 miles of railway in that country, beginning with 115 miles as an experiment.

The Metal Tungsten as "Valve" Electrode.—*Erratum*—In this article (by Mr. L. H. Walter), of which we gave an abstract in our last issue, in Fig. 1 on p. 991, Amps. $\times 10^3$ should read Amps. $\times 10^{-3}$.

The New Argentina-European Submarine Cable.—The Western Telegraph Co. will immediately commence the work in connection with the making and laying of the new cable uniting Argentina direct with Europe via Ascension. The making, laying and putting into work of the new cable is estimated to cost about £1,000,000 sterling, and it is hoped that it may be open for traffic by October next year at latest.

Institution of Municipal Engineers.—A visit will be paid by members of this Institution on Saturday next to the Swanscombe Works of the Associated Portland Cement Manufacturers (Ltd.). Members will proceed by train to Northfleet, where they will be entertained to luncheon by the company, and will afterwards be conveyed in special cars to the works. They will then return to Northfleet to tea, where a demonstration of the gauging and testing of Portland cement will also be given.

Amalgamation of American Electric Light Companies.—The "Engineering News" states that a consolidation of the electric light companies in and about Boston has been approved by the Massachusetts Gas and Electric Light Commission. The Edison Electric Illuminating Co. is allowed to purchase the electric plants of the Boston Consolidated Gas Co., of the Chelsea Gas Light Co., the Newton & Watertown Gas Light Co., and the Waltham Gas Light Co. Also the Newton & Watertown Gas Light Co. is permitted to purchase the gas franchises and property of the Waltham Company.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tourane—Amoy	June 17, 1909	—
Assab—Perim	July 8, 1909	—
Dakar—Conakry	Aug. 19, 1909	—
Sheik Seyd—Perim	Sep. 15, 1909	—
Hong Kong—Macao	Sep. 25, 1909	Oct. 1, 1909.

Lectures on "Fuel."—A course of lectures by Mr. J. S. S. Brame on this subject will be inaugurated on Monday next, October 11th, at the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. The special subject of the first lecture will be "Liquid Fuel and its Economical Aspects," and the chair will be taken by Sir Boverton Redwood.

Electric Furnaces in Canada.—Dr. E. Haanel, Director of Mines, has recently announced that furnaces for electric smelting of iron ore by electricity, and similar to those now in use in Sweden, are about to be installed at the Sault Ste. Marie plant of the Lake Superior Company. Plans are also in preparation for the erection of electric smelting furnaces at Chats Falls, on the Ottawa River.

Testing Stations.—Several of the borough councils of London have decided to support the Associated Municipal Electrical Engineers (Greater London) in their opposition to the proposals of the London County Council with reference to the provision of testing stations. The association is strongly opposed to the attempt of the County Council to establish testing stations except where complaint is made by consumers as provided by the Electric Lighting Act, 1899.

Newfoundland Cable Matters.—In connection with the dispute which has arisen in regard to submarine cable affairs in Newfoundland, Mr. Frederick Ward, manager of the Commercial Cable Co. in England, in a letter to the "Electrical Review," states that nearly twice as much English and Canadian money is invested in the securities of the Commercial Cable Co. and the Mackay companies, at present market values, as is invested in the securities of the Anglo-American Telegraph Co., at present market values, even if it be assumed that all the securities of the Anglo Company are held by English and Canadian investors; hence he fails to see how the contract between the Newfoundland Government and the Commercial Cable Co. is "prejudicial to British capital."

Directive Wireless Telegraphy at the Brescia Exhibition.—Among the electrical exhibits at the Brescia Exhibition is a complete installation of the Bellini-Tosi system of directive wireless telegraphy. Owing to the confined space (for the Exhibition is held in part of the Castle of Brescia), the transmitting and receiving stations are only 40 metres apart. But with the exception that the antennæ employed are reduced to only 3 metres in height, all the other apparatus is of full size; in fact the radio-goniometer at the receiving station is the actual apparatus which is to be installed in the new station of the French Government (Post Office), which will shortly be opened at Boulogne. All the special features of the system, such as directive emission and reception of the waves, and location of the direction of the transmitter, can be readily demonstrated in spite of the small distance between the stations.

City of London Union, Homerton Infirmary.—On Saturday, the 25th ult, the new workhouse and infirmary at Homerton, which have been built for the Guardians of the City of London Union, were formally opened by the chairman of the Board, the Rev. Thomas Grear. The engineering work in the new building comprises heating and hot water services, electric lighting as well as laundry and kitchen apparatus. The steam for the whole of these, with the exception of the electric light, is supplied from one boiler. Electric lighting is installed in all the new blocks and in parts of the old blocks, the current being obtained from the mains of the Hackney Borough Council. Metal lamps are chiefly used. All the main rooms are wired upon more than one circuit, so as to prevent total extinction of the light in case of fuses blowing. There is also a complete system of telephone and electric bells, and two electric passenger lifts.

Personal.—Mr. A. Whalley, M.I.E.E., is retiring from the British Insulated & Helsby Cables (Ltd.) to commence a consulting practice, from November 1st, at 27, Chancery-lane, London, W.C. (c/o Knox, Hassal, Dodd & Co.), and at 19, Croxteth-grove, Liverpool. During 23 years with the Telegraph Mfg. Co., Helsby, and with the British Insulated & Helsby Cables, he has been chief engineer at Helsby and manager and engineer at Liverpool respectively, and has been responsible for the design and manufacture of every description of insulated wire and cable for lighting, power, traction, telephony, &c., also of all apparatus for complete trunk and local telephone exchanges, telephone instruments, &c., and, in addition, of telegraph equipments for railway and postal administrations. He has had charge of important cable contracts abroad, and carried out the equipment of the London and other large telephone trunk exchanges for the Post Office during the last six years, besides common battery exchanges. For 20 years switchboards, &c., have been supplied under his control to the National Telephone Co. His connection with telephony dates from 1881 in the days of the Lancashire Telephone Exchange.

Electrically Driven Rail Bender.—The "Electrical Review and Western Electrician" gives an account of a machine of this kind in which the framework of the machine is a heavy steel casting made in one piece, the solidity of which ensures regularity of curvature and rapidity of work, which, with the small amount of manual labour required, renders the tool an almost indispensable one on construction work. The power-driven bending roll is mounted in a frame which is driven forward to give the desired curvature by a hydraulic cylinder, the power for which is a small hand pump mounted on the frame of the tool above the cylinder. The roll can be driven out under a pressure of 50 tons. The two fixed-roll centres are 34 in. apart. The driving roll is geared to make one turn to eight turns of the pulleys, which are 24 in. in diameter and have a 7 in. face. The bending rolls must be made to suit each shape of rail to be bent. The outer bending rolls are changed by loosening set screws and pulling out the pins. The arm holding the middle bending roll can be worked in and out by a lever without the aid of the pump, if the release valve is open, so that the pump is necessary only when bending a rail to get the desired curvature. The capacity of the machine is about one medium-length rail per minute when once adjusted.

London, Brighton & South Coast Railway Electrification.—We, unfortunately, gave circulation to a report which had appeared in some of the lay papers concerning this subject, and which report proves to be erroneous. We much regret having given publicity to the statements in question. The facts are as follow:—

It was found, on completing the overhead work of the electrification of the L.B. & S.C. Railway, that a certain number of signals would require to be altered in order not to interfere with the overhead construction and in order to be in such location as would in all probability fulfil Board of Trade requirements. No delay has been caused by any action of the Board of Trade, nor has the Board made any requirements which have necessitated any serious alterations in the construction. The Board's officials have inspected the full piece of line from Battersea Park to Peckham Rye; Victoria Station will shortly be ready to be finally inspected, and it is not anticipated that there will be any requirements which will in any way delay the opening of the line for traffic. Eight trains have run several thousands of miles and have been in daily operation between Battersea Park and Peckham Rye since January last; it is the alterations of the signal structures at London Bridge which have caused the delay, but the line will certainly be open for public traffic by December 1st.

It should be pointed out that the signal arrangements at London Bridge have always been exceedingly complicated, and it is essential, owing to the large number of trains that enter and leave this terminus, that special care should be observed in regard to signalling facilities.

Institution of Mining Electrical Engineers.—At the meeting held at Sheffield on Saturday last the president, Mr. W. Maurice, said considerable progress had been made since the Institution last met. Many new members had been enrolled, and the Council had decided to place the Institution on a legal basis by having it incorporated under the Companies Act. The articles of association would be submitted to the Board of Trade, and it was anticipated that by the end of this month they would be accepted, and then arrangements would be made for the inaugural meeting of the Institution. Formal application had been made for representation on the committee to be appointed by the Home Secretary to revise the rules relating to the use of electricity in mines, but the Home Secretary had replied that the constitution of the committee would not allow of representatives of that Institution being placed upon it. He would, however, be glad to receive information and suggestions, and it would be the business of the Institution to proceed in this way. A short time ago, some considerable stir was created by a section of the mining community who did not regard electricity as a safe medium

for use in coal mines. The Council felt that that action had had a prejudicial effect in regard to electricity, and they had decided to form a committee to inquire into the causes of mining accidents, and the means to be adopted to prevent them. That committee would draw up a report, which would be of considerable importance to mining electricians and would probably be submitted at the December meeting of the institution. Mr. Maurice also mentioned that a London branch was in course of formation, Mr. R. Krall, of Balfour House, Finsbury Pavement, E.C., being the secretary.

Obituary.—CHARLES JOHN ROBERTSON.—With sincere regret we have to announce the death on Wednesday, at his residence at Ealing, London, of Mr. C. J. Robertson, whose connection with the incandescent electric lamp dates back to the very early 80's. Mr. Robertson was born in 1860, and may be described as a Merchant Taylors' boy. It was at this famous school that he came out first for a seven years' scholarship and £100 per annum at St. John's College, Oxford. He studied analytical chemistry under Prof. Armstrong and electrical engineering under Profs. Ayrton and Perry at Finsbury, and in 1881 joined the Anglo-American Brush Co., leaving them in 1883 to join the Pilsen-Joel and General Electric Co., of London. All this time he was diligently at work on experiments and researches into filament materials and lamp-making processes. In 1885 he joined the Bernstein Co. at their London works, and later Mr. Boudewijnse at Venloo, Holland, where he remained until 1891. He then left for Vienna, where he joined Messrs. Latzco & Scharf at the Gluhlampenfabrik Watt, Mr. Robertson having evolved what was then known as the "Watt" lamp. Owing to continued ill-health, Mr. Robertson two or three years later returned to this country, and with some friends formed the Robertson Incandescent Electric Lamp Co., at Brook Green, London, where the manufacture of the "Robertson" lamp was, and is still, carried on. This establishment has grown into one of the largest incandescent electric lamp works in the world, and Mr. Robertson continued, up to within a few weeks ago, to take the keenest interest in its management. His whole life may be said to have been devoted to the evolution and development of the electric incandescent lamp. Mr. Robertson was greatly liked by all who came in contact with him, whether in social or business life. He was struck down by a serious illness about a month ago, which, as we have stated, terminated fatally on Wednesday.

Electric Cable Railway.—An interesting account of an electrically driven cable railway, which is said to be the steepest passenger cable railway in Europe, is given by Mr. E. Ommeganck in a recent issue of the "Railway Gazette." The railway is a third of a mile long and about three-quarters of it is in mountain cuttings, the only considerable elevation being a concrete vault viaduct 79 ft. long, the abutments of which have a difference of level of 82 ft. The gauge of the railway is 1 metre, and grooved 54 lb. rails 33 ft. long are used. The driving gear is in the upper station, and operates the cars at a speed of 5 ft. per second, the whole distance thus being covered in five minutes. An alternating-current motor rated at 55 H.P. is used. Current is supplied at 3,450 volts from a neighbouring power plant, and is stepped down to about 550 volts for use on the line. A hand brake and an automatic brake are placed on each car. The automatic brake acts whenever the speed of the driving gear exceeds the normal speed of travel by 15 to 20 per cent., whenever the cars run too far into the upper station, and when the current leading to the upper station is interrupted in the transmission line or in the power station. The driver can set the automatic brake at will. In all these cases the current supplied to the motor is also automatically interrupted. Braking tests with fully loaded cars, made on the 70 per cent. gradient, with a self-acting brake, gave very favourable results. On setting the brake the car would come to a stop within about 4 ft., half of which distance was traversed while the brake shoe was moving into engagement with the wheel. The wire cable has a breaking strength of 110,000 lb., the maximum tractive effort being 11,000 lb. The car is divided into four compartments and two platforms, the outer compartments being open and the central ones closed. The car has seats in these four compartments for 32 passengers.

British Standard Specification for Ammeters and Voltmeters.—The specification for ammeters and voltmeters (No. 49) just issued by the Engineering Standards committee should be of great service to both user and maker alike. The user can see at a glance the degree of accuracy he may expect for the class of instrument he requires, and the maker, if the specification is as widely adopted as we hope it will be, will be saved an immense amount of needless trouble in tendering, and also be able to standardise his detail work, which should tend to cheapen production. In what follows, we give some of the main points of the specification.

In the specification, instruments are classified as sub-standards, first grade and second grade instruments according to their accuracy. The second grade instrument although of not a very high order of accuracy should be useful in workshops and similar places where accuracy is not of vital importance. The Committee make certain definite recommendations for the construction of instruments which comply with the British standard. Some useful recommendations are made with reference to scales although no particular sizes for the figures are mentioned. Certain standard scale readings for ammeters and voltmeters have been adopted, and we understand that these lists have been very carefully selected, the committee keeping in view the ordinary requirements of the user, and the cheapening of production by reduction of the numbers which have to be kept in stock. The lists represent the present demands of the industry according to the makers' catalogues, but, of course, if the demand arises for other "maximum readings" the fact that it is open to revision gives a ready means of bringing the specification absolutely up to the needs of the industry. The drop in pressure on the shunt has been standardised in order to obtain interchangeability, and we note it is different from the German standard. The transformation ratio of a potential transformer has been fixed as well as the current in the secondary circuit of a series transformer. The Committee explain in the preface that they have not gone further into the questions affecting instrument transformers, as they intend dealing in a separate report with standards for instrument transformers, resistances and separate shunts. The question of accuracy has necessitated a great deal of investigation and prolonged discussion on account of the inherent differences in the various types of instruments, as well as of the degree of accuracy attainable under practical working conditions. The difficulty of expressing in a simple manner the permissible limits of error when these had been decided upon gave the Committee a considerable amount of preliminary work, before a useful result was attained, and we are assured that the figures for the accuracy are based on actual "test records" kindly supplied for the use of the members. The definitions which precede the specification proper should prove of great use towards the avoidance of misunderstanding, due to the user and seller not attaching the same meaning to the term employed. No definition is given for "dead-beat," but the preface explains the reason, which is due to the possibility of an instrument being made dead-beat by weakening the control, and so involving inaccuracy due to friction. Electrical instruments are now so generally used by the engineering industry that this specification should find a very extended field of usefulness. The price of the specification is 2s. 8d., post free, and it may be procured from any bookseller or direct from the offices of the Committee, 28, Victoria-street, Westminster.

ARRANGEMENTS FOR THE WEEK.

MONDAY, October 11th.

GRADUATES' SECTION OF THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's Gate, St. James's Park, Westminster, S.W. Paper on "Invention and Industrial Progress; with a Treatise on the British Patent System," by Mr. J. E. S. Lockwood.

WEDNESDAY, October 13th.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.

8 p.m. Meeting at St. Bride's Institute, Bride-lane, Fleet-street. Presidential Address on "Standardisation," by Prof. H. Adams.

FRIDAY, October 15th.

THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting in the Institution House, Storey's Gate, St. James's Park, S.W. Paper on "Heat Transmission," by Prof. W. E. Dalby.

Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

Monday, Oct. 11th, "A" Company — Practice for the Hopkinson Cup, 7:0 p.m. to 9:30 p.m.

Tuesday, Oct. 12th, "B" Company — Practice for the Hopkinson Cup, 7:0 p.m. to 9:30 p.m.

Wednesday, Oct. 13th. Gymnasium, 6:30 p.m. to 9:30 p.m.

Thursday, Oct. 14th, "C" Company — Practice for the Hopkinson Cup, 7:0 p.m. to 9:30 p.m.

Friday, Oct. 15th, "D" Company — Practice for the Hopkinson Cup, 7:0 p.m. to 9:30 p.m.

GLASGOW CORPORATION TRAMWAYS.

Next to the undertaking of the London County Council the Glasgow Corporation Tramways are usually regarded as the most important among tramway concerns in this country, and the results achieved at Glasgow are certainly of such excellence that they may be considered as typical of the best practice in this country. This particularly applies to the question of the allowance made for depreciation, which item figures prominently in the Glasgow accounts. For the year ended May 31st last no less than 2·26d. per car-mile was set apart for the depreciation of plant and the renewal of pemanent way. The total amount of £195,798 was arrived at by allowing £500 per mile of single track, 4·28 per cent. on the cost of the electrical equipment of the lines, 6·91 per cent. on the power station and sub-station plant, 7·5 per cent. on workshop tools and sundry plant, 7·5 per cent. on cars, including the electrical equipment, 11·24 per cent. on other rolling stock, and 7·5 per cent. on office furniture and miscellaneous equipment. The corresponding allowance last year for depreciation was 2·18d. per car-mile. Notwithstanding this ample allowance for depreciation a sum of £50,000 is paid over to the Corporation for the "Common Good," whilst £16,275 goes to the reserve fund. It is worth noting that the depreciation fund now amounts to £1,383,289 and the reserve fund to £70,631.

The Glasgow tramways, on which electrical working was first introduced in 1898, now consist of 94½ miles of double track and ½ mile of single track, the total length being, therefore, equivalent to 189½ miles of single track; during the past year extensions have been carried out in 5¼ miles of street. A sum of £41,120 was spent in ordinary repairs during the 12 months on the upkeep of the tramway track, whilst a sum of £90,261, on the basis of £500 per mile of single track, was laid aside to meet the costs of future renewal.

To meet the increasing demand for power a 3,000 kw. turbo-alternator has been installed at the Pinkston power station, and, in view of the interest which is at present being taken in the cost of supplying current for tramway purposes, the following details of the costs of power, which it will be remembered is obtained from the Tramway committee's own power station, deserve close attention:—

DETAILS OF POWER EXPENSES.

		Cost per unit sent out to substations. 1908-9.	1907-8.
Salaries and wages	£10,403	0·10d.	0·10d.
Fuel	17,720	0·16d.	0·17d.
Oil, waste, water, &c.	2,339	0·02d.	0·02d.
Repairs	7,352	0·07d.	0·07d.
Energy purchased (at 1d. per unit)	53	—	—
	£37,867	0·35d.	0·36d.
Rates and proportion of management	6,486	0·06d.	—
Depreciation	54,311	0·47d.	—
Interest and sinking fund	40.937	0·35d.	—
Total Power Expenses	£139,601	1·23d.	—

The number of units generated was 29,145,194, the load factor being 39·8 per cent., and 24,193,167 units (1·16 units per car-mile) were sent out from the substations.

The total number of cars in stock on June 1st last was 776—an increase of 17 compared with the number a year ago—and consists of 324 cars with top covers, 339 standard cars and 113 converted horse cars. The committee have decided to put covers on an additional 110 cars.

Turning next to the traffic details, a small decrease has to be recorded in the number of passengers, but this is not surprising in view of the general trade depression. The figures are 221,744,569 for the present year, and 226,948,290 a year ago, the receipts showing a corresponding decrease and being 10·26d. and 10·49d. per car-mile respectively. It should be noted that the number of car-miles was 20,802,797, an increase of 36,075 car-miles compared with last year.

Glasgow is always referred to as an example of the success of ½d. fares; it is therefore interesting to notice that the number of passengers paying a ½d. fare was 28·04 per cent. of the total number, whilst 59·65 per cent. of the passengers paid 1d., the corresponding percentages of the traffic receipts being 14·56 and 61·96 respectively.

It will be noticed, from our analysis of the accounts below, that rates and taxes have considerably increased, the amount charged under this heading being now £63,042, or 0·73d. per car-mile, as against 0·52d. a year ago. This increase is accounted for by the fact that the tramway lines within the city have been assessed for various purposes by the Corporation on the full valuation instead of one-fourth, as formerly. It is worth noting that in addition to the liberal contribution in the way of rates and taxes the present contribution to the "Common Good" brings the total amount so contributed since 1894 to the large total of £326,760, so that the ratepayers have benefited very considerably from the tramway undertaking, which, nevertheless, has made ample allowances for depreciation and reserve.

We give below an analysis of the expenses during the past year, June 1, 1908, to May 31, 1909, together with the cost per car-mile, the corresponding figures for the year 1907-8 being given for the sake of comparison. It will be seen that the working expenses show a small reduction per car-mile compared with those last year, but owing to heavier capital charges, the total expenses are 10·45d. per car-mile, compared with 10·15d. a year ago.

		Cost per car-mile. 1908-9.	1907-8.
Traffic Expenses.			
Superintendence	£5,167	0·06d.	0·06d.
Wages and bonuses	198,313	2·29d.	2·27d.
Cleaning and oiling cars	26,898	0·31d.	0·31d.
Cleaning track	5,267	0·06d.	0·05d.
Fuel, light and water for depots	2,600	0·03d.	0·03d.
Ticket check	10,791	0·12d.	0·13d.
Uniforms, &c.	6,236	0·07d.	0·08d.
Micellaneous	2,947	0·04d.	0·04d.
Total Traffic Expenses	£258,219	2·98d.	2·97d.
Repairs and Maintenance.			
Permanent way	£41,120	0·47d.	0·66d.
Electrical equipment of line	6,486	0·08d.	0·11d.
Buildings and fixtures	4,309	0·05d.	0·05d.
Tools and sundry plant	1,116	0·01d.	0·03d.
Cars	29,940	0·34d.	0·34d.
Electrical equipment of cars	17,992	0·21d.	0·21d.
Other rolling stock	1,572	0·02d.	0·02d.
Miscellaneous equipment	111	0·00d.	0·00d.
Total Repairs and Maintenance	£102.646	1·18d.	1·42d.
General Expenses.			
Salaries and wages	£6,906	0·08d.	0·08d.
Store expenses	858	0·01d.	0·01d.
Rents	3,508	0·04d.	0·04d.
Rates and taxes	63,042	0·73d.	0·52d.
Printing and stationery	1,497	0·02d.	0·02d.
Fuel, light and water	417	0·00d.	0·01d.
Law and insurance	24,157	0·28d.	0·28d.
Parliamentary expenses	136	0·00d.	0·03d.
Miscellaneous	6,365	0·07d.	0·07d.
Total General Expenses	£106,886	1·23d.	1·06d.
Power Expenses.			
Cost of generating current	£37.867	0·44d.	0·45d
TOTAL WORKING EXPENSES (ex. Capital Charges)	£505.618	5·83d.	5·90d.
Capital Charges, &c.			
Rental of leased lines	£9,734	0·11d.	0·11d.
Interest	63,349	0·73d.	0·61d.
Sinking fund	71.324	0·82d.	0·80d.
Income tax	10.445	0·12d.	0·11d.
Parliamentary expenses written off	—	—	0·03d.
Depreciation and renewals	195,798	2·26d.	2·18d.
Payment to "Common Good"	50,000	0.58d.	0·41d.
TOTAL CAPITAL CHARGES	£400.650	4·62d.	4·25d.
TOTAL EXPENSES (*inc.* Capital Charges)	£906,268	10·45d.	10·15d.
REVENUE (from all sources)	£922.543	10·64d.	10·59d.
Balance	£16.275	0·19d.	0·44d.

The balance of £16,275 is carried to the general reserve fund.

The capital expenditure during the past year was £161,704, this sum comprising £57,411 for permanent way, £22,608 for the electrical equipment of lines and £51,830 for power station and sub-station plant. The total capital expenditure now amounts to £3,307,280, and we give below, in detail, the

various items comprised in this sum, together with the percentage each bears to the total amount :—

CAPITAL EXPENDITURE.

		Per cent.
Permanent way	£1,051,981	31·8
Electrical equipment	679,057	20·6
Land	152,842	4·6
Buildings	469,315	13·9
Power station plant	442,498	13·4
Tools	31,193	0·9
Cars	262,453	7·9
Electrical equipment of cars	187,518	5·6
Other rolling stock	11,987	0·4
Miscellaneous equipment	19,123	0·6
Office furniture	5,256	0·2
Lease of Govan and Ibrox Tramways	4,057	0·1
	£3,307,280	100·0

THE MODERN TELEPHONE CABLE.*

BY FRANK B. JEWETT.

Summary.—The author here considers some of the essential requirements in the manufacture of modern telephone cables, first describing briefly the methods of construction adopted, and then showing how the modern processes meet the requirements.

To those not closely in touch with the telephone situation to-day the importance of the modern telephone cable may be indicated by stating that of the 8,000,000 miles of wire in the exchange plants of the Associated Bell telephone companies, more than 6,800,000 miles are in the form of underground, aerial or submarine cable. The concentration of hundreds of circuits in the form of cables is the only available method of providing the facilities necessary to meet present-day service demands, but it should be clearly recognised that even the best cable circuit is much less efficient than an open-wire circuit ; for example, 1 mile of No. 19 B. & S. gauge cable circuit ordinarily employed in exchange construction results in as much current attenuation as 35 miles of No. 8 B.W.G. open-wire copper circuit, or 3·5 miles of the smallest size open-wire iron circuit used in rural exchange work.

The extensive application of cable construction in the modern telephone plant has been made possible only through the development of a form of cable exceedingly efficient as compared with the earlier forms. It is the purpose of this Paper to consider a few of the essential requirements which have had to be met in the production of a modern telephone cable. These are : (1) The cable shall provide the maximum number of independent and non-interfering circuits within the minimum space. (2) These circuits shall have the maximum transmission efficiency for currents of telephonic frequency, compatible with the other electrical and mechanical requirements. (3) The dielectric strength of the cable shall be such as to ensure against failure from any of the potentials normally employed and to make possible its protection against damage from lightning and from foreign circuits operating at potentials in excess of those employed on telephone lines. (4) The mechanical arrangement adopted to obtain the necessary electrical properties shall be such as to ensure a continued maintenance of these properties after the cable has been installed. This assumes a construction which will withstand the hard usage unavoidably connected with cable installation. (5) This mechanical construction shall be made at a cost which will render the cable circuits economically available in comparison with other known means of circuit provision.

Standard Cable Construction.—While differing somewhat in details, the essential features of all modern telephone cables, known as dry core paper insulated, are the same whether the wires are in the little five-pair or ten-pair subscribers' cables ordinarily strung on pole lines or in the largest sizes employed underground. For making up telephone cables, wires of the proper size are first insulated by wrapping them individually with dry paper ribbon. This ribbon, which is usually about ⅝ in. wide and of a thickness varying from 0·002 in. upward, depending on the size of the wire, and coloured in some distinctive fashion, is spirally applied, but not with such a tension as to cause it to adhere closely to the wire. For the ordinary underground or aerial cable a single wrapping of paper suffices ; in some forms of submarine cable two wrappings of paper, laid on in reversed directions, are used. In any event, the ribbon is overlapped sufficiently so that the wire is completely covered. Thus insulated, the wires are twisted together in pairs, the two wires of a pair being insulated with different coloured papers and the length of twist depending upon the size of the conductors and the use to which the cable is to be put. The maximum length of twist, however, rarely exceeds 6 in., and for the smaller sized wires is ordinarily under 4 in. This twisting of the individual circuits is for the purpose of neutralising inductive and capacity effects, which would occasion "cross-talk" between the various circuits if the wires of the core were laid up parallel to one another.

The core of the cables is made up in cylindrical form by assembling the requisite number of twisted pairs together in concentric layers one or more pairs thick, the pairs in each layer being arranged spirally about the axis of the core and the direction of rotation in the alternate layers being reversed. This use of a concentric layer construction is adopted to ensure the necessary mechanical stability for the completed cable. The number of pairs in each layer is dependent upon the size and capacity of the cable required, and is varied by changing the size of the central strand.

When the cylindrical core has been completed it is wrapped with one or more thicknesses of paper tape to bind the conductors firmly in place, present a smooth exterior surface, and prevent the lead of the sheath from coming in contact with the insulation of the outer layer of conductors. This wrapping also gives the higher dielectric strength needed in the pairs of the outer layer. During the process up to this point the paper, being hygroscopic, has unavoidably taken on more or less moisture, which must be removed before the sheath is applied. To this end the core, suitably reeled, is placed in a drying oven in which air at a high temperature is circulated for a considerable period, after which the core is taken immediately to the lead press and the final sheath applied. This completes the process, except for the testing, sealing of the ends and reeling for shipment. The paper, which is loosely applied, serves merely as a mechanical separator to keep the wires apart and not as a dielectric per se. In cable of this type the real dielectric is the dry air between the wires.

To show how nearly the present dry-core cable meets the essential requirements of the telephone industry, the author examines these requirements and their actual fulfilment in detail, and also the evolutionary process by which the present form of construction has been arrived at.

Dielectric.—It is essential that the dielectric selected for maintaining the proper separation of the wires and providing the necessary mechanical properties required of the cable should have both a low dielectric capacity and small dielectric hysteresis. The importance of these characteristics of the dielectric are readily apparent if we examine the mathematical expressions for the propagation of high-frequency currents, such as those met with in telephony. For telephone cables, where the wires are close together, the inductance is negligibly small, and if the leakage component is small in comparison with the capacity component, the formula for the attenuation constant is approximately

$$a=\sqrt{\frac{RC\omega}{2}\left(1+\frac{S}{2C\omega}\right)},$$

where R is the resistance, C the shunt capacity, ω 2π times the frequency, and S, expressed in mhos, measures the combined conductance as determined from the insulation resistance and the dielectric hysteresis. Where S is zero—*i.e.*, for cables having high insulation and no dielectric dissipation—the expression for the attenuation constant is merely that of the so-called " KR law." The quantity S/2C in the above formula, known as the " damping constant," is dependent on the dielectric of the cable, and is independent of the capacity of the cable, provided the dielectric is unchanged in character by changing the separation of the wires. In order, therefore, that the transmission efficiency of any cable shall be high for some particular frequency or range of frequencies, it is necessary that in addition to low capacity, the dielectric shall have the smallest possible ratio of shunt conductance to shunt capacity for these frequencies.

In the following table are given the constants at 1,000 periods per second for No. 19 B. & S. gauge cables made up with rubber insulation, braided-cotton insulation impregnated with paraffin, and dry-core insulation :—

Constants of No. 19 B. & S. Gauge Telephone Cables.

Insulation.	Mutual capacity mfd. per mile. 1,000 ∿.	Mutual conductance m. mhos per mile. 1,000 ∿.	Damping constant S/2C. 1,000 ∿.
Rubber	0·15	40	133·0
Braided cotton filled with paraffin.	0·12	16	67·0
Dry-core paper	0·08	2	12·5

* Abstract of a Paper read before the American Institute of Electrical Engineers.

Taking the above constants and applying them in the approximate formula, it will be seen that the attenuation constant of the impregnated cable is 24 per cent., and that of the rubber 40 per cent., higher than that of the dry-core paper cable; also that while the dissipation of the dielectric increases the attenuation in the latter cable by less than 0·2 per cent. at 1,000 ∞, that in the impregnated cable increases it by 1·05 per cent. and in the rubber-insulated cable by 2·10 per cent. In addition to the effect of dielectric dissipation increasing the attenuation of the cable, the fact that this increase is not constant for all frequencies, but it is greater the higher the frequency, results in a cable with high dielectric dissipation having more distortion than one in which the dissipation is low over the range of frequencies involved in speech transmission.

From the above table it is also evident from the small value of the dissipation constant for the dry-core cable that with this type of construction conditions have been attained approximating very closely to those in which nothing but air would intervene between the wires. In addition to the numerous mechanical, electrical and economic defects which obtained in impregnated and rubber-cored cables, the fact that they were materially inferior in efficiency to the present type of dry-core construction was one of the principal factors leading to the adoption of the latter.

While the standard telephone cable of to-day is essentially an air-core cable, the amount of solid dielectric necessary for mechanical reasons is appreciable, and in specifying a wrapping of high-grade dry-rope paper ribbon the aim has been to utilise a material which will have the lowest possible dielectric capacity and dissipation, and at the same time possess the necessary mechanical properties to permit of its use in comparatively small quantities. That the paper should be spirally applied to the wires rather than put on in some other fashion is the result of actual experience with other types of construction.

Insulation Resistance for Telephone Cables made in the United States.—The customary specification requirements are: In every length of cable each conductor shall show an insulation resistance of not less than 500 megohms per mile at 68°F., each conductor being measured against all the rest and the sheath. In Europe the insulation requirements are frequently very much more severe than this, and sometimes necessitate drying the cable after it is laid and spliced. It is extremely doubtful, however, whether a high insulation specification can be justified in view of the extra expense incident to meeting it and the exceedingly small improvement in transmission resulting therefrom.

An inspection of the foregoing attenuation formula and the constants for different dielectrics will show at once that high insulation is not in itself necessarily an indication that the cable will be efficient. Figures given in the Paper show that, while the transmission efficiency in one case was increased 7·1 per cent. by the process of drying a paper cable, the improvement due directly to the increased insulation resistance was less than 0·001 per cent., that due to the reduced capacity being 7 per cent. and that to the reduced damping constant 0·1 per cent.

Dielectric Strength.—All dry-core paper-insulated cables used by the Associated Bell Telephone Companies are required to withstand a direct current potential of 500 volts between any wire and its mate, or between any wire and all of the remaining wires and the sheath of the cable.

Electrostatic Capacity.—It is now customary to specify mutual rather than earthed capacity, as the former is a constant of the cable directly indicative of its transmission efficiency. So far, however, as ensuring efficient construction and good workmanship are concerned, either mutual or earthed capacity would suffice, since within the range of capacities ordinarily met with in telephone cables the relation between the mutual capacity of a pair and the earthed capacity of its component wires is fairly constant, the mutual capacity being approximately 60 per cent. of the earthed capacity. If an attempt is made to secure too low a capacity by separating the wires and employing too small an amount of paper, the core becomes so soft that the completed cable is easily deformed, and consequently extremely hard to handle; on the other hand, any attempt to secure an extremely high capacity by putting an excessive number of pairs in the core renders the cable stiff and unwieldy, or if the amount of paper is sacrificed the dielectric strength will be unduly low. Experience has shown that an average mutual capacity of about 0·050 mfd. per mile marks the lower limit for single-wrap paper cable which can be readily handled without undue deformation, while approximately 0·09 mfd. per mile marks the upper limit.

Sheath.—No problem has been so difficult of solution as that of the proper type of sheath to employ. For the mechanical protection of the core wires during and after installation and for preventing the ingress of moisture at all times, a continuous sheath composed of an alloy of lead and tin (not less than 3 per cent.) is moulded firmly about the finished and dried core. This sheath, which varies in thickness from $\frac{1}{12}$ in. to $\frac{1}{8}$ in. for aerial and underground cables, depending upon the size of the core, is moulded in a continuous section over each individual length of core immediately on the removal of the latter from the drying oven. To ensure uniformity of practice in the cable plant it is necessary to set some limit on the maximum diameter of the sheath. At the present time the standard for a full-size cable is $2\frac{5}{8}$ in. outside diameter, this being the limiting size that can be satisfactorily drawn into a standard 3 in. duct. A cable of this size will contain 300 pairs of No. 19 B. & S. conductors having the capacity noted above.

As a result of the defects in the earlier forms the present process was developed of moulding the sheath directly on to the dried core so as to closely fit it, eliminating at once the necessity for factory joints and the need for clearance between the core and sheath.

The specification of a 3 per cent. tin alloy for the sheath is likewise a result of experience gained in the early days of cable development. Added primarily for the purpose of hardening the sheath so as better to withstand rough usage during manufacture and installation, the amount of tin used was long a matter of individual preference. The present standard requirement was only arrived at when a careful investigation was made to determine the proper remedy for the cracking of aerial cable sheaths, which developed when the sheath was subjected to continued vibration.

With the advent of creosoted wooden conduit a great deal of trouble from the chemical corrosion of the sheaths was experienced. Elaborate experiments proved that while not wholly free from such corrosion, the 3 per cent. tin alloy sheath was corroded much less than one of pure lead or with but a small proportion of tin. While improvements in the process of creosoting by the substitution of oil of coal tar for wood creosote, thereby eliminating the acetic acid, and the advent of vitrified clay ducts have practically eliminated chemical corrosion from the field of cable trouble, it was one of the factors which at the time led to the adoption of the present standard sheath material. Although an excess of tin renders the alloy too hard and brittle, only the minimum limit needs to be specified, the high price of tin automatically keeping the amount used as small as possible.

In conclusion, the standard cable specifications of to-day aim primarily to secure a certain standard for the finished product without unduly restricting the manufacturer as to the exact processes he shall employ to attain the desired end. While certain of the mechanical characteristics are incorporated, such as the use of a particular alloy for the sheath, and the employment of paper insulation to the exclusion of other materials, it is on account of experience having shown them to be the best available. As a result of this aim, the specifications, though brief, have the clauses so drawn as to ensure the equivalent of a process known to be satisfactory.

A NEW METHOD FOR THE ABSOLUTE MEASUREMENT OF RESISTANCE.*

BY E. B. ROSA.

Summary.—A revolving coil method of measuring with the highest precision the absolute value of a resistance is here described. Two coils are rotated in a magnetic field and the resultant E.M.F. is compared, by means of a differential galvanometer, with the fall of potential through a resistance.

The method of Lorenz is generally considered the best among the various methods that have been employed for the absolute measurement of resistance. It has, however, a very serious limitation in the very small E.M.F. generated, and in the appreciable thermoelectric forces produced at the sliding contacts. In studying the problem of how to secure an accuracy at least 10 times as great as has yet been done (for that is what is now demanded in order to keep pace with the possibilities in the absolute measurement of current) it occurred to me that a revolving coil, or two such coils, could be so disposed in the magnetic field of a pair of fixed coils as to yield an E.M.F. which could be compared with the fall of potential through a fixed resistance, by means of a differential galvanometer, and so give the absolute value of the resistance. The advantage of this method would be that the E.M.F. generated could be a thousand times greater than in the Lorenz apparatus, while the thermoelectric forces at the sliding contacts would be considerably less; for a revolving coil cuts the lines of force four times in each revolution, and two coils of only 125 turns each would therefore generate a thousand times the E.M.F. produced by a disc, supposing the field and speed the same, and the area of the coils equal to that of the disc.

* Abstract of an article in the "Bulletin" of the Bureau of Standards

The thermoelectric forces due to the brushes would be less because the commutator could be much smaller than the disc. An apparatus of this kind is being constructed for use at the Bureau of Standards.

The wave form of the E.M.F. generated has the form shown in Fig. 2. The field coils being rather further apart than in a Helmholtz galvanometer, the E.M.F. instead of varying at a maximum rate as it passes through zero, becomes tangential to the axis, permitting the E.M.F. to be commutated by means of a two-part commutator, without sensible loss. The lines of force between the field coils swell out as shown in Fig. 1, and the revolving coils slide along the lines very nearly for an appreciable distance at the region of minimum E.M.F., thus giving a very small E.M.F. for a considerable angle. It is not practicable to put this commutated E.M.F. in series with the constant difference of potential at the terminals of the resistance to be measured, for the commutator would then cut out an uncertain part of the integral E.M.F. of the latter; but they may be compared very accurately by means of a three-circuit differential galvanometer, preferably of the Broca type. By using two rotating coils, at right angles to each other, and so disposing the field coils as to make the E.M.F. at 45 deg. either side of the maximum equal to one-half the maximum (as can readily be done), the sum of the two currents is constant within about 3 per cent., and this small fluctuation has a frequency four times that of either component. The effect on the needle therefore, due to the two pulsating currents, i_1 and i_2, flowing in two of the three-strand windings of the galvanometer, is the same as though these two currents were combined in a single winding, and is equivalent to a direct current of the same average value. Each circuit has its two-part commutator and the same resistance as the third circuit which carries a constant current. Fig. 3 gives a diagram of the connections.

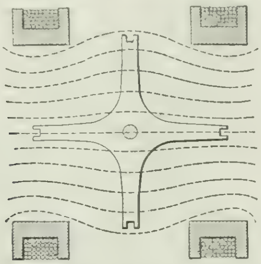


Fig. 1.—Revolving Coils and Magnetic Field of fixed Coils.

Let M_1 and M_2 be the mutual inductances of the two revolving coils with respect to the field coils, when each is in the position of maximum inductance, R_1 and R_2 the total resistances of the two circuits of which these coils form a part, including the resistances of the respective galvanometer windings, n the number of revolutions per second of the armature coils, and I the field current. Then the average value of the currents in the two circuits will be $i_1 = 4nM_1I/R_1$ and $i_2 = 4nM_2I/R_2$ if the effect of self-inductance is negligible. The third circuit carries a steady current i_3, due to the difference of potential at the terminals AB of the resistance R, to be determined absolutely, through which flows the main current I, which passes through the field coils. Hence $i_3 = RI/R_3$, R_3 being the total resistance of the circuit, including R. We may suppose the windings of the galvanometer not perfectly balanced, so that the currents in any two windings required to give zero deflection are not quite equal. Then let $i'_3 = f_1i'_1 = f_2i'_2$, f_1 and f_2 being factors very nearly unity.

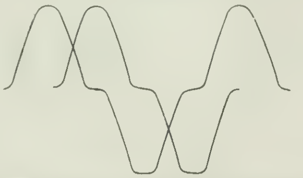


Fig. 2.—Waves Produced by the Revolving Coils of Model Apparatus.

If two circuits are balanced on the same E.M.F. E, for example that on the points AB, we should have $i'_1 = E/R_1$, $i'_2 = E/R_2$, and $i'_3 = E/R_3$. Therefore, $i'_1 = E/R_1 = E/f_1R_3$. Thus, when the galvanometer is balanced, $R_1 = f_1R_3$ and $R_2 = f_2R_3$. That is, leaving R_3 constant, the resistance R_1 is altered slightly, if necessary, until there is no deflection, and then the second circuit R_2 is put in place of R_1 and balanced in the same way. It is never necessary either to measure R_1, R_2, R_3, or even to compare them with one another except as is done in occasionally balancing the galvanometer in the manner described above. Any variations due to temperature changes or other causes will thus be corrected.

From what precedes $i_1 = 4nM_1I/f_1R_3$, and $i_2 = 4nM_2I/f_2R_3$. Since $i_3 = f_1i_1 + f_2i_2$ when running regularly, and the constant current i_3 is balancing the pulsating currents in the other two circuits $RI/R_3 = (4nM_1 + 4nM_2)I/R_3$, or $R = 4n(M_1 + M_2) = 4nM$; where R is the resistance whose absolute value is to be determined, M is the sum of the maximum values of the mutual inductances of the two revolving coils, with respect to the field coils, and n is the speed, or number of revolutions per second. (In the Lorenz apparatus the formula is $R = nM$.)

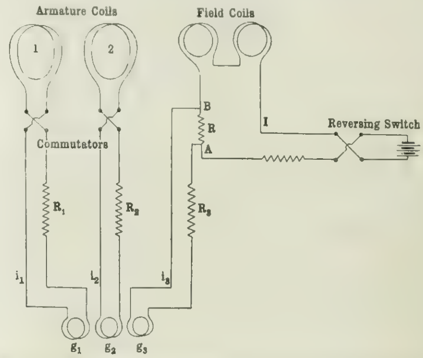
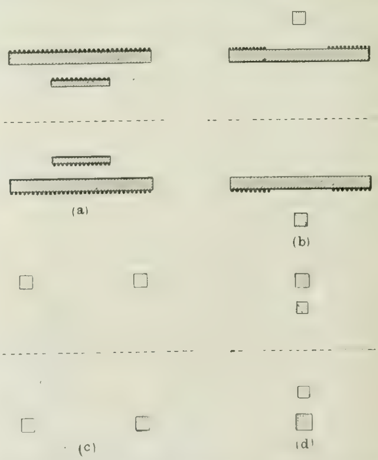


Fig. 3.—The Three Circuits of the Galvanometer with the Connections for Measuring the Resistance R.

If the commutators and brushes are properly made, the thermoelectric forces at the sliding contacts will be wholly negligible in comparison with the E.M.F. generated in each coil, and the variation of resistance at the brushes will be negligible in comparison with 500 or 1,000 ohms, the total resistance of each circuit. The temperature changes of resistance will be very slight, for probably 99 per cent. of the resistance can be manganin. A third winding of copper, having a resistance equal to that of one of the armature coils, in the i_3 circuit could be employed to balance any slight effect of varying room temperature. But that would probably be a needless refinement, if the room were kept at nearly constant temperature, as it should be for other reasons. These details are mentioned to show that the use of a differential galvanometer carrying an appreciable



(a) Two coaxial solenoids; (b) Campbell form; (c) Two equal coaxial coils; (d) Two coaxial coils in the same plane.

Fig. 4.—Different Forms of Mutual Inductance Standards.

current does not introduce sources of error that would be troublesome. From our experience in previous work, I am confident that the uncertainty in the speed need not exceed 1 part in 100,000. The use of the direct reading chronograph, which was developed especially for this kind of service, and the same method of maintaining constant speeds that we have employed for several years leaves little to be desired in this respect. The burden of the problem therefore is to determine M, the mutual inductance, with sufficient precision. There are decided advantages in obtaining it, not directly by calculation, but by comparison with a standard of mutual inductance, the latter having its value computed from its dimensions. These advantages are: (1) The resistance machine may be more compact, and its field coils may be wound with many layers of wire, thus giving a stronger field and higher E.M.F., and the machine will be lighter and less expensive to construct. (2) Being more compact, the stray field of the machine is relatively less, and having a strong field the disturbing effects of the earth's field are reduced. (3) The mutual inductances M_1 and M_2 can be measured under working conditions. (4) The mutual inductance can be redetermined by comparison with the standard every time a run is made, if desired. Any change due to changes in the windings or temperature effects will therefore be detected.

Various forms of mutual inductance standards are shown in Fig. 4. A form which I am now having constructed is a pair of coaxial coils in the same plane. (Fig. 4*d*.) The mean radii will be determined electrically by comparison with a standard single layer coil. Being in the same plane, there are no measurements of distance to make. The secondary can be most accurately centred electrically, being in a minimum position with respect to radial displacements, and in a maximum position with respect to axial displacements. The accuracy of the electrical comparisons is probably at least 1 in 100,000, so that the precision of the determinations of radii depend chiefly on the measurements of the standard coil. This can be measured at least as accurately as any single layer winding. The advantage of this form is that it avoids the measurement of lengths of coils or pitch of windings, and gives a very compact standard which may be of quite large value if desired. The electrical comparisons of radii can easily be repeated, and by winding each coil with a pair of wires which can be joined in series or parallel, one can have three values, as for example 50, 25 and 12·5 millihenrys, merely by changing the connections.

The best way is to build at least two different forms of mutual inductance of the same values, and having the same value as the resistance apparatus, so that they can be compared with one another and with the resistance apparatus by sending the same current in series through their primaries, and connecting their secondaries in opposition through a sensitive galvanometer. One primary may be shunted by a high resistance to secure an exact balance. This comparison can be made very quickly, and with standards of the above values there need not be an error exceeding 1 part in 1,000,000,000 in the comparisons.

THE SHORT-CIRCUITING OF CADMIUM CELLS.*

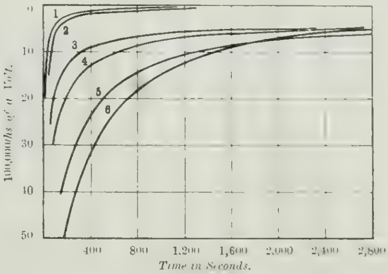
BY P. I. WOLD.

Several cadmium cells have been short-circuited for from 15 seconds to 10 minutes and the general shape of the recovery curves is the same in all cases and agrees very well with the curves obtained by F. E. Smith † and by Barnett.‡ The internal resistance of these cells is about 1,500 ohms so that the actual current while short-circuited is rather small. The deviation from the normal value was obtained by a Wolff potentiometer, the short-circuited cell being placed in opposition to a cell taken as a standard and their differences read. Deviations from the normal were read directly to 1/100,000 of a volt and were estimated, with a fair degree of accuracy, to 1/10 of this.

The diagram herewith shows the effect of short-circuiting a cell for different lengths of time. Curve 1 is for 15 seconds, curve 2 for 30 seconds, curve 3 for 60 seconds, curve 4 for 2 minutes, curve 5 for 5 minutes and curve 6 for 10 minutes. The axis *OA* represents the normal value of the E.M.F. of the cell and the ordinates represent the deviation from this normal in hundred-thousandths of a volt. An attempt to find a general form of equation for the recovery curve has, so far, been unsuccessful. The form suggests a logarithmic curve, but plotting logarithms of the deviation with time fails to give even an approximately straight line.

The general similarity of the decay curves in the case of phosphorescence, as shown by Profs. Nichols and Merritt,* with these recovery curves then suggested that these two effects might obey similar laws, since in both cases the curve is probably determined by the reunion of free particles; in the one case probably electrons, in the other case the chemical ions which cause the polarisation. The results given in the diagram above, when plotted as $D^{-\frac{1}{2}}$ and t, agree surprisingly well with the corresponding curves shown by Profs. Nichols and Merritt.

The author thinks that probably the shape of the curves obtained in this way is due to the fact that there are two, or more, effects giving or intensifying the polarisation from which the cell must recover, and these individual recoveries are of different velocities. It may be that one phase of the recovery is brought about by the diffusion of ions, which at first are concentrated close to a separating surface in the cell, and the other part of the recovery is due to the reunion of these ions. At first probably the diffusion effect would be the predominant one, following one law, but later the chief effect would be that due to reunion of ions, which would follow a different



law, similar perhaps to the law governing the reunion of electrons in the case of phosphorescence. It may be, on the other hand, that we have simply the case of an excess of ions producing polarisation at different points; as SO_4 ions near the cadmium and cadmium ions near or in the $HgSO_4$, and that the rate of recovery from these effects is different.

* Abstract of an article in the "Physical Review."

† Transactions of the Royal Society; Series A, Vol. CCVII., p. 393.

‡ "Physical Review," Vol. XVIII., p. 104, 1904

* "Physical Review," Vol. XXII., p. 279, 1906; Vol. XXIII., p. 37, 1905.

ELECTRIC CRANES.†

BY H. H. BROUGHTON.

(*Continued from page 907.*)

Summary.—The author here deals with the mechanism required for effecting the traversing and travelling motions. The article opens with a brief discussion on the determination of the size of motor required for each motion, and "constants" of American cranes are given. Then follow notes on slipping drives, axles, axle-boxes, roller bearings and track wheels. Constants are given in order to enable the several parts to be correctly proportioned. Traversing and travelling mechanism arrangements are also described.

Traversing Mechanism Arrangements.—In arranging the trolley it is often necessary to make the traversing mechanism very compact, on account of the large amount of space which has to be devoted to the main and auxiliary hoists. This circumstance favours the adoption of worm gear, as with such gears a speed reduction of 30 to 1 can be effected in a very small compass. When alternating current motors are used a speed reduction of 100 to 1 or more may be required. In such cases, if spur gears are adopted, it is necessary to have three reductions, say, 4 to 1, 5 to 1 and 5 to 1, and the whole arrangement looks unsatisfactory, whereas a worm and worm wheel with a 25 to 1 reduction used in conjunction with a 4 to 1 spur gear makes a workmanlike job and requires little room for its accommodation.

For trolleys of small and medium capacity it is usual to drive both wheels by a common spur keyed to the axle, but in heavy trolleys two driving pinions are used, and the main spur wheels are cast solid with the truck wheels in the manner previously explained, or keyed one on each

driving axle. Some makers arrange to drive all the wheels by means of coupling rods or chains or gearing.

On account of the high traverse speeds, and to admit of great nicety of control, it is advisable to provide a brake on the traversing mechanism. The controller can be arranged for rheostatic braking, or an electro-mechanical brake acting on the motor spindle may be used. We have

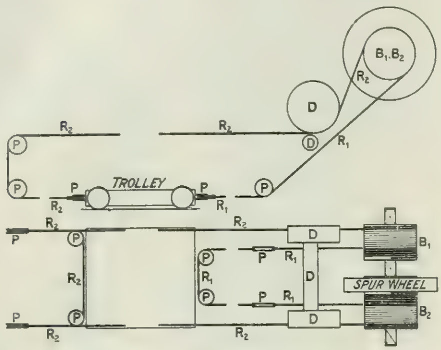


Fig. 112.—Diagram showing Traversing Rope Arrangement for Hammer Crane.

worked to specifications in which both rheostatic and electro-mechanical brakes are called for, but, generally speaking, in normal cranes such arrangements are extravagant, and the money expended upon them can, with better advantage, be devoted to other important details of the crane.

An excellent arrangement for high-traversing speeds is to mount a motor of the tramway type on springs upon the trolley frame, and drive the axle by means of a single en-

The rope arrangement for traversing the trolley of a hammer crane is shown in Fig. 112. Assume the trolley to be at the minimum distance from the centre. Let the rope which moves the trolley inwards be denoted by R_1, the rope which moves the trolley outwards be denoted by R_2, and the two drums by B_1 and B_2. In this position of the trolley the maximum length of rope R_1 will be wound on the drums

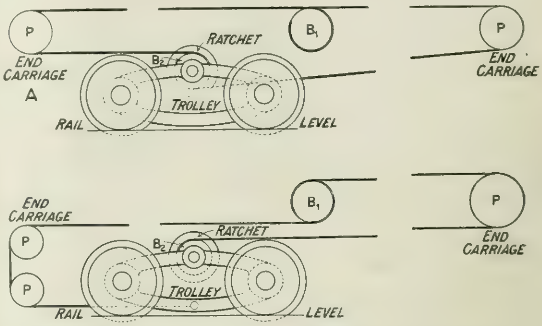


Fig. 113.—Traversing Rope Arrangements used for Single Motor Cranes.

B_1 and B_2 (starting from the inside edge in each case and coiling outwards), and the minimum length of R_2 will be wound on the drums (starting from the outsides and coiling inwards). The reverse is the case when the trolley is at its maximum distance from the centre. In an intermediate position the least movement to the right or left causes a little of one rope to be wound on the drums and a like amount of the other rope to be unwound.

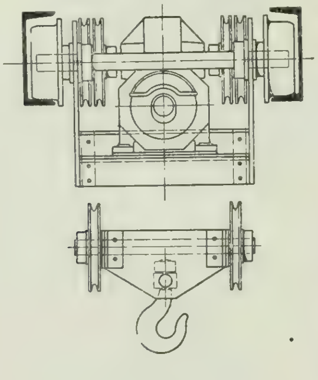
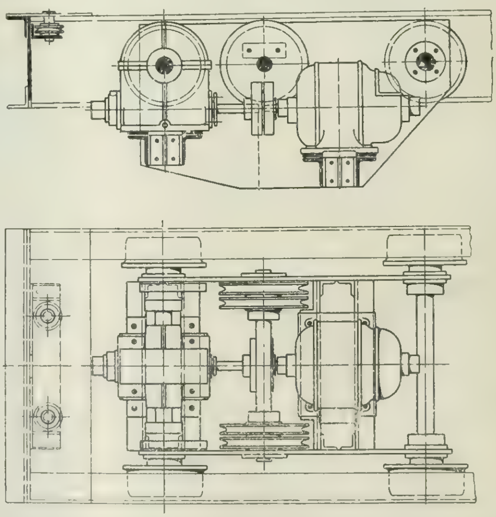



Fig. 114.—3-ton Tolley, by Stuckenholz.

closed spur gear, an electro-mechanical brake being fitted to the rear end of the motor spindle or to the axle.

The trolleys of certain cranes, such as the hammer type and overhead travellers of small capacity, are traversed by means of wire ropes passing over suitably situated guide pulleys on to a drum mounted at a convenient place on the jib or cross-girders.

For traversing a light trolley either of the rope arrangements shown in Fig. 113 may be used. As in the example previously described, two distinct ropes are required, and the drum D_1 is grooved to coil a length of rope equal to the traverse of the trolley, together with two extra turns. The drum D_2 on the trolley is provided with a ratchet for keeping the rope taut.

To find the length of each rope, consider the trolley to be at the end A of its travel; then

Length of rope R_1=apparent length+traverse of trolley
$=l_1$ (allowing one turn on each drum) $+L$,

and

Length of rope R_2=apparent length
$=l_2$ (allowing one turn on each drum).

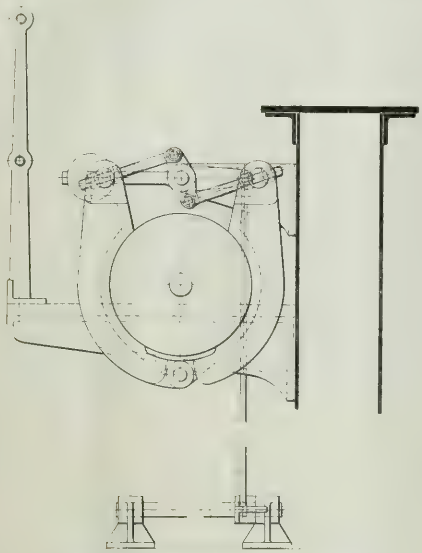


FIG. 115.—FOOT-PEDAL TOGGLE BRAKE.

Sometimes one or other of these arrangements has to be used for overhead travelling cranes of medium or even large capacity, in order to satisfy the requirements of pessimistic buyers, who prefer a single motor crane on account of the supposed unreliability of electric motors.

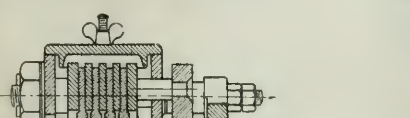


FIG. 116.—"WESTON" TYPE FOOT-PEDAL BRAKE.

We are of the opinion that the trolleys of practically all overhead travelling cranes should be traversed by means of a motor mounted on the trolley, and an excellent arrangement, for a crane of small capacity by Stuckenholz, is depicted in Fig. 114

It is only in special cases that a light trolley has to be provided in order to minimise the weight and, consequently, the cost of the cross-girders or jib. In such cases it is necessary to mount the lifting and traversing mechanism on or near the end trucks, or the rear end of the jib arm, where it serves to counterbalance the load.

Travelling Mechanism Arrangements.—In nearly every case cranes are driven at both ends, the pinions being keyed to the extremities of the cross-shaft. The track wheels and main spur wheels, when formed solid, relieve the axles of torsional stress.

To ensure equal turning moments at the two ends, either two motors, one on each end carriage, or a single motor fixed to the girder at the centre of the span, should be used.

As pointed out in a previous article,* the speed variation of induction motors between no load and full load is very slight; hence, when such motors are used, the cross-shaft may, if desired, be dispensed with. This is an advantage in cranes of very large span, as it enables the cross-girders to be braced together, the ropes hanging over the outside of the bridge.

When continuous current motors are used they should be coupled together, both electrically and mechanically, as the speed of such motors depends on the load.

In connection with overhead travelling cranes it is necessary to make some allowance for the expansion of the cross-girders. In a number of large span cranes overheating of the axle boxes and rapid wear of the wheel flanges led to an examination which resulted in this point being brought forward; after allowing the axles a little end play no further trouble was experienced.

A foot-pedal brake is sometimes required, and Figs. 115 and 116 show the general features of two forms of such brakes. The former is of the "toggle" type and the latter of the "Weston" type.

Electro-mechanical brakes should be provided on all high-speed cranes and on all heavy cranes.

(To be continued.)

BOOKS RECEIVED.

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"The Dynamo." By C. C. Hawkins and F. Wallis. 5th Edition. In two Vols. (London: Whittaker & Co.) 21s. nett.

"Wireless Telegraphy and Wireless Telephony." By A. E. Kennelly. (London: T. Fisher Unwin.) 4s. net.

"Dynamo Laboratory Manual." By Wm. S. Franklin and Wm. Esty, with the co-operation of S. S. Seyfert and C. E. Clewell. Vol. I.: "Direct-Current Studies and Tests." (New York: The MacMillan Co.) $1.75 nett.

"Dynamos and Motors." By Wm. S. Franklin and Wm. Esty. "Direct-Current and Alternating-Current Machines." (New York: The MacMillan Co.) $4.00 nett.

"Alternating-Current Motors." By A. S. McAllister. 3rd Edition. (New York: McGraw-Hill Book Co.) $3 nett post free.

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"Messungen der Stromstärke, Spannung, Leistung und Arbeit bei Gleich und Wechselstrom, Eichung und Graduieren von Messinstrumenten." By Fritz Hoppe. Part VII. of "Sammlung Elektrotechnischer Lehrhefte. (Leipzig: J. A. Barth.) M.4.40.

"Messungen an Maschinen und Motoren für Gleichstrom." By Fritz Hoppe. Part VIII. of "Sammlung Elektrotechnischer Lehrhefte." (Leipzig: J. A. Barth.) M.5.80.

"Continuous-current Dynamos and Motors and their Control." By W. R. Kelsey. 2nd edition. (London: The Technical Publishing Co.) 7s. 6d. net.

* THE ELECTRICIAN, October 25, 1907.

THE ELECTRICITY SUPPLY STATIONS OF THE NEW YORK EDISON COMPANY.

(*Continued from page 987.*)

Feed-water System.—The feed-water system in use involves a number of interesting features representing the most recent practice in the handling and conservation of the boiler water supply for a large plant. Of chief importance are the use of centrifugal boiler-feed pumps and the means adopted for measuring all water delivered and the blow-off wasted. The water for the boilers is taken from the city water mains, the water in the East River being salt and driven wells being impossible in the vicinity of the station. By the use of surface condensers all the condensed water from the large turbines is reclaimed and also practically all the steam used for the steam-driven auxiliary machinery in the turbine room basement. The system embraces, in general, a header and connections for the return of condensed water from the hot wells of the condensers, large open feed-water heaters utilising the exhaust from the reciprocating engines and the small turbines, and a system of feed piping with loops surrounding each of the boiler sections. Venturi meters, both indicating and recording, measure all the feed water delivered. Each of the two pump rooms in the boiler-house basement contains two open feed-water heaters, rated at 500,000 lb. of water per hour, and four centrifugal pumps.

The hot well returns from the condensers are collected in a 12 in. header located along the wall of the boiler room. A 14 in. pipe branching to two 10 in. pipes carries the returns into the tops of the heaters in both pump rooms. The flow is maintained by the hot-well pumps, which are designed to operate against a head of 25 ft. A float operating on a balanced regulating valve controls the amount of water delivered to each heater. The centrifugal pumps (Fig. 8) are of the five-stage type with 8 in. suction from a 16 in. suction tie line connecting the bottom of the four heaters. Each pump discharges into 6 in. feed-water ring headers on each tier of boilers through four 8 in. risers. Each set of six boilers is served with a 6 in. tie line between headers and a 3 in. loop, gate valves, angle check valves and 2 in. branch pipes leading into the drums of each boiler. The pumps, which operate at 1,650 revs. per min. and deliver 1,000 gallons per minute against a head of 700 ft., are connected through flexible couplings to Terry steam turbines rated at 300 H.P.

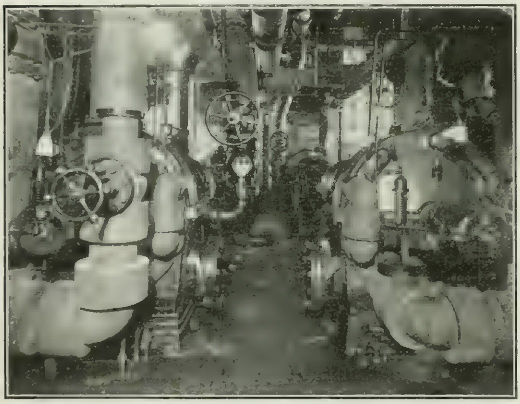


FIG. 8. TURBINE-DRIVEN CENTRIFUGAL FEED-WATER PUMPS.

Steam Pipes.—A diagram of the steam piping arrangement for the two floors of boilers is shown in Fig. 9. Two main 14 in. headers are located in the boiler room below the second and third floors respectively near the division wall. Six 14 in. vertical tie lines connect these main headers at intervals, and valves are arranged so that any section can be isolated should occasion require it. The turbines are fed with steam from the lower header, the piping passing under the floor of the turbine room, which is 5 ft. above the lower boiler room floor, and being supported from the steel framework of the operating room floor. The main ring header is supplied by eight boiler room headers made up of 10 in., 12 in. and 14 in. pipe, four feeding the upper and four the lower header. Besides being separated into sections by valves between each battery of boilers, each boiler room header forms a loop over one section in each tier. The boiler manifold is connected by means of 8 in. U bends to the headers. In the bends a combination stop-and-check valve is located which automatically opens when the pressure of the boiler equals that of the line. The high-pressure steam piping is made up of $\frac{3}{8}$ in. open-hearth steel with cast-steel fittings and double-lap joints.

Encircling the boiler room above the first tier of boilers is an 8 in. ring header which supplies steam to the blower and stoker engines of the first and second tiers and to the pump and compressor rooms in the basement. Each of the auxiliaries in the turbine room basement receives steam through a 6 in. connection to the 14 in. lines supplying the turbines. All the live steam lines to the turbines and auxiliary engines are equipped with separators inserted near the turbines and engines.

Along the north division wall of the boiler house basement is an auxiliary exhaust made up of 8 in., 14 in. and 24 in. pipe leading into an exhaust flue at the east end of the building through relief valves. Branch pipes lead from this header into the pump rooms to supply steam to the feed water heaters there installed. From the opposite end of the heaters a 12 in. pipe leads to the exhaust flue or stack. All the exhaust lines from the turbine auxiliaries, step-bearing pumps and auxiliary apparatus in the boiler house basement connect with the auxiliary exhaust header, and since the auxiliaries in the turbine room basement are also arranged to operate condensing when the supply of exhaust steam from other sources is sufficient for feed water purposes, the exhausts from these are passed through vacuum oil separators before entering the condensers. Free exhaust for the main turbines is provided by two tunnels. Each turbine is equipped with a 36 in. pipe connection in the exhaust to the turbine and a 6 in. chronometer valve and muffler for breaking the vacuum.

Generating Plant.—Running east and west the turbines are spaced 55 ft. apart, centre to centre, and running north and south the General Electric units are spaced 28 ft., centre to centre, and the Westinghouse units 32 ft., centre to centre. The operating room is $57\frac{1}{2}$ ft. wide and 306 ft. long. A view of this room is given in Fig. 11. Turbines No. 1 and No. 2 are of the multiple-expansion, parallel-flow, horizontal type built by the Westinghouse Machine Co. They are rated at 7,500 kw. when operating at 750 revs. per min. with dry saturated steam at 175 lb. pressure at the throttle and with a pressure in the exhaust pipe of 2 in. of mercury absolute at the exhaust outlet. When operating with steam superheated 100°F. at the above speed, pressure and vacuum, the steam consumption at full load does not exceed 15·9 lb. per kilowatt-hour, at half load 18·3 lb., and at 50 per cent. overload 17·6 lb. The turbine is provided with a governor of the balanced poppet-valve type enclosed within the valve chest for controlling the admission of steam. In addition there is a quick-operating throttle valve in combination with the auxiliary governor which automatically closes if the turbine speed increases beyond a certain limit.

The Westinghouse units are equipped with Alberger condensing apparatus. The surface condensers are located directly under the turbines, to which they are connected by an expansion joint. They are of the three-pass type and have 25,000 sq. ft. of cooling surface. The dry vacuum pumps are of the single-stage, two air cylinders in tandem type fitted with Corliss valve gear. The wet vacuum pumps are of the monitor duplex type and the circulating water pumps are of the double-suction centrifugal type direct-connected to two-cylinder vertical engines.

All the other main turbines are of the Curtis five-stage type, manufactured by the General Electric Co. Turbines Nos. 5, 6, 7 and 9 are rated at 8,000 kw. and operate at a speed of 750 revs. per min., and are equipped with governors of the hydraulic type. The condensing apparatus for these units was installed by the Wheeler Condensing & Engineering Co. The condensers are of the two-pass, dry-tube type, have a cooling surface of 18,000 sq. ft., and are set to one side of the turbine. The circulating water pumps are of the volute centrifugal type direct-connected to double engines. Double-acting steam dry vacuum pumps are used and the wet vacuum pumps are of the centrifugal type direct connected to Terry steam turbines. These are rated at 15 H.P., and run at 1,500 revs per min. Turbines No. 8 and No. 10 have the same rating as the four just mentioned but are equipped with Worthington condensing apparatus. Three-pass surface condensers with a cooling surface of 23,000 sq.ft. are used in connection with engine-driven centrifugal circulating water pumps and horizontal, tandem, rotative dry vacuum pumps. The wet vacuum pumps on these turbines are of the two-stage turbine type driven by 20 H.P. steam turbines built by the Kerr Turbine Co. Turbine No. 3 is rated at 14,000 kw. and is equipped with Wheeler condensing apparatus. The condenser has a cooling surface of

18,000 sq. ft., and the circulating water pumps are driven by Kerr turbines. Two pumps have been installed so that in winter, when the circulating water from the river is quite cold, only one is kept running; the other serving as reserve. During the summer both is brought into the station from the East River and up to the suction of the circulating pumps through the intake tunnel which extends to within 22 ft. of the west end of the station. This tunnel has a sectional area of approximately 118 sq. ft. The overflow tunnels

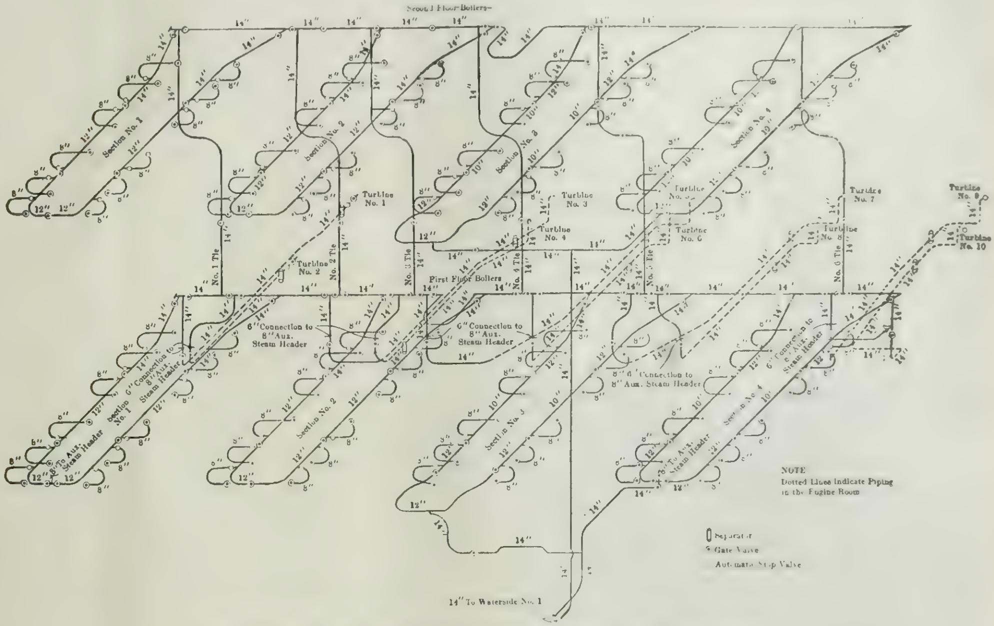


Fig. 9.—Isometric Diagram of High-pressure Steam Pipe Connections.

pumps are operated. The dry vacuum and wet vacuum pumps are driven by reciprocating steam engines. The foundations for turbine No. 4 have recently been erected. This unit will be rated at 14,000 kw. are located above the intake tunnel and each has an area of about 50 sq. ft. Both of the overflow tunnels unite into one large tunnel extending out to the river. This tunnel is made with an outer and inner shell, of ¼ in. steel, the shells being securely fastened together

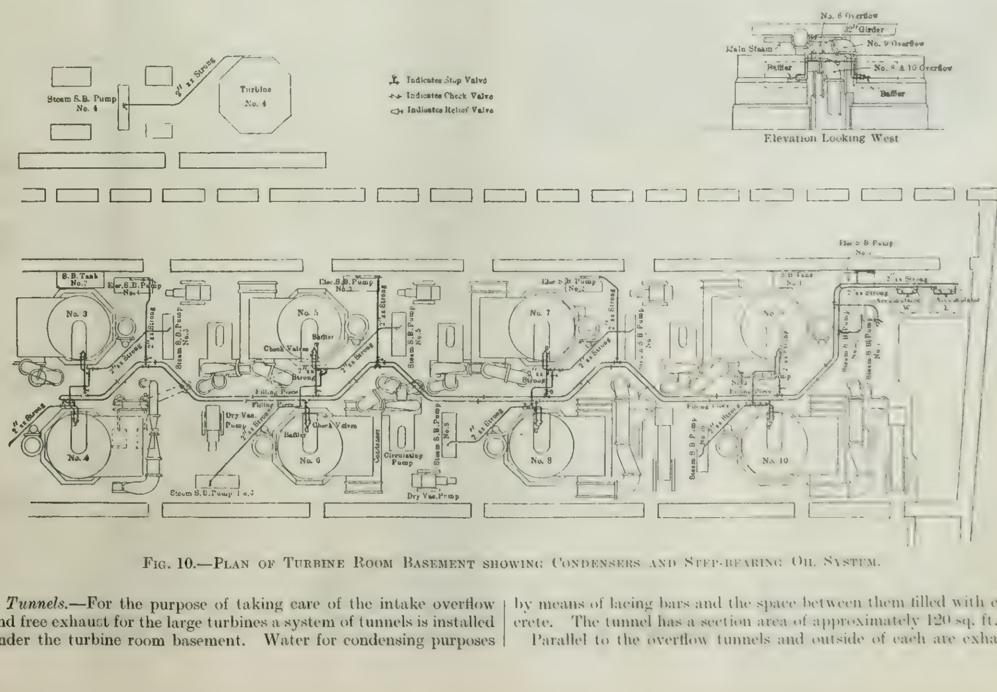


Fig. 10.—Plan of Turbine Room Basement showing Condensers and Step-bearing Oil System.

Tunnels.—For the purpose of taking care of the intake overflow and free exhaust for the large turbines a system of tunnels is installed under the turbine room basement. Water for condensing purposes by means of lacing bars and the space between them filled with concrete. The tunnel has a section area of approximately 120 sq. ft.

Parallel to the overflow tunnels and outside of each are exhaust

tunnels for carrying the steam from the large turbine to the exhaust ... at the south-west corner of the building. Each of these tunnels, of which there are two, has a sectional area of 30 sq. ft., and is lined with cast iron segments. The five tunnels are constructed in a solid concrete monolith, with separating walls approximately 2 ft. thick. At the east end of the building two electrically-driven sump pumps are installed to take care of the seepage into each of the exhaust tunnels, these being below the river.

Over the intake tunnel, just outside the building, a screen well 22 ft. by 12½ ft. by 29 ft. deep is erected with walls of reinforced concrete ranging from 3 ft. thick at the bottom to 2 ft. at the top. The screens consist of heavily galvanised-iron gratings, with others of finer mesh so arranged as to cover completely the intake tunnel. The gratings are made in four frames and weigh approximately 6,000 lb. each. They are removable and are supported on yellow pine timbers. The finer screens are constructed of ⅛ in. wire, with ½ in. mesh, three screens to the frame. Eight of these frames are arranged in four parallel guides and may be removed by a screen hoist. The latter consists of a 5 H.P. electric hoist with the necessary tackle. This is placed in a screen-well house of brick and granite similar to the masonry work of the station building.

Oiling System.—An elaborate oiling system is installed for supplying lubricant to the various engines, pumps, &c., and also for the

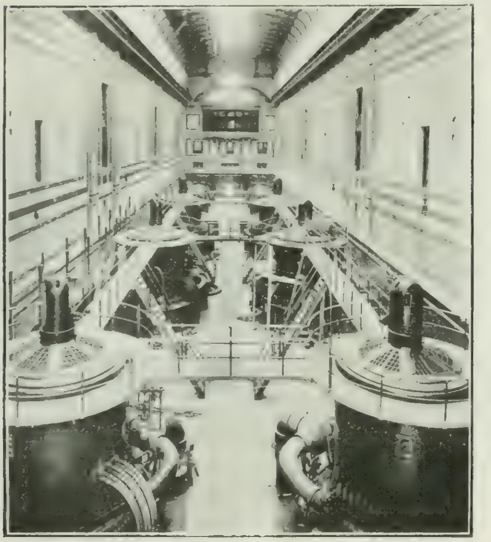


FIG. 11. ENGINE ROOM OF WATERSIDE STATION No. 2.

step bearings of the vertical turbines. In a sidewalk vault is an oil receiving and tank room for engine and cylinder oil. The oil is delivered in barrels through a hatchway, and separate steel tanks are provided for each lubricant. Three 2 ft. by 24 ft. tanks are provided for engine oil, and two 2 ft. by 7 ft. tanks for cylinder oil; the total storage capacity in the receiving tanks being over 2,000 gallons. In the roof house storage is provided for over 12,000 gallons of oil in two 7 ft. by 23 ft. tanks for engine oil and two 2 ft. by 6½ ft. tanks for cylinder oil. In addition, the filter tanks have a capacity of 5,100 gallons and the step-bearing tanks of 4,000 gallons. In the filter room, at the west end of the turbine-room basement, are four oil pumps which draw engine oil from the receiving tanks through a 5 in. line. From the filter room the oil is pumped to the tanks on the roof through 5 in. risers connected to the discharge of the pumps. The returns to the oiling system are also through 5 in. pipes. By this means a positive head of 50 lb. is maintained throughout the system, and oil under this pressure is used in the operation of the hydraulic governors of the turbines. By means of cross-connections in the filter room the roof supply can be cut off and oil pumped directly into the system. Cylinder oil is taken from the receiving room through two 2½ in. pipes and discharged through 2 in. pipes connecting with ring headers distributing cylinder oil throughout the station. The discharge is also connected through 2 in. vertical risers to the tanks in the roof house. Precaution is taken to make the oil vault, roof house and oil shaft strictly fireproof, with no direct communication through doors to the station interior.

The turbines receive their supply of oil from two 5 in. pipes leading from the engine oil tanks overhead and running along the centre of the turbine room basement to a point where taps are taken off to supply the horizontal turbines No. 1 and No. 2. From this point 4 in. mains are continued with branch pipes to supply the vertical bearings and hydraulic governors of the vertical turbines. The blower engines in the boiler-room basement, as well as the feed pumps, are supplied with oil through upper and lower ring headers consisting of two 1½ in. pipes, one for engine oil and the other for cylinder oil. The auxiliaries to the turbines in the turbine-room basement are lubricated from two similar headers. These headers are connected directly to the returns leading from the tanks on the roof.

For the step bearings of the vertical turbines the oil is maintained under a pressure of 1,200 lb. The main bearing area of the step is 168 sq. in., and the system installed for maintaining these steps under pressure is quite extensive. At each turbine is located a steam-driven step-bearing pump, and variations in the service rendered by these units is compensated for by an accumulator system. Two 4 in. lines run along the centre of the operating-room floor, as shown in Fig. 10, and are connected to the two accumulators at the east end of the station. Two steam step-bearing pumps (Fig. 12) operate in conjunction with the accumulators, and should these fail four electrically-driven step-bearing pumps automatically come into operation. The suction of all the step-bearing pumps is connected to a 6 in. ring header encircling the turbine-room basement, and supplied with oil from two step-bearing tanks. The latter are located near the north division wall, and are joined by a 6 in. equaliser pipe. The tanks in the filter room are also connected to this ring header. Each step bearing receives its supply of oil through a 2 in. pipe, stop valve, check valve and baffler, the pressure inside the latter being maintained at 1,000 lb. About 20 gallons of oil per minute is delivered to the step bearings, and the returns are led through 2½ in.

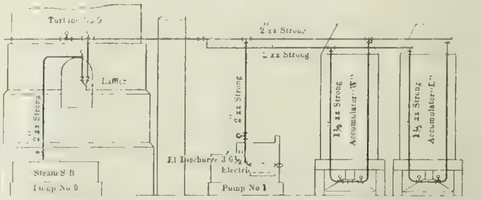


FIG. 12. STEP-BEARING OIL SYSTEM.

pipes to a 6 in. header connecting with both the step bearing and the filter tanks. In the filter room the oil is strained, dehydrated, cooled and returned to the step bearings.

The circulating water for the oil cooler is pumped by two single-stage centrifugal pumps direct connected to 15 H.P. motors. Three of the oil pumps are of the duplex piston type and one is a two-stage turbine pump driven by a 25 H.P. motor. Dirty oil is handled by three duplex piston pumps, and the cylinder oil by two pumps of the same type.

The generating equipment in Waterside Station No. 2 consists of two 7,500 kw. 25 cycle and two 7,500 kw. 60 cycle Westinghouse turbo-generators; six 8,000 kw. 25 cycle General Electric turbo-generators, which are being re-wound for 10,000 kw.; one 14,000 kw. 60 cycle General Electric turbo-generator, and another of the same rating, but built for a frequency of 25 cycles has just been erected. All of the generators are three-phase machines wound for 6,600 volts in the case of the 25 cycle machines, and 7,500 volts in the case of the 60 cycle machines, and operate at a speed of 750 revs. per min., making the 60 cycle machines 10 pole and the 25 cycle machines 4 pole. The rating of the 8,000 kw. units and the 7,500 kw. units is nominal, the former units carrying 14,000 kw. at times. The Westinghouse units are arranged in tandem, the 25 cycle machine being next the turbine and the 60 cycle generator at the end, both being driven from a common shaft. It was not intended that the turbine should be of such a size as to drive both alternators under full load at the same time. In practice, two 60 cycle alternators or two 25 cycle alternators are run under full load, with the others running light, or any three generators can be run at once. When the 25 cycle generator is in operation the other generator operates at a frequency of 62½ cycles. It is not desirable to operate the two 25 cycle and the two 60 cycle units in parallel, and thus to tie both systems so solidly together. Moreover, in the present instance, it is not possible to do so, since there is a relative total mechanical dis-

placement of the field structures of about 20 deg. measured on the 60 cycle sides. The double unit combination possesses an advantage. however, in that should the turbine become inoperative for any reason. the coupling between the 25 cycle alternator and the turbine could be disconnected. and one alternator driven by the other. operating as a synchronous motor.

Once a turbine is started and the throttle opened wide its control passes from the engineer to the switchboard operator. Each turbine governor is equipped with a small motor. by means of which its speed is altered for synchronising or for dividing load. This motor is controlled from the switchboard. The field rheostats of the alternators are also operated electrically from the high-tension switchboard. The rheostats are located on the exciter floor. The field switch has opening and closing magnets and discharge coil. and a ¼ H.P. series motor is used to cut in resistance or vice versa. The exciter 'bus bar switches are closed by hand on written instructions from the high-tension switchboard operator to the operator at the exciter board on the main floor. A telautograph is used for transmitting these written orders supplemented by a telephone in case of emergency.

(To be continued)

THE HÉROULT ELECTRIC STEEL FURNACE.*

BY R. TURNBULL.

Summary.-After describing the features of the Héroult furnace, the author gives particulars of its refining capabilities. the energy consumption, life of the electrodes, &c. Finally, reference is made to a furnace just constructed for the Illinois Steel Co.

The main points claimed by Dr. Héroult in connection with his furnace are the following: (1) The total absence of electrical parts in the furnace proper, it being nothing else than a modified open hearth. with the heat introduced above the metal by the electric current in place of gas. This in itself is an important factor. as it does away with the bottom pole. always the cause of much trouble in electric furnace work. and allows of any patching necessary to the bottom or sides. without interfering with the work of the furnace. (2) The heat being introduced by means of two electrodes working in series. the current passing through the bath from one electrode to another, and vice versa, necessitates carrying only half the current that would be the case should the current flow from one electrode through the bath and then through the bottom of the furnace; this cuts down all conductors to one-half the section required in the latter case and allows the electrodes to perform more efficient work. owing to the lesser density of current to be carried. (3) The possibility of refining impure metals and transforming them into the finest grade of tool steel. The heat being generated in the slag. and not in the metal itself. makes the slag the hottest part of the furnace. and all impurities can be removed by the use of special slags. This allows the use in the Héroult furnace of the poorest kind of scrap. high in sulphur and phosphorus. both these impurities being removed at small cost.

I have taken as an example showing the refining abilities of the furnace the average analysis of every fifth heat out of over 80 heats taken from a 2½-ton furnace at the works in La Praz. Savoy. France. The analysis of the scrap and product was as follows.

	Sulphur.	Phosphorus.	Manganese.	Silicon.	Carbon.
Scrap charged ...	0·052 ...	0·150 ...	0·638 ...	0·062 ...	0·211
Finished steel ...	0·006 ...	0·009 ...	0·254 ...	0·172 ...	1·013

The number of kilowatt-hours necessary in the Héroult furnace to melt and partially refine 1 ton of steel is 600. 100 more being necessary for the finishing slag, making 700 in all. These figures are for a 5-ton furnace and starting on cold scrap; in the case of a 15-ton furnace they would be considerably reduced. Should the metal be charged hot into the furnace—that is to say. in a molten condition. and no other work be demanded outside the recarburising. desulphurising and deoxidation of the steel, from 140 to 180 kw.-hours are necessary in the 5-ton furnace; for a 15-ton furnace this will probably be cut down to 100 kw.-hours. The life of the electrode depends on the conditions under which the furnace is run; in cold melting and continuous work the consumption is from 60 lb. to 65 lb. per ton of steel. but in cases where the metal is charged in the molten state this consumption would only be from 10 to 15 lb. per ton. those figures including the part of the electrode which cannot be utilised. In this type of furnace the lining ought to last almost indefinitely. as it is exposed at no time to silicious slags. and can be repaired after each heat by simply throwing in magnesite or dolomite as the case may be. The repairs are small; what suffers most is the roof. which has generally to be renewed once a month; as, however, a spare roof is always on hand. this can be done in a few hours. The best kind of lining is good magnesite mixed with basic slag. using tar for a binder; burnt dolomite can also be used with good results. The latest success is the adoption of the Héroult furnace in this country by the United States Steel Corp. in the manufacture of rail and structural steel. We are at present building two furnaces. each of 15 tons capacity. one at the south works of the Illinois Steel Co., Chicago. and the second at the works of the American Steel & Wire Co. The steel to be treated at the Chicago works will be brought direct from the Bessemers. and two refining slags will be used in the electric furnace. the first an oxidising slag to take out the phosphorus. the second a deoxidising slag for the removal of sulphur and the gases. The furnace is three-phase. the power being supplied by three transformers of 750 kw. capacity each. with which amount of power it is expected to turn out 16 heats a day. or about 240 tons of steel. The electrodes. of which there are three. are the largest which have so far been built in one solid block, being 2 ft. in diameter by 10 ft. long. and weighing something over 3,200 lb. The density of current passing through these electrodes will be about 28 amperes to the square inch. a figure which we consider a little high for the work. 25 being our ordinary practice. A view of one of the electrodes is given herewith. In regard to the question as to the maximum size of furnace which it is now possible to construct, it is our intention to build them up to 30 tons capacity. Very much will depend. however, on the work

AN ELECTRODE FOR A 750 KW. THREE-PHASE HÉROULT FURNACE

which has to be accomplished—that is to say. whether one or two slags would be used. In the case of one slag. I have no hesitation in saying that a 30-ton furnace is possible. but should two slags be used, owing to the difficulties which might be encountered in raking off the first slag, it may be found that a 15-ton capacity is nearing the limit; it would certainly be worked more quickly than one of 30-ton capacity.

*Abstract of a Paper read before the American Electrochemical Society.

ELECTRICITY IN BUILDING OPERATIONS.

(Continued from page [illegible].)

Summary. A description is first given of the application of the electric drive to the machinery employed by builders and contractors, typical installations being illustrated. The opinions of a few building contractors as to the advantages to be obtained by the use of electric power are then put forward, and finally the position of the electric supply authorities in various towns is outlined, as indicated by the prices charged for electrical energy and the provisions made for hiring-out electric motors.

CRANES AND HOISTS. An important portion of this subject is the application of electricity to hoists and derrick cranes used by builders. A typical form is shown in Fig. 7, this hoist being specially constructed by the Maschinenfabrik Oerlikon for the use of builders. As will be seen, it is perfectly

transportable, and is capable of taking loads up to 10 cwt. with a lifting speed of approximately 1 ft. 8 in. per second. The working of the hoist is extremely simple, the hoisting or lowering being accomplished by means of levers which any builders' labourer can understand. When hoisting, the brake opens before the motor starts, and when lowering the brake closes first. The motors are built for direct-current or alternating-current systems of all types, and a starter with reversing switch, fuses, a length of coiled flexible cable on the drum, and worm gear of high efficiency connecting the motor to the hoist are supplied. When the hoist is put to work the back wheels are blocked by means of a brake device placed at the back of the carriage. The length of rope enables a hoist of 82 ft. to be taken, and the motors are designed for the normal pressures of 110 or 120 volts direct current, or up to 500 volts alternating current, one, two or three-phases, 50 cycles. In addition to giving the usual services of a hoist, it is useful in places where haulage has to be done.

Fig. 7. Portable Electrically driven Hoist.

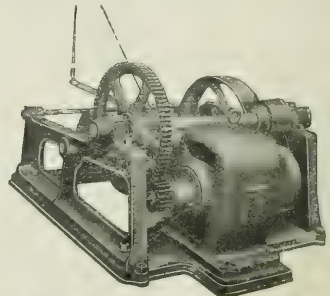


Fig. 8. -Electrically driven Friction Hoist.

As a further testimony of the importance of electricity for builders' hoists, it may be mentioned that the Langdon-Davies Motor Co., of London, have frequently supplied motors for hoists of very varied character. Most of them are of the friction type, which has three positions, namely, lifting, lowering free, and completely on the brake. In one recent installation Langdon-Davies motors were used for driving a considerable number of hoists, each consisting of a small drum, belt-driven by a motor, a fast and loose pulley being used for hauling up the material on to the scaffolding. Fig. 8 shows a type of friction hoist supplied by Electromotors (Ltd.) for this class of work.

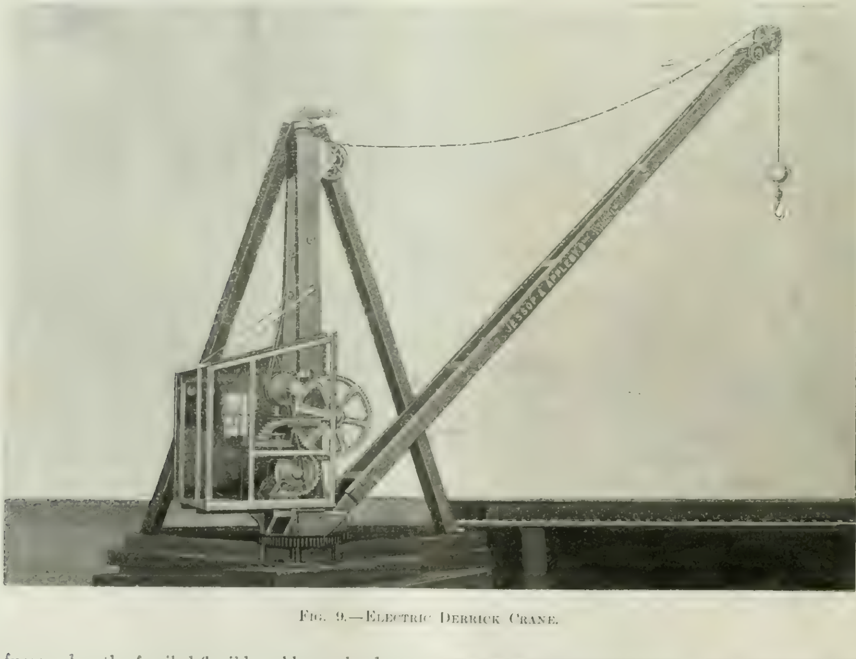


Fig. 9.—Electric Derrick Crane.

The following table, supplied by Messrs. Jessop & Appleby

Bros., gives some idea of the weight of electrically-operated cranes :—

Power of crane, tons	$1\frac{1}{2}$ ...	2 ...	3 ...	5 ...	7 ...	10
Length of jib, feet	40 ...	40 ...	40 ...	50 ...	50 ...	50
Maximum radius, feet.........	30 ...	30 ...	30 ...	40 ...	40 ...	40
Approximate weight in tons	4 ...	5 ...	8 ...	12 ...	14 ...	18

Fig. 9 illustrates a derrick crane with double jib, having a capacity of from 1 to 15 tons. The electric motor and controllers are fixed at the foot of the mast, the motor shaft being fitted with pinion gearing with the wheel which transmits the power for all motions. The lifting gear has single and double purchase, provided with a powerful adjustable strap brake. The derricking gear raises or lowers the jib with or without load suspended. The slewing gear is such that the crane can be turned to right or left without reversing the motor, and a wind brake secures the crane and prevents inconvenience when working. For the sake of comparison the following particulars of a steam crane somewhat similar in construction made by the same firm may be given :—

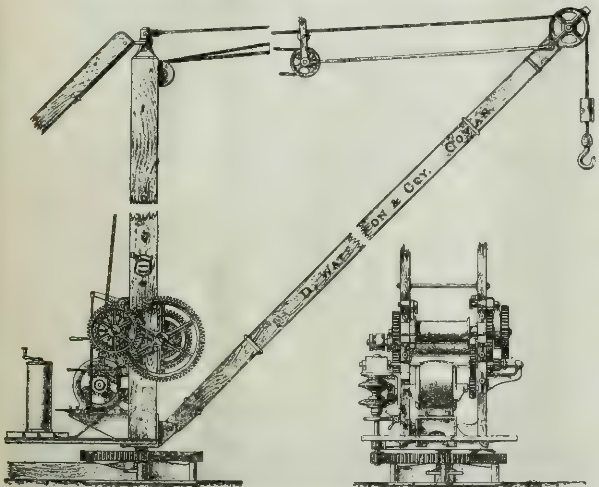


Fig. 10.—Electric Derrick Crane.

Power of crane, tons	$1\frac{1}{2}$ ...	2 ...	3 ...	5 ...	7 ...	10
Length of crane jib, feet ...	50 ...	50 ...	50 ...	50 ...	50 ...	50
Maximum radius, feet.........	36 ...	36 ...	36 ...	36 ...	36 ...	36
Approximate weight in tons	6 ...	$7\frac{1}{2}$ ...	9 ...	13 ...	17 ...	21

The decrease in weight with electric power is an obvious advantage where, as in many cases, derrick cranes have to be erected on gantries equal to or above the height of the finished building, as the amount of trouble taken in getting the steam crane to such a height is, in many cases, a very serious matter.

As another example of the way in which crane builders have recognised that building plant is an important sphere for electrical operation, we may mention a line of builders' derrick cranes which Messrs. D. Watson & Co., of Govan, have specialised. This is shown in Fig. 10 and is capable of lifting up to 3 tons, the motor being incorporated with the design. The uprights are made either of pitch pine or steel. The gearing consists of single or double purchase, which can be disconnected at will so as to lower by brake. The jib is raised and lowered separately by a connecting clutch and secured by a ratchet cast on the end of the jib barrel, thus taking the strain off the wheels. The load can be lowered by foot brakes without moving the motor. This is of the series-wound type with raw hide pinion, gearing into a machine-cut wheel. It is equipped with a tramway type reversible controller with automatic cut-out.

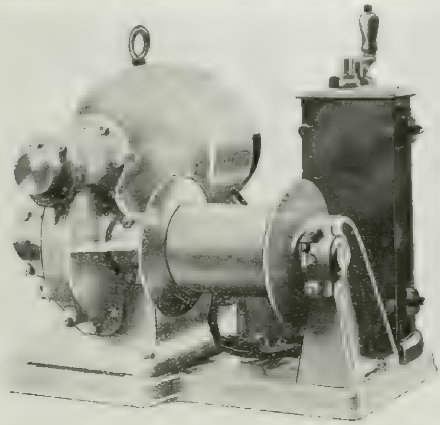


Fig. 12.—Messrs. Clarke, Chapman & Co.'s Modified Form of Standard Whip for Temporary Work.

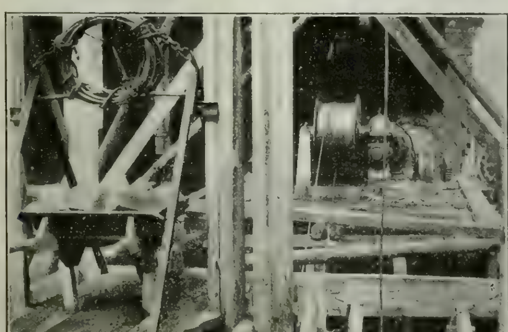


Fig. 11.—Messrs. Clarke, Chapman & Co.'s Winch at Sheffield Hippodrome.

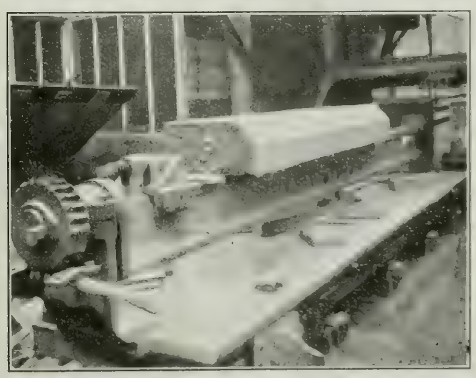


Fig. 13.—Stone-planing Machine.

Winches.—We have already mentioned the mortar mill electrically driven, used in the construction of the New Hippodrome at Sheffield. Here also an electric winch was employed by the contractors, Messrs. J. Parkinson & Sons, of Blackpool, to operate a small hoist for raising bricks, &c., during the construction work. Fig. 11 shows one of these winches at work. A number of small machines of this class have been supplied to Messrs. Parkinson by Messrs. Clarke, Chapman & Co., of Gateshead-on-Tyne. The winch

shown is capable of lifting a load of 10 cwts. at 200 ft. per min., and was driven in the Sheffield case by a two-phase motor operated by a tramway type controller, current being taken off the Corporation mains. It will be seen that the bricks are loaded into a barrow, and are then hoisted to a stage of the upper scaffolding, shown in Fig. 11, and in this way much time and labour is saved, as the barrow can be wheeled to any position where the bricklayers are at work or other material hoisted as required. Messrs. Clarke, Chapman & Co. manufacture various types of whips particularly suitable for light work of a temporary character.

FIG. 14. MOTOR DRIVING STONE CRUSHER.

Fig. 12 is a modification of their standard type. This type represents a form of hoist which has been supplied for many purposes, such as lifting ashes out of the stoke hole of a ship, or mails out of the hold. It is very suitable for quick-lifting work. The motor is shunt wound and runs constantly. The barrel is loose on the shaft, and when required to hoist, the clutch lever is raised, thus bringing the friction cone into gear. When the load reaches the required height, the clutch lever is dropped, and the load is held on an automatic selfholding brake. To lower the load, the brake lever must be slightly raised. The reduction of speed between the motor and barrel is obtained by means of one set of worm gear. The motor can be wound for any voltage.

It is not without interest to mention that Messrs. Parkinson & Sons have adopted electric driving throughout their large works at Blackpool.

FIG. 15. ELECTRICALLY DRIVEN ROCK CRUSHER.

OTHER USES.—For other building operations, such as stone planing and rock crushing, we may instance work which has been accomplished at Sheffield from the Corporation mains. Fig. 13 shows a stone-planing machine which, together with two large stone-sawing machines and other tools, were driven electrically at the new Post Office buildings, Sheffield, the contractors being the Waring White Building Co. (Ltd.) Fig. 14 shows an alternating-current motor placed in a temporary shed, driving a stone crusher, used for making up concrete steps and other work for the new Hippodrome, Sheffield.

Fig. 15 shows a rock crusher driven by an electric motor on the site of the new power-house at Neepsend. On the same site there was also a Bradley & Craven brick press and mortar mill, also driven by an electric motor which superseded the steam engine previously used. These examples sufficiently typify the class of plant which is at present available for electrical operation in the sphere of building work.

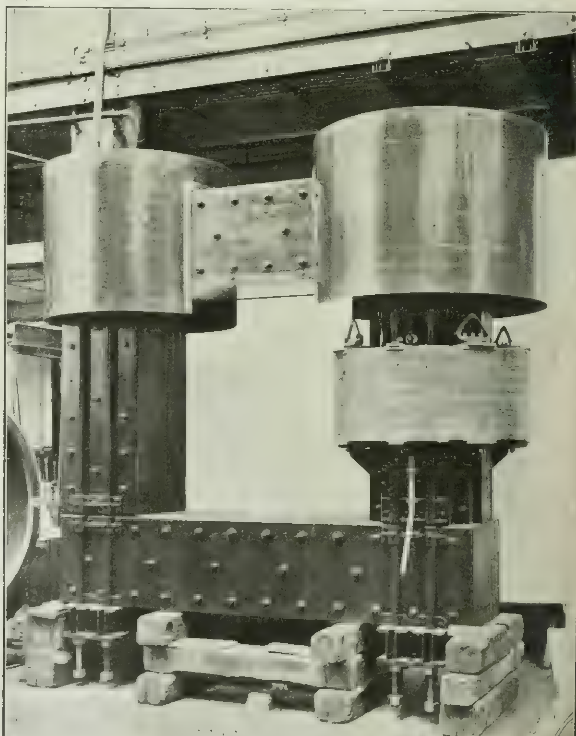
(To be continued.)

THE KJELLIN AND RÖCHLING-RODENHAUSER ELECTRIC FURNACES.*

BY DR. F. A. KJELLIN.

Summary.—The construction and advantages of the Kjellin furnace are first described, together with details of the cost of production of steel. The author then proceeds to explain the working of the Röchling-Rodenhauser electric furnace, giving the costs of production of steel for a 2 ton and a 7-ton three-phase furnace.

The Kjellin Electric Induction Furnace.—The history of this furnace is first given in the Paper. As to the peculiar qualities of the steel caused by the treatment in an induction furnace, I can cite two striking examples: When some years ago I visited one of the most prominent crucible steel works in France, I showed to the manager a bar of steel about 1 in. square with over 2 per cent. of



TRANSFORMER FOR RÖCHLING-RODENHAUSER FURNACE.

* Abstract of a Paper read before the American Electrochemical Society.

carbon, which had been twisted cold so that it looked like a corkscrew. The manager told me that he thought the same result could be obtained with their crucible steel, but it broke long before it had been twisted as much as mine. Another time I had the pleasure of seeing at Gysinge one of the best quality steel makers of the European continent, who came there with his own raw materials in order to melt them in the induction furnace and compare the product with the product he got at home with the same materials in crucibles. The result was that he could make his steel in the induction furnace with less additions of silicon and manganese than was necessary in the crucible. Trials made at Völklingen with a Kjellin furnace have also proved that molten Thomas-Bessemer steel poured in a Kjellin furnace and simply left there for some time has improved remarkably in quality. The only probable explanation I can think of is that the higher heat in the induction furnace expels a portion of the gases dissolved in the steel and perhaps also facilitates the removal of the combined oxygen, so that the deoxidation is more complete than that obtained in the crucible during that period of melting which the Sheffield steel makers call "killing."

Owing to the rather high price of pure scrap, we have in later years sometimes worked the furnace at Gysinge with cold pig iron and very pure iron ore briquette. In this case, as with cold pig iron and scrap, when using the electric furnace purely as a melting machine, without doing any refining, most of the different elements in the raw materials will be found in the steel except carbon and silicon, which naturally will be oxidised, and also dissolved or combined gases, the presence of which can scarcely be determined by analysis.

I have not been able to detect any difference in quality between the steel made from pure pig iron and pure scrap, and steel made from pure pig iron and pure iron ore briquettes.

Cost.—The necessary theoretical power per ton of steel produced from cold pig iron and scrap is about 489 kw.-hours. The furnace at Gysinge consumed about 800 kw.-hours per ton when working with cold pig iron and scrap. When cold pig iron and iron ore briquettes were used, the power consumption per ton of steel was increased about 50 per cent. The cost of production is stated as follows:—Power, 7s. 10d.; wages, 7s. 3d.; cost of casting, 4s. 6d.; flux, 2s. 1d.; lining and repairs, 3s. 5d.; general expenses, 5s. 7d.; total, 30s. 8d.

Advantages.—The experience both in Sweden and in some of the large European steel works with the Kjellin furnace has proved it to be an excellent melting machine when it is a question of making the highest class of steel from pure raw materials, and that, both technically and economically, it can very easily compete with the old methods, especially with melting in crucibles, even when the power is generated by coal.

In the induction furnace the steel can be better protected against injurious effects than even in the crucible. It allows tappings which are very large compared with the contents of a crucible, and the steel seems to be of even better quality than steel produced in crucibles from the same raw materials. The alternating current has a stirring effect upon the steel, so that the contents of the furnace get thoroughly mixed. As the heat is created by a current passing through a bath with uniform cross-section, the temperature of the whole bath is the same, and there is no risk that the steel is overheated in one part of the furnace while it might be too cold in another.

A list of furnaces constructed after the original Kjellin type is given, the two largest being those at Krupp's works, Essen, and at the Röchling'sche Eisen and Stahlwerke, Völklingen, each of 750 kw. capacity and taking a charge of 8,500 kg. The two English works mentioned are Messrs. Vickers, Sons & Maxim and the Gröndal Kjellin Co. It is interesting to note that the Poldihütte furnace made about 2,000 tons of crucible quality steel in their four-ton furnace during the last quarter year. The furnace at Völklingen has been replaced by a furnace of the Röchling-Rodenhauser type, allowing of a convenient refining of the material.

The Röchling-Rodenhauser Electric Furnace.—After describing this furnace the following method of working for refining purposes is given:—After tapping, fluid steel from the converters is poured into the furnace, and suitable materials—burnt limestone and mill scale—for forming a dephosphorising basic slag are added. When the reactions are ended this slag is taken off by tilting the furnace. For making rails the phosphorus is brought down sufficiently low in one operation, but for the making of the highest class of steel the operation has to be repeated. When the phosphorus is removed, the carbon in the steel (if carbon steel is made) is adjusted by adding pure carbon to the bath, and afterwards a new basic slag is formed in order to remove the sulphur. This slag is also formed of burnt lime, sometimes with the addition of fluxes such as fluorspar. One necessary condition for successful desulphuration is that the slag is free from iron, and therefore sometimes ferro-silicon is added in order to quicken the reduction of the iron in the slag.

The first furnace of this type built at the Völklingen works was a 3·5-ton furnace, and its power consumption and other details are given below. Later it was decided to build a furnace for three-phase current, so obtaining a considerable increase in the power factor. The latest progress at Völklingen is the construction of a single-phase furnace with a capacity of about 8 tons, which furnace was started last autumn. The reason why the single-phase type was last chosen was that the low period single-phase dynamo formerly used for the 8½-ton Kjellin furnace could then be used.

The details regarding power, frequency, power factor, production and cost of plant for different sizes of three-phase combined furnaces are as follows:—

Röchling-Rodenhauser Three-phase Electric Furnaces.

Contents, lbs.	Kw.	Voltage.	Cycles	Cos ϕ	Tapping, lbs. Cold charging	Tapping, lbs. Hot charging	Output per 24 hours, in lbs. Cold charging	Output per 24 hours, in lbs. Hot charging.
2,200	175	500	50	0·8	1,540	2,200	9,240	35,200
6,600	350	3,000	50	0·6	4,620	6,600	27,720	105,600
11,000	500	3,000	25	0·65	7,700	11,000	46,200	176,000
15,400	750	3,000	25	0·6	10,780	15,400	64,680	246,400

The weights given are calculated at six charges per 24 hours for cold melting and 16 charges for hot melting, whereas the actual times are 3½ hours per cold charge, and 1 hour 20 min. per hot charge.

The Costs of Production, based on the Experience gained at Völklingen, for a 2-ton 3-phase furnace producing Steel for Steel Castings from Fluid Steel. The power price is taken at 1·09d. per kilowatt-hour. The life of the lining is taken at 10 days, in which time 160 tons can be produced. The figures are given per ton of steel. Lining, 1s. 6d.; heating up furnace (2,000 kw.-hours for 160 tons of steel), 1s. 2d.; refining (300 kw.-hours per ton + wages) 29s.; mill scale, lime, ferro-silicon, &c., 4s. 5d.; repairs 10d.; total 36s. 11d. To this must be added interest and depreciation of the plant. Taking 5 per cent. interest and 10 per cent. depreciation on £2,700 (the approximate cost of the plant), we get £405 per year, which for 300 working days would give 20·6d. per ton, so that the conversion of the fluid product from the converters into high-class steel, suitable for replacing crucible steel for steel castings, will cost 38s. 4d. per ton. For working the furnace three men are required. The time required for the removal of the lining is 24 hours. The transformer for a single-phase Röchling-Rodenhauser furnace is illustrated herewith.

Production Costs for a 7-ton Three-phase Röchling-Rodenhauser Furnace.—In this case the power is supposed to be generated with blast furnace gas engines, and the cost of power is taken at 0·29d. per kilowatt-hour. The estimated working costs per ton of steel rails (or steel of like quality) are as follows:—Materials charged, 69s.; power, 3s.; wages: on furnace, 8d., on linings 0·5d.; lining materials 3·5d., tools 5d., repairs 10d., amortisation (10 per cent.) and interest (5 per cent.) 8·5d., licences 2s. 6d.); total per ton of steel 77s. 5½d. For soft boiler plate steel, this becomes 82s. 3½d. The energy required for refining 1 ton of steel for rails is taken at 125 kw.-hours, whilst the heating up takes 3,500 kw.-hours, but will stand for 12 days during which 1,000 tons of rails are produced.

Besides having the same advantages as other induction furnaces, the Röchling-Rodenhauser furnace also allows of a convenient refining and a thorough elimination of phosphorous and sulphur. How far this refining will have to be carried, naturally depends on the quality of steel wanted. By repeated refining operations with fresh slag, the phosphorus and sulphur can be brought down to an exceedingly low percentage, but then the refining, of course, takes longer time and consequently more electric energy per ton of finished product.

There seems not to be the slightest doubt but that furnaces of much larger type than the present 8-ton furnace at Völklingen can be built, and I think that the next step will be the erection of a 15-ton furnace. This type of furnace has now been so thoroughly tested in continuous work that there is no doubt about its reliability. The 3·5-ton furnace was worked continually for a whole year, almost all the time producing steel for rails.

The 8-ton furnace at Völklingen, since it commenced work in November last, has been running an average of 13 to 15 days on each lining, the output varying from 500 to 600 tons of high-grade steel to 1,200 tons of rail steel to one lining. As this plant is now turning out in the neighbourhood of 600 tons of rail steel per week, the assertion that these furnaces are not running commercially may be considered as effectually answered.

For some time past steel made in a Röchling-Rodenhauser electric furnace has been manufactured into rails of standard section No. 8

for use on the United Prussian State Railway. The specifications with reference to electric furnace steel rails, particularly as to physical qualities and resistance to wear, are as follows: Tensile strength for track rails, a minimum of 99,000 lb. per square inch. For point or switch rails 160,000 lb. per square inch. For ordinary basic Bessemer or Thomas rails, a tensile strength of 85,000 lb. per square inch is stipulated. Elongation, in the case of electric steel rails, a minimum of 10 per cent., determined on samples about 8 in. between marks. Drop tests specify $3\frac{3}{16}$ in. minimum bend on a bar 1 metre between supported ends, with a falling weight of about 10,800 ft.-lb. Guaranteed life of track rails, 10 years; of point rails, seven years.

The mean of six charges of electric furnace rail and 16 charges of Thomas rails showed tensile strengths of 119,000 lb. and 97,000 lb. respectively, elongation of 15·4 and 17·6 per cent. and contractions of 24·1 and 26·2 per cent. respectively.

An electric steel rail, made for the Metropolitan Railway of London, and tested at the Clarence Steel Works of Messrs. Dorman, Long & Co., contained carbon 0·78, silicon 0·196, manganese 0·285, sulphur 0·035, phosphorus 0·022. By the Brinell hardness test, with a 19 mm. ball and 50 tons pressure, it gave an impression 3·7 mm. in diameter. With a 2,240 lb. drop test, falling 25 ft., it gave 3·56 in. deflection; second fall of 21 ft. did not break it, but it broke at the third blow with 37 ft. fall.

DISCUSSION ON THE ELECTROMETALLURGY OF IRON AND STEEL.

At the last meeting of the American Electrochemical Society an interesting discussion took place on the electrometallurgy of iron and steel, and served to emphasise the growing importance of this subject. The following is an abstract of the proceedings:—

Mr. Louis Simpson remarked that the electrochemical profession was becoming very active. The Germans and English had both been convinced by the report of the Commission presided over by Dr. Haanel, and he thought it was time for the iron and steel trade of the States to wake up on this matter and to recognise things as they were. He did not say that the electric furnace was going to supplant the blast furnace, but there existed in the United States and in Canada certain locations where pig iron could be produced with the electric furnace equal or superior to anything now made in the States, and at a cost as low or lower than was the cost to-day at Pittsburg. The principles were all laid down, and he thought now that the furnace was so perfected that it was a commercial possibility worthy of the attention of every good business man. In Norway, during this summer, a new works was being constructed to use electric furnaces for reducing iron, also electric furnaces for refining that iron to make steel. During this year there would be a works built in India, and there were other works now on the tapis. He himself hoped during this year to start a company which would use about 80,000 h.p. for the purpose of reducing iron ores found in Canada.

Dr. J. A. Mathews said that however dubious they might be about the commercial future of electric furnaces they could scarcely doubt the fact that steel, and very good steel, could be electrically made. As to just how good this steel was, compared with the product of the older methods, there might still be doubt in the minds of many. Electrochemists made statements that they had not taken the trouble to substantiate by actual experimental data. For instance, it was generally assumed or claimed for each electrical process that the superiority of its product depended upon the fact that the steel was melted in a neutral or reducing atmosphere, and hence the product was better deoxidised and freer from dissolved gaseous impurities. While this sounded reasonable, and, he believed, was true in most cases, he had never seen any experimental proof or any determinations of the gaseous content of electric steel. As scientific men, he asked them whether it would not be a good idea to make an exhaustive investigation of this subject, and also in regard to the gaseous impurities of steels made by the old processes. It was such a stupendous task that it could not be done at odd times or in a college laboratory. Several workers must give their undivided attention to it for years. As regards the quality of electric steel, few could entertain reasonable doubts but that several electrical processes were capable of producing steel fully equal to that of the older processes. In this country the use of Swedish iron was fast passing away; the crucible steel industry of this country, with very few exceptions, was a mere business—not an art, as abroad. In the speakers works they used a Swedish iron which cost more in the bar than the finished product of some crucible mills sold for. They retained tenaciously the best traditions of English crucible steel practice and methods, but they were not standing still. They had the first commercial electric furnace, he believed, that was built in the Western Hemisphere. They were making steel in it, and good steel, too. To the best of his knowledge and belief it was chemically superior and physically and mechanically superior to most, and equal to any crucible steel made. Other electrical processes might produce as good steel, but he doubted whether the product of any gas or coke fuel furnace, no matter how choice the raw materials used, could more than equal it. To one contemplating the installation of an electrical furnace, the choice of process depended upon many things—the material to be produced and the materials from which it was to be produced, the location, the source of power, whether bought or manufactured. However, assuming that these matters had sufficient attention, and sufficient care had been given to the development of a good furnace practice, then, in his opinion, there could be no doubt but that success would attend the experiment, whichever of several processes might be adopted. It appeared that so far as types of furnaces and processes were concerned, they were fairly well supplied; attention now must be devoted by inventors to improving the furnace design, the lining materials, the electrodes if used, the power factor and thermal efficiency and thermal control.

Mr. Paul Girod (communicated) said, in contradiction to the general opinion, one could not succeed in bringing, by means of the electric furnace, steel previously melted in Thomas or Martin furnaces to the point of quality of crucible steel. The reasons why were not yet well known, but his opinion was the following: It was a general opinion that steels manufactured in the Thomas or the Martin furnace and refined in the electric furnace were of such a quality that they might be compared with the best crucible steels. However, personal experience and the facts they knew about the working of electric furnaces used for the refining of metal previously melted in the one or the other kind of above-mentioned apparatus, put them in a position to affirm that two kinds of steel of exactly the same final composition, but manufactured in different ways, viz., the one manufactured in the above described manner and the other manufactured exclusively in the electric furnace by starting from cold raw material having the same composition as the hot metal from the Thomas or Martin furnace, would not show the same qualities, namely, not the same resistance to shock, and, with regard to tool steels, not the same hardness nor the same tenacity and durability after hardening. From experiments and without presenting a formal explanation of this fact, they judged that the difference came from the fact that in the Martin furnace, and so much the more in the Thomas converter, the steel took up metallic oxides, oxide of carbon, nitrogen, hydrogen, &c. The faculty of solution of these elements and combinations of elements generally increased with the heat of the metal. Now, by charging into an electric furnace this hot metal saturated with these elements and combinations of elements, the temperature of the metal was still further increased, and thus the elimination of these gases and oxides became more difficult. From their experiments, they considered that in order to produce the deoxidation and get rid of the gases of such a metal, the temperature must be lowered to 700°C. or 900°C. They had, in fact, remarked that a Thomas steel charged hot into an electric furnace gave results very inferior to that of a steel obtained by charging this very same Thomas steel in the cold state into an electric furnace and re-heating it progressively up to the temperature of tapping. Therefore, they considered that prospects based on this process of refining, in the electric furnace, of steel previously melted in the Martin or Thomas furnace, might meet much disappointment, and they considered that the charging of cold metal into an electric furnace, however more expensive it might appear, led to results which liberally compensated the increase of cost resulting from the cold charge, whenever the price of a kilowatt-hour was 0·3d. to 0·5d., as was the case in most metallurgical works. When the price of the current was only 0·1d. to 0·2d. per kilowatt-hour, the most economical process, in any case, was that of the cold charge, on the condition, however, that the furnace was suitable, *i.e.*, that its working was regular and that it was possible to make in this furnace all chemical operations of refining from the oxidation of the carbon, manganese, silicon, phosphorus, to the recarburisation, addings of alloys and desulphurisation. They never would recommend the manufacture of fine tool steels, for instance, starting from melted Thomas or Martin steel charged liquid into the electric furnace.

In a later communication Mr. Girod said they did not employ aluminium alone as a final addition to their steels, but used instead alloys which gave as the results of their oxidation (deoxidation of the bath) liquid slags composed of oxides and silicates of several metals. They used especially ferro-mangano-silico-aluminium, Mn 20, Si 20, Al 12 per cent.; silico-calcium-aluminium, Si 45 to 50,

Ca 20 to 30, Al 6 to 10; silico-aluminium, Si 40 to 60, Al 20 to 30 per cent. When adding silicon to steel they preferred performing deoxidation by very rich silicon alloy, 50 to 95 per cent. silicon; but for making silicon steels they preferred to use ferro-silicon, with 25 to 40 per cent. silicon.

Prof. J. W. RICHARDS, considering the statement in Mr. Turnbull's Paper, that in the furnace having a bottom pole, *i.e.*, an electrode passing through the bottom of the furnace into the bath, there was always a source of trouble in the hearth, said he had seen Mr. Girod's furnace, which had a bottom pole, and he was very much pleased to see the way in which it had stood hard work on a furnace which had been working for a year or more. Mr. Girod wrote: "One might think that the bottom poles are in danger of wearing out, but that is an error. A 1·8-ton furnace in our works has run for a year without renewing the bottom electrodes. On stopping, for inspection only, we found that they were changed to a depth of about 10 cm., and below that were the original poles, intact." He thought, therefore, that, as far as Mr. Girod's method of introducing those poles was concerned, it might be concluded that they were a permanent feature of the furnace and gave no trouble whatever.

Mr. FITZGERALD asked Prof. Richards if he could give any information as to repairing the lining. Thus, if the furnace had been running for some time, and the bottom was worn out in a hole between the electrodes, how was it repaired? He had seen the Héroult furnace repaired. The furnace was emptied and magnesite or dolomite shovelled on the surface. In repairing the Girod furnace, if the bottom was badly cut and then covered with magnesite, would there not be some difficulty in starting up?

Prof. RICHARDS thought it would be a very minor difficulty, and almost any steel maker would know how to overcome it. He would put some scrap steel in on top of the electrodes, or lay a piece of scrap iron over the top to protect it when shovelling in the mixture of magnesite and resin.

Mr. LANE believed manganese was blamed for rapid corrosion of steel as compared with wrought iron, and that in the electric furnace it was possible to make a non-manganese metal. He asked if any such corrosion experiments had been made.

Mr. R. MOLDENKE said that in the manufacture of tubes they took care to keep the manganese down on that account.

Mr. H. D. HIBBARD noticed that in the Papers the dimensions of the test bar were usually not given.

Mr. A. VICTORIN (partly communicated) said he had been engaged for over a year in investigating the commercial merits of certain electric steel furnaces, and was prepared to furnish some data in regard to the value of commercially produced electric steels. Admitting that the present state of the art was not favourable for the use of the electric steel furnace in the production of grades of material used in the manufacture of rails, structural steel, sheet steel, plates, &c., at present prevailing prices, it was evident that steels of higher grades physically, chemically and mechanically could be produced to-day, uniformly and safely at a higher rate of profit in the electric furnace than by any other method in vogue. He demonstrated this by a graphical illustration, assuming for this purpose a steel casting plant located within the industrial district of Philadelphia. The relative factory costs, total costs and market values of electrical and non-electrical steel castings were given, and the absolute and relative cost values of electric steel castings when compared with those of the other processes showed that the production now of electric steel castings was justified from a commercial standpoint. The chemical, physical and machining qualities of such castings, as well as the facility and safety with which any desired quality might be produced uniformly, placed electric steel castings in the front rank in respect to commercial value and profit. In conclusion, he mentioned that the rate quoted for hydro-electric power at Niagara Falls did not seem to favour the choice of that locality particularly for the manufacture of electric steel castings; more favourable inducements were desirable in regard to peak loads. The cost of power was largely influenced by the operating arrangements of the foundry, especially under restricted production. In an example cited the load factor for electric furnace operations was 67 per cent. in using hot charges and 82 per cent. with cold charges. The load factors were reduced, however, through the influence of the necessary operating system to 50 and 75 per cent. respectively. The influence of power cost was frequently misunderstood. This item, for the electric furnaces referred to, represented only $2\frac{1}{2}$ to $3\frac{1}{2}$ per cent. of the entire production cost using hot charges and from 4 to 7 per cent. with cold charges. A similar misconception existed often in regard to the labour cost of steel in the ladle, which amounted to less than 3 per cent. of the entire production cost. The open-hearth process and the small Bessemer process would show losses when the production factor fell below 40 per cent., while electric process losses did not appear until production was reduced below 30 per cent. (or even less) under the conditions quoted.

Mr. MOLDENKE represented the American Foundrymen's Association, of which he was secretary, and wished to learn something on the probable future of the electric furnace for the steel casting foundry. He was to report at the Cincinnati Convention,* and had formed the following conclusions: That they were not ready to make steel castings directly from the ore at a price low enough to justify the steel founder to look into it as an investment. That they could, however, take steel scrap and even billets, and re-melt as well as purify and cast into small castings and compete commercially with other processes. That they could do this even better, if they would use the ordinary methods of the regenerative furnace for the heating up to the melting point, and then apply the current for the final melting and purification. Where the method thus suggested would be applied in a works having molten steel, as, for instance, the large Bessemer or open-hearth establishments, the problem became even simpler. The high cost of the installation and the large amount of power required would make it difficult for a foundry to consider the electric process. If, however, especially for the small castings industry, a very small installation was arranged for, and the actual melting by the current was put for the night shift, or when practically no other work was done in the shop, the initial expense for power installation would become greatly reduced. As there were some 6,400 foundries in North America, and very many of these were looking seriously into the production of small steel castings, he recommended the members of the society to take up the matter seriously and in such a way that with a minimum of first cost and disturbance in an existing establishment, a small electric plant could be installed and operated, using only steel scrap and billets, preferably pre-heated by means other than the electric—say, the soaking pit or regeneration of gas and air.

Mr. H. M. LANE said he had a great many inquiries from foundrymen throughout the country as to how they could make their own steel castings to fill a wide variety of specifications, and in many cases the expense was almost a negligible quantity. The proposition was to be able to get delivery and to get quality. Those two elements were demanded, and a tonnage, in some cases, not to exceed 1,000 lb. If some process could be developed which would enable a manufacturing concern to make its own steel castings to fit in with its equipment, *i.e.*, as it wanted them, there would be a demand. If the process would utilise waste material about the plant, viz., iron borings, steel borings and such material as that, so much the better, and every plant had quantities of that kind of material. It had seemed to him for a long time that the electric furnace was a solution of the problem. He had had to recommend the introduction of small units in converter process, in crucible steel and in open hearth, in the last few years, where he knew that they were having lots of trouble with it, and yet it was the only thing that was available to-day, and he did believe that if the electric furnace men would study that field and study also the composition of the alloys that were required for that work, *i.e.*, the composition of the steels and the material available in a plant, they would find there a big field.

The Ventilation of Libraries.—According to the "Electrical Review and Western Electrician" frequent complaints have been made in regard to the musty flavour of the air in some of the rooms of the Chicago Public Library, due to the library proving a resort for undesirable "out-of-works." So great has become the nuisance that an ozonising apparatus has been installed in conjunction with the existing ventilating devices. The apparatus is located in the basement of the building, and continuous current at 110 volts is taken from the mains to a "Peerless" rotary converter, the alternating current thus obtained at 120 volts pressure being stepped up to about 8,000 volts by a special transformer. The high-tension secondary current discharges between the plates of the ozoniser through which air is sucked into the air-duct uptake leading from the ventilating apparatus to the floors above. The air drawn into the building by an electrically driven suction pump is washed and dried before being ozonised. The washing is accomplished by driving it through sprays of pure water, and drying is effected by forcing it through a series of baffle plates with upturned edges so as to throw off the moisture by a sort of centrifugal action. It was at first believed that the air should be washed after being ozonised on account of the nitrous fumes which are usually generated by electric ozonising apparatus, but a series of tests showed that the Shaffner ozoniser generated practically no nitrogenous compounds. The air so treated dissipates any odour in the rooms.

* In a written communication later he mentioned that the greatest interest was taken in the matter at the Convention.

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THE ELECTRIC FURNACE AS A POWER LOAD.

The electric furnace for the production of iron and steel is so comparatively young that many people often fail to grasp its possibilities, and still look upon it as something experimental. Less than ten years ago such furnaces were regarded, not unnaturally, more or less as curiosities and the work of enthusiasts, but during this interval a remarkably rapid development has taken place, and the experimental furnace of those times has developed into the fairly commercial appliance of to-day. It is noticeable, however, that very little work in this direction has been carried out in Great Britain. As so often happens, in this country at the present day there is a tendency to leave the subject to other people, although it may be remarked that Mr. FERRANTI many years ago designed an induction furnace which, like some of his other work, seems to have been before its time. From that period onwards the steel furnace seems to have been left severely

alone, notwithstanding that in the iron and steel industry, as worked by ordinary metallurgical methods, we have led the way for very many years. On the Continent it has been otherwise. GIROD and KELLER in France have made ferro-alloys by the electric furnace for some years with marked success, and HÉROULT, so well known in connection with the electric production of aluminium, has been applying similar methods to the production of steel. In Italy, STASSANO has been working indefatigably with the arc furnace. In Sweden, KJELLIN has applied the induction furnace with very considerable success, and in Germany this type of furnace has been modified by RÖCHLING and RODENHAUSER, so as to eliminate some of its disadvantages. Six years ago Canada realised the importance of the subject, and appointed a Commission to inquire into what was being done in Europe in this respect, and to report upon the commercial possibilities of the new processes. The work of this Commission is now historic, and has provided an authoritative statement as to the position of electro-thermal methods.

No one, after quite a brief consideration of the subject, would suggest that electrical methods are about to supersede the older processes in the production of both iron and steel. It becomes obvious at once that it is much more difficult to carry out the reduction of ores electrically on a commercial basis than to carry out refining. The blast furnace, though essentially wasteful in its action, is characterised by great simplicity, and the work spent upon it during the past century has led to considerable efficiency. At present it must be allowed that the electric furnace cannot compete with the blast furnace unless the price of electrical energy is exceedingly low and the cost of fuel very high. There are countries, however, where these conditions hold; also it must not be forgotten that the electric furnace for the reduction of iron ores is still in its infancy, and it would be rash to suggest that great improvements will not take place. On the other hand, in the refining of iron, in the production of steel and the numerous ferro-alloys which are now to be obtained, there is no question that electrical methods can compete with our present metallurgical methods. It may seem that the energy required to melt and refine a ton of iron is rather considerable, but it must be remembered that the cost of energy in such cases is not a preponderating cost, and if desired there is no reason why the iron should not in many cases be first melted in an ordinary furnace and the refining carried out in an electric furnace.

The greatest progress is naturally being made in those countries where water power abounds and fuel is somewhat scarce. Thus, steps are being taken to apply 80,000 H.P. in Canada to the electric reduction of iron ores. It may be noted that the ores in that country are particularly suitable for electro-thermal treatment, and do not lend themselves so readily to treatment by the blast furnace. Sweden, again, is taking the matter in hand vigorously, and it is stated that three electric furnaces, each of 2,500 H.P., are to be installed at Trollhättan, where the Government owns a large hydro-electric power station. These furnaces are to be used for the electro-thermal reduction of Swedish iron ores, and it is calculated that each will be capable of an output of 7,500 tons of pig iron per annum. Coke is to be used as the reducing agent, and it is to be imported from Westphalia for the purpose, as it is cheaper than Swedish charcoal.

In this country we cannot expect to emulate these proceedings, because we have cheap coal. Nevertheless, there are countries in much the same position as Great Britain where considerable progress is being made, not in the reduction of iron ores, but in the application of the electric furnace to the production of steel. Thus, the Illinois Steel Co. is taking the matter in hand vigorously, and has a 750 kw. Héroult furnace, with which they expect to obtain 16 heats per day and a daily production of 240 tons of steel. Particulars of what is being done by this company will be found in our present issue, along with certain other Papers read before the last meeting of the American Electrochemical Society. One cannot help being struck with the rapid progress the movement is making. There appear to be at least a dozen Girod steel furnaces and a dozen Kjellin steel furnaces in use on the Continent, not to mention those of other makes. There seems no particular reason why we in this country should not be making progress along similar lines, or why we should not enter the field of producing ferro-alloys in the electric furnace. It has been shown pretty conclusively that the refining of a ton of steel, apart from the melting, requires only about 200 B.T.U., or even less, and the cost of this quantity of electrical energy is not a serious matter, whether it is preduced by water or by coal. In some of our midland towns the price at which electrical energy is sold is so very low that the difference in cost of this small amount of energy must be trifling, so that the field of ferro-alloys need scarcely be restricted to a country with the advantages of water-power and disadvantages of heavy freights.

From the point of view of the supply engineer, the matter is not without very distinct interest. Steel furnaces are apt to be worked more or less continuously, and, therefore, if such a load can be secured the load factor obtained should be fairly high. In other words, electrical energy can be supplied at a fairly low price. The power required by such furnaces runs into hundreds of kilowatts, and as time goes on will, no doubt, run into still higher figures. To melt and refine a ton of iron requires from 800 to 1,000 units per ton, and if the metal is melted first, and then merely refined in the electric furnace, the energy required is, say, 200 units per ton. Consequently, the amount of energy required by a steel works would be considerable. It should be noted, also, that the supply to such furnaces is a comparatively easy matter, as, generally speaking, alternating current is used and frequently three-phase. In arc, or combined arc and resistance, furnaces the power factor is high. In the induction furnace, on the other hand, with the large magnetic leakage which it is difficult to avoid, the power factor is apt to be low. This difficulty, however, has been removed to a considerable extent by the combination type of furnace, in which resistance heating is combined with induction heating, so that the power factor is maintained at a reasonable figure. The next few years will, no doubt, see much improvement in the design of electric furnaces and very great development in their use, and it is, therefore, to be hoped that the supply engineer will keep this new opening in mind, so that the requisite supply of electrical energy shall be obtained from public power stations rather than by the installation of private plant.

REVIEWS.

(Copies of the undermentioned work can be had from *The Electrician* Office, post free on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Die asynchronen Wechselstrommaschinen. Part I., Die Induktionsmaschinen. By E. Arnold and J. L. la Cour, assisted by A. Fraenckel. Berlin: Julius Springer.) Pp. xv.—587. M.18

The present volume forms Part I. of the treatise on asynchronous machines, edited by Prof. E. Arnold, as Vol. V. of his series "Die Wechselstromtechnik," and is devoted to the theory, calculation, construction and method of working of the induction machine. Part II., yet to appear, will deal with alternating-current commutator machines, and has obviously been kept out of the present volume for want of space. With Part II., the whole of this admirable series of books on alternating-current working will have been published, and the authors will then be able to pride themselves for many years to come on what is probably the most complete treatment of the subject occupying the foremost rank in electrical engineering.

In the volume now before us it is explained why the same did not follow the preceding volumes with equal rapidity—the reason being that Prof. Arnold was engaged with the second edition of his treatise "Die Gleichstrommaschine," whilst Herr la Cour left the academical side to take up practice. Thus further assistance was found necessary and the authors are to be congratulated on obtaining such an indefatigable worker as Dr. Fraenckel, the thoroughness of whose work shows itself throughout the present book. But Dr. Fraenckel might well be mentioned as another example of the type of man Dr. Arnold has ever been able to draw to Carlsruhe, such as Prof. Bragstad, Herr la Cour, &c., not to mention a number of other excellent, though perhaps less well-known, men.

It is now some twenty years since the induction motor was simultaneously and independently discovered by Ferraris and Tesla, whilst in 1891 it received its greatest impetus by the introduction of polyphase currents. An idea of the enormous progress made since that time can be had by a mere glance at the contents of a book such as the present, which deals with these machines in all their various forms.

In the first two chapters the production of rotary fields in polyphase and single-phase motors is explained, and the method of working illustrated. The following four chapters are devoted to the theory of the polyphase motor. In chapter III. the equations of the asynchronous motor are developed, and the equivalent electric circuit shown. The calculation of the magnetising current then follows. In the determination of the ampere-turns required for the iron, it would have been interesting if the question of whether a magnetisation curve obtained ballistically is sufficiently correct for alternating currents had been discussed. If we remember rightly it was from the same Institute that a Paper dealing with this very subject recently appeared, though, of course, such a refinement is much more important in the case of transformers than of induction motors. The method of calculation used for determining the ampere-turns required for the air-gap is interesting. As is known, the distribution of the flux in the gap is not sinusoidal owing to the effect of saturation in the teeth. The method of procedure given here is based on the following: For a large number of normal motors the flux curve is calculated for given values of M.M.F. and a curve is then drawn taking the actual form factors thus obtained into account. A further curve is then deduced from this latter under the assumption of a sinusoidal flux distribution. These curves provide the correction for finding the maximum flux density in the gap and teeth, after the same has been first calculated under the assumption that the flux is sinusoidally distributed. Such in rough outline is the method used, and it may interest designers to compare the results thus obtained with those given by other methods. This chapter concludes by showing how to find the resistance and reactance of squirrel-cage windings.

The analytical theory—based on the pressure diagram, from which the Heyland diagram is derived—is given in chapter IV., whilst in chapter V. the theory is treated graphically and the current circle diagram is developed from the equivalent electric circuit of the polyphase induction motor. In the following chapter it is shown how this same diagram can be drawn by aid of the no-load and short-circuit constants of the motor, and the output, efficiency, slip and power factor directly obtained.

Two whole chapters are then taken up with the single-phase induction motor—in the one the method of working of this machine is deduced from the rotary-field theory, and in the other from the cross-field theory. As far as we are aware this is the first time it has been shown that both these theories lead to the same result, despite the conflicting opinions which have hitherto prevailed. To all concerned with the design and working of single-phase motors these chapters will prove invaluable, along also with a following chapter dealing with the starting and regulation of these machines.

In the chapter on the effect of higher harmonics some very interesting curves of torque and slip, &c., are shown explaining how irregularities may occur during acceleration, whilst the injurious effects on the power factor and efficiency are well described.

We now come to the more practical part of the book, and must be content with merely mentioning some of the more interesting features. In the calculation of the iron losses, a section is devoted to the eddy current losses due to the field pulsations caused by the relative movement of the rotor and stator teeth. Judging the magnitude of this loss from the cases worked out, it would seem to form quite an appreciable percentage of the total iron loss. Of course the existence of such losses has long been known, and the experience of many firms has led them to make some allowance for the same by using larger coefficients in their iron loss formulæ. According to the authors, these additional losses, in the case of semi-closed slots, may amount to some 50 to 100 per cent. of the stator iron loss produced by the rotary field. The additional copper losses deserve more complete treatment than is here devoted to them. An interesting section is occupied by a mathematical investigation of the heating of the stator copper, especially applicable to long cores. The superiority of axial ducts over radial is also emphasised.

The starting and speed regulation of three-phase and single-phase motors are dealt with in two succeeding chapters. Most of the known methods seem to have been included, and the more important are presented in a way directly useful to the designer. In the chapters on the calculation of induction motors all the various quantities are discussed, and their relation to one another shown along with the dimensions for minimum cost, maximum power factor, efficiency, &c. The rules given for design are illustrated by the complete calculation of a three-phase motor with (*a*) slip-ring, (*b*) squirrel-cage rotor, and also of a single-phase motor with starting-device. Then follows a chapter devoted to the constructional details of these machines, containing examples of the designs of leading firms.

The last chapters of the book are amongst the most interesting, dealing, as they do, with the induction generator, the cascade connection of two induction machines, in the case of these latter the diagram for the equivalent circuit is deduced which makes it possible to deal with this somewhat complicated arrangement in a simple but accurate manner. Then comes the cascade connection of an induction machine, and a synchronous machine (frequency changer) and lastly the cascade converter, the origin of which is closely associated with the authors of this book.

As in the other books of this series there is an index and complete list of symbols, which enable the reader to find quickly what he needs. Both printing and illustrations are excellent, being characteristic of the well-known publishing firm. The diagrams have been prepared with the usual care, and in most cases are accompanied by explanations. This book will be used by all connected with induction machines—from the student to the engineer.

Stanley P. Smith.

THE MAGNETIC STORM OF SEPTEMBER 25th.

The magnetic storm that occurred on Saturday, the 25th ult., caused a very great deal of interruption to telegraphic communication, not only in this country but in many other countries also. In London for a few hours in the afternoon telegraphic work was practically at a standstill. In communicating with Newcastle there was a delay of 3½ hours, with Norwich and Yarmouth 3 hours, with Dublin 2 hours, with Oban and Mull 3 hours, Fort William 3 hours, Aberdeen 2½ hours, and Edinburgh 1 hour. Not only was there delay on land lines, but the cables to the Continent, to South Africa and to America were unworkable for some time. The disturbances were very severely felt in America, both North and South, and on the other hand trouble was experienced in India, telegraphic work being practically stopped for about six hours between Bombay, Calcutta and Madras. Other reports which are coming in show that interruption to telegraphic business was general all over the world, although varying considerably in degree.

By the kind permission of the Director of the National Physical Laboratory, Dr. R. T. Glazebrook, F.R.S., and through the courtesy of Dr. C. Chree, F.R.S., Superintendent of the Kew Observatory, we are able to reproduce some of the records traced at Kew on this occasion. These show in a very complete way the character of the magnetic disturbances, which caused so much confusion in the telegraphic world. The usual records taken are of (1) the declination, (2) the horizontal component of the earth's magnetic force, and (3) the vertical component of this force. The records are obtained by a beam of light falling upon photographic paper, and as each sheet is used for two days, two traces are obtained on each sheet. Thus Fig. 1 is a record of the declination from 10:37 a.m. on September 25th to 10:22 a.m. on September 26th on the upper curve, and from one minute later to 10:21 a.m. on September 27th on the lower curve. This has the advantage in the present instance that normal and abnormal conditions are easily compared. Looking first at the normal record, as obtained on September 26th—27th, we see that there is a gradual variation throughout the day and night. This variation, however, as shown by the scale, is only small, amounting usually to something like 12′. The average value of the declination at Kew during 1908 was 16° 16′·9 West.

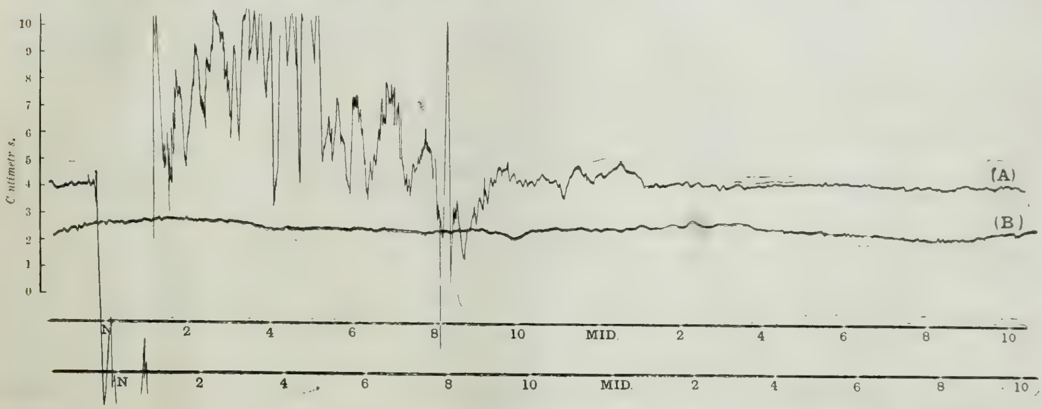


Fig. 1.—Declination: (A) Sept. 25, 10:37 a.m., to Sept. 26, 10:22 a.m.; (B) Sept. 26, 10:23 a.m., to Sept. 27, 10:21 a.m. (G.M.T.), 1909.
Vertical scale (placed arbitrarily) is a centimetre scale reduced with the record so that each division equals 8′·6. Upwards represents increase in Westerly declination.

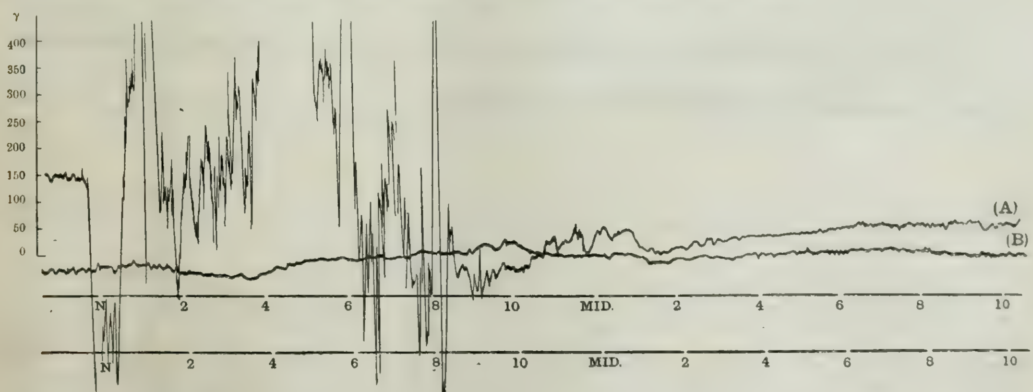


Fig. 2.—Horizontal Force: (A) Sept. 25, 10:37 a.m., to Sept. 26, 10:22 a.m.; (B) Sept. 26, 10:23 a.m., to Sept. 27, 10:21 a.m. (G.M.T.), 1909
Vertical scale (placed arbitrarily) shows variation in terms of γ where γ = 0·00001 C.G.S. Upwards represents increase in horizontal force.

On looking at the record for September 25th—26th, the day of the storm, a very different state of things is evident. At about 11:43 a.m. the trace became disturbed, and the extent of the movement increased so rapidly that after about 12 minutes, during which the needle moved increasingly to the east, the trace left the sheet; the movement was more than 72′, but how much more it is impossible to say. After a few minutes the trace reappeared, but after

a few oscillatory movements it again disappeared off the sheet on the same side, and remained off for about 40 minutes. It returned at about 12:52, when, with some oscillations, it drifted across the sheet, the width of which represents 2° 7′; this was crossed in less than half an hour, and the trace disappeared once more on the opposite side at about 1:20. A number of large oscillations followed. It is, of course, impossible to tell the full extent of the oscillations, but among those recorded it may be noticed that between 8:7 and 8:22 p.m. a movement of 98′ to the west is followed by one of 84′ to the east. We may mention that previous magnetic storms, such as that of October 31, 1903, have given very large variations, if not quite so large as those here shown, but the special feature of the present storm is the highly oscillatory character of the disturbance (rendering a continuously clear photographic record impossible) and its unusually energetic character. Probably this extremely oscillatory character accounts for the very marked interference with telegraph lines. In the diagrams the rate of variation is rather exaggerated because the paper moves through only about 3 cm. in two hours. (The records as here given are reduced in reproduction.)

Fig. 2 shows the disturbance in the horizontal component of the earth's magnetic force, and is equally remarkable. The mean value of the horizontal force at Kew is 0·18515 C.G.S. Normally, as shown by the curve for September 26th–27th, it varies more or less regularly through the day, the total variation being, say, 0·0005 C.G.S. At 11:43 on September 25th it began to fall rapidly in value, and in 10 minutes the trace had passed off the sheet, indicating a fall of 0 00430 C.G S. After 5 minutes the trace reappeared, and in about an hour it passed off the other side, the change during this interval being 0·00740 C.G.S., or practically 4 per cent. of the normal value. It is, of course, impossible to say what was the full extent of the disturbance. The trace is seen to be very oscillatory, similar to that of the declination.

The trace of the vertical force is not reproduced because it was not so extremely disturbed as the other two, and for a considerable time was beyond the limit of the paper, the main variation being in the direction of increase of the force. All that can be said definitely is that the range exceeded 0 00530 C.G.S., the average value of the force last year being 0·43651. The oscillations carried it both above and below the normal, but the average value during the storm was much above the normal.

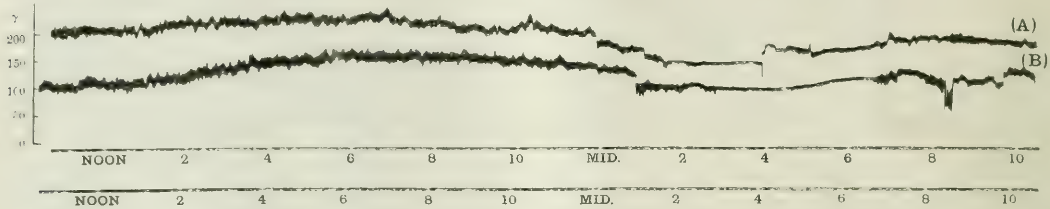


FIG. 3.—VERTICAL FORCE: (A) April 17, 10:39 a.m., to April 18, 10:31 a.m; (B) April 18, 10:32 a.m., to April 19, 10:36. a.m. (G.M.T.), 1908.

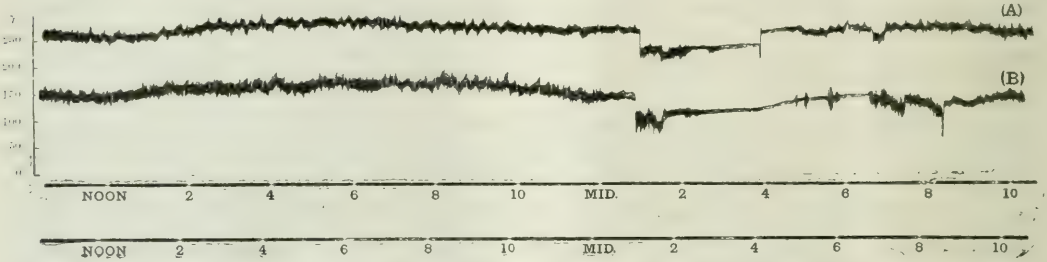


FIG. 4.—VERTICAL FORCE: (A) Aug. 6, 10:23 a.m., to Aug. 7, 10:33 a.m, ; (B) Aug. 7, 10:34 a.m., to Aug. 8, 10.34 a.m (G.M.T.), 1909.

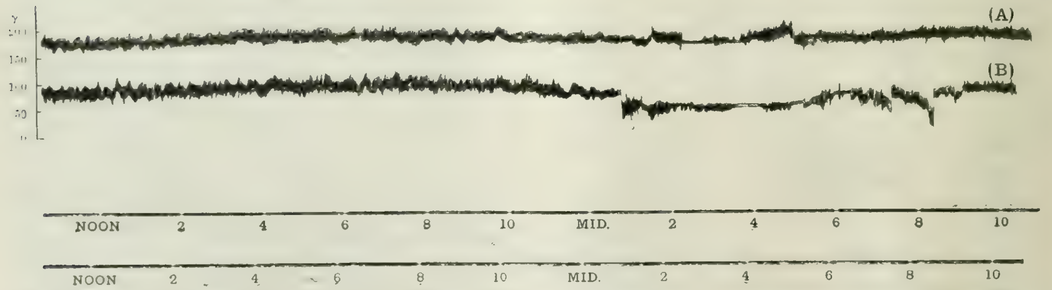


FIG. 5.—VERTICAL FORCE: (A) Sept. 17, 10:33 a.m., to Sept. 18, 10:48 a.m.; (B) Sept. 18, 10:49 a.m., to Sept. 19, 10:37 a.m. (G.M.T.), 1909.

As to the cause of magnetic storms there are numerous theories, but nothing very conclusive can be said as yet. The sun is generally accepted as the first cause, whether by ions, electrons or other carriers of electricity remains to be proved. The fact that such storms are generally associated with auroral displays lends support to the theories of Birkeland and Arrhenius. But as pointed out by Dr. Chree in a recent issue of "Nature," it is difficult to reconcile the rapid changes of the aurora with the much more leisurely changes in the magnetic force as observed, though possibly there may be large auroral variations which are not visible, and the visible changes may be comparatively unimportant. There is a further difficulty in that magnetic storms in high latitudes, although very frequent, are not so closely associated with auroræ, which are also

frequent. It is noticeable that the horizontal force is generally considerably depressed below the normal after a magnetic storm (as seen in Fig. 2) for some considerable time. This also is not easy of explanation.

In Figs. 3, 4 and 5 we reproduce some records of the vertical force, not as throwing any light on the magnetic storm, but because they are interesting as showing the vicissitudes to which this force is subject at Kew. Some years ago there was a good deal of discussion as to the effect that the London United Tramways would have upon the magnetic records of Kew Observatory. It will be noticed in these diagrams that the electrical working of the trams causes very marked effects. The magnetic needle is continually on the swing, but it does not merely swing regularly like a pendulum; it receives numerous buffets which stop, check or reverse the swing in progress at the moment. The oscillations would be much greater than they are but for the fact that the magnet is damped by the presence of metal plates. By comparing these traces with those of the horizontal force it will be seen that the vertical force is much the more affected of the two. It is also noticeable that there is a very marked change at about 1 a.m., or a little earlier, every morning. This change is not merely a rapid variation, but a definite change in the mean value of the force, and at about 4 a.m. there is again a sudden change back to the previous value or something approaching it. The change is also noticeable, to the practised eye, in the trace of the horizontal force. Between these hours there is still apt to be some disturbance with intervals of complete quiet. On Sunday mornings it will be noticed that the time when the force resumes its old value is later (about 7 o'clock), the change is more gradual and the periods of quietness are longer. It is noticeable that quiet periods occur with the trace at different levels, so that it cannot be safely assumed that because the trace is smooth the field is normal. It should be noted that in Figs. 3, 4 and 5 a movement upwards means increase in the vertical force, the scale being the same as in Fig. 2.

For an explanation of these very definite changes one naturally looks to the working of the tramway system, and in order to see if any connection could be traced we forwarded the records to Sir Clifton Robinson, managing director and engineer of the London United Tramways, who has kindly supplied us with some particulars. It appears that the usual procedure is to shut down the sub-stations at stated intervals during the night, during which time current is still supplied to the trolley wires from the generating station at Chiswick. During such times very few cars are run. It appears that on the nights of August 6th–7th and 7th–8th the sub-stations (of which there are six) were shut down, and started to work again at the hours given below:—

Sub-station.	—	Night of Aug. 6–7.	Night of Aug. 7–8.
Fulwell	Stopped	1:0 a.m.	1:0 a.m.
	Started	4:0 a.m.	8:30 a.m.
Kingston	Stopped	12:30 a.m.	12:30 a.m.
	Started	6:30 a.m.	8:30 a.m.
Wimbledon	Stopped	12:0 m.n.	12:0 m.n.
	Started	5:30 a.m.	7:30 a.m.
Hounslow	Stopped	1:30 a.m.	1:30 a.m.
	Started	5:0 a.m.	9:0 a.m.
Hanwell	Stopped	1:15 a.m.	1:0 a.m.
	Started	5:0 a.m.	8:30 a.m.
Hayes	Stopped	1:0 a.m.	1:0 a.m.
	Started	4:30 a.m.	8:45 a.m.

From this it appears that the hours when the Fulwell sub-station was shut down, viz., 1 a.m. on both days, and when it was started again, viz., 4 a.m. on the night of August 6th–7th and 8:30 a.m. on the night of August 7th–8th, coincide with marked disturbances shown in Fig. 4. It will be noticed that Kingston sub-station on the night of August 6th–7th was started at 6:30 a.m., which may account for a momentary drop in curve A. It is somewhat curious that the rise on these occasions is frequently preceded by a momentary drop. We may mention that Fulwell station is about $2\frac{3}{4}$ miles from the Observatory. As to the disturbed portions of the curve after the shutting down of the sub-station, it would appear that these are due to the running of cars after the sub-station has been shut down: for example, on weekdays, on five of the routes in the Southern section, the last cars are timed to arrive at the Fulwell sub-station after 1 o'clock, at times varying from 1:10 a.m. to 1:29 a.m. It is noticeable that the disturbance after the sub station is shut down is liable to be larger than it was just before shutting down. This, we presume, is due to the gathering of the cars near the sub-station. It will be noticed that Figs. 3, 4 and 5 differ considerably, and we presume that this is due to differences which may be introduced in the mode of operation by special circumstances. Thus, it would almost appear from curve A, Fig. 5, that the Fulwell sub-station on the night of September 17th–18th, 1909, was not shut down at all, but in regard to this we have no definite information. It also seems a little curious that there should not be the same abrupt change in the mean value of the vertical force on Sunday morning at the starting up of this sub-station. This may be due to the fact that the routine is somewhat altered on Sunday mornings.

As to whether such disturbances seriously affect the value of the records at Kew, we are informed by Dr. Chree that the vertical force curves are too disturbed for any purpose other than the verification of dip circles. No attempt is made to tabulate these curves or to deduce diurnal variations, as was the case before 1901, but for testing ordinary dip circles they are of service. It requires a change of about 0·0004 C.G.S. to alter the dip by 1′, and the order of accuracy in dip circle observations is at best 0′·5. Thus the curves serve to link up the observations taken with dip circles under test and those made with the Kew circle.

In the case of declination and horizontal force, the tabulation and publication is continued of the diurnal inequalities for five quiet days a month, corrected as far as possible for visible tram effects, but the inequalities so obtained are not considered suitable for minute analysis. They serve to indicate the general features, such as the fluctuation in range with the season of the year, and the probable variation with sun-spot frequency.

Again, for the study of the general features of magnetic storms, the artificial disturbances of declination and horizontal force—as is evident from the records here reproduced—are not of very much consequence. In the case of the vertical force there is greater interference. Even in the case of the declination and horizontal force curves there are many researches for which these are spoilt. They can no longer be trusted for details, such, for instance, as the commencing movements of magnetic storms, and they are quite useless for the study of the minute regular waves or pulsations which not infrequently occur. Thus, whilst all the instruments are still continued at work, their utility has suffered a very great deal, and their continuance in action is largely due to the fact that the records so obtained are still useful for the testing of instruments.

THE GOVERNMENT PURCHASE OF THE MARCONI WIRELESS STATIONS.

In response to our inquiries, we have received the following particulars concerning the purchase by the State of the Marconi wireless telegraph stations and their equipments:—

Arrangements have now been completed with the Marconi Company for the transfer to the Post Office of all their coast stations for communication with ships, including all plant, machinery, buildings, leases, &c., and for the surrender of the rights which they enjoy under their agreement with the Post Office of August, 1904, for licences or facilities in respect of coast stations intended for such communication.

In addition, the Post Office secures the right of using, free of royalty, the existing Marconi patents and any future patents or improvements, for a term of 14 years, for the following purposes: Communication for all purposes between stations in the United Kingdom and ships, and between

stations on the mainland of Great Britain and Ireland on the one hand and outlying islands on the other hand, or between any two outlying islands; and (except for the transmission of public telegrams) between any two stations on the mainland; and on board Post Office cable ships.

The inclusive consideration to be paid to the company is £15,000.

The arrangement is in no sense an exclusive one. All the stations will, under the International Radio-telegraphic Convention, be open for communication equally to all ships, whatever system of wireless telegraphy they may carry; and the Post Office will be free to use or to experiment with any system of wireless telegraphy at its discretion. All inland communication of messages by wireless telegraphy will be entirely under the control of the Post Office.

The company will retain the licence for their long-distance stations at Poldhu and Clifden, which are primarily intended for shore-to-shore communication with America.

Arrangements have also been made with Lloyd's for the transfer to the Post Office of their wireless stations for communication with ships, and for the surrender of all claims to licences for such communication. In return Lloyd's will receive the plant value of their stations, and will have transmitted to them (with due regard to the secrecy of private telegrams) information received at the Post Office stations in regard to the position and movements of ships, and other maritime intelligence.

Lloyd's and the Marconi Company have mutually arranged to cancel an agreement between themselves which was made in 1901, and which has proved a source of dispute and therefore an obstacle to the development of wireless telegraphy.

The negotiations and arrangements have been conducted with the knowledge of and in consultation with the Admiralty; and it is considered to be to the public interest, from a strategical as well as from a commercial point of view, that the coast stations used for communication with ships should be in the hands of the Government, and should be worked as part and parcel of the general telegraphic system of the country. It is regarded as important also that no private monopoly in wireless telegraphy should be allowed to grow up. It is hoped that the new arrangements will result in an even more rapid extension of the use of this important invention than has taken place in the past.

ELECTRICAL INVENTIONS AND THE TRAINING OF THE ELECTRICAL ENGINEER.

On Wednesday last Prof. J. A. Fleming, F.R.S., delivered a lecture on the subject of "Electrical Inventions and the Training of the Electrical Engineer" at University College, preparatory to the session of the engineering department. Mr. W. M. Mordey, president of the Institution of Electrical Engineers, was in the chair.

Prof. Fleming began by briefly sketching the progress of electrical technology. He showed that its inception was co-existent with the Victorian era, and that from telegraphy we had passed through telephony and the generation of electric power and light to wireless telegraphy and telephony. Development at the present time was being made in the production of nitrates, and possibly we should also see in the near future the wireless transmission of power. This condition of things had, the lecturer contended, been mainly brought about by certain men only, although much capital and many men had been concerned in the general development of electrical engineering. He instanced the names of Faraday and Kelvin in this connection. The development of engineering was essential owing to the greater population of the earth, which required that the material at our disposal should be developed and used in the best possible way.

Prof. Fleming then turned to the question of the education of the young electrical engineer. He said that, although it was necessary at the present time that each student should specialise, this specialisation should not commence too early. A broad foundation of the general principles should be laid and some business knowledge should also be imparted. He did not think that engineering subjects should form a part of the school curriculum, but that the ethical qualities of the public school should be taken full advantage of, and attention should there be paid to such subjects as foreign languages and mathematics, for there was no doubt that at the present time technical colleges were handicapped by the insufficient knowledge of first-year students. As to which boys should eventually become engineers, he argued that something more was wanted than the so-called mechanical turn of mind. The best augury, in his opinion, for success was, in addition to strong bodily constitution, a natural tendency of mind to do things rather than to talk or read about them, and the next most important thing was efficiently to concentrate the attention on the matter in hand, combined with a steady determination to reach the goal in some way if possible.

As to the question of the particular way in which the student should be trained, he thought that there should be a thorough preliminary education in pure and applied science, followed by instruction in technical subjects, which must be based on practical work by the student himself. There were four main divisions of electrical engineering—telegraphy, electricity supply, manufacture and technical teaching—each of which demanded special preparation. He emphasised that success in the second of these was not merely a matter of engineering knowledge, but, so far as the higher positions were concerned, required organising and business abilities of more than average excellence. Turning to the actual methods employed for training students, he mentioned the "sandwich" system. He said that its great disadvantage was the large distance apart of the works, the student's home and the college. The better way was, he thought, to have two years at college, then a year in works, and finally another year at college. The college engineering societies were useful and their potentialities should certainly be developed. The visits made by them gave the student an insight into actual practice, and he thought that an essential part of every English engineer student's education should be a visit to Germany to see the methods by which natural power was employed for various purposes.

With regard to subsequent employment, the lecturer considered that employment agencies should be formed, as advertising was an unsatisfactory method.

Turning to new fields for the use of electrical energy, Prof. Fleming said that there was an unlimited field for invention and improvement in adapting the energies of Nature to the satisfying of the natural and artificial wants of mankind. As an example he referred to the nitrate industry now growing up in Norway and Germany. The electric energy from water-power necessary to develop this industry could only be obtained by the aid of the electrical engineer. Several examples of the use of hydro-electric power were illustrated by the lecturer, by means of lantern slides. The problem of the immense quantities of energy yet unapplied in the sun was dealt with, and it was shown that the average of energy available on the earth's surface from this source was 7,000 H.P. per acre. He thought that the wireless transmission of energy was by no means an impossible problem, as telegraphy had first been made possible by means of wire and was now possible without wires. One way of doing this might be to set the electrical charge of the earth in oscillation, and tap off the energy at any desired point. The question of domestic electric heating and cooking was also of immense importance at the present time, and it was also becoming necessary to replace the malodorous petrol 'bus by some form of electric traction. He thought that if it was only possible to transmit wirelessly energy a small distance from mains underneath the street to the 'bus on the road above, a great advance would have been made. He finally drew attention to the fact that electrical engineering was essentially the profession of the young man, and concluded by giving some advice to the students, which he summed up in the well-known text: "Whatsoever thy hand findeth to do, do it with all thy might."

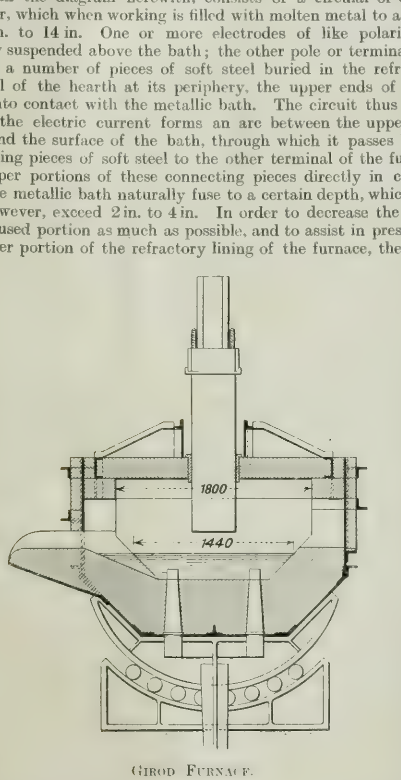
Shunt Motors in Mechanical and Electrical Parallel.—In a recent issue of the "Electrical World" a patent issued to Mr. B. Frankenfield is described. The claim relates to an arrangement whereby the load on several shunt-wound direct-current motors connected in both mechanical and electrical parallel can be divided equally among the machines. Each motor is provided with as many separate field-coil sections as there are individual motors, the sections on one machine being joined in series with those on the other machines. The arrangement is such that any change in the field circuit resistance of one machine varies the strength of the fields of all the machines equally. This action prevents any motor from taking more than its share of the load, as would be the case if the motors were independently connected to the supply system and the field winding of one became hotter and therefore admitted less current than the field winding of another motor.

THE GIROD ELECTRIC FURNACE FOR THE MANUFACTURE OF STEEL.*

BY PAUL GIROD.

Summary.—After describing the construction and advantages of the Girod furnace, the author gives particulars of the energy consumption, cost of electrodes, life of lining, labour, &c., as obtained from actual practice.

The working portion, or hearth, of the Girod electric furnace, as shown in the diagram herewith, consists of a circular or oblong chamber, which when working is filled with molten metal to a depth of 12 in. to 14 in. One or more electrodes of like polarity are suitably suspended above the bath; the other pole or terminal consists of a number of pieces of soft steel buried in the refractory material of the hearth at its periphery, the upper ends of which come into contact with the metallic bath. The circuit thus established, the electric current forms an arc between the upper electrode and the surface of the bath, through which it passes by the connecting pieces of soft steel to the other terminal of the furnace. The upper portions of these connecting pieces directly in contact with the metallic bath naturally fuse to a certain depth, which does not, however, exceed 2 in. to 4 in. In order to decrease the depth of the fused portion as much as possible, and to assist in preserving the lower portion of the refractory lining of the furnace, the lower



GIROD FURNACE.

extremities of the connecting pieces are fitted with a water-cooling arrangement, in a cavity about 6 in. deep, in that portion of the steel connectors projecting outside of the furnace; this also serves for connecting the cable to this terminal.

According to the capacity of the furnace, one or more electrodes are used above the bath, but if more than one is used they are always in parallel, connected to the same terminal of the generator or transformer, the other terminal being connected to the metallic connecting pieces. The furnace may be run with either continuous or alternating current, but in the latter case it is necessary to take into account that cos ϕ will be about 0·88.

The furnace body consists of a metallic shell of plate steel, forming a chamber round, square or rectangular, as may be desired, lined with suitable refractory material (magnesite or dolomite). The furnace is supplied with suitable charging and working doors and a taphole. The steel is tapped by tilting the furnace, for which purpose it may be mounted on trunnions or rollers. A cover lined with silica brick is mounted over the furnace, the ports for the electrodes being fitted with a removable cast-iron water-cooled frame.

The electrodes are so fitted that air cannot enter the furnace, this and the use of metallic frames or collars being possible by the fact that the electrodes have the same polarity, and there is, therefore, no danger of short-circuits across the cover. The use of the metallic frames for the electrode ports is not altogether necessary, but has the advantage of more perfectly closing the furnace and stiffening the cover.

Advantages of the Girod Furnace.—As this furnace, although of the arc type, works also partially by resistance, this latter feature becomes of prime importance in starting up with a charge of cold scrap, turnings or cast iron. In fact, the great ease with which the furnace may be started up with cold charges is a marked advantage of the Girod furnace over other systems. The method of arranging the electric circuit permits of easy automatic regulation of the arc, as there is but one drop of potential to be regulated in the circuit, instead of two successive drops, as is the case in furnaces having two electrodes in series. Like all arc furnaces, the Girod furnace lends itself extremely well to the work of refining the metal; it permits of obtaining very hot and fluid slags, which may be entirely removed during the handling of a charge. The low voltage at which the furnace works (about 55 volts) makes it very easy to insulate thoroughly all parts of the furnace circuit, or any places where short-circuits might occur; this is an additional safeguard for workmen who may, by reason of their duties or accidentally, come in contact with the current.

In the Girod furnaces in actual operation at Ugine, in the works of the Compagnie des Forges et Aciéries Electriques Paul Girod, the raw materials consist of scrap, turnings and some cast iron, gathered indiscriminately in the market. The problem, therefore, is to refine these materials, charged cold, to obtain a high-grade steel. The finished steels are of any desired grade, of all degrees of hardness, carbon and special structural steels, tool steels, cast steels, &c.

The characteristics of electric furnace steels are, compared with Bessemer, open-hearth or crucible steels, their high elastic limit, and their great resistance to shock. These qualities seem due to the chemical purity of electric furnace steel, to its homogeneity and freedom from occluded gases. The two latter points are of greater importance, inasmuch as the sulphur and phosphorous content hardly ever exceeds 0·030 per cent.

GENERAL DATA AS TO COSTS OF MELTING.

Treatment of a Charge of Cold Scrap, with Refining.—The average energy consumption for fusing, refining and finishing a charge of cold scrap is 900 kw.-hours per ton of steel in a 2-ton furnace, and 700 kw.-hours in a furnace holding 8 to 12 tons, the energy being measured at the furnace terminals. These figures will, of course, be slightly increased in the case of special steels, or diminished as the refining period is shortened.

The electrode consumption is about 16 kg. to 18 kg. (35 lb. to 40 lb.) in a 2-ton furnace, and 13 kg. to 15 kg. (29 lb. to 33 lb.) in an 8 to 12-ton furnace per ton of steel produced. The unused portions of the electrodes, corresponding in length to the height of the arched cover above the bath, are included as having been actually consumed. The consumption of electrodes will obviously depend upon their quality; that indicated above refers to ordinary amorphous carbon electrodes made from retort carbon, and not to graphitised electrodes.

The lining is of brick (or, better still, a paste) made of magnesite or dolomite. These materials give equally good results, and, therefore, the one is used which can be had at the lowest price. One such lining will last 40 to 50 heats without any repairs, after which the lateral walls of the furnace receive partial repairs. Now and then, generally after 100 heats, the upper portion of the hearth lining for a distance of about 10 cm. (4 in.) is repaired also. The hearth otherwise does not require any repairs.

The cover is of silica or high-grade fire brick, the life depending upon the quality of the brick; with good material a cover will last through 40 to 50 heats. Under these conditions, in France, the expense for furnace linings will be 7 to 8 francs (about 6s.) per ton of steel produced in a small furnace, and 4 to 5 francs (3s. to 4s.) in a large furnace of 8 to 12 tons capacity.

To handle the furnace three men are sufficient, a melter, an assistant melter and a boy, for small furnaces; four men for a large furnace. At Ugine the large furnaces are charged by an electric charging machine.

To the expense above mentioned should be added the sundry additions, such as lime, ore and fluorspar, for the various slags, on one hand; and ferro-alloys, ferro-manganese, ferro-silicon, silico-manganese, &c., added during the final period and finishing of the metal, on the other hand. The total of these items will vary essentially with the purity of the prime materials used and with the quality of the steel to be made; it varies between 3 and 7 francs (2s. 6d. to 5s. 6d.) the ton.

The loss in the furnace will depend mostly upon the composition and state of oxidation of the scrap and materials charged; with heavy scrap but little oxidised, the loss is from 6 to 7 per cent.

Treatment of a Charge of Cold Scrap, without Refining.—This is

* Abstract of a Paper read before the American Electrochemical Society.

the case where a charge of selected and sufficiently pure materials is simply melted in the electric furnace. The time of the heat is diminished by 25 per cent., so that the various expenses of melting, as above, are reduced to about 75 per cent. of the figures given.

Treatment of a Charge of Liquid Steel.—The molten steel can be taken from a Bessemer converter, or from a Martin, or open-hearth furnace. The time of the heat is then reduced to 20 to 30 per cent. of the length of a heat of material charged cold and refined, and the various factors entering into the cost are brought to 20 to 30 per cent. of the values given above.

In addition to two 12½ ton and three 2-2½ ton furnaces in operation at Ugine, Girod furnaces are also installed at the works of Oehler & Co. (Switzerland), John Cockerill Co. (Belgium), Stotz & Co. (Germany), Ternitzer Stahlwerke (Austria), Steirische Gusstahlwerke Danner & Co. (Austria), Poldihütte (Austria), and Marrel Frères (France), and a few details of these installations are mentioned by the author.

THE STATUS OF THE ENGINEERING PROFESSION.*

BY G. A. THOMAS.

Summary.—The author deals at length with a number of ways in which the present position of the engineer, both internally and relative to other professions, might be improved. Overcrowding, misuse of word "engineer" and multiplication of societies and other evils requiring mitigation are gone into, and schemes for education and registration suggested. The disabilities of consulting engineers are also considered.

It is obvious to the most casual observer that, although the science of engineering enters very largely into our modern civilisation, yet the position of engineers at the present day is very far from being satisfactory, and, on account of the conflicting influences at work, is not likely to improve until some definite steps are taken to secure for them that recognition which is accorded to members of other professions. Members of every branch of the profession, civil, mechanical or electrical, are equally concerned, whether they are actively employed in carrying out engineering works as consulting engineers and superintendents, or engaged in research work and the like. It is lack of unity from which engineering is suffering at the present day. It is high time, therefore, that all those who realise the present state of affairs should endeavour to find some means whereby the various bodies may be united under one central authority, for the enhancement of the dignity of the profession and the correction of those evils which are the result of too independent action on the part of the younger branches. Stated briefly, the following are the main difficulties with which the profession has to contend at the present time: Overcrowding, misuse of the term engineer, multiplication of societies, what may be called the advertising problem, and, finally, with regard to consulting engineers, the question of fees and the malpractice of some manufacturing firms in giving free advice to clients.

Overcrowding.—This objection might be brought almost equally well against any of the professions, but engineering, perhaps, suffers more than others from the constant influx of men lacking sufficient scientific training, having no great love for their work, but apparently tempted by the ease with which a footing may be gained as compared with other professions. Technical schools should confine their efforts to training mechanics in theoretical work, and encouraging them to think for themselves. Then, if a pupil shows a distinct engineering bent, let him be encouraged in every possible way by scholarships and subsidiary grants to continue his education at a recognised centre, where he may qualify for the profession.

Misuse of the Word Engineer.—The title of engineer is to be seen tacked on to almost every imaginable industry, and can be freely adopted by anyone who cares to do so. It ought to be possible to restrain persons from misleading the public—whether intentionally or otherwise—in this way, so that the term engineer would convey but one idea to the public mind. Unfortunately, the evil has gone on for so long that it will be difficult to find a remedy. Perhaps it would be possible to find a new name by which to designate professional engineers, or to devise means for preventing the misuse of the old title.

Multiplication of Societies.—Specialisation has reached such a point that the tendency of the present day is all towards an increase in the number of engineering societies. When used for the purpose which they are intended to fulfil—viz., for encouraging the interchange of ideas on specialised technical subjects and attracting men who are not yet qualified, apart from the special subject in which they are interested, to join the older institutions—such societies cannot be too highly commended; but for these societies to allow their members to adopt the initials of their titles as a distinguishing mark must result in cheapening the value of such distinctions and cause confusion in the minds of the public.

Advertising.—Medical men have recognised the advisability of differentiating strongly between profession and trade, and have, as far as possible, relegated the merely mechanical duties to an inferior body of men. To accentuate the distinction more strongly they have made it an unwritten law that no professional man as such shall advertise himself in any way. The mechanical branch of engineering is brought into much closer contact with actual trading than any other, consequently it behoves those engaged in this class of work to be doubly careful. Engineers must remember that this matter, in common with other points referred to in this essay, must not be regarded solely from their own view point, but also from that of the general public, and considerations which they themselves could afford to neglect must for this reason receive careful attention. In these days of keen competition it is very evident that engineering businesses, in common with others, cannot afford to abstain from advertising. At the same time, to allow managers of these concerns to use their position as members of the engineering profession for the purpose of personal advertisement and yet to veto the purely consulting engineer from advertising himself in any way would be the height of injustice. It must be considered essential that the professional man who is allied to a business concern shall not allow his name to be displayed in any advertisement whatever, nor shall the product manufactured by his firm bear his name by way of a trade-mark.

Professional Fees.—The position of consulting engineers is, perhaps, particularly unsatisfactory. To take the question of fees first. In the absence of any legal status, it is exceedingly difficult to define or establish a scale of fees which shall receive universal recognition. One is frequently hearing of cases where a consulting engineer has been asked to state an inclusive fee for certain work, only to find that it has been undertaken by someone else for a much lower figure. Such a procedure is unheard of in any profession but our own, and points to a lack of unity and professional concord. Many manufacturing firms at the present time make a practice of giving advice on engineering matters, preparing estimates, and even drawings, free of any charge, if the order for a part of the intended work is placed with them. Such advice is naturally biassed, and often results in expensive plant being installed which is quite unsuited for the purpose in view. Such a state of affairs is manifestly unfair to the consulting engineer, as well as detrimental to the interests of the public. The consultant, for the sake of his professional reputation, would naturally take greater care to consider the real interests of his client, and, acting independently of any commercial bias, would be more fitted to judge what would best suit the requirements of the case. The profession would hold a higher position in the estimation of the public when once it was realised that the advice given was as independent as that given by any other body of consultants. It would then become an understood thing that a consulting engineer's opinion was not only desirable, but practically essential, and their recognition as a special branch of the profession would be secured.

Suggested Reforms.—Having thus sketched the chief hindrances to the advancement of the profession, it is now time to outline a scheme whereby these obstacles may be removed. At the head of such a scheme should be placed the formation of a central organising body, whose duties would be either to deal with problems affecting the profession, as they may arise, or, if deemed more advisable, to delegate their authority to select committees. The institution and composition of this body is the next step to be considered, and here, as in every other case where it may be possible, such organisation as already exists should be utilised to the fullest extent. The three largest and most representative societies at the present time are the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers, of which the first-named, by reason of its greater age and better organisation, stands undoubtedly on a higher plane than the other two. It is, therefore, very desirable, in the first place, that the two latter institutions should place themselves on an equality with the Civil Engineers, since they are in no way inferior as regards the scientific training of their members. It would be advisable that these three societies or their councils should convene a joint meeting for the purpose of appointing a committee of their members to consider the better organisation of the profession, the preliminary expedients to be adopted, and the form which the permanent scheme should take. The committee would first proceed to organise a central governing body consisting of a president and council. This body should be

* Abstract of the "Status Prize" Paper read before the Society of Engineers.

equally representative of each of the three societies before mentioned, the members being either nominated or elected by the respective councils. Vacancies on the central council as they occurred would be filled from the society affected, so as to maintain the equality of representation. The president should hold office for a limited term, a representative of each of the constituent societies being elected in rotation by the central council. A member of the central council need not necessarily have sat on the council of the society which he represents, each council having the right to nominate any full member of their society as their representative. The central council being complete, it would be advisable that it should endeavour, at the earliest possible date, to obtain recognition as a legalised corporation by act of Parliament. In the meantime, it would devote itself to instituting such machinery as could deal most effectively with the main questions affecting engineering, arranging for committees to inquire into the needs of the profession, and to consider schemes of reform, so that no branch or subdivision of the profession might appear to be neglected. All such schemes should be as comprehensive as possible, and in view of the fact that engineering is ever developing new spheres of influence, ample provision should be made for future extensions and alterations, subject to the approval of the central body. In all matters relating to the profession this body would have supreme jurisdiction, its duties being both organising and judicial, though in practice it would probably be found advisable to give as free a hand as possible to the three component societies in matters specially relating to their respective branches. Having once obtained a legal status, the central body should turn its attention to the following points: (i.) Registration of members; (ii.) education; (iii.) regulation of fees; (iv.) organisation of funds for aiding invention and research, &c. An endeavour should then be made to formulate a scheme for the establishment of an information bureau for engineers, and the institution of benefactions for the more needy or unfortunate of its members.

Registration.—A register should be compiled containing the names and addresses of qualified members of the profession, their present occupation and an outline of their qualifications. No one should be allowed to have his name entered on this register unless he be a full member of one of the three societies and at least an associate member of one of the others. Anyone not thus registered should be legally disqualified from receiving fees as a consulting engineer, and debarred from holding any public engineering appointment. Moreover, any infringement of the laws drawn up by the central body for the protection of the profession, or serious breach of professional etiquette, should make the offender liable to have his name struck off this register, so that he ceases to be a recognised member of the profession.

Education.—Men desirous of entering the engineering profession should be obliged to qualify at certain recognised centres. These centres should be limited to the existing engineering colleges and the universities; technical and other schools being allowed to enter their pupils for entrance examinations only, as in the case of other professions. At the same time, to prevent any undue hardships arising from these restrictions, ample opportunities should be given to all who may desire to enter the profession, by a liberal provision of scholarships and exhibitions. In this way none need be debarred from becoming engineers by lack of means to meet the educational requirements. The standard of the profession as a whole would tend to rise, while the problem of overcrowding would be solved, as far as it is possible nowadays, since the output of mere rule-of-thumb men would be restricted. Another result would be that a higher value would be set on the qualified engineer, so that he would obtain a better return for his services than he can at present command.

Having passed through a course of theoretical and practical training such as may be deemed sufficient to qualify him as an engineer, and having specialised in some one branch of the profession, the young engineer would now prepare himself for admission to one of the societies as a preliminary to registration. These societies—the Institutions of Civil, Mechanical and Electrical Engineers—would practically remain as at present constituted; but, where their differences are such as tend to place one on an inferior plane to both or either of the other two, such changes should be introduced as would ensure professional equality for them all; such an equality being essential if engineering is to have that unity which alone could make it hold its own with the other professions. The standard of qualifications for admission to each of the three societies should be of the same high order, associate membership being by examination only and preceding full membership, except in the case of honorary members. Exceptional merit, of course, would alone admit to the latter class, the ordinary full member attaining that position either by writing a thesis or by having distinguished himself in professional work in a special manner. The class of student members might or might not be retained, but it would probably be found more convenient to abolish it eventually. The existing members of these societies would naturally remain on their present footing, but no new members should be admitted after the scheme is once established, except in accordance with the new regulations.

The examiners would be appointed and the examinations conducted as the councils of the separate societies should determine, but all appointments and regulations should be approved by the central body. A candidate who has passed the examination entitling him to assume the initials of the "degree" conferred by any one institution, when sitting for his second examination should be exempted from again taking any subject in which he is already qualified, so that he may not be unduly hindered from having his name entered on the register as soon as possible.

A certain amount of practical work in a recognised centre should be insisted on as a necessary qualification of registration, the time so spent to be regulated by the central body. The main points to be borne in mind in all details of schemes relating to engineering education are that, although thorough efficiency should be aimed at, yet its cost from first to last should not be excessive, and the time to be spent in qualifying should not be unduly prolonged.

The profession once having obtained a legal status, it would not be a very difficult matter to establish a scale of fees for consulting engineers. The funds of the central body would be applied (i.) to defray the working expenses of the body as a whole, which should be curtailed as far as might be compatible with efficiency; (ii.) to the establishment of studentships for the furtherance of research work; and (iii.) to assist inventors in the development of their patents.

Research studentships should be granted only to members of the various societies who showed special aptitude for such work, and who would be unable to devote themselves to it without such aid. They should be held for a limited time only, which might, however, be extended at the discretion of the committee.

Information Bureau.—If it were possible to establish a world-wide organisation for the sole purpose of ascertaining engineering requirements in regard to material and men, its value would be incalculable, and there is no apparent reason why such a scheme should not be self-supporting. Again, British engineers, when competing with foreign firms on their own ground, are often sadly handicapped by ignorance of local requirements materially affecting the design of machinery, &c., owing to the means of transport, the conditions under which it has to work, and the amount of attention it receives in service. In all these cases a bureau supplying the necessary information would be of the greatest value. It should have its headquarters in London, and should issue pamphlets from time to time containing the most recent available information based on facts obtained in that particular country.

Benefactions.—A sub-committee should be appointed to consider how far it would be possible to organise a scheme for extending necessary financial assistance to the poorer members of the profession, quite apart from educational or similar grants.

The above rough outline of a scheme by which the engineering profession might be placed on a firm basis, and maintained on an equality with other professions, would, in the opinion of the author, be found workable and efficient. The principal difficulties would arise in the initial stages, and would prove doubly difficult in our case, because the organisation of the profession as a whole has not kept pace with its growth in numbers. It is the duty of everyone who feels strongly on this subject—the improvement of the status of engineers—to take his part without hesitation in any undertaking which has this object in view, and to endeavour to the utmost of his power to rouse a real interest in the question amongst his fellows.

DISCUSSION.

Mr. C. Collingwood, in a written communication, said that the Institution of Mechanical Engineers were doing the right thing in raising the standard of qualification. The young engineer should not only be properly trained, but he should be put where he was wanted. He thought that an engineering Intelligence Department was needed. He suggested that a conference of all the engineering societies should be called in order to form a Union, one of whose first duties might be the annual publication of a directory giving the requirements of foreign countries. Parliament should also be asked to make the registration of engineers compulsory.

Mr. H. Howard Humphreys congratulated the author on the case for reform that he had put forward, which he, the speaker, thought could be carried out with a minimum of friction. For a great number of years the engineering profession had been diverging along three different lines—viz., the purely civil, the mechanical and the electrical—and, perhaps, a fourth, the municipal. He agreed with the author that what was needed was a general engineering council composed of members of the three societies. Regarding education, he thought that the public and secondary schools were to a certain extent to blame. Science must be taught with an eye to commerce, whereas Englishmen were inclined to teach

it was an end in itself. He did not agree with the author that technical schools should confine their efforts to training mechanics in theoretical work, and encouraging them to think for themselves. The usual course of training adopted in this country was not quite a success, and he suggested an inversion of the present system. He did not see how a definite scale of fees could be fixed, as there were innumerable factors which had to be considered when settling such a question. As to tendering for consulting work, the duty of the consultant in such cases was to refuse the work point blank. He thought an information bureau was certainly wanted at the present time, even more than registration. Such a bureau would be of great assistance to the pupil, who, after having served his pupilage, would have all particulars concerning his work during that period placed before the bureau. Thus, the boy would do his level best, in order that his future prospects might be enhanced. England should, he thought have better facilities for obtaining information about other countries, and he gave an outline of a scheme adopted in Germany to gain this end. Strong co-operation, however, was what was needed.

Mr. C. J. YORATH thought that the multiplication of societies was due to the fact that engineers not able to get on the council of existing institutions formed one of their own. It was no good, he thought, insisting upon future engineers being fully qualified when they shirked making themselves so.

Mr. P. GRIFFITH thought that tactful progress was necessary before anything successful could be accomplished. He deprecated any further consideration of progress on the lines suggested by the author in regard to the various existing societies. The author had too much discounted the value of the smaller societies. No society could exist unless there was room for it. Progress must be through general and universal co-operation, and not through the selection of any one or two of the societies.

Mr. H. ROSS HOOPER disagreed with the author that the engineering profession was similar to the medical and legal professions. They were, he thought, entirely different, and it was in that difference that the whole difficulty in front of improving the engineering profession lay. He thought that if the existing Institutions would take up the question of unqualified engineers, they would soon get a harvest of facts to work upon. A great deal of money was wasted every year in this country by employing such men. Supreme jurisdiction and legal status were the two points on which the whole of the suggestions in the Paper turned, and supreme jurisdiction could only be obtained from Parliament. He also considered that it would be very doubtful in the present stage to attempt such a gigantic measure as a central body with those powers. The proper course to follow at present was to urge upon the councils of the Institutions already mentioned the importance of bringing before the public, and before the engineering profession, the influence which they ought to exert. A little less dry bones and a little more vitality was what was needed to encourage engineers in their profession, and that would be a much easier task than the construction of a central body. He agreed with the author as to the information bureau.

Mr. J. W. WILSON said it seemed obvious that in all Papers dealing with the status of the engineering profession a beginning should be made with education. It was a pity that the great public schools did not do more to help the boy at the beginning of his career. The time so lost was terrible to contemplate. He agreed with the author as to the order in which the student should be trained. The most fatal mistake a student could make was to work in a groove, as he did not know what he was best suited for until he had tried. Specialisation should come later on. Engineers did not care to take pupils straight from public schools, but they stipulated that some previous training should have been given them. The problem was how best to lay out the first two or three years of the student's life in order to fit him best for the profession. He quite agreed that the engineer should not advertise himself, but he saw no reason why others should not advertise him. Why should not the name of the engineer be mentioned in descriptions of any engineering achievement? He thought that something could be done between themselves to see that they were not ignored altogether, and that the engineer's name should be given in articles dealing with any new engineering work carried out.

Mr. E. BENEDICT was inclined to be of the opinion of one of the previous speakers who spoke up for the Institution of Civil Engineers, as he, the speaker, was amongst the 100 senior members of that Institution. They were certainly not going ahead as fast as they might, but they were going very much in the direction that the author advocated. They were greatly raising the status of their members. As to the letters after a were man's name, he thought they were certainly very confusing. He did not think it probable that any of the large societies would be willing to sink their identity in any such scheme as a central body. The enormous subscription was one of the reasons why the Institution was not so generally entered by engineers. He considered that the German military training was most valuable to engineers, as it not only taught them to obey without demur, but it also taught them how to manage their inferiors. He noticed in regard to fees that the author did not put in the word "minimum," which was rather important. How could one compare, unless the minimum fee was put in, with the medical or legal professions. Surely the fees varied very much. It was, he thought, very important that an examination for character should be held. Why should not a man who engineered some important work advertise himself as well as a man who read a Paper, and whose name went all over the world as the author of that Paper? Specialisation was a good thing, and instead of there being too much specialisation there was a good deal of overlapping. Every kind of engineer was represented in the Institution of Civil Engineers, and so it was in the case of the Electrical Engineers.

Mr. R. BROWN thought there should be an easy way of getting rid of the misuse of the word "engineer." The "Civils" as a premier body should take the lead, and the proper course to adopt would be to bring the whole matter before the council, and to get them to move to improve the status, and to keep the use of the word "engineer" only to members of the chartered institutions, of which there were, he believed, only three. He thought, however, that specialised societies were an advantage, but that members of them should be made to put "limited" before the initials after their names.

Mr. H. CONRADI said that some years ago a similar attempt to the present one was made, and an offer being made for a building in which all the engineering societies could meet together, but it came to nothing. He considered, however, that the Paper was a very interesting one.

Mr. G. A. THOMAS (in reply) thanked the members for their criticisms, which, he thought, were much more enlightening than the Paper itself.

SPECIAL WORKSHOP TOOLS.

A well equipped repair department is essential to any large electric tramway undertaking, and much depends on the machines installed. Messrs. Tangyes (Ltd.) have made a feature of special tools for turning and grinding commutators, banding armatures, winding coils, &c., and the following particulars of these tools will, doubtless, prove of interest to our readers.

The armature banding machine, illustrated in Fig. 1 herewith, has been specially designed for banding traction and other armatures up to 18 in. diameter by 4 ft. 6 in. long. The headstock is fitted with a steel spindle having adjustable gunmetal bearings, the thrust being taken by hardened and ground collars at the rear end of the spindle. The drive is obtained from fast and loose pulleys, 14 in. diameter and $3\frac{1}{4}$ in. wide, and through worm and wormwheel to the spindle. This latter is arranged so that it can be freed from the wormwheel for putting turns on or off by hand, if desired.

The saddle is of cast iron, spans both shears of the bed and has taper strips for taking-up wear, and locking bolts for clamping where

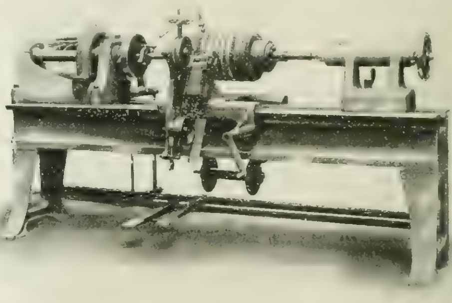


FIG. 1.—ARMATURE BANDING MACHINE.

desired. It is moved along the bed by machine-cut rack and pinion. Substantial cast-iron arms are dropped from the back of the saddle to carry the spool on which the wire is wound. The spool is arranged so that it will not revolve in the event of the wire breaking, to avoid entanglement of the latter. The leading-on guide pulleys are mounted on a horizontal slide having 2 in. of traverse. The pulleys are turned all over and hardened on the face. A band brake is provided in a convenient position, so that the tension may be altered at will, also a guide at the top with adjustment in the horizontal and vertical planes.

The machine is controlled by foot levers working on square shafts underneath the bed, the former can be moved to any desired position so that the operator has the machine under complete control in either direction. The levers are automatically thrown off when the pressure on the lever is removed, one lever being for the forward motion and the other for the reverse. With this machine a traction armature can be bound in a few minutes; and owing to the fact that an even tension can be maintained on all bands the risk of slack bands or excessively tight ones bursting is minimised.

The coil winding machine shown in Fig. 2 has been designed for winding heavy section fields such as are used for electric traction motors, &c. The headstock is carried on a strong hollow box pedestal, the inside of which forms a useful tool cupboard. The drive is through worm and wheel from a set of three pulleys, the driving belt being 3 in. wide. The pulleys are so arranged that opened and crossed belts are brought into operation by means of feed levers which are automatically thrown off when the pressure on the lever is removed. One lever is used for forward motion and the other for reverse. The spindle is of hard steel, running in

adjustable gunmetal bearings with removable caps; it is so arranged that it can be freed from the wormwheel when required to be moved by hand. The spindle nose is fitted with an oblong faceplate with slots. A counter is provided registering up to 999 and so that turns put-on or taken-off are recorded.

Messrs. Tangyes have also designed a special lathe for turning and grinding commutators, the height of the centres being 11 in., and it will take armatures up to 16 in. diameter by 4 ft. long. The fast headstock has a steel spindle running in conical bearings, the thrust being taken by an adjustable hardened steel tail pin at the rear end. The cone pulley has four steps which, with the eccentric back gear provided, give a total of 8 speeds. Reversing motion is also fitted to the headstock.

The saddle, whilst having long bearing surfaces, is made as light as possible for rapid handling, and is fitted with the usual compound rest in the front, the latter being fitted with a swivel for turning down staggered tails, &c. At the back of the saddle a grinding head is carried on a middle slide consisting of a steel spindle running in oil ring bearings, which are carried on a substantial cast-iron frame. An emery wheel is mounted on the spindle, and is moved to and from the centre by means of a conveniently placed handle arranged in the front of the saddle. The longitudinal self-acting traverse to the saddle is obtained from a back shaft running through a three speed feed box which is again driven by means of belt from the fast headstock. Any of the aforementioned speeds can be obtained whilst the lathe is running. A heavy clamp plate is fitted

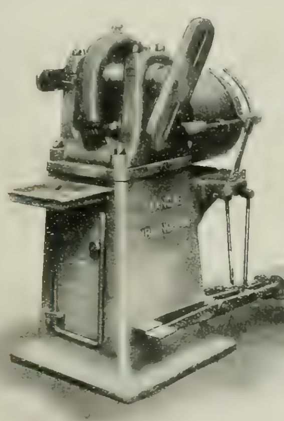


Fig. 2.—Coil Winding Machine.

over the front shear of the lathe, and when clamped in position, obviates any risk of a turning tool or emery wheel running into the commutator tails.

In addition to the automatic feed described above, a quick hand feed is introduced for use when roughing down a badly grooved commutator or setting the stops. The lathe is provided with the usual countershaft to the fast headstock, and a light cast-iron drum for driving the grinding head. This drum is made in sections to avoid warping.

This combination tool has proved particularly useful in dealing with commutators, as the roughest commutator can be turned and ground in a few minutes, flats being entirely removed.

LEGAL INTELLIGENCE.

Harvey v. Wycombe (Borough) Electric Light & Power Co. (Ltd.)

At Wycombe County Court last week plaintiff sought to recover £100, for allgeed damage caused by "improper and negligent laying of an electric cable, belonging to defendant Company, in Newland-street, High Wycombe." The damage aleged was personal injuries to plaintiff, whilst engaged at work on May 3, 1909. The particulars of expenses were:—Loss of wages as a pavior at 35s. odd per week, such loss still continuing, £2. 10s. for clothes, and shock and personal injuries.

Mr. Winter Taylor, for plaintiff, said that a plan of the work to be carried out by the company ought to have been submitted to the Corporation, and the exact position of the cable. That had not been done.

Plaintiff said that on May 3 last he was engaged in paving work. He had got the pavement up. The first thing he had to do was to fix an iron post to stop the traffic. After that he wanted to fix a line from the post to the end of the channel, and started to drive in an iron pin to tie the line to on the edge of the channel. As far as he knew he struck the pin about twice with a hammer. After that he knew nothing. He was, after treatment, taken to the Cottage Hospital, where he remained for eight days. He was an out patient for some time, and since then had been under doctor's care. He returned to light work on Aug. 16. Eventually he hoped to return to his old employers. He was still suffering, his right eye was not quite so good and his nerves were not the same. The bill was £2. 11s. for medical treatment. His employers gave him half his weekly wages for about nine weeks. He went to that firm on July 16, and remained there for about a fortnight, during which time he had wages at the rate of 7d. per hour for one week and 9d. per hour for the other. He worked 56½ hours per week. Since then he had earned scarcely anything. He did not know there were electric light cables at the point where he was working. The labourer witness employed had a pickaxe on the job

Geo. Windridge, labourer, said on May 3 he got the earth out ready for Harvey, who, when the accident happened, was driving a pin so as to fix a line. Harvey fell forward. He ran away through fright. An "immense flame came out of the ground." When he came back he "gathered up Harvey" and took him to the doctor. Harvey was burnt black.

Leonard Dallimore, foreman, said that when he arrived on the scene he discovered that a pin had been driven into the cable and had caused "an explosion." The depth of the cable from the top of the sets was only 8 in. He had no idea there was a cable in the street. In cross-examination witness said he had not told anyone that the man had had an accident in his absence; nor did he say the men ought not to have taken a pick there, as the cables were placed in very shallow ground. He expected to find gas mains, &c., in roads. He could tell of their presence by the softness of the ground. There was loose ground in Newland-street (the place of the accident), and his men knew of that fact, but he did not think Harvey knew it.

Medical evidence having been given by Dr. Reynolds, Mr. T. J. Rushbrooke, borough surveyor of High Wycombe, said he had inspected the cable at the scene of the accident, and had taken certain measurements. Underneath the cable there was a 6 in. gas main. Witness had not received from the Electric Light Co. either notice or plan regarding the cable. He had received other notices and plans from the Company. He had made suggestions to the Electric Light Co. with regard to the depth when putting in cables in other streets. The Company generally acceded to his suggestions. In cross-examination he said that notice was usually given when the company wanted to break up a road, but that was not done in this case. When the company had not given him notice, he had written them, and the reply he got was to the effect that he should receive notice in the future. He did not see the Newland-street cable put in. The ground was opened and filled in in a very short time. The cable in question went over a bridge and witness saw the cable by the side of the bridge after it had been put there a few days.

Mr. Emanuel, for defendants, submitted that there was no case to go to the jury, and no evidence of neglect. There was no duty devolving on the Electric Light Company to put in their cables at a certain depth. They could put them above the road, and in various instances they were placed by the side of bridges and walls. There was a plan deposited in the company's office, showing where the cables were laid, together with their depths. If those responsible for carrying out the work did not take the trouble to go and see the position of the mains, then trouble was upon their heads. With regard to the Workmen's Compensation Act, he submitted that Harvey's case came under that Act, and that as he had been receiving money under that Act, he could not come there under common law and claim damages.

The Judge having decided that the case must go to the jury,

Mr. Harry Langley, partner in Messrs. Langley & Johnson, said they insured their workmen. Witness knew of the accident to Harvey, and paid him half his wages for nine weeks, continuing until notice was received from Harvey's solicitor not to do so any longer.

Mr. J. C. Wigham, electrical engineer, said that at the time of the accident the cable was 8 in. in the ground. Under the circumstances and the peculiar conditions of the case, that was a proper depth. There were no regulations issued by the Board of Trade as to what depth cables should be laid. He knew of the presence of pipes in Newland-street, and after the accident had occurred plaintiffs did not think of altering the direction of the cable. In cross-examination he said he did not recollect that particular cable being put in. The average depth to put in cable was 10 in. where there was foot traffic, and from 18 in. to 20 in. where there was vehicular traffic.

Mr. W. E. Brandreth, resident engineer and manager of defendant companys produced the document from the Board of Trade giving his Company permission to lay cables in Wycombe. Witness visited Newland-street within five minutes of the accident. He found a pin jammed into one of the large cables, and the ground around had been blown out. Witness had the pin knocked out of the cable. In his opinion the cable was properly laid. Since the accident it had been relaid in Newland-street in consequence of a joint box being necessary. About February the Corporation were making tests to find out leakages into the sewer, and the manhole was removed in Newland-street. A hole, covered over by boards, was left for some time, and the cable was exposed for quite a week. After the accident, witness made a claim for the damage done to their cable against the contractors to the Corporation, and Messrs. Langley & Johnson paid.

Horace Williams, cable jointer, also gave evidence.

After counsel had addressed the Court, his Honour, in summing up, pointed out to the jury that they had to seriously consider whether there had been any wilful neglect on the part of the Electric Light Company. There was no evidence to show that Harvey knew of the existence of the cable, but there was evidence that went to prove that other of Messrs. Langley & Johnson's men did know that it was there. Negligence of other people did not implicate Harvey. If they came to the conclusion that the Company had been negligent, and that there had been no contributory negligence on the part of Harvey, then they would have to consider the question of damages.

The jury were unable to agree, but after a consulation between counsel Mr. Emanuel said as far as defendants were concerned the litigation would stop. The case would not be tried again.

The jury were then discharged without giving a verdict.

A Consulting Engineer's Fees in Australia.

In the Second Civil Court, Melbourne, Mr. Justice Hood and a jury recently heard an action by Mr. F. E. Bradford, electrical engineer, against the Crown, for recovery of £3,500 damages for alleged breach of contract by the Government of Victoria, with respect to an agreement with plaintiff to carry out certain work in connection with the proposal to electrify the Melbourne suburban railways. Plaintiff alleged that in 1904 an agreement was made between himself and Sir Thomas Bent, the late Premier, under which plaintiff was to report (for £1,700) to the Government of Victoria upon the electrification of the Melbourne suburban railway system. Plaintiff had been willing to carry out the contract, but had been refused an opportunity to do so. For the defence it was pleaded that, if any contract was made, the amount agreed to be paid was £300, and any such contract was terminated by mutual consent, and petitioner was appointed and consented to perform, and did perform, other work for the Government in lieu thereof. There was no contract in writing. After hearing evidence for the plaintiff,

His Honour said it was clear that Mr. Bradford had been engaged for £300, but he was then engineer for the well-known firm of Noyes Bros. There was then (in 1904) opposition by other firms to plaintiff's engagement. Mr. Bradford said that Mr. Bent (as he then was) suggested that he should leave his firm, and he did resign, but he had not said that he did so for the sake of the £1,700 itself, nor did he (the Judge) think that was the reason. It was rather because of something much bigger behind it. If the Appropriation Bill was passed, in compliance with his report, he would probably get a good billet at a good salary for 8 or 10 years, and establish his reputation in the electrical world. On the other hand, it did not seem clear to him why Mr. Bent should cancel an agreement for £300 and agree to £1,700 instead. There was no explanation of that to his satisfaction, but it was a question for the jury to decide. Sir Thomas Bent was clear that he did not agree to £1,700. His Honour had no doubt that Sir Thomas Bent did mean to do Mr. Bradford a good turn, and put himself into opposition with the Railway Commissioners so that he (Mr. Bradford) should be retained in his position. Even when the Commissioners dismissed Mr. Bradford, Sir Thomas Bent gave instructions for reinstatement. If the jury were satisfied that there was a contract, and that the contract was broken, the utmost damage plaintiff was entitled to was the amount he would have got if he had done the work.

The jury were unable to agree, and were discharged.

Elliot v. National Telephone Co.

In the Edinburgh Sheriff Court on Monday pursuer sought to recover from defendants £12. It appeared that pursuer had had at his office the telephone on the unlimited service system, and before the year to Feb. 13 last he also had had a through connection from his office to his private house, for which he paid £4. 15s. per annum. At the beginning of the year he contemplated leaving his house and the company were prepared to transfer the telephone to his new house if he paid the cost of removal (£2). The rate for the new service was to be the same provided the house was within a mile. It was on the faith of that understanding (he contended) that he paid his rent for the year from Feb. 13. A representative of the company called upon him and said the yearly subscription would be £7. 12s. in addition to £2 for removal. Ultimately he agreed to have an exchange wire at £8 per annum. He insisted in inserting in the agreement a clause, "subject always to the Corporation agreement of 1900 with the Telephone Co." The Company, however, refused to accept that clause, and no telephone was installed. Pursuer now sought £12 as loss sustained through not having the use of the telephone and repayment of a proportion of the £4. 15s. for the unexpired period from the date upon which he left his old address.

After hearing evidence, Sheriff Guy dismissed the action. He stated that if the clause in question had been added, a title to sue on the conditions of the agreement would be given.

P.O. Engineering Staff.—Mr. T. J. West, superintending engineer of the P.O. Telegraphs is about to retire under the age limit, and it is proposed, after Dec. 1, to abolish the Nottingham district and to divide the territory between the Leeds and Birmingham districts, opportunity being afforded to the existing staffs at Nottingham of transferring to other centres of administration.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A practical manager, having complete knowledge of ingredients and methods, is required for the rubber department of a cable factory in Spain; also a business man, with experience in estimating costs of manufacturing similar goods and capable of general representation, is required. See an advertisement.

An instructor is wanted in the electrical department of a London Educational Institute. See advertisement.

Applications are invited for the chair of engineering at the University of Melbourne (Australia). Particulars from the Agent-General for Victoria, Melbourne-place, Strand, London, W.C., to whom applications by Oct. 15.

A railway telegraph foreman, with experience in telegraph department of a British railway, is required for the Ceylon Government Railway. Salary £200 per year, with extra allowance of R.5 a day when on duty away from headquarters. Applications to the Crown Agents for the Colonies, London, by Nov. 1.

A demonstrator is required for the electrical and mechanical laboratories of the engineering department of the Technical College, Dundee. Applicants must be technical graduates and have had practical experience. Salary £80 per annum. Particulars from the Head of the engineering department, to whom applications must be sent by Oct. 20.

Mr. J. S. G. Thomas, B.Sc., has been appointed demonstrator in physics at the University College of Wales, Aberystwyth.

Mr. Andrew Fitzgerald has been elected assistant instructor in the engineering department of the Cork Municipal Technical Institute.

Hebden Bridge Council have appointed Mr. H. H. Sutcliffe as assistant electrical engineer.

Mr. R. E. Michael has been appointed a travelling lecturer in electrical engineering by Glamorgan Education committee at £150 per annum.

Mr. J. Fletcher, jun., has been appointed shift engineer at Heston and Isleworth electricity works.

Mr. L. C. Horrell has been appointed assistant electrical engineer to Pretoria (South Africa) Municipal Council.

York Tramways committee recommends the appointment of Mr. J. W. Hame, city electrical engineer, as general manager of the tramways.

Mr. C. W. Bentley, engineer and manager of the Alderley & Wilmslow Electric Supply (Ltd.) has been appointed engineer and manager of the electricity supply works of Edmundson's Electricity Supply Corpn. at Cromer, while Mr. E. Hesketh, of the Cromer station, has taken up the appointment of engineer and manager of the Alderley & Wilmslow Co. at Alderley Edge.

EDUCATIONAL NOTICES.

Armstrong College, Newcastle-on-Tyne.—The session 1909-1910 commenced on Sept. 27. Full courses of instruction are given in the department of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science and letters. Particulars may be obtained from the secretary (Mr. F. H. Pruen, M.A.), Armstrong College, Newcastle-on-Tyne.

Northampton Polytechnic Institute, London.—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Oct. 4, and include periods spent in commercial workshops and extend over four years.

The evening technical courses in all branches of electrical and mechanical engineering commenced on Monday, Sept. 27. Particulars as to fees, &c., can be obtained at the Institute or on application to the principal, Dr. R. Mullineux Walmsley.

University of Bristol.—We have received a copy of the preliminary prospectus of the faculty of engineering, which is provided and maintained in the Merchant Venturers' Technical College. The courses provide for complete theoretical and practical training in electrical, mechanical, mining, civil and motor-car engineering, physics, mathematics, &c. There are day and evening classes, and the lecture rooms, laboratories and workshops are well equipped.

University Education in Natal.—It has been decided to establish a university college in Pietermaritzburg which will have fully equipped laboratories for chemical and physical research. Professors are now required to fill the chairs in University College, Pietermaritzburg, for mathematics, physics and chemistry.

Argentina. "The Times" states that on Sept. 29 Congress sanctioned two concessions for underground electric railways in Buenos

Ayres, one of which will extend to La Plata. The existing railway companies are considering a proposal to convert 100 miles of suburban railways to electric traction.

Australasia.—The "Australian Mining Standard" states that the Mararoa Gold Mining Co. of Norseman (W.A.) have installed electric lighting plant.

The manager reports that the electric lighting plant at the West Berry Consols Gold Mine, Creswick (Victoria) is a great improvement. An electric haulage plant is also being installed at this mine.

Mr. F. J. Coote, manager of the Cassilis Gold Mining Co., states that the electric power used in the mines costs £3. 17s. 6d. per horse-power per annum, or £7. 15s. 6d. less than steam power.

Boulder Tin Mining Co. (Tasmania) are laying down hydro-electric transmission plant. Mr. T. K. Steanes is the contractor for the supply and erection of the electrical machinery, and Messrs. Finlayson Bros. for the Pelton wheel and piping. Mr. G. H. Lofts is consulting engineer.

Mr. Lofts has been engaged by Leven Council to report upon the question of the electric lighting of the town of Ulverstone (Tasmania).

The dispute as to the terms upon which the Perth (W.A.) Council will take over the Perth Gas Co.'s business (which includes electricity supply) will not be settled for some time. The evidence in the arbitration proceedings was commenced on June 8 and concluded on Aug. 24, but the question as to the basis upon which the valuation is to be made is to be referred to the Supreme Court, and after this has been settled, the board will consider their award.

Sir John Quick (Postmaster-General) informed the Commonwealth Parliament on Aug. 27 that the cost of the new works required to place in an efficient condition the telephone and telegraph services of the Commonwealth States was £1,828,152. This estimate is based on the present requirements and on the assumption that the payment is spread over three years.

Beckenham (Kent).—A sub-committee has been appointed to consider and report upon a scheme, prepared by the chairman, for free wiring of premises and supplying current for a fixed sum per lamp per annum, and also as to the street lighting of Shortlands.

Bethnal Green (London).—On Thursday last the Council discussed in private proposals with regard to the supply of electricity in bulk to the Council, but it was decided to adjourn the question until after Nov. 9, when the new Council will come into office. It is reported that the main business at the private meeting was the discussion of a scheme submitted by Shoreditch Council, but by 14 votes to 7 it was resolved not to entertain the proposal.

Bournemouth.—On Tuesday the Council rejected a motion to institute a limited tramway service on Sundays.

Brazil.—The Rio de Janeiro Tramway, Light & Power Co. has been authorised to substitute electric for steam traction on the Corcovado railway and the expenditure of £26,000 for this purpose has been sanctioned.

The Chamber of Deputies have approved the authorisation granted to the Central of Brazil Railway for the electrification of its suburban lines.

Bridlington.—Application has been made for sanction to a loan of £3,000 for extensions of the electricity undertaking.

Brighton.—In order to provide for the prospective demands for electric current for power at the L.B. & S.C. Railway locomotive and carriage works, the Electricity committee propose to expend £2,850 in laying an additional feeder cable.

Bulgaria.—A report by the Belgian Legation at Sofia states that the principal source of supply of electrical goods imported into Bulgaria during the years 1906 and 1907 was Austria-Hungary, whilst Germany, Belgium and Switzerland shared a minor portion of the trade. The principal importers at Sofia of electrical machinery and apparatus are Ch. Alcalay, Rue Pirotska; Iv. Bojadjieff & Co., Boulevard Dondoukoff; M. Weber, Place Alexandre; Caviano and Tramontelli, Rue Legué; Herbst & Co., Boulevard Marie-Louise; the Direction General of Posts and Telegraphs; the Electric Tramways Company of Sofia (a Belgian company with headquarters at Brussels); the Franco-Belgian Trust, Avenue des Arts; the Electricity Company of Sofia and Bulgaria (a Belgian company), 18, Rue des Comédiens, Brussels. The best means of introducing goods on the Sofia market, the report states, is to address offers and prices directly to the companies and firms mentioned above. Bulgaria produces none of the raw materials used in the electrical industry.

Burslem.—The Council have obtained sanction to a further loan for additional generating plant at the electricity works, extensions of mains, &c.

Canadian Export of Electricity.—The annual report of the gas and electricity inspection branch of the Inland Revenue Department, Ottawa, shows that during the last fiscal year the total amount of electricity exported by the four companies operating under the Electricity and Fluid Exportation Act was 359,283,286 units, compared with 135,075,680 units generated for home consumption.

The Canadian Niagara Power Co. exported 221,927,240 units, and generated for home consumption 5,405,760 units; the Electrical Development Co. exported 4,680,500 units, and generated for home consumption 85,515,700 units; the Ontario Power Co. exported 131,833,782 units, and the home consumption was 44,150,580 units; and the Maine and New Brunswick Power Co. generated for export 841,764 units, and the home consumption was 3,940 units.

Cardiff.—The farm buildings at the Mental Hospital are to be lighted by electricity.

Church Lighting.—The historic church of St. Giles', Cripplegate (London, E.C.) is to be wired for the electric light.

St. Peter's Church, Wolverhampton, has recently been wired. The borough electrical engineer (Mr. C. E. C. Shawfield) prepared the specification and superintended the installation work.

Coventry.—In future accounts of consumers having radiators and taking electrical energy from the lighting circuit are to be averaged for a period of two years, this average to be taken as the lighting account and charged at the ordinary rate, and all units in excess of this to be taken as the heating account and to be charged at the power rate.

Derby.—The Corporation propose to apply for a provisional order to extend the electricity supply area to Alvaston and Boulton and parts of Shardlow and Belper.

Dover.—Mr. M. Parker, who is applying for a provisional order for Deal, Sandwich, Walmer, Eastry, &c., has asked Dover Corporation to state their terms for supply of electricity in bulk.

The borough electrical engineer (Mr. L. W. Woodhouse) has prepared a preliminary report on the subject, and negotiations are to be continued on the basis of this report.

Dudley.—The annual report of the electricity department states that the capital expended at March 31 was £89,720, an increase of £2,912, chiefly expended on new cables.

There had been a reduction in the number of units sold of 44,571 compared with 1907-8. The gross profit was £5,872, a decrease of £105. Interest, repayment of loans and bank charges absorbed £5,748, and the net profit was £103.

On Tuesday, the chairman of the Streets, Tramway and Lighting committee in moving the adoption of the report, said it was satisfactory to know that the decrease had not been due to any falling off in the popularity of electricity, but to very depressed trade. The decrease was entirely confined to the tramway and motor supply. The output in connection with the tramways showed a decrease of 45,843 units. The shrinkage in the output for power was 28,700 units. As the total decrease was only 44,000 units, it was apparent that there had been a considerable increase in consumption for private lighting. The total works costs was 1·560d. per unit and the average price per unit sold 1·573d.

The report was adopted.

East London Electrical Exhibition.—At the invitation of Mr. C. Newton Russell, electrical engineer to the borough of Shoreditch, a meeting of exhibitors was held at the electricity offices, Coronet-street, Hoxton, N., on Sept. 30, when the following committee was appointed:—

Messrs. F. Pooley (chairman), H. Harrison (vice-chairman), E. P. Barfield, T. Lambie, S. Rentell, H. Dixon (secretary, 11, Victoria-street, S.W.)

It was announced that nearly all the available space had been taken up, and firms desirous of exhibiting who have not secured space should communicate at once with Mr. Russell.

Egypt.—Suez Town and Port Tewfik are now lighted by electricity supplied by the Electricity & Ice Supply Co. The cables are partly overhead and partly underground. About 4,000 lamps are in use in dwelling houses and public buildings and 250 for lighting the public roads.

Electric Organ Blowing Equipments.—The Adnil Electric Co., who specialise in electric blowing installations for church and public hall organs, have recently received a number of orders for both direct and alternating current. We have received a list of 14 of the most important of them.

In the majority of cases the wiring installations are being carried out by local contractors. Marples' patent system of regulation is employed in all the d.c. installations and the "Adnil" single-phase self-starting a.c. motor in the a.c. installations. We have already referred to the interesting pamphlet issued by this firm, describing the various systems employed by them to meet special cases, and any interested reader can obtain a copy from the company on request.

Finchley.—In connection with the Council's proposal to light the Great North-road and Regent's Park-road by arc lamps, for which sanction to a loan of £2,000 was applied for some time ago, the L.G. Board have again intimated that they consider the Council should carefully consider the relative cost of public lighting by gas and electricity. The Council, in reply, say they have nothing to add to their previous letter, that they consider they are the best judges of the character of illuminant to be adopted for any public thoroughfare, and they have also decided to expend out of the current rate £240 for the electric lighting of Regent's Park-road.

Germany.—Consul General Schwabach, in dealing with the subject [illegible] in his report on the year 1908, says: Some of the [illegible] concerns made special efforts to put a first class article on the market at a moderate price, and with this object in view they [illegible] to reorganise their works by means of the centralisation of various departments and by affiliation with makers of celebrated brands likely to command a ready sale in the future. Experiments are being carried on in Berlin with a new type of electrically-driven motor omnibuses; when fully charged these vehicles can carry 36 passengers a distance of over 80 miles at an average speed of 12½ miles per hour; but, as the working expenses are very heavy, it is considered that they would be run at a profit only on lines with plenty of short-distance traffic.

Gillingham (Kent).—The Council have appointed Mr. John F. C. Snell, [illegible] an inclusive fee of 150 guineas, to prepare a report upon the present position of the electricity undertaking.

Hounslow.—For the year ended March 31 there was a profit on the electricity undertaking of £293. The chairman of the committee at the last meeting of the Council said that in the report of the auditor the deficiency in the revenue account of £1,200 had been decreased by £676. 19s. 4d. If they continued the same method of work, they would in five years' time be in a good position.

Huddersfield.—The Board of Trade arbitrator (Mr. W. W. Beaumont) sat on Thursday last to hear the evidence as to the works to be executed by Linthwaite Council in order to put their tramway track into good repair and working condition, in accordance with an agreement between them and Huddersfield Corporation by which body the lines were leased to the latter in June, 1899. The parties were legally represented. The proceedings were private and the arbitrator will give his award in due course.

Ilford.—The salary of the superintendent of the electricity works (Mr. J. R. Myers) has been increased to £200.

India.—The "Indian and Eastern Engineer" states that the European portion of Pondicherry is now lighted electrically.

Messrs. Siemens Bros. supplied the generating plant, which was started in July. It is expected that the native quarter of the town will also have electric light by the end of the year. There are two suction gas engines, each driving a 14 kw., 460 volt, d.-c. generator. The distribution is on the three-wire system, and the voltage at consumers' terminals is 220. Street lighting so far comprises 324 lights.

Irvine (N.B.)—The Council have received an intimation that a firm of manufacturers would erect large works in the town provided a cheap supply of electricity for power and lighting were available, and consequently the Council have decided to consider in committee the whole question of electricity supply.

Islington (London).—Reporting upon the accounts of the electricity department the district auditor (Mr. A. Carson Roberts) states that:

The overcharges for current supplied for public lighting was the most important defect referred to in his 1907 report. The charge at that date was 3·31d. per unit approximately double the average amount charged in other metropolitan boroughs. It was reduced as from March 31, 1907, to 2·6d. per unit, and has recently been further reduced, as from March 31, 1909, to about 2d. per unit. The absence of charge to the electricity revenue account of a fair share of the central establishment expenses has been set right from March 31, 1907, and no objection has been raised to the amounts which have been charged since that date.

The financial position shown at the close of the 13th year of working is considerably better than that which appeared at the close of the 11th, and it is apparent that the statements in regard to it which are set out in the accounts are no longer to any very large extent affected by the defects which he then had to report. The following facts are also of importance to a complete review of the position, and it will be seen that they all tend to give an improved estimate thereof:—

(1) The loans are no longer being raised upon the equated period of 42 years, but upon specific periods estimated to be within the lives of the several items; (2) the output and number of connections has shown a satisfactory growth during the interval when allowance is made for the reduction in the consumption for private light due to the introduction of metal filament lamps; (3) the engineer certifies that the plant has been maintained out of revenue in a fit and proper condition, and that all plant and machinery which has been discarded has been taken off the list of capital assets; (4) the cost of generation per unit has been reduced, and the load factor has improved.

Italy.—A decree granting to the Societa Anon. Les Tramways de Bologne powers to construct and work an electric tramway from the Alemanni terminus to Crociali di Bologna has been issued.

[illegible] Anon. des Tramways de Livourne have been authorised to construct and work an electric tramway from Piazza Cavour-San Iacopo [illegible] Leghorn.

During 1908 a large electric generating station was erected in Messina and a supply given for private lighting. Owing to an unexpired contract between Messina Council and the gas company the street lighting by electricity could not be undertaken except along the quay, where several arc lamps had been erected. An agreement was come to for the conversion to electric traction of the steam tramway which ran through Messina and along the coast to the south and north of that city. These works were, it is believed, completely destroyed by the earthquake which occurred in December last.

The Società Anonima Tramvia e Ferrovia Elettrica Civita Castellana Viterbo has obtained a 70 years' concession for a branch line between Civita Castellana and Viterbo. The total length will be nearly 30 miles, and it will be constructed to a metre gauge, and will be worked by electricity. The State will grant an annual subvention of £240 per mile for 35 years.

Italy's Telephone Service.—The financial arrangements of the Italian Government for 1908-9 include £364,831 for the taking over of the telephone lines by the State and £339,240 for improving the telephone service.

Japan.—Osaka City Assembly have voted £60,000 for restoration work in the city, necessitated by the recent fire. Amongst other work to be done is the construction of electric tramways to connect with the existing system.

The "Bulletin Commercial" of Brussels reports that there are good openings in Japan for all kinds of electrical machinery and appliances. There are 177 firms and companies engaged in electrical enterprises, 146 providing electricity for light and power, their total capacity being about 300,000 kw. Some 210,000 houses are lighted electrically and 860,000 incandescent and 910 arc lamps are installed. The Tokio Electric Light Co. has three power stations and nine sub-stations, is about to add to its plant four generating sets and 47 transformers, and has under consideration the erection of new power stations, sub-stations, &c. Several other companies are also about to undertake improvements and extensions, whilst others newly constituted have not yet completed their installations. The number of officially recognised electric tramway companies is 60; but only about 20 are working, the installations being generally slow for lack of capital. Some of these companies supply also electric light and power, the most important being the Tokio Jetsudo Kabushika Kaisha, which is about to carry out considerable extensions.

London County Council Tramways.—Col. Yorke inspected the new section of the electric tramways between Queen's-road, Battersea, and Clapham Junction, via Lavender-hill, on Wednesday, and expressed his satisfaction with the way the line had been constructed.

Marylebone (London).—For the June quarter the gross income of the electricity undertaking from the sale of current to private consumers was £23,303, compared with £22,002 for the corresponding quarter of 1908, and meter rents, public lighting charges, &c., bring the total income to £25,530, an increase of £1,528, due to large consumers connected during the 12 months.

The units sold were 1,864,294, an increase of 18·8 per cent. The average price of current was 3·24d. per unit sold against 3·66d., and the fall in price has been balanced by the large additional business and improved load factor, and the extended sale of current for power. The total costs for the quarter were 1·29 against 1·54d., and 1·78d. in the corresponding periods of 1908 and 1907.

Up to Sept. 25, 1,760 of the 1,964 street lamps the Council resolved to light by electricity in place of gas, had been converted, and the results have been quite satisfactory. As a considerable saving in street light expenditure will be effected in the extension of the system, 165 more street gas lamps are to be converted on the same terms, and authority has been given for further lamps to be taken over as mains are extended. £500 has been earmarked from revenue surplus to be used as occasion requires for the purchase of apparatus to be hired from the Department by consumers. A scheme of commissions for sales department representatives has been approved. The rates vary in the general manager's discretion within an approved maximum or minimum.

Middlesex Tramways.—The Acton to Willesden tramway route was opened for traffic yesterday, Thursday.

National Electrical Manufacturers' Association.—The next committee meeting of this association will be held on Tuesday, Oct. 12, at Balfour House, Finsbury Pavement, E.C., at 2:30.

National Institution of Apprenticeship.—The report of this Institution for 1908 has been issued. It is a philanthropic undertaking, supported by voluntary contributions, and its object is to effect apprenticeship on conditions which will prove a benefit to both boys and girls.

It is pointed out that there is a revival in the interest taken in the subject of apprenticeship, and we desire to join in the general recognition of the advantages of the system. We attribute a great deal of our trading troubles to the lukewarmness, not to say indifference, which has been shown on this most important question in the immediately preceding quarter of a century. We believe the importance of the apprenticeship question cannot be exaggerated, and it is therefore gratifying to know that the National Institution of Apprenticeship, which has a powerful Council and committees, is successful in its working. On the Council the name of Mr. W. C. Steadman, M.P., is included, and this is somewhat of a surprise to us, as we were under the impression that Mr. Steadman was not enamoured of the apprenticeship idea, and, more particularly, of the probationary period stipulated for in the regulations of the National Institution.

The report states that during 1908 1,157 applicants for apprenticeships were interviewed, but a large number of parents withdrew their applications when they were informed that the wages paid to appren-

tices for the first year or two were lower than those paid to messenger boys and the like. Over 600 applicants received advice and 182 apprenticeship indentures were signed. This brings the total of apprentices bound through the medium of the institution to 505, and there are 60 more boys on probation. The number of "National" apprentices in the purely electrical branches is 37, the electrical and allied trades being (next to the printing business) the most popular. The institution receives warm support from many of the principal City Guilds, and the list of subscribers contains the names of a number of the leaders of industry in this country. Many of our readers will be interested in the published particulars relating to this institution, and the hon. sec., Mr. J. S. Ballin, 39, York-place, Baker-street, W. (telephone 4,342 Mayfair), will be pleased to suppy these on application.

Obituary.—The death is announced of Mr. Frederic Newton, late head of the firm of Newton & Co., electrical and general scientific instrument makers, 3, Fleet-street, London, E.C. Mr. Newton was in his 85th year.

The death is also announced of Mr. A. A. Cahen, B.Sc., A.M.I.E.E., in his 30th year. Mr. Cahen finished his education at the Central Technical College, South Kensington, and, leaving college, spent some years with Marconi's Wireless Telegraph Co. in South America, Spain, Germany and France. He left the Marconi Co. to take up an important position with Callender's Cable & Construction Co. at Erith, but about a year ago he was stricken with a painful illness which ultimately proved fatal.

Servia.—The communal authorities of Velke Hradiste have applied for powers to erect large electrical works.

Sevenoaks.—Mr. Freeman proposes to erect overhead wires for electric lighting at Otford and has asked Sevenoaks Rural Council to consent to the erection.

South Africa.—The "British and South African Export Gazette" states that three 2,000 kw. generators are to be ordered for the new Farrar Anglo-French power station.

It is understood that orders will shortly be placed for electric motors by the Rand Water Board.

Orders for telephone and telegraph material for the Transvaal Government may be expected shortly.

Monomotapa Concessions (Ltd.) will shortly be in the market for large hydro-electric plant.

"South Africa" says Roodepoort-Maraisburg Municipality are making arrangements to take a supply of electrical energy from the Victoria Falls Power Co., for distribution in Maraisburg, Florida and Roodepoort.

The Centro Commercial (the new Chamber of Commerce at Lourenço Marques) has urged upon the Government that electric generating plants should be inspected by a Government inspector.

Spalding.—As the Council have been informed by the Board of Trade that, unless their provisional order of 1905 is put into force it will be revoked, a special committee has been formed to deal with the question.

Stourbridge.—The Midland Electric Corporation for power distribution has commenced the supply of electricity in this district.

Stretford.—On Wednesday the annual abstract of the accounts of the Council was submitted.

The total capital expended on the electricity department was £78,559 and the loans sanctioned amounted to £93,969. On the trading account there was a net surplus of £1,117 after meeting interest and loan repayments. The total to credit of reserve and renewal fund was £6,508.

Telegraphic Codes in Turkey.—It is announced that the Imperial Ottoman Government has decided to allow the use of certain selected telegraph codes in Turkey.

Tonbridge.—The Council have decided, contrary to a recommendation of a committee, to obtain centrifugal pumps for pumping the sewage, and these pumps are to be driven electrically, current being supplied from the Council's mains.

Turkey.—The U.S. Consul at Brunswick (Mr. T. J. Albert) states that the group of Continental electrical manufacturers and financiers formed to promote electrical enterprises in Turkey and the East includes the Ges. fur Elektrische Unternehmungen, the Elektrische Licht u. Kraftanlagen A.G., and other firms closely related to the Siemens Schuckert Co., the Allgemeine Elek. Ges., the Kommerz u. Disconto Bank, M. M. Warburg & Co. (bankers), the Zurich Bank for Electrical Enterprises, the Soc. Generale de Paris, the Banque Ottomane, A. Spitzer & Co. (Paris) and Josse Allard (Brussels). The entire syndicate is being organised by the Deutsche Bank (Berlin).

Whitby.—The annual report of the electricity department, which has just been issued, shows a profit of £700 for the past year.

Will.—The will of the late Mr. Hugh Erat Harrison, principal of Faraday House, has been proved, and the estate has been valued at £17,012. Among the bequests is one of £100 to Mr. Howard Foulds, secretary of Faraday House.

Winchester.—Hants County Council have decided to wire the new county offices.

Wireless Telegraph Notes.—Prof. Stroud, of Armstrong College, Newcastle-on-Tyne, on Saturday last addressed an audience at the college (which is a licensed experimental station for wireless telegraphy) on the general principles of the method of communication by means of electric waves. Numerous experiments with lantern slides were employed by Prof. Stroud, whose address was much appreciated by his hearers. Communication was kept up during the lecture with Cullercoats.

A correspondent at Simla states that the Indian Government recently issued an order making the importation of wireless telegraph apparatus contraband. It is understood that the Government is considering a scheme to provide important centres in India with a wireless system worked entirely under European control. Lord Morley is likely to be addressed on the subject shortly. (It may be added that the report that the Indian Government contemplates a considerable scheme is denied in some quarters. There is a station at Bombay, and the P. & O. steamer "Mantua," due at Bombay, Oct. 22, will be the first ship to exchange wireless messages with India.)

The Admiralty are in course of erecting at Wick, N.B., a wireless telegraphy station. The West Banks has been selected for the site of the station, which is to be completed early in 1910.

Wireless Telephone Notes.—In a communication to the "Liverpool Post and Mercury" Dr. J. Erskine-Murray has pointed out the many advantages which wireless telephony offers to ships at sea. Dr. Murray concluded his communication as follows :—

Every vessel or land station could be spoken to, through fine or bad weather, directly, and with the rapidity of question and answer which is so distinctive a feature of telephony. It is possible to have a general conversation between several persons, all at different places, by wireless telephone. Thus the arrangements between several vessels entering port and the harbour master, or between the component units of a fleet, can be made directly, each person concerned joining in the conversation when necessary.

Woolwich.—The Electricity committee have received application for electric power for a large building which is due to be completed and ready for use by the end of the year.

The committee's estimate was accepted for wiring a prominent institution in the borough, and this work was carried out by C. J. Wilkins & Son, of New Cross.

The charge to the electricity department for steam generated from refuse and to be used for the generation of electrical energy is to be 0·072d. per unit, equivalent to £657. 2s. 6d. for the year ended March 31 next.

The Council have obtained sanction to a loan of £3,060 for extensions of the electricity supply mains.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Directors of the Great Western Railway invite tenders for one year's supply (from Dec. 1, 1909, to Nov. 30, 1910) of various stores, including electric wires and cables, telegraph ironwork and tools, electric light carbons, telegraph apparatus (insulators, &c.), and drysalteries, rivets, bolts and nuts, fishplates, nails, screws, galvanised goods, indiarubber goods, acids and turpentines. Samples and patterns may be seen at the general stores, Swindon, from Oct. 11 to 16 inclusive. Specifications, with forms of tender, may be obtained at the offices of the stores superintendent, Swindon. Tenders, addressed to the secretary, Mr. G. K. Mills, Paddington Station, W., by Monday, 18th inst. See also an advertisement.

Tenders are invited for the supply of 50 coin attachments, suitable for coins of different values, to the Postmaster-General's department in Victoria. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 100,000 porcelain insulators to the Postmaster-General's Department, Victoria. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-st., London, S.W.

Tenders are invited for the supply to the Postmaster-General's Department, New South Wales, of a common battery switchboard for the North Sydney telephone exchange. Tender form, specifications, &c., may be obtained from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Manchester Tramways committee want tenders by 10 a.m. Oct. 19 for supply of steel tie bars and bolts and nuts. Specifications from Mr. J. M. M'Elroy, 55, Piccadilly, Manchester.

Manchester Baths and Washhouses committee want tenders by 9 a.m. Oct. 12 for the electric lighting of Cheetham baths and public hall.

WORTHING Corporation want tenders by noon Oct. 11 for supply of vulcanised bitumen sheathed concentric and triple concentric cables. Specification from the Resident Engineer at the Electricity Works.

WALLASEY Council want tenders by noon. Oct. 13 for supply of about 260 tons of tramway rails, and for fishplates, tiebars, anchor plates, points and crossings. Specification, &c., from the Public Offices, Egremont, Cheshire.

WALLASEY Council also want tenders by the morning of Oct. 19 for paper-insulated lead-covered and armoured cables, and for overhead line material, poles, wires, ears, &c., required in the construction of about 3 miles of tramways. Specifications, &c., from the Engineer, Electric Supply Station, Seaview-road, Liscard.

KEIGHLEY Corporation want tenders by Oct. 16 for supply of two boiler feed pumps, h.t. switchboard and transformers, 300 kw. motor-generator and mains. Specifications from the borough electrical engineer.

BRUMBY and FRODINGHAM Council want tenders by Oct. 16 for the electric lighting of the streets. Specifications, &c., from Mr. J. Green, Council Offices, Frodingham, Scunthorpe.

BRAY (Ireland) Council want tenders by 10 a.m. Oct. 19 for the supply of 50 B.H.P. Diesel oil engine, high and low-tension disconnecting boxes, &c. Specifications, &c., from the Electrical Engineer.

LOURENCO MARQUES Port and Railway Department want tenders by cable by Oct. 16 or by mail by Nov. 5, for supply and erection of a 60-ton electric crane and coal handling appliances. Specifications will only be issued to crane builders.

Tenders are invited by the Director-General of Public Works, Madrid, for a 60 years' concession for the construction and working of an electric tramway from the Calle Mayor del Gras to the end of the West Quay, VALENCIA. The "Madrid Gazette" for Sept. 23 contains particulars and may be seen at 73, Basinghall-street, London, E.C.

The Director-General of Posts and Telegraphs, Madrid, wants tenders by noon, Nov. 2, for the working of the urban telephone system at ORVIEDO, the present lease expiring on Oct. 31. Deposit of £110 (to be increased to £330) is required. The "Madrid Gazette" of Sept. 24, containing particulars, may be seen at 73, Basinghall-street, London, E.C.

Tenders will be received at the Préfecture of Calvados, CAEN, until Nov. 15 for the concession for a tramway from Mezidon to Pont l'Evêque.

Tenders will be received until Oct. 16 at the Gas, Water and Electricity Offices, ALTONA, Germany, for the supply of an electric locomotive with accumulators.

TENDERS RECEIVED AND ACCEPTED.

Woolwich Borough Council received the following tenders for 580 yds. of four core 0·05 cable:—

W. T. Henley's Telegraph Works Co. (*accepted*), £152. 11s. 6d.; Siemens Bros. & Co., £154. 8s. 6d.; Callender's Co., £158. 10. For 310 yds. of 0·2 and 250 yds. of 0·05 cable the following tenders were received: Siemens Bros. & Co. (*accepted*), £46. 14s. 7d., alternative £192; W. T. Henley's Co., £47. 8s., alternative £194. 7s.; Callender's Co., £48. 1. 6d., alternative, £196. 2s. 7d.

Marylebone (London) Council have accepted the tender of C. A. Parsons & Co. (at £162. 10s.) for putting carbon brushes on three turbo-generators, and that of the Auto-Recorder Co. (at £60, less 5 per cent.) for two flue gas recorders.

Kingston-on-Thames Council have accepted the tender of W. T. Henley's Telegraph Works Co. for 880 yards 0·1 sq. in. l.-t. cable at £191. 10s., and that of W. T. Glover & Co. for 880 yards of 10 ampere cable at £72.

Salford Council have accepted the tender of the Tudor Accumulator Co. for the maintenance of the battery supplied by them in July last for 10 years, with the option of extension at £530 per annum.

Fulham (London) Council has accepted the tender of the Electrical Co. (the lowest tender received) for 150 meters in various sizes for £202. 5s.

St. Pancras (London) Council received three tenders for rewinding a 500 kw. armature at Regent's Park station, and the lowest (that of White, Jacoby & Co.) at £130 was accepted.

Bearpark (co. Durham) Council have accepted the tender of Mr. Holliday for overhead lines and for supplying current for 10 25 c.p. lamps for lighting Broom-lane at £40.

Salford Baths committee have accepted the tender of B. Thomas for supplying and fixing two "Westminster" arc lamps at the Sedley baths.

Stoke-on-Trent Guardians have accepted the tender of Electromotors (Ltd.) for an 11 H.P. motor and starter at £58.

Halifax Guardians have accepted the tender of J. Sunderland & Co. for electrical fittings for six months.

Mansfield Council have accepted the tender of the Western Electric Co. for 500 yards of cable.

Smethwick Council have accepted the tender of H. W. Ludlow for wiring the fire station at £45.

For wiring the new servants' home at Blackpool for the L. & Y. Railway Co. the tender of Geo. Morrison has been accepted.

Messrs. Gent & Co. have recently supplied a number of electric clocks for the Cape Government Railways Department.

Luton Guardians have accepted the tender of P. T. King for wiring the workhouse.

Brighton Lighting committee have accepted the tender of Siemens Bros. & Co. for cables at £2,380.

Warrington Guardians have accepted the tender of the Economic Electrical Co. for six months' electrical requisites.

Hull Corporation have accepted the tender of C. J. Thursfield & Co. for the electric light fittings for the new town hall at £891.

Derby Council have accepted the tender of Taylor, Whiting & Taylor for wiring the Kedleston-road schools at £235.

Grimsby Council have accepted the tender of Johnson & Phillips for two years' supply of cables at £756. 19s. 1d.

York Council have placed an order with Dick, Kerr & Co. for extensions of the electric lighting mains.

York Corporation have accepted the tender of Cox-Walkers (Ltd.) for the supply and erection of a traction switchboard at £383. 8s. 1d.

BUSINESS NOTICES.

Messrs. Arthur L. Gibson & Co. have removed to Radnor Works, Strawberry Vale, Twickenham.

The Beck Flame Lamps (Ltd.) have removed their offices to Suffolk House, Laurence Pountney-hill, London, E.C.

The Holophane Glass Co. have removed to 12, Cartaret-street, Westminster, S.W. Telegraph address remains "Holophane London." Telephone No. 2491 Victoria.

Messrs. Geary, Adams & Co. (Ltd.), electric light and power engineers, 25, Central-arcade, Wolverhampton, have been appointed sole agents for Birmingham and district for Messrs. Davey, Paxman & Co.'s vertical high-speed and horizontal low-speed steam engines, boilers and superheaters, condensing plant, gas engines and producer gas plant, &c.

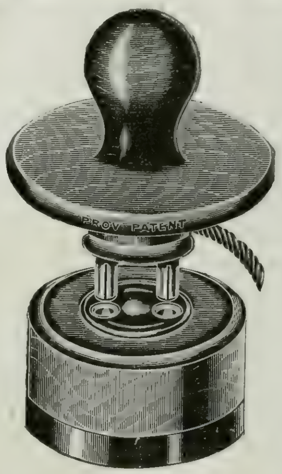
Patent Development.—The proprietor of patent No. 29,363/1904, for "Improvements in and relating to Electrical Measuring Instruments," desires to enter into arrangements for exploiting and developing same in this country. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

"Metfil" Lamps.—The following unsolicited testimonial has been received by the Edison & Swan Co. from one of their customers:—

Sept. 24.

DEAR SIRS: We have to day despatched for your inspection one of your 32 c.p. 100-volt Metfil lamps. This has been in use for 5,880 hours, and has only just burned out.

New Hand Shield Plug.—The accompanying illustration shows a new hand shield plug, recently placed on the market by the British Central Electrical Co. This plug has been specially designed to comply with the Home Office regulations, and, as may be seen from the illustration, the shield is provided to protect the operator against all shocks and burns. Further, the new method of cable attachment entirely overcomes the rapid deterioration of the flexible and the consequent dangers that exist with many of the present designs of plugs. The handle, it is claimed, provides an efficient means of removing the plug, and the existing method of pulling the plug out by tension on the flexible is prevented, as, in this case, the plug can only be withdrawn by applying the hand to the handle.



New Hand Shield Plug.

CATALOGUES, &c.

Fuse Boxes.—The Reason Mfg. Co., Brighton, have issued a new fuse-box catalogue, containing full details of house-service fuse boxes of various kinds. Fuse boxes for single cables and multiple way fuse boxes of a more important character for use with cables of large size are also described. Engineers who are in a position to give orders for this class of work should certainly see what the Reason Mfg. Co. can supply in this way.

"Marion" Lamps.—Messrs. Marion & Co., Soho-square, London, have ready an artistic pamphlet giving illustrations (photographs) which have been taken by Boardman's multi-carbon arc lamp. The details of some of the apparatus used in connection with this lamp are also given.

Tantalum Lamp Folders and Show Cards.—Messrs. Siemens Bros. Dynamo Works are continuing, with unabated energy, their campaign in favour of Tantalum lamps. As an aid to this work, a new folder has been issued which contains the principal points of interest in connection with these lamps. A space is left at the bottom of the front page, on which Messrs. Siemens will print the name and address of any electrical contractor or ironmonger who wishes to handle these lamps, and to whom many thousands of these pamphlets have been supplied. Messrs. Siemens are glad to supply any of these pamphlets free of charge.

The accompanying illustration shows a new design of show card which has recently been got out. This is well designed in attractive colours, and if the electrical contractors who stock "tantalums" give it a prominent position it should be to their advantage. Messrs. Siemens are absolutely certain that the lamp gives entire satisfaction to the consumer, both from the point of view of satisfactory illumination and economy in the lighting account.

Empire Engines.—The Empire Engineering Co. have issued a catalogue dealing with their well-known petrol and gas engines. The principal features are shortly described, and a good idea can be obtained of the work this plant is capable of doing.

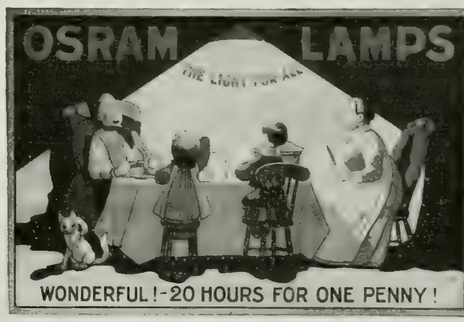
Bearings.—Messrs. Kynochs (Ltd.), Birmingham, have sent us leaflets dealing with roller and self-oiling bearings.

Electric Radiators.—The Dowsing Radiant Heat Co. forward a copy of a pamphlet dealing with their well known type of radiators. Various forms of these handsome appliances are illustrated and described, so that a good idea can be obtained of the class of work turned out by the company. A number of new types have been added this season, designs such as "Adams," "Flemish," "Georgian," "Sheriton," "Tudor," &c.

Illustrations as Samples of Leather Belting.—One of the most realistically illustrated lists we have seen is a new copyright catalogue being sent out by Mr. James Hendry, the well-known laminated leather belting manufacturer, of Glasgow. The illustrations are first-rate substitutes for samples of the articles Mr. Hendry manufactures, and show more than it is possible to show with samples. The letterpress serves as a monograph on the use of leather belting which should be of much practical interest to users, who might usefully apply for a copy of this publication (entitled "From a Single Strand") to the Laminated Leather Works, Bridgeton, Glasgow.

Insulation Tester.—The Union Electric Co. forward a pamphlet describing a new insulation tester. This apparatus, it is considered, should appeal particularly to contractors who require an efficient and yet not too expensive testing set, and, further, one they are able to carry about without trouble or fatigue. It should also appeal to the mining industry, and, in fact, should prove useful in all places where electrical machinery is used, for by periodical testing of the equipment many faults can be discovered before they have badly developed.

Osram Lamp Poster.—We have received from the General Electric Co. an example of their latest Osram show card, a reduced facsimile of which is given in the accompanying illustration. We must congratulate the artist on the facial expressions, not forgetting the harmless, necessary cat. The striking feature of this card is the announcement, "20 hours for 1d." This showcard and postcard business is getting exciting.



English Gauges.—Mr. H. M. Budgett, of Chelmsford, has sent us a copy of a list dealing with English-made gauges. Those interested in these goods should certainly secure a copy of this list.

Electricity for all Industrial Purposes.—The Union Electric Co. have issued a brochure with this title, containing a number of illustrations showing Union motors doing all classes of work. These include large polyphase motors for direct coupling to machinery, such as mine-exhausing fans, and polyphase motors driving screen separators at a coal mine are also shown, while electrically-driven pumps, bending and straightening rolls, girder cutters, saws, boring mills and other similar plant, textile machinery, cranks and traversing plant of various kinds driven electrically are also illustrated and described.

BANKRUPTCIES, &c.

A meeting will be held at Basildon House, Moorgate-street, London, E.C., on Nov. 8, to receive an account of the winding up of the Mexican Power Development Synd. (Ltd.), in vol. liq.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted a quotation to a further issue of £175,000 5 per cent. mortgage debenture stock (in lieu of Loch Leven debentures now quoted) of the *British Aluminium Co.* The committee have been asked to appoint a special settling day in, and grant a quotation to £700,000 5 per cent. 1st debenture stock of the *Para Electric Railways and Lighting Co. (Ltd.)*, and to allow a further issue of $61,000 5 per cent. consolidated first mortgage bonds of the *Shawinigan Water and Power Co.* to be quoted.

COMPANIES' MEETINGS AND REPORTS.

Willans & Robinson (Ltd.)

The ordinary general meeting was held on Tuesday, Mr. JAMES C. PEACHE, M.Inst.C.E. (Managing Director) in the chair.

The SECRETARY (Mr. C. S. Essex) read the notice convening the meeting, and the auditors' certificate.

The CHAIRMAN then said the result shown for the half-year's working has been, the directors regret to say, unsatisfactory. After allowing for the loss on the half-year's working, the balance standing to credit of profit and loss is insufficient to provide for payment of the full preference dividend, and there is no surplus to go to payment of interest on, or redemption of the funding certificates. The directors realise it is a result that the shareholders must view with concern and anxiety.

This disappointing result is entirely due to the continued depression in trade. The principal business of this company is the production of machinery for the generation of electricity, a line of business that has been adversely affected to a greater extent than perhaps any other in this country. The introduction of the metallic filament lamp and the great economy in current realised by its use, is having a very serious effect on the revenue of electric lighting stations, and in all parts of the country the output of current is falling off, and electricity concerns, instead of having to order new plant, are finding that their existing plant is in excess of their present requirements. In the end no doubt this cheapening of electric light will lead to a great extension of its use, and renewed demand for plant. For the present, however, new construction is at a standstill, and the business of building electric generating plant, for this country at all events, is in a state of stagnation. The orders obtained in recent half-years have been insufficient to keep the works fully employed. In the second half of 1908 the value of orders obtained was disappointing, but that half-year profited by a large balance of unexecuted orders brought forward. In the first half of 1909 (the half-year we are considering) the value of orders obtained was considerably larger than in the previous half-year. That is an encouraging feature, but the bulk of our old orders had then been worked off, and for two months in that half-year it was necessary to put the works on short time. Since June, I regret to say that the improvement experienced in the early part of the year has not been maintained, and there is no doubt that for the present, and for the immediate future, we have to face a continued scarcity of work. We have devoted great efforts to obtaining orders for steam turbines abroad, and in this direction we have met with considerable success. We have obtained good orders for Canada, Australia, South Africa, and Japan. Indeed, in the absence of work coming forward for this country, the bulk of our orders for electrical generating plant has been from abroad. We have endeavoured with some success to extend our connection with industrial concerns in this country, and have supplied a number of turbine plants for driving the machinery of cotton mills, collieries, harbour works, and so forth, but in these directions have been restricted by the general depressed state of trade.

Under our agreement with the English Diesel Company we are entitled to a considerable volume of orders for Diesel oil engines. Unfortunately, due to the depressed state of trade, the Diesel Company has not so far been able to keep us supplied with orders at the rate we are entitled to expect under our agreement. We are still building a certain number of Willans engines, and have several in course of manufacture at the present time. Repair parts also furnish us with a substantial volume of work. Condensing plant, a comparatively new manufacture with us, brings in a certain number of orders. Parts for motor vehicles also give us profitable employment, but all branches are adversely affected by the present slackness.

There are several new branches of manufacture in process of development. Hydraulic turbines and high-lift turbo pumps form two of these, and there are a number of both on order. The first of the turbo pumps has passed its trials with most satisfactory results. In this new departure we have the co-operation of Mr. Orten-Böving, an engineer of wide experience in the manufacture and working of hydraulic turbines and pumps. He has already obtained a number of orders for us, and it is hoped that an increasing business in this class of machinery may be relied upon in the future.

We are also engaged on the development of some other branches of manufacture, which have not yet reached the final stage.

Notwithstanding the poor result of the past half-year's working, the position of the Company's affairs to-day is a sound one. In cash and marketable securities we have a substantial provision against the needs of the immediate future. The cash balance at June 30 was £19,339; marketable investments £11,653; debtors £168,703, of which £74,000 has since been received, and the balance is a good asset. At December 31 last our reserve fund stood at £36,331, at June 30 it was £62,629. Since June 30 we have settled a claim arising out of a contract made for the supply of large gas engines. This contract was entered into in 1903. For some years past it has been known that the company had incurred a heavy liability on this account, and in July, acting under the advice of counsel, a settlement was arrived at by payment of £15,000. This loss has to be set against our reserve.

For the Queen's Ferry Works there has been one or two encouraging enquiries, and there is some hope that a sale may result from negotiations now in progress. In the meantime the works are being kept in good order and repair. The present depressed condition of trade is against the prospect of our being able to find a purchaser, but the works form a very fine industrial property, and we must be content to hold it for the present. A bad time like the present affords a favourable opportunity for cutting down expenses, and, as you are aware, the directors have devoted their special attention to this point since 1904. The process cannot be carried on indefinitely. Nevertheless during the past half-year it has been possible to effect further material reductions, and there are still other reductions that are being carried out. In bad times like these, however, certain expenditure is even more necessary than in good times. The cost of patents and development work again shows an increase, £7,974 at June 30, against £7,281 at December 31. Depreciation at the rate of 10 per cent. per annum has, as usual, been written off this half-year, but the additions during the half-year have more than balanced this. The board is not in a position to make any proposals with regard to the vacant post of chairman or additional directors. The board are giving this important matter their careful attention. The company has a most capable staff of servants, and the works are in a high state of efficiency. We trust that the present set back is but temporary, and that as, and when, the state of trade returns to a more normal condition the works are well prepared to take full advantage of it. He concluded by moving the adoption of the report and accounts.

Mr. HENRY SHERLEY-PRICE (a shareholder) seconded the resolution.

A discussion followed to which the chairman replied, and the motion was then carried with one dissentient.

A resolution was afterwards passed approving the payment of a dividend at the rate of 3 per cent. per annum on the preference shares.

A cordial vote of thanks was passed to the chairman and directors, and the proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

HALESOWEN LIGHTING & TRACTION CO. (LTD.) (105,136.)—Reg. Sept. 29, capital £10,000 in £1 shares, to acquire the rights, powers and privileges granted to G. Balfour by the provisional order for Halesowen (Worcs.) as amended and confirmed by the Electric Lighting Orders Confirmation (No. 1) Act, 1908, and to carry on the business of electricians, suppliers of electricity, &c. First directors, G. Balfour, W. Shearer and A. H. Beatty.

STATUTORY RETURNS.

BRAY, MARKHAM & REISS (LTD.)—Return to Aug. 9 gives capital as £20,000 in £1 shares, of which 8,000 shares have been taken up. £8,000 has been received. Mortgages and charges nil.

ELECTRIC SUPPLY CO. OF VICTORIA (LTD,)—Return to Sept. 2 gives capital as £300,000 in £1 shares (150,000 preference), of which 147,375 preference and 125,000 ordinary have been taken up. £1 per share has been called up on 22,382 and £22,382 has been received. £249,993 is considered as paid. Mortgages and charges, £167,955.

MORTGAGES AND CHARGES.

DAVIS ELECTRICAL CO. (LTD.)—Issue on Sept. 22 of £500 debentures, part of series created Nov. 12, 1908, to secure £2,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £500.

PENRITH ELECTRIC SUPPLY CO. (LTD.)—Mortgage on certain land and premises in Penrith, dated Sept. 1, 1909, to secure all moneys due or to become due to the Bradford District Bank.

RECEIVERSHIPS.

LIONEL ROBINSON & CO. (LTD.)—H. J. Page, 21, Ironmonger-lane, E.C., ceased to act as receiver or manager on Sept. 25.

CITY NOTES.

MEMORANDA (Oct. 7).—Bank rate 3 per cent. (October 7, 1909). Price of silver, 23$\frac{11}{16}$d. per oz. Consols 83—83$\frac{1}{8}$ for money; 83$\frac{1}{16}$—83$\frac{3}{16}$ for account. Consols Pay Day, Nov. 4; Stock and Shares Continuation Days, Oct. 12 and 26; Ticket Days, Oct. 13 and 27; Pay Days, Oct. 14 and 28; Mining Shares Carry Over Days, Oct. 11 and 25.

PRICES OF METALS (London).—*Copper*, cash, 57$\frac{15}{16}$; three months 58$\frac{7}{8}$. *Lead*, English, 13$\frac{1}{2}$—13$\frac{3}{4}$; foreign, cash, 13$\frac{1}{4}$—13$\frac{5}{16}$; three months, 13$\frac{7}{16}$. *Spelter*, cash, 23$\frac{1}{2}$; three months 23$\frac{3}{8}$—23$\frac{1}{4}$. *Tin*, English, 136—138; foreign, cash, 139$\frac{1}{4}$; three months, 140$\frac{3}{8}$. *Iron*, Cleveland, cash, 52/4$\frac{1}{2}$, and three months, 52/11$\frac{1}{2}$. *Magnet Steel* (price supplied by W. F. Dennis & Co.), £55.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have resolved, after placing £5,000 to credit of renewal fund, to declare an interim dividend for the quarter ended Sept. 30 of 15s. per cent. on the ordinary stock and £1 10s. per cent. on the preferred stock (less tax), payable on Nov. 1.

BRISBANE ELECTRIC TRAMWAYS INVESTMENT CO. (LTD.)—The directors have decided to pay a dividend of 3s. 6d. each on the ordinary shares (tax free) for the half-year ended June 30.

CALCUTTA TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend of 2s. per share on the ordinary shares (at the rate of 4 per cent.), tax free, for the half-year to June 30.

PARA ELECTRIC RAILWAYS AND LIGHTING CO. (LTD.)—The directors announce a dividend on the preference shares for the half-year ended May 31, at the rate of 6 per cent. per annum (less tax).

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate: No. of weeks.	Aggregate: Amount.	Aggregate: Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 29	1,506	+ 63	17	26,636	− 521
Airdrie	„ 24	224	− 4	38	8,316	− 83
Anglo-Argentine	„ 30	39,071	+ 1,816	39	1,521,564	+ 92,730
Ayr Corporation	Oct. 2	275	− 31	20	8,105	− 72
Baker St. & Waterloo Ry.	„ 2	3,130	...	13	38,025	− 70
Barnsley	Sept. 24	167	− 10	38	6,429	− 329
Barrow	„ 24	248	− 24	38	8,949	− 614
Bath Electric Trams, Ltd.	„ 29	841	+ 5	39	30,770	+ 1,145
Birmingham Corporation	Oct. 2	7,076	+ 395	27	174,703	+ 4,367
Birmingham & Mid.	Sept. 17	849	+ 12	37	31,225	+ 316
Blackburn Corporation	Oct. 4	1,075	− 109	27	30,647	− 852
Blackpool and Fleetwood	„ 2	798	+ 2	...	...	...
Bolton Corporation	„ 3	2,310	− 170	27	63,895	− 338
Bombay	Sept. 2	R39,681	+ R3,973	35	R1,316,774	+ R80,653
Bournemouth Corporation.	„ 29	1,692	+ 60	26	48,072	+ 223
Bradford Corporation	Oct. 2	5,036	− 16	26	132,444	+ 3,567
Brighton Corporation	„ 3	959	− 84	27	28,715	+ 1,326
Bristol Trams & Carriage	„ 1	5,914	+ 644	19	112,692	+ 6,553
Burnley Corporation	„ 2	1,368	+ 9	...	...	...
Burton Corporation	„ 3	271	− 20	27	7,269	− 207
Bury Corporation	„ 3	1,171	− 171	†27	32,186	− 599
Calcutta Tramways Co.	„ 2	R51,326	− R1,550	13	R647,678	+ R27,734
Camborne-Redruth	„ 2	129	− 18	40	4,924	− 198
Cardiff Corporation	Sept. 25	2,218	+ 55	26	58,803	+ 602
Cavehill	„ 24	106	+ 28	38	3,453	− 79
Central London Railway	Oct. 2	5,342	− 2,989	13	61,803	− 31,433
Charing C., Euston & H'stead	„ 2	3,700	+ 300	13	47,330	+ 4,970
Chatham & Dist. Lt. Rys.	Sept. 30	876	− 82	39	32,305	+ 1,628
City & South London Rly.	Oct. 3	3,045	+ 118	13	39,797	+ 1,286
City of Birmingham	Sept. 24	2,874	+ 141	38	105,454	+ 1,281
Colchester Corporation	„ 29	206	− 14	13	2,699	− 904
Cork Electric Trams Co.	„ 30	523	+ 63	13	17,570	− 604
Croydon Corporation	„ 24	1,801	+ 314	38	40,219	+ 2,527
Devonport & Dist. Trams	„ 24	357	− 104	38	14,114	− 3,529
Dover Corporation	Oct. 2	213	− 33	27	6,179	− 432
Dublin & Lucan Railway	„ 1	161	+ 14	13	2,177	+ 72
Dublin United	„ 1	5,659	+ 56	‖13	78,544	+ 1,473
Dudley-Stourbridge	Sept. 24	843	− 44	38	31,356	− 763
Dundee Corporation	„ 29	1,193	− 43	†20	23,709	− 541
East Ham Council	Oct. 2	987	+ 27	§26	27,125	+ 3,571
Exeter Corporation	„ 1	338	− 22	1	338	− 22
Gateshead & Dist. Trams	Sept. 24	1,008	− 70	38	37,853	− 443
Glasgow Corporation	Oct. 2	17,902	− 1,316	‡18	301,203	− 4,077
Glossop Trams	...	..	...	...	...	...
Gravesend—Northfleet	Sept. 24	239	+ 5	38	8,088	− 100
Great Northern & City Rly.	Oct. 2	1,374	+ 2	13	16,424	− 31
Gt. Northern, Piccadilly, &c	„ 2	5,445	+ 115	13	64,460	+ 450
Greenock & Port Glasgow	Sept. 24	621	+ 116	38	21,319	+ 1,013
Hartlepool Tramways	„ 24	252	...	38	9,060	− 187
Hastings Elec. Trams Co.	„ 30	1,107	− 97	13	18,116	− 190
Hong Kong	Oct. 2	$9,339	+ $1,714	...	...	...
Huddersfield Corpn.	„ 2	1,973	+ 270	26	44,925	+ 1,377
Hull Corporation	„ 2	2,579	+ 105	26	67,447	+ 1,143
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	Sept. 29	135	− 116	26	3,618	− 227
Ipswich Corporation	Oct. 2	423	− 34	27	11,582	+ 133
Isle of Thanet Co.	„ 2	604	− 18	52	31,981	+ 653
Jarrow	Sept. 24	116	+ 6	38	4,523	+ 412
Keighley Corporation	„ 30	171	+ 2	26	4,588	+ 160
Kidderminster & District	„ 24	126	+ 22	38	4,253	− 172
Kilmarnock Corporation	„ 2	144	− 12	20	3,059	− 115
Lanarkshire Trams Co.	„ 30	1,461	+ 41	39	50,603	− 84
Lancashire United	„ 29	1,358	− 85	39	53,152	− 446
*Leamington	„ 24	178	− 1	38	6,810	+ 248
Leeds Corporation	Oct. 2	7,042	− 66	27	184,129	+ 4,079
Leicester Corporation	„ 2	2,294	− 11	13	29,450	− 67
Leith Corporation	Sept. 25	616	+ 131	19	12,317	+ 1,643
Lincoln Corporation	Oct. 2	120	− 3	27	3,355	+ 106
Liverpool Corporation	Sept. 25	10,982	+ 322	‖38	410,895	− 1,837
Liverpool Overhead Rly.	Oct. 3	1,263	− 111	‡14	20,232	+ 55
Llandudno & Colwyn Bay Ry	„ 1	263	+ 15	44	13,054	+ 2,152
*London County Council	Sept. 18	37,982	+ 1,074	§24	856,195	+ 33,694
London United	Oct. 2	5,997	− 1,574	‖24	242,261	− 25,233
Lowestoft	...	...	...	...	...	...
Maidstone Corporation	...	...	...	...	...	...
Manchester Corporation	„ 2	15,799	− 566	27	404,806	− 3,027
Mersey Railway	„ 2	2,055	+ 113	13	25,019	+ 963
Merthyr	Sept. 24	213	− 10	38	8,184	+ 82
Metropolitan Dist. Railway	Oct. 2	9,933	+ 253	13	123,675	+ 5,451
Metropolitan Elec. Trams	Sept. 24	6,989	+ 501	38	237,565	+ 18,822
Middleton	„ 23	362	+ 33	38	13,030	− 883
Nelson Corporation	Oct. 2	143	+ 2	§26	3,807	− 21
Newcastle-on-Tyne Corp.	„ 2	3,852	− 107	26	103,576	− 1,570
Newport (Mon.)	„ 2	677	− 26	27	18,045	− 337
Northampton Corporation	„ 1	539	+ 54	‖27	13,376	+ 489
Oldham, Ashton & Hyde	Sept. 24	578	+ 5	38	21,455	− 1,237
Oldham Corporation	Oct. 3	1,820	− 263	27	51,785	− 3,788
Perth (N.B.) Corporation	Sept. 29	173	+ 8	19	3,310	+ 20
Perth (W.A.) Elec. Trams	Oct. 1	1,342	+ 30	39	51,619	+ 527
Peterborough	Sept. 24	123	− 16	38	4,536	− 376
Portsmouth Corporation	...	...	...	..	...	...
Potteries	„ 24	1,859	+ 56	34	67,593	− 1,037
Preston Corporation	„ 29	760	+ 14	13	9,960	− 12
Rotherham Corporation	„ 30	578	− 51	26	15,598	− 758
Rothesay	„ 24	255	+ 41	38	9,239	+ 177
Salford Corporation	Oct. 4	4,578	− 544	†27	124,351	− 3,824
Sheerness	Sept. 24	53	− 7	38	1,992	− 248
Sheffield Corporation	Oct. 3	5,741	− 83	§27	151,334	− 1
Singapore Trams	„ 2	$9,465	+ $668	...	...	...
South Metropolitan	Sept. 24	907	+ 17	38	30,806	− 297
South Staffs	„ 24	897	+ 12	39	31,993	− 1,578
Southend Corporation	„ 29	513	+ 40	26	16,055	+ 2,327
Southport Tramways	„ 24	309	− 2	38	11,401	− 275
Stalyb'dge, Hyde, &c., Jt. Bd.	Oct. 2	752	− 66	§26	20,868	− 598
Sunderland Corporation	„ 3	1,118	− 227	27	31,551	− 1,411
Sunderland District	Sept. 29	457	− 43	48	22,103	− 1,010
Swansea Trams	„ 24	1,052	+ 69	38	36,939	+ 841
Swindon Corporation	...	...	...	...	...	...
Taunton	„ 24	50	+ 4	38	1,568	− 26
Tynemouth and District	„ 23	251	+ 25	38	9,943	+ 787
Tyneside Trams Co.	„ 29	410	− 14	13	5,947	+ 267
Wallasey District Council	Oct. 2	953	− 4	§26	25,840	+ 690
Walsall Corpn.	„ 2	533	− 32	39	20,032	− 1,263
Warrington Corpn.	Sept. 30	378	− 5	26	10,004	+ 23
West Ham Corporation	„ 23	2,391	+ 165	25	60,246	+ 3,881
Weston-super-Mare	„ 24	192	+ 30	38	6,578	+ 406
Wolverhampton Co.	„ 24	422	− 24	38	15,995	− 1,375
Wolverhampton Corpn.	„ 29	960	+ 87	13	10,884	− 69
*Worcester	„ 24	316	− 16	38	10,908	− 128
Wrexham	„ 24	128	+ 1	38	3,802	− 136
Yorkshire W.R. Trams	Oct. 3	1,175	− 165	40	47,772	...
Yorkshire Woollen District.	Sept. 24	1,004	+ 104	38	34,858	− 71

(a) These comparisons are with the corresponding period last year. § Plus 3 days. ‖ Plus 2 days. * Partly electrical. † Minus 3 days ‡ Minus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share.	Last Dividend	Name.	Price Wed., Oct. 6.	Rate % Yielded	Dividend Due.	Business Week to Oct. [illegible]: Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	9¼ −10¼	5 17 0	Mar, Sep	9⅞	9⅞
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½ −10	4 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 −10½	5 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 −104	4 9 0	Jan, July	103	..
5	2/0	†Bromley (Kent) El. Lt. & Power Shares	4½ −4¾	6 0 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	93 −96	4 16 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7¼ −7¾	6 9 0	March	7½	7½
5	3/6	Do. 7 per Cent. Pref.	7½ −8	4 8 0	Mar, Sept	..	—
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	97 −100	4 0 0	June, Dec	..	—
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 −4½	5 16 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4½ −5	4 10 0	Feb, Aug	4½	—
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 −99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 −102	4 8 0	..	101½	101½
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅞ −4⅜	5 2 6	Jan, July	3⅞	3⅞
5	2/0	Chelsea Electric Supply Ord.	3½ −4	4 10 0	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100 −103	4 7 0	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord.	10½ −11	5 0 3	Feb, Aug	10⅞	10⅝
10	6/0	Do. 6 per Cent. Cum. Pref.	12 −12½	4 11 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 −124	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 −103	4 7 6	Jan, July	102½	—
5	..	County of Durham Elec. P.D. Ord.	1½ −2	—	April, Oct	—	..
5	2½%	Do. 5 per Cent. non Cum. Pref.	3 −3½	3 14 1	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7½ −8½	3 3 9	Feb, Aug	7½	7⅜
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞ −11½	5 8 0	Mar, Sept	11	11
St.	4½%	Do. 4½% Deb. Stock (red.)	104 −107	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 −103	4 7 6	May, Nov	102	101½
5	2/0	†Folkestone Electricity Supply Co. Ord.	4½ −4¾	5 12 6	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅝ −5⅛	4 13 6	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	97 −100	4 10 0	Feb, Aug	—	—
5	4/6	Hove Electric Lighting Ord.	7½ −7¾	5 11 6	April, Oct	..	—
5	4/0	Kensington & Knightsbridge Ord.	7 −7½	5 6 8	Feb, Aug	7	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ −5⅞	4 14 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	95 −98	4 2 0	..	—	—
St.	4%	†Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96½ −98½	3 19 6	April, Oct	..	..
St.	4½%	Kent Elec. Power Co.	85 −89	5 1 0	Jan, July	..	..
3	1/9⅜	London Electric Supply Ord.	1⅞ −2¼	3 6 8	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 −5¼	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 −97	4 2 6	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	4 −4½	6 2 0	April, Oct	4½	4½
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜ −5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	105 −108	4 2 6	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	83½ −86½	3 19 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	97 −100	4 10 0	June, Dec	..	—
10	2%	Newcastle & Dist. Elec. Ltg. Ord.	5½ −6	3 12 9	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	85 −87	5 4 8	Jan, July	..	..
5	..	Newcastle Elec. Supply Ord.	4¼ −4¾	..	Feb, Aug	—	—
5	5%	Do. 5 per Cent. non Cum. Pref.	4½ −5	5 0 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 −98	4 1 8	Jan, July	—	..
100	50/	North Metro. Elec. Power Sup. 5 Morts	100 −102	4 2 0	..	..	—
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	89 −91	5 0 0	Jan, July	—	—
10	6/0	Notting Hill Electric Ord.	12½ −13½	5 6 0	March	..	—
5	2/6	Oxford Electric Ord.	5 −5½	5 8 0	March	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	95 −98	4 2 0	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅝ −9½	5 9 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7 −7½	4 13 4	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 −88	3 19 6	Jan, July	—	..
5	..	Smithfield Markets Electric Sup. Ord.	½ −¾	—	Feb	..	..
5	4/0	South London Electric Supply Ord.	2⅞ −3	6 16 0	April	—	—
St.	5%	Do. 5% 1st Mort. Stk. Red.	101 −103	4 17 0	—	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	[illegible]	4 14 0	..	..	—
1	0 8⅖	Do. 7 per Cent. Cum. Pref.	[illegible]	5 18 0	Feb, Aug	1⅛	..
St.	4½%	†Do. 4½ 1st Db. Stk. Red.	100 −103	4 7 0	April, Oct	101	—
5	2/6	†Urban Electric Supply Ord.	⅝ −⅞	—	April, Oct	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	1¼ −1¾	..	April, Oct	—	—
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb.	74½ −79½	5 14 9	April, Oct	—	—
5	5/0	Westminster Elec. Sup. Ord.	8½ −9	5 11 0	Mar, Sept	8¾	—
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 −5½	4 3 0	Jan, July	5½	5½
		ELECTRIC RAILWAYS & TRAMWAYS.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St	99 −101	3 19 0	Jan, July	100	99½
1	..	Bath Elec. Trams Pref. Ord.	⅛ −¼	..	April	..	—
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	7 5 0	Jan, July	..	—
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	85 −89	5 1 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	87 −90	5 0 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	8 −8½	7 2 6	Feb, Aug	..	—
10	4%	Do. Cum. Pref. (fully paid)	8¼ −8¾	4 16 0	..	..	—
St.	4%	Do. 4 per Cent. Debs.	100 −101	3 19 0	Feb, Aug	..	—
10	..	British Electric Traction Ord.	½ −⅞	—	June, Dec	1	..
10	3/0	Do. 6 per Cent. Cum. Pref.	1⅝ −2⅝	12 0 0	Feb, Aug	2	1⅝
St.	5%	†Do. 5 per Cent. Perpetual Debs.	82 −85	5 15 6	April, Oct	83½	82
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	62 −65	6 16 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	61 −63	4 15 0	Feb, Aug	62½	61½
St.	4%	Do. 4 per Cent. Pref. Stock	85 −87	4 12 0	Feb, Aug	85½	..
St.	2½%	Do. Deferred Stock	43 −45	5 11 0	Feb	45	41
100	4%	Do. 4 per Cent. Debs.	101 −103	3 18 0	Jan, July	101½	..
St.	4%	Charing X, Euston & Hmpstd Per Db. Stk.	95 −97	4 2 6	Jan, July	95½	95½
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ −5¼	4 10 9	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs	98 −102	3 18 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	30½ −31½	4 1 3	Feb, Aug	30½	..
St.	5%	Do. 5 per Cent. Perp. Pref. (1891)	108 −110	4 1 0	Feb, Aug	..	..
St.	5%	Do. (1896)	101 −107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1901)	100 −103	5 2 0	Feb, Aug	..	..
St.	5%	Do. (1903)	96 −100	5 0 0	Feb, Aug	—	—
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 −102	3 15 0	May, Nov	..	..
10	6/0	Dublin United Trams. 6 per Cent. Pref.	12¾ −13¾	4 7 6	Feb, Aug	..	..
10	..	Gateshead & Dist. Trams Ord.	8½ −9	..	..	8½	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾ −1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G.P.	8 −8½	—	Feb, Aug	..	—
St.	4%	Do. 4 per Cent. Deb. Stock	93 −98	4 2 6	Jan, July	97	93¼
5	3/0	Hastings & District Elec. Trams. 6% C.P.	1¼ −1¾	..	Mar, Sept	..	—
St.	4½%	†Do. 4½ Db. St.	74 −79	5 14 0	April, Oct	..	..
10	6%	Imperial Tramways Ord.	4 −4½	13 6 8	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	5 −6	5 0 0	Mar, Sept	..	..
St.	4½%	‡Do. 4½ per Cent. Debs.	79 −81	5 11 0	Jan, July	..	—
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞ −1⅛	..	Mar, Sept	—	—
St.	4%	Do. 4 per Cent. Deb. Stock	58 −63	6 7 0	Jan, July	..	—
10	5/0	Lanarkshire Tramways	9¾ −10	5 15 0	Feb, Aug	9¾	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	89½ −90½	5 10 6	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	¾ −¼	..	Feb, Aug	—	—
10	5%	Do. 5 per Cent. Pref.	4½ −5	5 0 0	Feb, Aug	—	—
St.	4%	Do. 4 per Cent. Deb.	82 −84	4 15 3	Jan, July	—	..
10	2/6	London United Trams. 5% Cum. Pref.	2¼ −2¾	..	Jan, July	2½	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 −70	5 14 0	Jan, July	..	—
St.	—	Mersey Con. Ord. Stock	1 −2	—	Feb, Aug.	..	..
1	10⅕	Metropolitan Elec. Tramways Ord.	[illegible]	—	..	..	..
1	—	Do. Deferred	[illegible]	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 1 6	Feb, Aug	..	—
St.	4½%	Do. 4½ per Cent. Deb. Stock	94½ −95½	4 13 0	Jan, July	95½	95½
St.	1%	Metropolitan Railway Consolidated	38 −38½	1 6 0	Feb, Aug	38½	38½
St.	3½%	Do. Surplus Lands Stocks	65 −67	4 5 6	Feb, Aug	65	—
St.	3½%	Do. 3½ per Cent. Preference	89 −91	3 16 9	Feb, Aug	90½	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	86 −88	3 19 0	Feb, Aug	87½	86
St.	3½%	Do. 3½ per Cent. Convertible Pref.	85 −87	4 0 6	Feb, Aug	85½	85
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 −94	3 14 6	Jan, July	92½	—

In calculating the yield allowance has been made for accrued interest but not for redemption.
* Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Divi-dend	Name	Price Wed., Oct. 6.	Rate % Yield-ed £ s. d.	Dividend Due	Business Week to Oct. 6 High-est	Low-est
		ELECTRIC RAILWAYS & TRAMWAYS—Continued.					
St.	3½	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 8	Jan, July	91⅝	..
St.	..	[illegible] Railway Ord.	1[illegible]—16½	—	Feb, Aug	16¾	16¾
St.	..	Do. Extension Pref. (6 per Cent.)	47 —49	..	Feb, Aug	15⅝	15⅝
St.	3½	Do. [illegible] Ext. Pref. (Int. Guar. by [illegible] of London, Ltd.)	66 —68	5 3 6	Feb, Aug	67½	67
[illegible]	3½	[illegible] Rent-charge	76 —78	3 17 0	Jan, July	..	..
[illegible]	4½	[illegible] Mid and Rent-charge	101 —104	3 16 0	Jan, July	103	102¾
[illegible]	5	[illegible] Stock 4 per Cent.	93 —96	4 3 6	Mar, Sept	94½	92
St	[illegible]	[illegible] Perp. Deb. Stock	143 —145	4 2 9	Jan, July	143	..
St.	[illegible]	[illegible] Cent. Ditto	95 —97	4 2 6	Jan, July	..	..
5	..	New [illegible] Tract. 6 per Cent. Cum. Pref.	¼—⅜	—	May	..	—
1	..	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	—
1	6	Do. 5 per Cent. Cum. Pref.	¼—⅜	6 14 0	Feb, Aug	—	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	86 —89	5 1 0	May, Nov	..	..
1	0/7½	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	9 12 0	Feb, Aug	..	..
St.	4	Do. 4 per Cent. Deb. Stock	69 —73	5 9 6	Jan, July	..	—
100	5½	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	81 —85	5 18 0	Jan, July	81	..
..	..	Underground Elec. Rys. Lond. In bds. with coup. 3	34 —36	..	June, Dec	..	—
..	..	Do. 5 Prior Lien Bonds	101½—102½	4 17 0	..	101½	..
—	4½	Do. 4½ Bonds with coup. 8	87 —89	5 1 0	..	88	87½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	—	..	..	..
St	4½	Do. 4½ per Cent. 1st Debs.	81 —85	5 6 0	Jan, July	—	—
		ELECTRIC MANUFACTURING, &c.					
St.	..	Anchor Cable Co. 4½% Deb. Stock	102 —104	—	..	..	—
			1/16—⅛	..	..	1/16	..
1	..	Aron Electricity Meter Ord.	⅝—⅞	6 17 0	April, Oct	..	..
1	1/4½	Do. 6% Cum. Pf.	4⅜—4⅝	4 11 0	April, Oct	4½	4½
1	1/7	Babcock & Wilcox Ord.	1⅜—1½	4 0 0	..	..	..
1	0/7½	†Do. Pref.	7¼—7⅜	6 11 0	July, Feb	7½	7⅛
5	4/0	British Insulated & Helsby Cables Ord.	6 —6½	4 12 0	Jan, July	..	—
5	3/0	Do. 5 per Cent. Pref.	103 —106	4 3 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	89 —94	4 16 0	Mar, Sept	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	⅛—⅜	—	Feb, Aug	—	—
5	..	British Westinghouse 6 per Cent. Pref.	95 —97	6 2 6	..	96	..
1	[illegible]	†Do. 6 per Cent. Prior Lien Dbs (rd.)	38 —42	9 10 0	Jan, July	42	—
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	41 —46	9 18 0	Mar, Sept	42½	41½
St	4½%	Brush E. Eng Co 4½% Perp. 1st Deb. Stock	27 —31	14 10 0	Jan, July	.	..
St	4½%	Do. Perpetual 2nd Deb. Stock	10⅞—11⅛	5 17 0	Jan, July	10⅞	..
1	[illegible]	Callender's Cable Con. Ord.	6⅞—6⅞	4 7 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	105 —107	4 4 0	Nov, May	—	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	2 —2¼	5 18 0	May, Nov	2⅛	2⅛
1	1/0	Castner-Kellner Alkali Co.	106 —108	4 2 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	1⅛—1¼	6 11 9	March ..	..	—
1	0/1	Chadburn's (Ship) Telegraph Ord.	1 —1⅛	5 6 6	April, Oct	..	..
[illegible]	[illegible]	†Do. 6 per Cent. Cum. Pref.	⅜—½	7 0 0	August ...	1⅛	..
1	0/7½	Consolidated Electrical Co.	1⅛—1 3/16	9 8 0	April, Oct	..	..
1	1/0	Consolidated Signal Co.	⅝—1	6 0 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	13 7 0	Jan, July	..	..
[illegible]	3/0	*Crompton & Co. (Nos. 1 to 85,000)	90 —93	5 7 6	Jan, July	..	—
1	5	Do. 5 per Cent. 1st Mort. Debs. (red.)	1 —1⅛	..	Mar, Sept		—
1	0/7½	Davis & Timmins	1 —1⅛	8 18 0	Sept	1/16	..
[illegible]	[illegible]	†Dick, Kerr & Co. Ord.	1 1/16—1 3/16	5 1 0	Sept	..	..
[illegible]	0/7½	†Do. 6 per Cent. Cum. Pref.	100 —103	4 7 6	Jan, July	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	3/16—5/16	..	Feb, Aug	½	..
[illegible]	1/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1 —1⅛	9 3 0	Feb, Aug	1	—
[illegible]	2/6	Do. (£5 paid)	69 —73	5 9 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	82 —85	5 17 0	Mar, Sept	..	..
St	5%	†Do. 5 per Cent. 2nd Deb. Stock	⅛—5/16	..	Jan, July	..	—
	..	Edmundson's Elec. Corp. Ord.	⅝—⅞	..	May, Nov	..	..
6	..	Do. 6 per Cent. Cum. Pref.	57 —60	7 10 0	Jan, July	57	—
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	7/16—11/16	..	Jan, July	½	—
[illegible]	..	Electric Construction Co.	1 3/16—1 7/16	9 16 0	July	..	..
[illegible]	2/9	Do. 7 per Cent. Cum. Pref.	65—69	5 16 0	Jan, July	—	..
St	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	68½—71½	6 14 0	...	..	..
St.	5	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	8 —8½	6 18 0	June, Dec	8½	8 1/16
1	5/0	General Electric (1900) 5% Cum. Pref.	83 —87	4 12 0	Mar, Sept	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Debs.	12½—13½	5 15 6	Feb, Aug	12½	..
[illegible]	5/0	Henley's Telegraph Works Ord.	5⅛—5½	4 2	Feb, Aug	..	..
[illegible]	2/3	Do. 4½ per Cent. Pref.	106 —108	4 4 0	Mar, Sept	..	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	13⅛—15⅛	6 9 0	Feb, Aug	..	..
1	5/0	India Rubber, Gut. Per., &c., Wrks.	10½—10⅞	..	..	..	—
1	6/4	Do. 5 per Cent. Cum. Pref.	99 —101	3 19 0	April, Oct	..	—
10	4%	Do. 4 per Cent. Debs. (red.)	⅜—⅝	..	April	..	..
1	..	National Elec. Construction Co.	⅛—3/16	..	Nov	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	11/16—13/16	..	May, Nov	—	..
1	..	Do. 6 per Cent. Cum. Pref.	82 —85	5 5 0	Jan, July	..	..
5	4½%	Do. 4½ per Cent. Perp. Deb. Stock	1½	..	—	..	—
1	..	Simplex Conduits Ord.	5 —5½	..	..		
5	..	Do. 6 per Cent. Cum. Pref.	34½—36	5 0 0	Mar, July	35¾	34½
12	12/0	Telegraph Construction & Maintenance	101 —103	3 17 6	Jan, July	101⅛	101
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	2¼—2⅜	4 7 0	—	2[illegible]	2[illegible]
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	1⅛—1¼	4 0 0	—	1[illegible]	1[illegible]
1	0/6	Do. 5 per Cent. non-Cum. Preference	114 —117	4 5 3	..	..	..
St.	6%	Do. 5 per Cent. non-Cum. Preferred	103 —105	3 16 6	June, Dec	104½	103½
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	105 —107	4 8 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 —108	4 12 6	..	107½	106
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	10—11	7 5 4	..	..	..
1	6	J. G. White & Co. 6% Cm. Pref.	⅛—⅜	5 5 3	Apr, Oct	..	..
1	1/0	Willans & Robinson Ord.	2¼—2½	10 18 0	Apr, Oct	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	76 —80	5 0 0	May, Nov	78	77
St.	4%	Do. 4 per Cent. 1st Mort. Debs.					
		TELEGRAPHS.	3 —3½	—	June, Dec	..	..
1	..	Amazon Telegraph	93 —96	5 4 0	June, Dec	93½	..
100	5%	Do. 5 per Cent. Debs. (red.	61½—63½	5 2 6	F,My,Ag,N	62	..
St.	15/0	Anglo-American	104 —105	5 15 0	F,My,Ag,N	104½	104
St.	30/0	Do. Preferred	21½—21¾	1 10 9	F,My,Ag,N	22[illegible]	21⅞
St.	8/0	Do. Deferred	89 —91	4 5 0	Jn,Ap,Jy,O	90	88⅞
St	4%	†Commercial Cable 4 per Cent. Deb. Stk.	8⅞—9⅛	6 8 0	Feb, Aug	..	—
10	6/0	Cuba Submarine Ord.	17½—18½	5 5 0	Feb, Aug	18⅛	..
10	10/0	Do. Preference 10 per Cent.	3 —3½	6 14 0	April, Oct	—	..
5	2/0	Direct Spanish Ord.	8 —8½	5 18 0	April, Oct	8[illegible]	..
5	5/0	Do. 10 per Cent. Cum. Pref.	100½—102½	4 8 6	Jan, July	..	..
50	4½%	Do. 4½ per Cent. Deb.	13¼—13¾	6 3 6	Jn,Ap,Jy,O	13½	13½
20	5/0	Direct United States Cable	100 —102	4 8 0	June, Dec	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	129 —132	5 6 0	Ja,My,Jy,O	131½	128¾
St.	25/0	Eastern Ordinary	85 —87	4 0 6	Ja,My,Jy,O	81¼	80½
St.	17/6	Do. 3½ per Cent. Pref. Stock	104 —106	3 15 6	May, Nov	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	11¾—12¼	5 14 0	Ja,Ap,Jy,O	12⅛	11⅞
[illegible]	[illegible]	Eastern Extension	102 —104	3 16 0	Feb, Aug	—	..
[illegible]	[illegible]	Do. 4 per Cent. Deb. Stock	100 —102	4 8 0	May, Nov	..	..
[illegible]	[illegible]	Eastern & S.Af. 4% Mauritius Sub. Debs.	26 —27	6 13 6	Jan, July	26[illegible]	—
[illegible]	[illegible]	G. N. of Copenhagen, with Coupon 77	100 —102	4 9 0	June, Dec	..	..
[illegible]	[illegible]	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	61½—63½	5 16 9	May, Nov	62½	..
[illegible]	[illegible]	Indo-European, ex. all	[illegible]—97	4 2 6	Ja,Ap,Jy,O	96[illegible]	..
[illegible]	$1	[illegible] Companies Common	80 —82	4 17 6	Ja,Ap,Jy,O	78½	..
100	$1	Do. [illegible]	[illegible]	..	April	¾	[illegible]
1	..	[illegible] Wireless Teleg. Co.	[illegible]—102	3 15 0	June, Dec	—	—
1	[illegible]	[illegible] 4% Guar. Deb. (red.)	[illegible]	3 16 0	May	1⅛	1½
[illegible]	[illegible]	[illegible] America	[illegible]—102	3 15 0	Jan, July	..	..
1	[illegible]	Do. [illegible] Debs.	[illegible]	..	May, Nov	—	—
[illegible]	[illegible]	[illegible]	[illegible]	6 10 0	May, Nov	[illegible]	—
[illegible]	[illegible]	[illegible] Pref	[illegible]	6 6 0	May, Nov	—	—
[illegible]	[illegible]	[illegible]	[illegible]	..	Jan, July	..	..
[illegible]	[illegible]	[illegible] Debs.	101½—103½	4 16 6	Mr,Jn,O,D	13½	13
[illegible]	[illegible]	[illegible]	13½—14	6 0 0	June, Dec	104½	..
[illegible]	[illegible]	[illegible] (red.)	103 —105	3 16 0	..	..	..
[illegible]	[illegible]	[illegible] Teleg. $1,000 4% Bonds	105 —107	3 14 0	..	..	..
		TELEPHONES.					
100	2½	†Amer. Telephn. & Telegh. Cap. St.	146 —148	5 8 0	..	147	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	97 —99	4 1 0	Jan, July	98	97½
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —103	4 17 0	Mar, Sept	..	—
5	1/0	Chili Telephone	3 —3⅛	4 15 6	August ..	..	—
1	0/7½	Monte Video Telephone Ord.	⅝—⅞	6 17 0	Nov	..	..
1	0/6	Do. 6 per Cent. Pref.	⅝—⅞	5 14 0	May, Nov	1⅛	..
St.	6%	National Co. Pref. Stock	106½—108	5 11 0	Feb, Aug	107½	107
St.	6%	Do. Def. Stock	121 —123	4 17 6	Feb, Aug	122½	121½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11	5 9 0	Feb, Aug	10⅞	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 —5¼	4 8 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	..	—
St	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Oriental	1⅛—1¼	5 4 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 11 0	April, Oct	1¼	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	85 —88	4 11 0	Jan, July	87½	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100½—101½	4 8 6	Jan, July	..	..
5	5/0	United River Plate	6¾—7¼	5 11 0	July	7	6⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅜	4 9 0	June, Dec	5⅜	..
St	4½%	Do 4½ Deb. St. Red.	104 —106	4 5 6	Jan, July	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3 —3½	8 11 6	Jan, July	—	—
10	2/0	Globe Telegraph & Trust	10½—10⅞	6 8 6	SpDcMrJu	10½	10⅜
10	3/0	†Do. 6 per Cent. Pref.	13⅝—14⅛	4 5 0	SpDcMrJu	13⅝	13⅛
10	6%	Submarine Cables Trust (Cert.)	131 —134	4 9 6	April, Oct	..	..
		COLONIAL AND FOREIGN ELECTRIC RAILWAYS, TRAMWAYS, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅜—4⅝	5 2 6	April, Oct	4½	4⅜
1	..	Do. 5% Cum. 2nd Pref.	4⅛—4⅜	5 5 0	Jan, July	4⅛	4⅛
1	—	Do. 4% Deb. Stock	92½—93½	4 6 0	June, Dec	93	92¾
St	4%	Do. 4½% Deb. Stock	96 —98			97½	96⅞
St	..	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 6	Jan, July	..	..
St	5%	Brisbane Electric Trams. Invest. Ord.	6⅞—7⅛	4 5 0	May	6⅞	6⅞
1	3/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 15 0	May, Nov	5⅛	..
5	2/6	Do. 4½ per Cent. Db. Prov. Certs.	101 —104	4 6 6	Jan, July	103	101½
St.	4½%	Brit Columbia El. Ry. Df. Ord.	144 —149	5 7 6	Mar, Sept	..	..
St.	8%	Do. Pref. Ord. Stock	120 —125	4 16 0	May, Nov	123½	123
St.	6%	Do. 5% Cum. Perp. Pref. Stock	108 —111	4 10 0	Jan, July	109⅞	109½
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
100	4½%	Do. 4½% Perp Con. Deb. St.	101½—103½	4 2 0	—	101⅞	102⅜
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —100	5 0 0	Mar, Sept	98½	..
St.	5%	Buenos Ayres Port & City Tram. 1st Mt. Deb. Stock	90 —94	6 8 0	Feb, Aug	..	..
St.	6%	Calcutta Tramways (1 to 137,610)	4⅞—5⅛	3 14 6	Mar, Sept	4⅞	..
5	2/0	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	4[illegible]	..
100	2/6	Do. 4½% 1s. Deb. Stock (red.)	99 —102	4 8 0	Jan, July	102	..
1	4½%	Cape Electric Tram Shares	[illegible]	4 1 6	F,My,A,N	5⅛	5⅛
St.	..	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—6	3 19 0	June, Dec	..	..
5	1/3	Do. 4 per Cent. Deb. Stock	98 —101	4 19 0	May, Nov	99	—
St.	4%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	98 —101				
..	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	82 —85	5 17 0	June, Dec	..	—
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94 —97	5 2 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	93½—95½	5 4 6	Jan, July	94½	91
5	6%	Do. 6 per Cent. "B" Ditto	68 —72	8 6 0	Jan, July	70½	70
5	1/0	Lisbon Elec. Trams. Ord.	[illegible]—1 3/16	4 4 9	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]—1 1/16	5 1 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	99 —103	4 17 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —95	5 2 0	Jan, July	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	96 —97	5 3 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	127 —130	3 17 0	..	128⅞	128
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	92 —94	5 6 6	..	93⅛	12½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent.					
		Debs. (1922) (Nos. 601 to 2,000)	103 —105	4 6 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	104 —106	4 5 0	..	..	..
St.	4½%	Perth Elec. Trams Ord.	⅝—⅞	8 0 0	May	½	—
1	0/6	Do. 1st Mt. Db. Stock	100½—103½	4 16 6	Jan, July	..	..
St.	5%	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅝—5¾	5 4 8	..	5½	..
5	3/0		99 —101	4 9 0	..	94½	93½
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	93 —95	..	..	93½	91½
100	..	Rio Janeiro Tram, Lt. & P. Co.	94 —96%	6 4 6	—	87⅞	85⅝
..	5%	Do. 30 yr. Gold Bnds.	85 —86	5 16 0	..	..	..
100	5%	Do. 50 yr. Mt. Bnds.				..	..
—	$1½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	149 —152	6 11 6	..	..	..
			101 —103	4 17 0	June, Dec	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	99 —101	4 9 0	Feb, Aug	..	..
100	4½%	Toronto Ry Co. 1st Mt. 4½% Ster. Bonds					
		COLONIAL AND FOREIGN ELECTRICITY SUPPLY &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	6¼—6¾	5 4 0	Mar, Sept	..	..
10	6/0	Bombay E. S. & T. 6% Cm. Pf.	9⅞—10⅛	5 18 9	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 —96	4 14 0	Jan, July	..	—
..	..	Do. 5 per Cent. 2nd Mort. Deb. Stock	93½—95½	..	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	6⅛—6½	6 0 0	April, Oct	..	..
100	$1½	†Canadian Gen. Elec. Co. Com. St.	120 —125	5 12 0	..	124½	123
100	$3½	†Do. 7% Cm. Pf. Stock	118 —120	5 16 6	..	118½	—
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
			84 —86	5 16 0	—	..	—
500	5%	Elect. Development Co of Ontario					
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	91 —94	5 6 6	Jan, July	—	..
		Indian Elec. Sup. & Trac. Co.	1½—2	—	..	—	..
5	..	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	..	..
108	[illegible]	Do. 6 per Cent. Cum. Pref.	[illegible]	6 18 3	April, Oct	[illegible]	—
1	0/7½	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	76 —80	6 5 0	April, Oct	..	..
St.	5%	Melbourne E. S. Co. 6% Cum. Pref.	[illegible]	..	..	92⅞	92½
St.	—	Do. 5% 1st Mortg. Deb. Stock	91 —93	..	—		
St.	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	81 —83%	6 0 9	..	83⅛	81½
500	5%		70 —74	6 15 9	—	72½	71
St.	$1	Mexican Lt & Power Co. Com. St.	83 —85	5 14 0	..	84	83½
500	5%	Do. 5% 1st Mort. Gold Bnds.	127 —131	4 15 0	F,My,A,N	..	—
100	$1	Montreal Lt. Ht. & Power Co. Cap. St.	[illegible]	4 10 0	April	[illegible]	1½
1	1/1½	River Plate Electricity Co. Ord.	1 —1¼	5 6 6	May	1[illegible]	—
1	1 2⅞	Do. 6 per Cent. non-Cum. Pref	103 —106	4 11 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	[illegible]	5 5 0	April, Oct	..	—
5	3/0	†Rosario Elec. Co. 6% Pref. (1-20,000)	[illegible]	5 1 0	—	5⅝	..
[illegible]	2/0	†Do. 2nd Pref.	97 —99	4 1 0	—	8½	..
100	$1	Shawinigan Water & Power Co. Ca	105½—107½	4 13 0	Jan, July	100½	—
..	5%	Do. 5 per Cent. Bds.	99 —100	4 10 0	—	99¾	99½
St.	4½%	Do. 4½ per Cent. Con. Mt. Db. St.	99½—100½	4 9 6	..	100⅜	100
St.	4½	Toronto Power Co. 4½% Db. St.	[illegible]	5 8 0	Jan, July	[illegible]	[illegible]
..	[illegible]	Victoria Falls Power Co. Pref.	⅞—1	..	..	..	..
[illegible]	—	Do. 15/- paid					

[illegible] allowance has been made for accrued interest but not for redemption. † Ex dividend ‡ The London Stock Exchange Committee have declined to quote these.